IN THE UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF TEXAS
FORT WORTH DIVISION

COMPETITIVE ACCESS SYSTEMS, INC.	)	
	)	
	)	Case No: 4:25-cv-00948
Plaintiff,	)	
	)	**JURY TRIAL DEMANDED**
v.	)	
	)	
	)	
MOTOROLA MOBILITY LLC	)	
	)	
	)	
Defendant.	)	

ORIGINAL COMPLAINT

Plaintiff Competitive Access Systems, Inc. (“CAS” or "Plaintiff") makes this Complaint, including a demand for a jury trial, against Motorola Mobility LLC (“Defendant” or “Motorola”) and alleges as follows:

NATURE OF THE ACTION

1. This is an action for infringement of U.S. Patent Nos. 8,861,349; 9,350,649; 11,418,641; 11,582,343; and 8,228,801 (the “Asserted Patents”). This action seeks past money damages for Motorola’s acts of making, using, selling, offering for sale, and/or importing its infringing products that infringe CAS's rights in five issued U.S. Patents. Such infringing products include consumer electronic products, including but not limited to Motorola’s Smartphones that implement 3GPP standards in conjunction with Motorola’s device’s simultaneous use of 4G LTE and 5G connections.

THE PARTIES

2. Plaintiff Competitive Access Systems, Inc., is incorporated under the laws of the State of Texas, and its principal place of business is located in Plano, Texas.

Competitive Access Systems EX2011
Red Hat, Inc. v. Competitive Access Systems, Inc.
IPR2025-01372

3. On information and belief, Motorola is a Delaware limited liability company with its principal place of business at 222 W. Merchandise Mart Plaza, Suite 1800, Chicago, Illinois 60654. Motorola designs, develops, manufactures, sells, offers for sale, markets, and imports mobile phones in the United States and does business in Texas, directly or through intermediaries, and offers its products and/or services, including those accused herein of infringement, to customers and potential customers located in Texas, including in the Judicial District of the Northern District of Texas. Motorola has multiple places of business in the state of Texas, including a place of business at 13301 Park Vista Boulevard, Fort Worth, Texas 76177. As of March 10, 2022, Motorola had at least 13 employees in the Fort Worth area. Motorola is registered to do business in the state of Texas and has a registered agent located at 1999 Bryan St., Ste. 900, Dallas, Texas 75201.

4. Motorola designs, manufactures, imports, distributes, offers to sell and/or sells the infringing products throughout the United States, including within this judicial district, and introduces infringing products and services into the stream of commerce knowing that they would be sold and/or used in this judicial district and elsewhere in the United States.

JURISDICTION AND VENUE

5. This action arises under the United States patent laws, 35 U.S.C. § 101, *et seq.*, including 35 U.S.C. § 271, *et seq*. This Court has subject matter jurisdiction under 28 U.S.C. § 1331 and § 1338(a).

6. This Court has personal jurisdiction over Motorola in this action because Motorola has committed acts of infringement within this District giving rise to this action, has a regular and established place of business in this District, and has established minimum contacts with this forum such that the exercise of jurisdiction over Motorola would not offend traditional notions of fair

play and substantial justice. Motorola, directly and/or through subsidiaries or intermediaries, conducts its business extensively throughout Texas, by shipping, distributing, offering for sale, selling, and advertising its products and/or services in Texas and the Northern District of Texas, regularly does business or solicits business, engages in other persistent courses of conduct, and/or derives substantial revenue from products and/or services provided to individuals in Texas, and committed acts of infringement of CAS's patents in this District by, among other things, making, using, importing, offering to sell, and selling products that infringe the Asserted Patents, including without limitation the Motorola smartphones accused of infringement in this case. Motorola, directly and/or through subsidiaries or intermediaries, has purposefully and voluntarily placed one or more products and/or services in the stream of commerce that practice the Asserted Patents with the intention and expectation that they will be purchased and used by consumers in the Northern District of Texas. These products and/or services have been purchased and used in the Northern District of Texas.

7. Venue is proper in this judicial district pursuant to 28 U.S.C. §§ 1391 and 28 U.S.C. § 1400(b). Motorola has transacted business in this District and has committed acts of direct infringement in this District by, among other things, making, using, importing, offering to sell, and/or selling products that infringe the Asserted Patents.

INTRODUCTION

CAS and Eric Delangis

8. CAS was founded by Eric Delangis as a technology design and development company.

9. Mr. Delangis has extensive experience designing communications systems for satellites and terrestrial applications. While living in rural Colorado, Mr. Delangis was unable to

obtain high speed internet. Rather than settle for slow, dial-up internet, Mr. Delangis attempted to find a commercial solution for pooling multiple internet connections. When he was unable to locate any solutions to his problem, Mr. Delangis invented innovative router technology to route data over several internet connections, including DSL, ISDN, dial-up, and wireless connections, and combine the received data for the intended receiving device.

10. In particular, Mr. Delangis developed a variety of systems and protocols for transmitting and receiving data in a faster and more efficient manner by transmitting data over multiple communication channels to improve the effective bandwidth between the sender and recipient of the data. The usage of multiple communication channels further provides enhanced reliability as data can be transmitted even when some of the communication channels are suffering from reduced performance or are unavailable. This improves the functionality of the computer networks themselves, particularly as compared to the solutions available at the time Mr. Delangis invented his router technology.

11. Mr. Delangis' solution is necessarily rooted in computer technology and wired and wireless communications to overcome a problem specifically arising in the realm of computer networks. By enabling the simultaneous use of multiple communication channels, Mr. Delangis' technology reduces the likelihood of dropped connections, slow data rates, or service interruptions. This is particularly important for wireless applications that demand high reliability, including video conferencing, real-time navigation, and emergency communications, where network interruptions can have significant consequences. The increased speed, bandwidth, and reliability this technology offers is a key advantage for users.

Motorola and Motorola's Smartphones

12. Motorola designs, markets and sells, among other consumer electronics, wireless

portable electronic devices, including smartphones.

13. With the release of E-UTRAN New Radio Dual Connectivity ("EN-DC") based on the 3GPP 5G New Radio (NR) standard in 2019 ("3GPP"), Motorola smartphones applying dual connectivity technology can use both 4G and 5G networks to obtain high speeds, low latency, and increased connectivity by combining the capabilities of both 4G and 5G networks.

14. As explained more fully below, CAS asserts that each Motorola product implementing 3GPPP, including through EN-DC, infringes the Asserted Patents. To recover appropriate remedies for past infringement, CAS brings this action for patent infringement.

THE CAS ASSERTED PATENTS

15. The claims in this Complaint are for infringement of U.S. Patent Nos. 8,861,349; 9,350,649; 11,418,641; 11,582,343; and 8,228,801 (collectively the "Asserted Patents"). CAS does not waive, and expressly reserves, all rights and claims for relief against Motorola and others with regard to its patent rights beyond those set forth in this Complaint.

THE '349 PATENT

16. U.S. Patent No. 8,861,349 (the "'349 Patent") is entitled "Broadband Communications Device." The '349 Patent was duly and legally issued on October 14, 2014, by the United States Patent and Trademark Office. A copy of the '349 Patent is attached to this Complaint as Exhibit A and incorporated herein by reference.

17. CAS is the owner and assignee of the '349 Patent and possesses all rights of recovery under the '349 Patent.

18. The '349 Patent expired on October 14, 2023. This Complaint seeks damages for infringement of the '349 Patent prior to its expiration.

19. The '349 Patent claims are valid and enforceable.

THE ‘649 PATENT

20. U.S. Patent No. 9,350,649 (the "'649 Patent") is entitled “Multipath Communication Devices and Methods." The '649 Patent was duly and legally issued on May 24, 2016, by the United States Patent and Trademark Office. A copy of the '649 Patent is attached to this Complaint as Exhibit B and incorporated herein by reference.

21. CAS is the owner and assignee of the '649 Patent and possesses all rights of recovery under the '649 Patent.

22. The '649 Patent expired on October 14, 2023. This Complaint seeks damages related to infringement of the ’649 Patent prior to its expiration.

23. The '649 Patent claims are valid and enforceable.

THE ‘641 PATENT

24. U.S. Patent No. 11,418,641 (the "'641 Patent") is entitled “Devices and Methods for Multipath Communications." The '641 Patent was duly and legally issued on August 16, 2022, by the United States Patent and Trademark Office. A copy of the '641 Patent is attached to this Complaint as Exhibit C and incorporated herein by reference.

25. CAS is the owner and assignee of the '641 Patent and possesses all rights of recovery under the '641 Patent.

26. The '641 Patent expired on December 11, 2023. This Complaint seeks damages related to infringement of the ’641 Patent prior to its expiration.

27. The '641 Patent claims are valid and enforceable.

THE ‘343 PATENT

28. U.S. Patent No. 11,582,343 (the "'343 Patent") is entitled “Devices and Methods for Multipath Communications." The '343 Patent was duly and legally issued on February 14,

2023, by the United States Patent and Trademark Office. A copy of the '343 Patent is attached to this Complaint as Exhibit D and incorporated herein by reference.

29. CAS is the owner and assignee of the '343 Patent and possesses all rights of recovery under the '343 Patent.

30. The '343 Patent expired on October 14, 2023. CAS seeks damages for infringement of the ‘343 Patent occurring prior to its expiration.

31. The '343 Patent claims are valid and enforceable.

THE ‘801 PATENT

32. U.S. Patent No. 8,228,801 (the "'801 Patent") is entitled “Broadband Communications Device." The '801 Patent was duly and legally issued on July 24, 2012, by the United States Patent and Trademark Office. A copy of the '801 Patent is attached to this Complaint as Exhibit E and incorporated herein by reference.

33. CAS is the owner and assignee of the '801 Patent and possesses all rights of recovery under the '801 Patent.

34. The '801 Patent expired on January 22, 2025. CAS seeks damages for infringement of the '801 Patent occurring prior to its expiration.

35. The '801 Patent claims are valid and enforceable.

DEFENDANT’S INFRINGING PRODUCTS

36. Upon information and belief, Motorola smartphones demonstrate EN-DC technology via simultaneous use of 4G LTE and 5G New Radio (NR) connections, using simultaneous throughput on the 5G network and on the 4G-LTE network. *See, e.g.*, Exhibit F.

37. On information and belief, Motorola smartphones deploy EN-DC technology which implements the standards described in 3GPP protocols, such as 3GPP TS 37.340 and related

protocols.

38. More specifically, Motorola smartphones use core processor chipsets (e.g., Snapdragon or MediaTek chipsets) deploying Non-Standalone (NSA) 5G mode, which inherently supports EN-DC technology in compliance with 3GPP standards. *See id*.

39. 3GPP protocols explain that when the device user is connected to 4G-LTE and 5G-NR networks via EN-DC, it communicates via both networks with any remote system which the user is accessing, leveraging a "Master Cell Group" or "Master Node" in a first network (e.g., 4G-LTE), and a "Secondary Cell Group" or "Secondary Node" in a second network (e.g., 5G-NR). *See* Exhibit G, at Section 4.2.2, 4.3.2.1.

40. An example of Motorola's commercially available smartphones deploying a fully integrated NSA 5G modem – and thus using EN-DC technology – was the Motorola Edge Plus, which was commercially released in May 2020. *See* Exhibit H.

41. Since at least as early as 2020, Motorola has continued to highlight its use of EN-DC technology, for example, disclosing in its product specifications that its devices support both 4G LTE and 5G NR frequency bands within a single device. *See, e.g.*, Exhibit F.

42. Motorola infringed CAS's patents rights by making, using, selling, offering for sale, and/or importing its smartphones that comply with portions of 3GPP protocols, including but not limited to through its use of EN-DC. The Motorola "Infringing Products" include, but are not limited to, the following models:

- Moto E Series
  - Moto E6
  - Moto E6 Play
  - Moto E6 Plus
  - Moto E6s
  - Moto E
  - Moto E7
  - Moto E7 Plus

Moto E6i
Moto E7 Power
Moto E7i Power
Moto E20
Moto E30
Moto E40
Moto E22
Moto E22s
Moto E32
Moto E13
Moto E14

- Moto G Series
  - Moto G7
  - Moto G7 Play
  - Moto G7 Power/Optimo Maxx/Supra
  - Moto G7 Plus
  - Moto G8 Play
  - Moto G8 Plus
  - Moto G8
  - Moto G8 Power
  - Moto G8 Power Lite
  - Moto G7 Optimo
  - Moto G 2020 line:
    - Moto G Fast
    - Moto G Power
    - Moto G Stylus/G Pro
    - Moto G 5G Plus
  - Moto G9 Play/G9
  - Moto G9 Plus
  - Moto G9 Power
  - Moto G 2021 line:
    - Moto G 5G
    - Moto G Pure
    - Moto G Play
    - Moto G Power
    - Moto G Stylus
    - Moto G Stylus 5G
  - Moto G10
  - Moto G10 Power
  - Moto G20
  - Moto G30
  - Moto G40 Fusion
  - Moto G50
  - Moto G50 5G
  - Moto G60

  - Moto G60S
  - Moto G100
  - Moto G 2022 line:
    - Moto G Power
    - Moto G 5G
    - Moto G Stylus
    - Moto G Stylus 5G
  - Moto G31
  - Moto G41
  - Moto G51 5G
  - Moto G71 5G
  - Moto G200 5G
  - Moto G22
  - Moto G52
  - Moto G52j
  - Moto G82
  - Moto G62
  - Moto G32
  - Moto G72
  - Moto G53 5G
  - Moto G13
  - Moto G23
  - Moto G53j/G53s/G53y
  - Moto G73 5G
  - Moto G14
  - Moto G34 5G
  - Moto G84
  - Moto G54
  - Moto G54j/G54j 5G

- Moto S Series
  - Moto S30 Pro

- Moto X Series
  - Moto X30 Pro
  - Moto X40

- Moto Z Series
  - Moto Z4

- Motorola Razr Series
  - Motorola Razr
  - Motorola Razr 5G
  - Motorola Razr
  - Motorola Razr 40
  - Motorola Razr+

- Motorola Edge Series
  - edge
  - edge+
  - edge S/moto g100
  - edge 20 Lite
  - edge 20 Fusion
  - edge 20
  - edge 20 PRO/edge S PRO (PRC)
  - edge S30 (PRC)
  - edge X30 (PRC)
  - edge 30
  - edge 30 PRO
  - edge 30 ULTRA
  - edge 30 FUSION
  - edge 30 NEO
  - edge 40
  - edge 40 PRO/edge+ (2023) (US)/edge X40 (PRC)

- Motorola One Series
  - Motorola One P30 Note
  - Motorola One Vision
  - Motorola One Action
  - Motorola One Zoom
  - Motorola One Macro
  - Motorola One Hyper
  - Motorola One Fusion
  - Motorola One Fusion+
  - Motorola One 5G Ace

CLAIMS FOR RELIEF

43. CAS’s averments of infringement against Motorola that follow in Counts One – Five are exemplary of, and without prejudice to CAS's ultimate infringement contentions. In providing these averments, CAS does not convey or imply any particular claim constructions or purport to describe the precise scope of the claims. CAS's claim constructions, as necessary, regarding any particularized meaning of the claim terms for the Asserted Patents' claims will be provided in accordance with the Court's scheduling order and any applicable local rules or standards.

COUNT ONE
(INFRINGEMENT OF U.S. PATENT NO. 8,861,349)

44. CAS repeats, re-alleges, and incorporates by reference the averments of all preceding paragraphs of this Complaint as though fully set forth herein.

45. Motorola's Infringing Products infringe at least claim 13 of the '349 Patent.

46. By way of further illustrative infringement, claim 13 of the '349 Patent recites as follows:

> **13**. A device comprising:
> an interface that establishes a network connection at a first location to a first network and receives first data packets over the network connection;
> a wireless interface that is configured to establish a wireless connection to a remote communications device, the remote communications device being connected at a second location to a second network; and
> a processor that sends a multilink request over the wireless interface to the remote communications device to join the multilink connection, receives from the interface the first data packets from the first network and when the multilink request is accepted by the remote communications device, concurrently receives from the wireless interface second data packets from the second network, the second data packets being received at the second location from the second network.

47. For example, any Motorola device implementing 3GPP, including through EN-DC, has "an interface that establishes a network connection at a first location to a first network and receives first data packets over the network connection." For example, each Motorola Infringing Product can connect to a "Master Node" (e.g. ENB and/or GNB) at a first location and receive first data packets through a 4G-LTE network connection according to 3GPP specifications. *See* Exhibit G, at Sections 3, 4.1.2, 4.1.3.1, 4.3.1, 4.3.2, and 10.2.1, 10.3.1.

48. Any Motorola device implementing 3GPP, including through EN-DC, has "a wireless interface that is configured to establish a wireless connection to a remote communications device, the remote communications device being connected at a second location to a second network." For example, each Motorola Infringing Product can connect to one or more "Secondary

Nodes" (e.g. GNB) at a second location and receive second data packets through a 5G-NR wireless interface according to 3GPP specifications. *See id.*, at Sections 3, 4.1.2, 4.1.3.1, 4.3.1, 4.3.2, 10.2.1, and 10.3.1.

49. Any Motorola device implementing 3GPP, including through EN-DC, has "a processor that sends a multilink request over the wireless interface to the remote communications device to join the multilink connection." For example, a Motorola device in the EN-DC configuration exchanges several messages and data structures including but not limited to those described in the following 3GPP specifications:

a. **RRC Connection Setup Complete** which also includes the "Attach Request," "PDN Connectivity Request," and "UE Network Capability" data structures and elements. *See* Exhibit I, at Sections 5.5.1.2.4, 5.5.3.2.4, 8.2.4, 8.3.20, and 9.9.3.34.

b. **UE Capability Information** which also includes the "UE-MRDC-Capability" and "SupportedBandListNR" data structures. *See* Exhibit J, at Section 6.3.3; *see also* Exhibit K, at Section 4.2.8.

c. **GNB Addition Request** which also includes the "CG-Config" data structure. *See* Exhibit J, at Section 11.2.2.

d. **RRC Connection Reconfiguration for 5G-NR Bearer** which also includes the "CG-Config" and the "RRCReconfigurationComplete" data structures. *See id.*, at Sections 11.2.2 and 6.2.2.

e. **SgNB Reconfiguration Complete** which also includes the "RRCReconfigurationComplete" data structure. *See* Exhibit L, at Section 8.7.5; *see also* Exhibit J at Section 6.2.2.

f. **NR PDCCH DCI** and **NR MAC PDU**. *See* Exhibit M, at Section 7; *see also*

Exhibit N, at Section 6.

50. Any Motorola device implementing 3GPP, including through EN-DC, has a processor that "receives from the interface the first data packets from the first network." For example, a Motorola device in the EN-DC configuration is connected to a “first network” (e.g. a 4G-LTE network via an ENB) and second network (e.g. a 5G-NR network via a GNB) and can receive data packets from the “first network” via wireless base stations (e.g. the 4G-LTE ENB) according to 3GPP specifications.

51. Any Motorola device implementing 3GPP, including through EN-DC, has a processor that "when the multilink request is accepted by the remote communications device, concurrently receives from the wireless interface second data packets from the second network, the second data packets being received at the second location from the second network." For example, a Motorola device in the EN-DC configuration is simultaneously connected to a “first network” (e.g. a 4G-LTE network via an ENB) and second network (e.g. a 5G-NR network via a GNB). Using the “split bearer” configuration, the Motorola device receives data packets from both the first network (e.g. the 4G-LTE ENB) and the second network (e.g. the 5G-NR GNB). *See* Exhibit G, at Sections 4.2.2 and 4.3.2.1.

52. As such, Motorola, without license or authorization to do so, has directly infringed one or more claims of the '349 Patent, literally or under the doctrine of equivalents, by making, using, offering for sale and/or selling its Infringing Products within this District and elsewhere in the United States, and/or importing into the United States its Infringing Products, in violation of 35 U.S.C. § 271(a).

53. CAS is entitled to damages for past infringement in an amount to be determined by the Court but in no event less than a reasonable royalty.

COUNT TWO
(INFRINGEMENT OF U.S. PATENT NO. 9,350,649)

54. CAS repeats, re-alleges, and incorporates by reference the averments of all preceding paragraphs of this Complaint as though fully set forth herein.

55. Motorola's Infringing Products infringe at least claim 18 of the '649 Patent.

56. By way of further illustrative infringement, claim 18 of the '649 Patent recites as follows:

> **18**. A data-requesting device comprising:
> at least one interface capable of connecting concurrently to a plurality of network-edge devices during a multipath connection, the multipath connection comprising the connections between the data-requesting device and each of the network-edge devices; and
> at least one processor coupled to the at least one interface that
> sends multipath information to each of the network-edge devices that is capable of joining the multipath connection; and
> receives different data at the data-requesting device from different ones of the network-edge devices that are able to join the multipath connection.

57. For example, any Motorola device implementing 3GPP, including through EN-DC, is "a data-requesting device."

58. Any Motorola device implementing 3GPP, including through EN-DC, has "at least one interface capable of connecting concurrently to a plurality of network-edge devices during a multipath connection, the multipath connection comprising the connections between the data-requesting device and each of the network-edge devices." For example, each Motorola Infringing Product is capable of connecting concurrently to these one or more "Master Nodes" (e.g. ENB and/or GNB) and one or more "Secondary Nodes" (e.g. GNB), each of which comprise network edge devices, and maintaining a multipath connection via the network edge devices' 4G-LTE or 5G-NR wireless interfaces according to 3GPP specifications for EN-DC. *See* Exhibit G, at Sections 3, 4.1.2, 4.1.3.1, 4.3.1, 4.3.2, 10.2.1, and 10.3.1.

59. Any Motorola device implementing 3GPP, including through EN-DC, has "at least one processor coupled to the at least one interface[.]"

60. Any Motorola device implementing 3GPP, including through EN-DC, has a processor that "sends multipath information to each of the network-edge devices that is capable of joining the multipath connection[.]" For example, a Motorola device in the EN-DC configuration exchanges several messages and data structures including but not limited to those described in the following 3GPP specifications:

a. **RRC Connection Setup Complete** which also includes the “Attach Request,” “PDN Connectivity Request,” and “UE Network Capability” data structures and elements. *See* Exhibit I, at Sections 5.5.1.2.4, 5.5.3.2.4, 8.2.4, 8.3.20, and 9.9.3.34.

b. **UE Capability Information** which also includes the “UE-MRDC-Capability” and “SupportedBandListNR” data structures. *See* Exhibit J, at Section 6.3.3; *see also* Exhibit K, at Section 4.2.8.

c. **GNB Addition Request** which also includes the “CG-Config” data structure. *See* Exhibit J, at Section 11.2.2.

d. **RRC Connection Reconfiguration for 5G-NR Bearer** which also includes the “CG-Config” and the “RRCReconfigurationComplete” data structures. *See id.*, at Sections 11.2.2 and 6.2.2.

e. **SgNB Reconfiguration Complete** which also includes the “RRCReconfigurationComplete” data structure. *See* Exhibit L, at Section 8.7.5; *see also* Exhibit J at Section 6.2.2.

f. **NR PDCCH DCI** and **NR MAC PDU**. *See* Exhibit M, at Section 7; *see also* Exhibit N, at Section 6.

61. Any Motorola device implementing 3GPP, including through EN-DC, has a processor that is capable of receiving "different data at the data-requesting device from different ones of the network-edge devices that are able to join the multipath connection." For example, any Motorola Infringing Product implementing 3GPP receives different data from the Master Node and Secondary Node, as described in 3GPP specifications including TS 37.340, via a "multipath connection", where the data is transmitted through the 3GPP "split bearer" configuration. *See* Exhibit G, at Sections 4.2.2, 4.3.2.1.

62. As such, Defendant Motorola, without license or authorization to do so, has directly infringed one or more claims of the '649 Patent, literally or under the doctrine of equivalents, by making, using, offering for sale and/or selling its Infringing Products within this District and elsewhere in the United States, and/or importing into the United States its Infringing Products, in violation of 35 U.S.C. § 271(a).

63. CAS is entitled to damages for past infringement in an amount to be determined by the Court but in no event less than a reasonable royalty.

COUNT THREE
(INFRINGEMENT OF U.S. PATENT NO. 11,418,641)

64. CAS repeats, re-alleges, and incorporates by reference the averments of all preceding paragraphs of this Complaint as though fully set forth herein.

65. Motorola's Infringing Products infringe at least claim 1 of the '641 Patent.

66. By way of further illustrative infringement, claim 1 of the '641 Patent recites as follows:

> **1**. A communications device that is capable of providing broadband communications services, comprising:
> at least one connection for connecting to a communications network;
> at least one wireless interface for connecting wirelessly to at least one remote communications device; and
> a processor that

requests the at least one remote communications device to assist in transferring data,
sends a request to the at least one remote communications device for availability for participating in a multilink communication,
if available, sends control information through the at least one remote communications device for participating in a multilink connection,
receives packets from the at least one remote communications device, and
aggregates the data from the at least one remote communications device with data transfers from the at least one connection to increase data bandwidth for the communications device.

67. For example, any Motorola device implementing 3GPP, including through EN-DC, is "a communications device that is capable of providing broadband communications services."

68. Any Motorola device implementing 3GPP, including through EN-DC, has "at least one connection for connecting to a communications network." For example, each Motorola Infringing Product can connect one or more “Master Nodes” (e.g. ENB and/or GNB) and receive first data packets through a 4G-LTE communications network according to 3GPP specifications. *See* Exhibit G, at Sections 3, 4.1.2, 4.1.3.1, 4.3.1, 4.3.2, 10.2.1, and 10.3.1.

69. Any Motorola device implementing 3GPP, including through EN-DC, has "at least one wireless interface for connecting wirelessly to at least one remote communications device." For example, each Motorola Infringing Product can connect to one or more “Secondary Nodes” (e.g., GNB) and receive second data packets through a 5G-NR wireless interface according to 3GPP specifications. *See* Exhibit G, at Sections 3, 4.1.2, 4.1.3.1, 4.3.1, 4.3.2, 10.2.1, and 10.3.1.

70. Any Motorola device implementing 3GPP, including through EN-DC, has "a processor that requests the at least one remote communications device to assist in transferring data." For example, a Motorola device in the EN-DC configuration exchanges several messages and data structures including but not limited to those described in the following 3GPP specifications:

a. **RRC Connection Setup Complete** which also includes the “Attach Request,”

"PDN Connectivity Request," and "UE Network Capability" data structures and elements. *See* Exhibit I, at Sections 5.5.1.2.4, 5.5.3.2.4, 8.2.4, 8.3.20, and 9.9.3.34.

b. **UE Capability Information** which also includes the "UE-MRDC-Capability" and "SupportedBandListNR" data structures. *See* Exhibit J, at Section 6.3.3; *see also* Exhibit K, at Section 4.2.8.

c. **GNB Addition Request** which also includes the "CG-Config" data structure. *See* Exhibit J, at Section 11.2.2.

d. **RRC Connection Reconfiguration for 5G-NR Bearer** which also includes the "CG-Config" and the "RRCReconfigurationComplete" data structures. *See id.*, at Sections 11.2.2 and 6.2.2.

e. **SgNB Reconfiguration Complete** which also includes the "RRCReconfigurationComplete" data structure. *See* Exhibit L, at Section 8.7.5; *see also* Exhibit J at Section 6.2.2.

f. **NR PDCCH DCI** and **NR MAC PDU**. *See* Exhibit M, at Section 7; *see also* Exhibit N, at Section 6.

71. Any Motorola device implementing 3GPP, including through EN-DC, has a processor that "sends a request to the at least one remote communications device for availability for participating in a multilink communication." For example, as discussed in the paragraph above, a Motorola device in the EN-DC configuration exchanges several messages and data structures. *See* Exhibit G, at Section 3, 4.1.2, 4.1.3.1, 4.3.1, 4.3.2, 10.2.1, and 10.3.1.

72. Any Motorola device implementing 3GPP, including through EN-DC, has a processor that "if available, sends control information through the at least one remote communications device for participating in a multilink connection." For example, a Motorola

device in the EN-DC configuration sends several messages and data structures as mentioned above.

73. Any Motorola device implementing 3GPP, including through EN-DC, has a processor that "receives packets from the at least one remote communications device." For example, a Motorola device in the EN-DC configuration can receive packets from the at least one remote communications device (e.g. a 4G-LTE network via an ENB) via wireless base stations (e.g. the 4G-LTE ENB) according to 3GPP specifications.

74. Any Motorola device implementing 3GPP, including through EN-DC, "aggregates the data from the at least one remote communications device with data transfers from the at least one connection to increase data bandwidth for the communications device." For example, a Motorola device in the EN-DC configuration is simultaneously connected to “at least one remote communications device” such as a 4G-LTE base station (ENB) and a 5G-NR base station (GNB) via “at least one connection” such as a 4G-LTE wireless link and/or a 5G-NR wireless link according to 3GPP specifications. Using the “split bearer” configuration, the data is aggregated to increase bandwidth for the Motorola device. *See* Exhibit G, at Sections 4.2.2 and 4.3.2.1.

75. As such, Motorola, without license or authorization to do so, has directly infringed one or more claims of the '641 Patent, literally or under the doctrine of equivalents, by making, using, offering for sale and/or selling its Infringing Products within this District and elsewhere in the United States, and/or importing into the United States its Infringing Products, in violation of 35 U.S.C. § 271(a).

76. CAS is entitled to damages for past infringement in an amount to be determined by the Court but in no event less than a reasonable royalty.

COUNT FOUR
(INFRINGEMENT OF U.S. PATENT NO. 11,582,343)

77. CAS repeats, re-alleges, and incorporates by reference the averments of all preceding paragraphs of this Complaint as though fully set forth herein.

78. For example, Motorola's Infringing Products infringe at least claim 12 of the '343 Patent.

79. By way of further illustrative infringement, claim 12 of the '343 Patent recites as follows:

> **12**. A communication device capable of providing broadband communications services comprising:
>
> a first connection via a first device to a first network having a first bandwidth including an allocated first portion of the first bandwidth;
> a second connection via a second device to a second network having a second bandwidth including an allocated second portion of the second bandwidth; and
> a third connection to a remote device via the first network and the second network, the third connection having an effective bandwidth including the allocated first portion of the first bandwidth and the allocated second portion of the second bandwidth;
> wherein, in response to transmitting a request to the remote device via the third connection, the communication device receives a response from the remote device wherein a portion of the response is received via the first network and a portion of the response is received via the second network.

80. For example, any Motorola device implementing 3GPP, including through EN-DC, is "communication device capable of providing broadband communications services."

81. Any Motorola device implementing 3GPP, including through EN-DC, has a "first connection via a first device to a first network having a first bandwidth including an allocated first portion of the first bandwidth." For example, the Motorola devices implementing 3GPP can have a 4G-LTE link to a serving 4G-LTE base station (ENB), or "Master Node." This network provides a "first bandwidth" which is allocated for use by the Motorola device, and an "allocated portion of the first bandwidth" is used to communicate via the 4G-LTE network according to 3GPP

specifications. *See* Exhibit G, at Sections 3, 4.1.2, 4.1.3.1, 4.3.1, 4.3.2, and 10.2.1, 10.3.1.

82. Any Motorola device implementing 3GPP, including through EN-DC, has "a second connection via a second device to a second network having a second bandwidth including an allocated second portion of the second bandwidth." For example, the Motorola devices implementing 3GPP have a second connection to a 5G-NR link to a serving 5G-NR base station (GNB), or "Secondary Node." The "second device" is connected to either a 4G-LTE core network (EPC) or a 5G core network (5GC) which has a "second bandwidth." An "allocated second portion of the second bandwidth" is used to communicate via the 5G-NR network. *See* Exhibit G, at Sections 3, 4.1.2, 4.1.3.1, 4.3.1, 4.3.2, and 10.2.1, 10.3.1.

83. Any Motorola device implementing 3GPP, including through EN-DC, has "a third connection to a remote device via the first network and the second network, the third connection having an effective bandwidth including the allocated first portion of the first bandwidth and the allocated second portion of the second bandwidth." For example, a Motorola device in the EN-DC configuration is simultaneously connected to a "first network" (e.g. a 4G-LTE network) and "second network" (e.g. a 5G-NR network), both of which are used to communicate with a remote server via a "third connection", which aggregates bandwidth from the first network and the second network to provide an effective bandwidth which combines the allocated first portion of the first bandwidth (e.g. from the 4G-LTE network) and the allocated second portion of the second bandwidth (e.g. from the 5G-NR network). *See* Exhibit G, at Sections 4.2.2. and 4.3.2.1.

84. Any Motorola device implementing 3GPP, including through EN-DC, "wherein, in response to transmitting a request to the remote device via the third connection, the communication device receives a response from the remote device wherein a portion of the response is received via the first network and a portion of the response is received via the second network." For

example, a Motorola device in the EN-DC configuration is simultaneously connected to a "first network" (e.g. a 4G-LTE network) and "second network" (e.g. a 5G-NR network). Both the "first network" and the "second network" are used to communicate with a "remote device" via a "third connection." Using the "split bearer" configuration, the Motorola device receives data packets from both the first network and the second network. *See* Exhibit G, at Sections 4.2.2 and 4.3.2.1.

85. As such, Motorola, without license or authorization to do so, has directly infringed one or more claims of the '343 Patent, literally or under the doctrine of equivalents, by making, using, offering for sale and/or selling its Infringing Products within this District and elsewhere in the United States, and/or importing into the United States its Infringing Products, in violation of 35 U.S.C. § 271(a).

86. CAS is entitled to damages for past infringement in an amount to be determined by the Court but in no event less than a reasonable royalty.

COUNT FIVE
(INFRINGEMENT OF U.S. PATENT NO. 8,228,801)

87. CAS repeats, re-alleges, and incorporates by reference the averments of all preceding paragraphs of this Complaint as though fully set forth herein.

88. For example, Motorola's Infringing Products infringe at least claim 1 of the '801 Patent.

89. By way of further illustrative infringement, claim 1 of the '801 Patent recites as follows:

> **1**. A communications device that is capable of providing broadband communications services, comprising:
>
> at least one connection for connecting to a communications network;
>
> at least one wireless interface for connecting wirelessly to at least one remote communications device; and
>
> a processor that requests the at least one remote communications device to assist in transferring data, sends a request to the at least one remote communications device for requesting use of a portion of unused bandwidth of the at least one remote communications device, receives a response from the at least one remote communications device, the response containing information about the portion of unused bandwidth, selects the at least one remote communications device with unused bandwidth, sends control information to the at least one remote communications device for participating in a multilink connection, receives packets from the at least one remote communications device and aggregates the data from the at least one remote communications device with data transfers from the at least one connection to increase data bandwidth for the communications device.

90. For example, any Motorola device implementing 3GPP, including through EN-DC, is a "communications device that is capable of providing broadband communications services."

91. Any Motorola device implementing 3GPP, including through EN-DC, has "at least one connection for connecting to a communications network." For example, each Motorola Infringing Product can establish at least one connection through a 4G-LTE link to a serving 4G-LTE base station (ENB) or a 5G-NR link to a serving 5G-NR base station (GNB) and subsequent connections via the "communications network" according to 3GPP specifications. The "communications network" is the 4G-LTE network (e.g. ENB and EPC) or the 5G-NR network (e.g. GNB and 5GC) which provides connection to a remote system via a network such as the Internet.

92. Any Motorola device implementing 3GPP, including through EN-DC, has "at least one wireless interface for connecting wirelessly to at least one remote communications device." For example, each Motorola Infringing Product has a network interface (modem) which connects to a 4G-LTE link to a serving 4G-LTE base station (ENB) or a 5G-NR link to a serving 5G-NR base station (GNB). The ENB and/or GNB are the "remote communications device" to which the

Motorola device is connected wirelessly according to 3GPP specifications. *See* Exhibit G, at Sections 3, 4.1.2, 4.1.3.1, 4.3.1, 4.3.2, and 10.2.1, 10.3.1.

93. Any Motorola device implementing 3GPP, including through EN-DC, has "a processor that requests the at least one remote communications device to assist in transferring data." For example, a Motorola device in the EN-DC configuration has a processor that exchanges several messages and data structures including but not limited to those described in the following 3GPP specifications:

a. **RRC Connection Setup Complete** which also includes the "Attach Request," "PDN Connectivity Request," and "UE Network Capability" data structures and elements. *See* Exhibit I, at Sections 5.5.1.2.4, 5.5.3.2.4, 8.2.4, 8.3.20, and 9.9.3.34.

b. **UE Capability Information** which also includes the "UE-MRDC-Capability" and "SupportedBandListNR" data structures. *See* Exhibit J, at Section 6.3.3; *see also* Exhibit K, at Section 4.2.8.

c. **GNB Addition Request** which also includes the "CG-Config" data structure. *See* Exhibit J, at Section 11.2.2.

d. **RRC Connection Reconfiguration for 5G-NR Bearer** which also includes the "CG-Config" and the "RRCReconfigurationComplete" data structures. *See id.*, at Sections 11.2.2 and 6.2.2.

e. **SgNB Reconfiguration Complete** which also includes the "RRCReconfigurationComplete" data structure. *See* Exhibit L, at Section 8.7.5; *see also* Exhibit J at Section 6.2.2.

f. **NR PDCCH DCI** and **NR MAC PDU**. *See* Exhibit M, at Section 7; *see also* Exhibit N, at Section 6.

94. Any Motorola device implementing 3GPP, including through EN-DC, has a processor that "sends a request to the at least one remote communications device for requesting use of a portion of unused bandwidth of the at least one remote communications device, receives a response from the at least one remote communications device, the response containing information about the portion of unused bandwidth, selects the at least one remote communications device with unused bandwidth." For example, as discussed in the paragraph above, a Motorola device in the EN-DC configuration has a processor that exchanges several messages and data structures.

95. Any Motorola device implementing 3GPP, including through EN-DC, has a processor that "sends control information to the at least one remote communications device for participating in a multilink connection." For example, as discussed in the paragraphs above, a Motorola device in the EN-DC configuration has a processor that exchanges several messages and data structures. *See* Exhibit G, at Sections 3, 4.1.2, 4.1.3.1, 4.3.1, 4.3.2, and 10.2.1, 10.3.1.

96. Any Motorola device implementing 3GPP, including through EN-DC, has a processor that "receives packets from the at least one remote communications device and aggregates the data from the at least one remote communications device with data transfers from the at least one connection to increase data bandwidth for the communications device." For example, a Motorola device in the EN-DC configuration is simultaneously connected to "at least one remote communications device" such as a 4G-LTE base station (ENB) and a 5G-NR base station (GNB) via "at least one connection" such as a 4G-LTE wireless link and/or a 5G-NR wireless link. Both or either of these wireless links and base stations may be used to communicate with a remote system using the 3GPP "split bearer" configuration. The "split bearer" configuration of EN-DC transfers data simultaneously via multiple network connections (e.g. 4G-LTE and 5G-

NR) which "aggregates the data" and "increases data bandwidth." *See* Exhibit G, at Sections 4.2.2 and 4.3.2.1.

97. As such, Motorola, without license or authorization to do so, has directly infringed one or more claims of the '801 Patent, literally or under the doctrine of equivalents, by making, using, offering for sale and/or selling its Infringing Products within this District and elsewhere in the United States, and/or importing into the United States its Infringing Products, in violation of 35 U.S.C. § 271(a).

98. CAS is entitled to damages for past infringement in an amount to be determined by the Court but in no event less than a reasonable royalty.

PRAYER FOR RELIEF

WHEREFORE, CAS respectfully requests that the Court find in its favor and against Defendant Motorola Mobility LLC, and that the Court grant CAS the following relief:

a. A judgment in favor of CAS that Defendant Motorola Mobility LLC has infringed one or more claims of each of the following Asserted Patents of CAS: 8,861,349; 9,350,649; 11,418,641; 11,582,343; and 8,228,801;

b. An accounting of and an award to CAS of damages adequate to compensate CAS for Defendant Motorola Mobility LLC's acts of infringement, including a reasonable royalty, and also including supplemental damages for any post-verdict infringement up until entry of final judgment with an accounting as needed, together with pre-judgment and post-judgment interest pursuant to 35 U.S.C. § 284;

c. A declaration that this is an exceptional case, including an award to CAS of its costs, expenses, and reasonable attorneys' fees under 35 U.S.C. § 285 and all other applicable statutes and rules in common law as may apply;

d. An award to CAS of its costs pursuant to 35 U.S.C. § 284 and/or Fed. R. Civ. P. 54(d); and

e. An award of any such further relief that the Court deems just and proper.

JURY DEMAND

CAS herby demands a jury trial on all issues so triable.

Dated: September 2, 2025

Respectfully submitted,

By: */s/ Kevin P. Robinowitz*

Kevin P. Robinowitz
Texas Bar No. 24000917
2200 Ross Avenue, Suite 2900
Dallas, TX 75201
Telephone: (214) 560-2201
Facsimile: (214) 560-2203
Email:kevin.robinowitz@stinson.com

B. Scott Eidson (Pro Hac Vice forthcoming)
Timothy D. Krieger (Pro Hac Vice forthcoming)
Julie C. Scheipeter (Pro Hac Vice forthcoming)
STINSON LLP
7700 Forsyth Blvd., Suite 1100
St. Louis, MO 63105
Phone: 314-863-0800
Email: scott.eidson@stinson.com
Email: tim.krieger@stinson.com
Email: julie.scheipeter@stinson.com
Email: judith.araujo@stinson.com

Judith Araujo (Pro Hac Vice forthcoming)
1144 Fifteenth Street, Suite 2400
Denver, CO 80202
Phone: 303-376-8400
Email: judith.araujo@stinson.com

Alexandra P. Stanley (Pro Hac Vice forthcoming)
50 South Sixth Street, Suite 2600
Minneapolis, MN 55402
Phone: 612-335-1500
Email: alexandra.stanley@stinson.com

Attorneys for Plaintiff Competitive Access Systems, Inc.

JS 44 (Rev. 03/24)

CIVIL COVER SHEET

The JS 44 civil cover sheet and the information contained herein neither replace nor supplement the filing and service of pleadings or other papers as required by law, except as provided by local rules of court. This form, approved by the Judicial Conference of the United States in September 1974, is required for the use of the Clerk of Court for the purpose of initiating the civil docket sheet. *(SEE INSTRUCTIONS ON NEXT PAGE OF THIS FORM.)*

I. (a) PLAINTIFFS

Competitive Access Systems, Inc.

(b) County of Residence of First Listed Plaintiff _____
(EXCEPT IN U.S. PLAINTIFF CASES)

(c) Attorneys *(Firm Name, Address, and Telephone Number)*
Kevin P. Robinowitz
Stinson, LLP,2200 Ross Ave., Suite 2900
Dallas, TX 75201

DEFENDANTS

Motorola Mobility LLC

County of Residence of First Listed Defendant _____
(IN U.S. PLAINTIFF CASES ONLY)

NOTE: IN LAND CONDEMNATION CASES, USE THE LOCATION OF THE TRACT OF LAND INVOLVED.

Attorneys *(If Known)*

II. BASIS OF JURISDICTION *(Place an "X" in One Box Only)*

- ☐ 1 U.S. Government Plaintiff
- ☒ 3 Federal Question *(U.S. Government Not a Party)*
- ☐ 2 U.S. Government Defendant
- ☐ 4 Diversity *(Indicate Citizenship of Parties in Item III)*

III. CITIZENSHIP OF PRINCIPAL PARTIES *(Place an "X" in One Box for Plaintiff and One Box for Defendant)*

(For Diversity Cases Only)

	PTF	DEF		PTF	DEF
Citizen of This State	☐ 1	☐ 1	Incorporated *or* Principal Place of Business In This State	☐ 4	☐ 4
Citizen of Another State	☐ 2	☐ 2	Incorporated *and* Principal Place of Business In Another State	☐ 5	☐ 5
Citizen or Subject of a Foreign Country	☐ 3	☐ 3	Foreign Nation	☐ 6	☐ 6

IV. NATURE OF SUIT *(Place an "X" in One Box Only)*

Click here for: Nature of Suit Code Descriptions.

CONTRACT
- ☐ 110 Insurance
- ☐ 120 Marine
- ☐ 130 Miller Act
- ☐ 140 Negotiable Instrument
- ☐ 150 Recovery of Overpayment & Enforcement of Judgment
- ☐ 151 Medicare Act
- ☐ 152 Recovery of Defaulted Student Loans (Excludes Veterans)
- ☐ 153 Recovery of Overpayment of Veteran's Benefits
- ☐ 160 Stockholders' Suits
- ☐ 190 Other Contract
- ☐ 195 Contract Product Liability
- ☐ 196 Franchise

TORTS

PERSONAL INJURY
- ☐ 310 Airplane
- ☐ 315 Airplane Product Liability
- ☐ 320 Assault, Libel & Slander
- ☐ 330 Federal Employers' Liability
- ☐ 340 Marine
- ☐ 345 Marine Product Liability
- ☐ 350 Motor Vehicle
- ☐ 355 Motor Vehicle Product Liability
- ☐ 360 Other Personal Injury
- ☐ 362 Personal Injury - Medical Malpractice

PERSONAL INJURY
- ☐ 365 Personal Injury - Product Liability
- ☐ 367 Health Care/ Pharmaceutical Personal Injury Product Liability
- ☐ 368 Asbestos Personal Injury Product Liability

PERSONAL PROPERTY
- ☐ 370 Other Fraud
- ☐ 371 Truth in Lending
- ☐ 380 Other Personal Property Damage
- ☐ 385 Property Damage Product Liability

FORFEITURE/PENALTY
- ☐ 625 Drug Related Seizure of Property 21 USC 881
- ☐ 690 Other

LABOR
- ☐ 710 Fair Labor Standards Act
- ☐ 720 Labor/Management Relations
- ☐ 740 Railway Labor Act
- ☐ 751 Family and Medical Leave Act
- ☐ 790 Other Labor Litigation
- ☐ 791 Employee Retirement Income Security Act

IMMIGRATION
- ☐ 462 Naturalization Application
- ☐ 465 Other Immigration Actions

BANKRUPTCY
- ☐ 422 Appeal 28 USC 158
- ☐ 423 Withdrawal 28 USC 157

INTELLECTUAL PROPERTY RIGHTS
- ☐ 820 Copyrights
- ☒ 830 Patent
- ☐ 835 Patent - Abbreviated New Drug Application
- ☐ 840 Trademark
- ☐ 880 Defend Trade Secrets Act of 2016

SOCIAL SECURITY
- ☐ 861 HIA (1395ff)
- ☐ 862 Black Lung (923)
- ☐ 863 DIWC/DIWW (405(g))
- ☐ 864 SSID Title XVI
- ☐ 865 RSI (405(g))

FEDERAL TAX SUITS
- ☐ 870 Taxes (U.S. Plaintiff or Defendant)
- ☐ 871 IRS—Third Party 26 USC 7609

OTHER STATUTES
- ☐ 375 False Claims Act
- ☐ 376 Qui Tam (31 USC 3729(a))
- ☐ 400 State Reapportionment
- ☐ 410 Antitrust
- ☐ 430 Banks and Banking
- ☐ 450 Commerce
- ☐ 460 Deportation
- ☐ 470 Racketeer Influenced and Corrupt Organizations
- ☐ 480 Consumer Credit (15 USC 1681 or 1692)
- ☐ 485 Telephone Consumer Protection Act
- ☐ 490 Cable/Sat TV
- ☐ 850 Securities/Commodities/ Exchange
- ☐ 890 Other Statutory Actions
- ☐ 891 Agricultural Acts
- ☐ 893 Environmental Matters
- ☐ 895 Freedom of Information Act
- ☐ 896 Arbitration
- ☐ 899 Administrative Procedure Act/Review or Appeal of Agency Decision
- ☐ 950 Constitutionality of State Statutes

REAL PROPERTY
- ☐ 210 Land Condemnation
- ☐ 220 Foreclosure
- ☐ 230 Rent Lease & Ejectment
- ☐ 240 Torts to Land
- ☐ 245 Tort Product Liability
- ☐ 290 All Other Real Property

CIVIL RIGHTS
- ☐ 440 Other Civil Rights
- ☐ 441 Voting
- ☐ 442 Employment
- ☐ 443 Housing/ Accommodations
- ☐ 445 Amer. w/Disabilities - Employment
- ☐ 446 Amer. w/Disabilities - Other
- ☐ 448 Education

PRISONER PETITIONS

Habeas Corpus:
- ☐ 463 Alien Detainee
- ☐ 510 Motions to Vacate Sentence
- ☐ 530 General
- ☐ 535 Death Penalty

Other:
- ☐ 540 Mandamus & Other
- ☐ 550 Civil Rights
- ☐ 555 Prison Condition
- ☐ 560 Civil Detainee - Conditions of Confinement

V. ORIGIN *(Place an "X" in One Box Only)*

☒ 1 Original Proceeding ☐ 2 Removed from State Court ☐ 3 Remanded from Appellate Court ☐ 4 Reinstated or Reopened ☐ 5 Transferred from Another District *(specify)* ☐ 6 Multidistrict Litigation - Transfer ☐ 8 Multidistrict Litigation - Direct File

VI. CAUSE OF ACTION

Cite the U.S. Civil Statute under which you are filing ***(Do not cite jurisdictional statutes unless diversity)***:
35 U.S.C. § 101, et seq., including 35 U.S.C. § 271, et seq.

Brief description of cause:
Patent Infringement

VII. REQUESTED IN COMPLAINT:

☐ CHECK IF THIS IS A **CLASS ACTION** UNDER RULE 23, F.R.Cv.P.

DEMAND $

CHECK YES only if demanded in complaint:
JURY DEMAND: ☒ Yes ☐ No

VIII. RELATED CASE(S) IF ANY

(See instructions): JUDGE _____ DOCKET NUMBER _____

DATE
09/02/2025

SIGNATURE OF ATTORNEY OF RECORD
/s/ Kevin P. Robinowitz

FOR OFFICE USE ONLY

RECEIPT # _____ AMOUNT _____ APPLYING IFP _____ JUDGE _____ MAG. JUDGE _____

INSTRUCTIONS FOR ATTORNEYS COMPLETING CIVIL COVER SHEET FORM JS 44

Authority For Civil Cover Sheet

The JS 44 civil cover sheet and the information contained herein neither replaces nor supplements the filings and service of pleading or other papers as required by law, except as provided by local rules of court. This form, approved by the Judicial Conference of the United States in September 1974, is required for the use of the Clerk of Court for the purpose of initiating the civil docket sheet. Consequently, a civil cover sheet is submitted to the Clerk of Court for each civil complaint filed. The attorney filing a case should complete the form as follows:

I.(a) Plaintiffs-Defendants. Enter names (last, first, middle initial) of plaintiff and defendant. If the plaintiff or defendant is a government agency, use only the full name or standard abbreviations. If the plaintiff or defendant is an official within a government agency, identify first the agency and then the official, giving both name and title.

(b) County of Residence. For each civil case filed, except U.S. plaintiff cases, enter the name of the county where the first listed plaintiff resides at the time of filing. In U.S. plaintiff cases, enter the name of the county in which the first listed defendant resides at the time of filing. (NOTE: In land condemnation cases, the county of residence of the "defendant" is the location of the tract of land involved.)

(c) Attorneys. Enter the firm name, address, telephone number, and attorney of record. If there are several attorneys, list them on an attachment, noting in this section "(see attachment)".

II. Jurisdiction. The basis of jurisdiction is set forth under Rule 8(a), F.R.Cv.P., which requires that jurisdictions be shown in pleadings. Place an "X" in one of the boxes. If there is more than one basis of jurisdiction, precedence is given in the order shown below.
United States plaintiff. (1) Jurisdiction based on 28 U.S.C. 1345 and 1348. Suits by agencies and officers of the United States are included here.
United States defendant. (2) When the plaintiff is suing the United States, its officers or agencies, place an "X" in this box.
Federal question. (3) This refers to suits under 28 U.S.C. 1331, where jurisdiction arises under the Constitution of the United States, an amendment to the Constitution, an act of Congress or a treaty of the United States. In cases where the U.S. is a party, the U.S. plaintiff or defendant code takes precedence, and box 1 or 2 should be marked.
Diversity of citizenship. (4) This refers to suits under 28 U.S.C. 1332, where parties are citizens of different states. When Box 4 is checked, the citizenship of the different parties must be checked. (See Section III below; **NOTE: federal question actions take precedence over diversity cases.**)

III. Residence (citizenship) of Principal Parties. This section of the JS 44 is to be completed if diversity of citizenship was indicated above. Mark this section for each principal party.

IV. Nature of Suit. Place an "X" in the appropriate box. If there are multiple nature of suit codes associated with the case, pick the nature of suit code that is most applicable. Click here for: Nature of Suit Code Descriptions.

V. Origin. Place an "X" in one of the seven boxes.
Original Proceedings. (1) Cases which originate in the United States district courts.
Removed from State Court. (2) Proceedings initiated in state courts may be removed to the district courts under Title 28 U.S.C., Section 1441.
Remanded from Appellate Court. (3) Check this box for cases remanded to the district court for further action. Use the date of remand as the filing date.
Reinstated or Reopened. (4) Check this box for cases reinstated or reopened in the district court. Use the reopening date as the filing date.
Transferred from Another District. (5) For cases transferred under Title 28 U.S.C. Section 1404(a). Do not use this for within district transfers or multidistrict litigation transfers.
Multidistrict Litigation – Transfer. (6) Check this box when a multidistrict case is transferred into the district under authority of Title 28 U.S.C. Section 1407.
Multidistrict Litigation – Direct File. (8) Check this box when a multidistrict case is filed in the same district as the Master MDL docket.
PLEASE NOTE THAT THERE IS NOT AN ORIGIN CODE 7. Origin Code 7 was used for historical records and is no longer relevant due to changes in statute.

VI. Cause of Action. Report the civil statute directly related to the cause of action and give a brief description of the cause. **Do not cite jurisdictional statutes unless diversity.** Example: U.S. Civil Statute: 47 USC 553 Brief Description: Unauthorized reception of cable service.

VII. Requested in Complaint. Class Action. Place an "X" in this box if you are filing a class action under Rule 23, F.R.Cv.P.
Demand. In this space enter the actual dollar amount being demanded or indicate other demand, such as a preliminary injunction.
Jury Demand. Check the appropriate box to indicate whether or not a jury is being demanded.

VIII. Related Cases. This section of the JS 44 is used to reference related cases, if any. If there are related cases, insert the docket numbers and the corresponding judge names for such cases.

Date and Attorney Signature. Date and sign the civil cover sheet.

EXHIBIT A

US008861349B2

(12) United States Patent

Delangis

(10) Patent No.: US 8,861,349 B2
(45) Date of Patent: Oct. 14, 2014

(54) **BROADBAND COMMUNICATIONS DEVICE**

(76) Inventor: **Eric M. Delangis**, Huntsville, AL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **13/531,294**

(22) Filed: **Jun. 22, 2012**

(65) **Prior Publication Data**

US 2012/0258673 A1 Oct. 11, 2012

Related U.S. Application Data

(63) Continuation of application No. 12/581,852, filed on Oct. 19, 2009, now Pat. No. 8,228,801, which is a continuation of application No. 10/686,375, filed on Oct. 14, 2003, now Pat. No. 7,606,156.

(60) Provisional application No. 60/418,521, filed on Oct. 15, 2002.

(51) **Int. Cl.**

H04L 12/26	(2006.01)
H04J 3/16	(2006.01)
H04W 88/16	(2009.01)
H04L 12/54	(2013.01)
H04W 8/26	(2009.01)
H04W 28/06	(2009.01)
H04W 40/02	(2009.01)
H04W 72/04	(2009.01)
H04W 80/00	(2009.01)
H04W 84/12	(2009.01)
H04W 84/18	(2009.01)

(52) **U.S. Cl.**

CPC ***H04W 88/16*** (2013.01); ***H04L 12/5692*** (2013.01); *H04W 8/26* (2013.01); *H04W 28/06* (2013.01); *H04W 40/02* (2013.01); *H04W 72/04* (2013.01); *H04W 80/00* (2013.01); *H04W 84/12* (2013.01); *H04W 84/18* (2013.01)

USPC **370/230**; 370/468

(58) **Field of Classification Search**

USPC 370/230–235, 278, 282, 328, 338, 468, 370/477

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,307,839 B1 * 10/2001 Gerszberg et al. 370/235
6,941,151 B2 * 9/2005 Takahashi et al. 455/502

(Continued)

OTHER PUBLICATIONS

H. Balakrishnan et al., "A Comparison of Mechanisms for Improving TCP Performance over Wireless Links", IEEE/ACM Transactions on Networking, 17 pages; 1997.

(Continued)

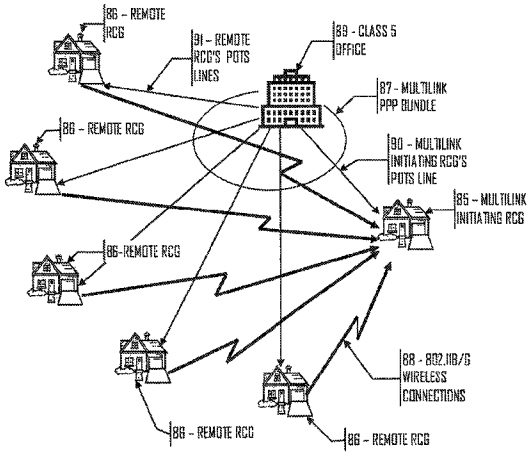
Primary Examiner — Hong Cho

(74) *Attorney, Agent, or Firm* — Clay McGurk; The Law Office of Clay McGurk

(57) **ABSTRACT**

The Residential Communications Gateway (RCG) is a broadband communications device that combines all voice, data and video communications to and from a typical residence or small business for transmission over a single, or a plurality of Plain Old Telephone Service (POTS) lines separately or in conjunction with, a wireless broadband backbone. The RCG does this by employing packetized data with Voice over Internet Protocol (VoIP) technologies combined with RF communications technologies. A key consideration to the design of the RCG is that no additional or special transmission equipment must be installed at the Central Office or anywhere else in the network to enable new calling features provided by the RCG as is the case with DSL and Cable systems. By eliminating the requirement for costly infrastructure enhancements, ubiquitous high speed communications and services can be deployed to every POTS subscriber.

20 Claims, 9 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

7,068,623	B1 *	6/2006	Barany et al.	370/329
7,113,173	B1 *	9/2006	Bi et al.	345/169
7,257,106	B2 *	8/2007	Chen et al.	370/338
7,308,279	B1 *	12/2007	Zweig	455/522
7,385,924	B1 *	6/2008	Riddle	370/235
7,426,316	B2 *	9/2008	Vehvilainen	382/275
7,562,110	B2 *	7/2009	Miloushev et al.	709/201
7,653,089	B2 *	1/2010	Jost et al.	370/485
2002/0102987	A1 *	8/2002	Souisse et al.	455/454
2003/0063591	A1 *	4/2003	Leung et al.	370/338
2003/0202468	A1 *	10/2003	Cain et al.	370/229
2006/0079274	A1 *	4/2006	Gallagher et al.	455/552.1
2009/0150924	A1 *	6/2009	Xu	725/31

OTHER PUBLICATIONS

J. Chen et al., "An Efficient Multipath Forwarding Method", Proceedings of IEEE Infocom '98; 9 pages; 1998.

J. Chen, "New Approaches to Routing for Large-Scale Data Networks", Thesis for Doctor of Philosophy, Rice University; 259 pages; 1999.

M. Handley et al., "Network Intrusion Detection: Evasion, Traffic Normalization, and End-to-End Protocol Semantics", Proceedings of the 10th USENIX Security Symposium; 18 pages; 2001.

H. Hsieh et al., "A Transport Layer Approach for Achieving Aggregate Bandwidths on Multi-homed Mobile Hosts", Proc. of MobiCom; 12 pages; Aug. 2002.

E. Kohler et al., "The Click Modular Router", Proc. of the 17th Symposium on Operating Systems Principles; 34 pages; 1999.

S. Lee et al., "Split Multipath Routing with Maximally Disjoint Paths in Ad hoc Networks", Infocom 98—Proceedings, IEEE (vol. 3); 5 pages; 1998.

Y. Lee et al., "Improving TCP Performance in Multipath Packet Forwarding Networks", Journal of Communications and Networks, vol. 4, No. 2; 10 pages; Jun. 2002.

L. Magalhaes et al., "Transport Level Mechanisms for Bandwidth Aggregation on Mobile Hosts", IEEE-ICNP; 7 pages; 2001.

S. Mascolo et al., "TCP Westwood: Bandwidth Estimation for Enhanced Transport over Wireless Links", Proc. of the ACM Mobicom; 11 pages; 2001.

J. Mo et al., "Analysis and Comparison of TCP Reno and Vegas", University of California at Berkeley; 19 pages; 1998.

J. Mo et al., "Analysis and Comparison of TCP Reno and Vegas", IEEE; 8 pages; 1999.

P. Rodriguez et al., "Dynamic Parallel Access to Replicated Content in the Internet", IEEE/ACM Transactions on Networking; 11 pages; 2000.

P. Srisuresh et al., "Request for Comments: 2663—IP Network Address Translator (NAT) Terminology and Considerations"; The Internet Society; 30 pages; 1999.

E. Steinbach et al., "A Simulation Study of Packet Path Diversity for TCP File Transfer and Media Transport on the Internet", Stanford University; 8 pages; Aug. 2002.

* cited by examiner

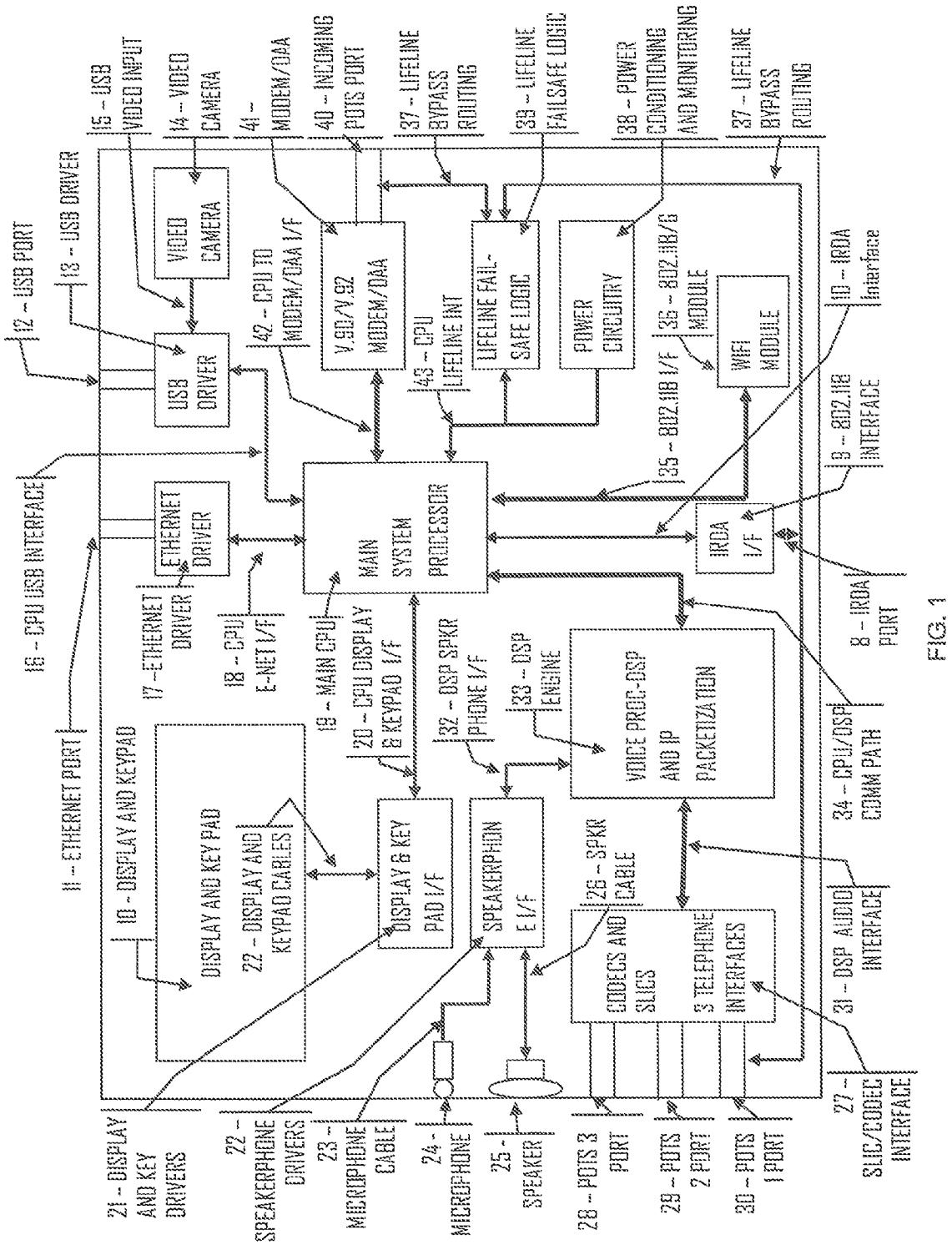

MAIN SYSTEM PROCESSOR
USB DRIVER
ETHERNET DRIVER
VIDEO CAMERA
V.92/V.92 MODEM/DAA
LIFELINE FAIL-SAFE LOGIC
POWER CIRCUITRY
WIFI MODULE
IRDA I/F
VOICE PROC-DSP AND IP PACKETIZATION
DISPLAY AND KEY PAD
DISPLAY AND KEYPAD CABLES
DISPLAY & KEY PAD I/F
SPEAKERPHON E I/F
CODECS AND SLICS
3 TELEPHONE INTERFACES
12 - USB PORT
13 - USB DRIVER
15 - USB VIDEO INPUT
14 - VIDEO CAMERA
41 - MODEM/DAA
40 - INCOMING POTS PORT
37 - LIFELINE BYPASS ROUTING
33 - LIFELINE FAILSAFE LOGIC
38 - POWER CONDITIONING AND MONITORING
37 - LIFELINE BYPASS ROUTING
42 - CPU TO MODEM/DAA I/F
43 - CPU LIFELINE INT
36 - 802.11B I/F
36 - 802.11B/G MODULE
16 - CPU USB INTERFACE
17 - ETHERNET DRIVER
18 - CPU E-NET I/F
35 - 802.11B INTERFACE
10 - IRDA Interface
8 - IRDA PORT
11 - ETHERNET PORT
19 - MAIN CPU
20 - CPU DISPLAY & KEYPAD I/F
32 - DSP SPKR PHONE I/F
33 - DSP ENGINE
34 - CPU/DSP COMM PATH
10 - DISPLAY AND KEYPAD
22 - DISPLAY AND KEYPAD CABLES
26 - SPKR CABLE
31 - DSP AUDIO INTERFACE
21 - DISPLAY AND KEY DRIVERS
22 - SPEAKERPHONE DRIVERS
23 - MICROPHONE CABLE
24 - MICROPHONE
25 - SPEAKER
28 - POTS 3 PORT
29 - POTS 2 PORT
30 - POTS 1 PORT
27 - SLIC/CODEC INTERFACE

FIG. 1

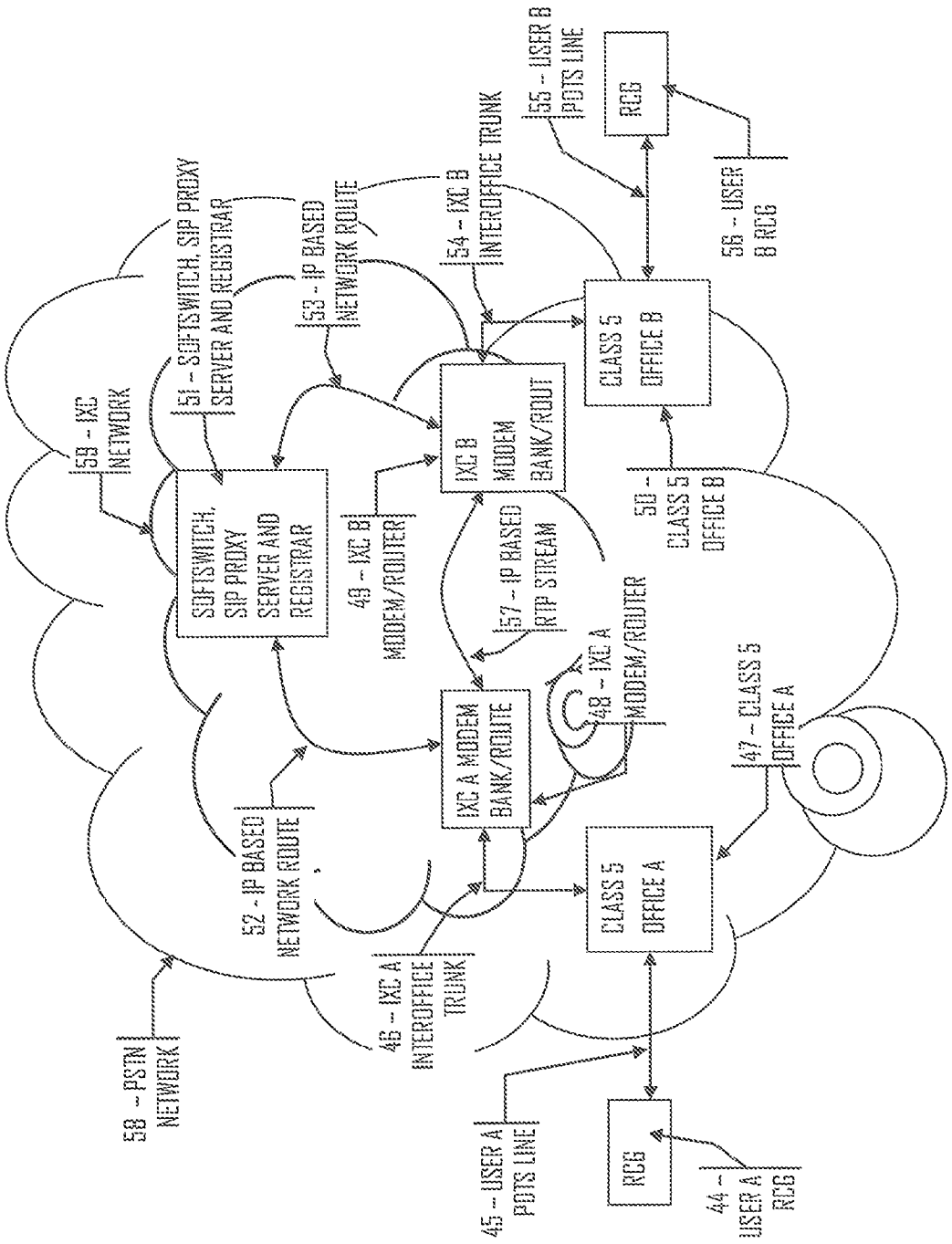

58 – PSTN NETWORK
59 – IXC NETWORK
51 – SOFTSWITCH, SIP PROXY SERVER AND REGISTRAR
SOFTSWITCH, SIP PROXY SERVER AND REGISTRAR
52 – IP BASED NETWORK ROUTE
53 – IP BASED NETWORK ROUTE
46 – IXC A INTEROFFICE TRUNK
54 – IXC B INTEROFFICE TRUNK
IXC A MODEM BANK/ROUTE
IXC B MODEM BANK/ROUT
49 – IXC B MODEM/ROUTER
48 – IXC A MODEM/ROUTER
57 – IP BASED RTP STREAM
CLASS 5 OFFICE A
CLASS 5 OFFICE B
47 – CLASS 5 OFFICE A
50 – CLASS 5 OFFICE B
45 – USER A POTS LINE
55 – USER B POTS LINE
RCG
RCG
44 – USER A RCG
56 – USER B RCG

FIG. 2

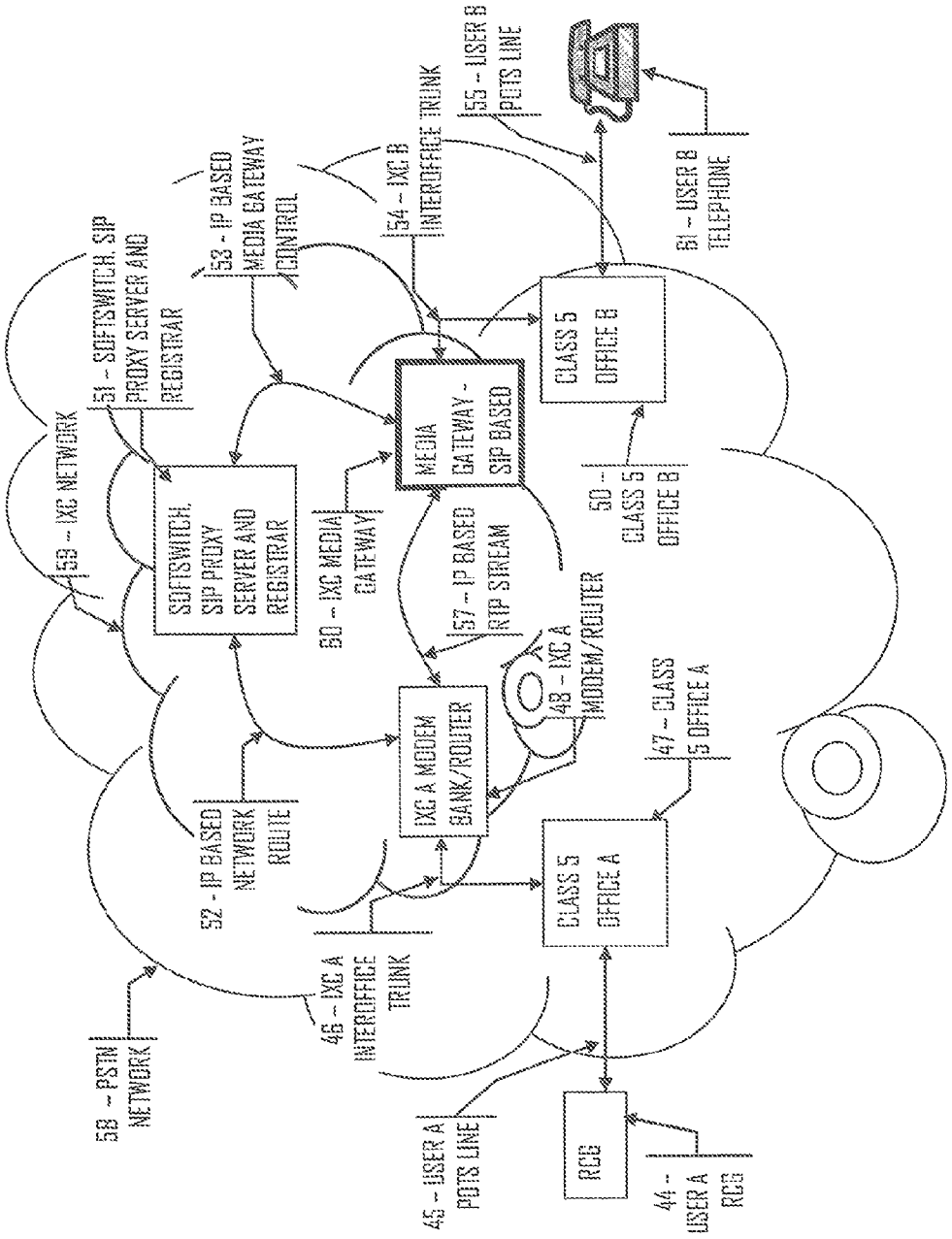

58 – PSTN NETWORK
46 – IXC A INTEROFFICE TRUNK
52 – IP BASED NETWORK ROUTE
53 – IP BASED MEDIA GATEWAY CONTROL
51 – SOFTSWITCH, SIP PROXY SERVER AND REGISTRAR
153 – IXC NETWORK
SOFTSWITCH, SIP PROXY SERVER AND REGISTRAR
60 – IXC MEDIA GATEWAY
IXC A MODEM BANK/ROUTER
57 – IP BASED RTP STREAM
MEDIA GATEWAY - SIP BASED
48 – IXC A MODEM/ROUTER
47 – CLASS 5 OFFICE A
CLASS 5 OFFICE A
45 – USER A POTS LINE
RGB
44 – USER A RGB
54 – IXC B INTEROFFICE TRUNK
55 – USER B POTS LINE
CLASS 5 OFFICE B
50 – CLASS 5 OFFICE B
61 – USER B TELEPHONE

FIG. 3

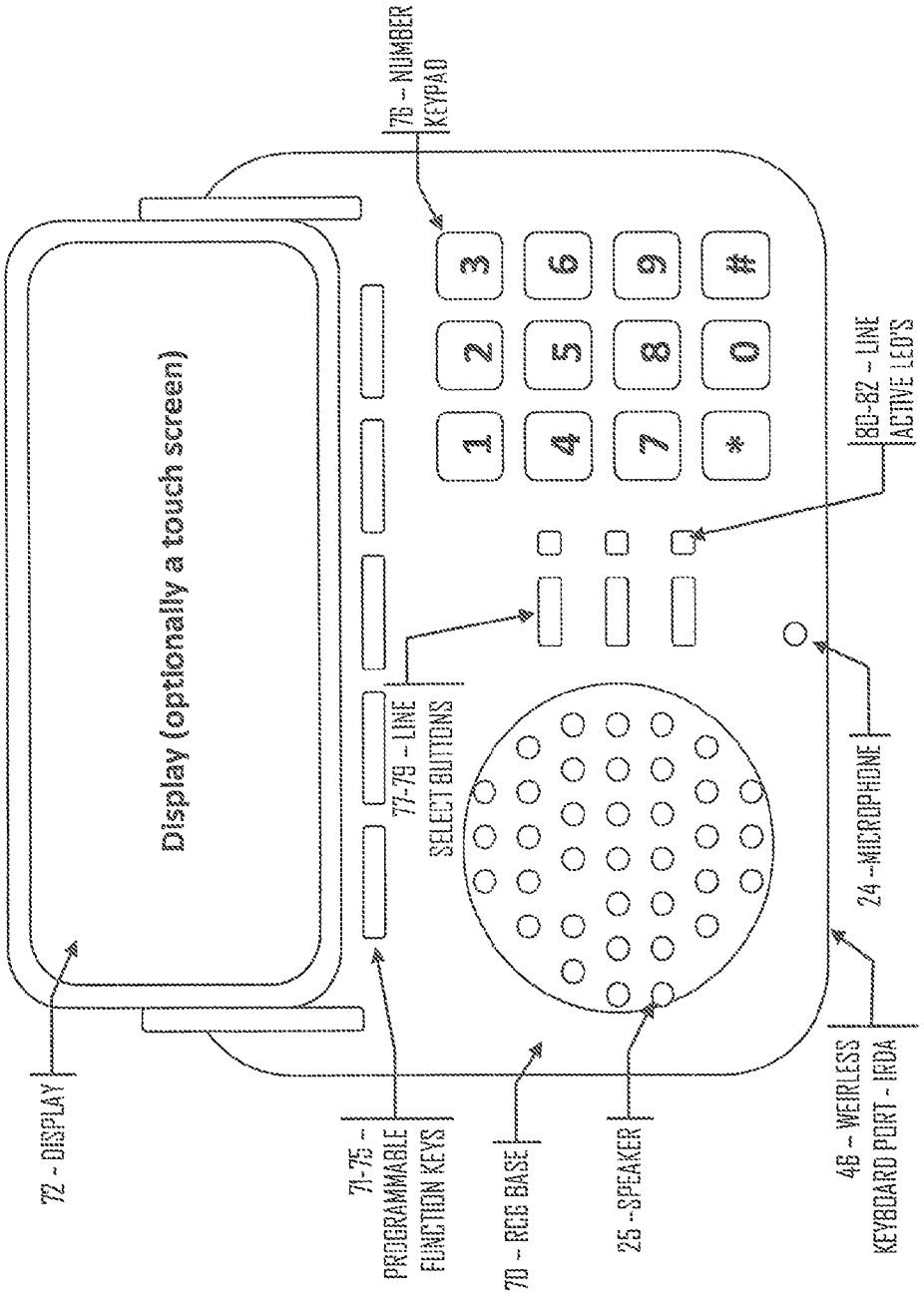

76 - NUMBER KEYPAD
Display (optionally a touch screen)
1
2
3
4
5
6
7
8
9
*
0
#
80-82 - LINE ACTIVE LED'S
77-79 - LINE SELECT BUTTONS
24 - MICROPHONE
72 - DISPLAY
71-75 - PROGRAMMABLE FUNCTION KEYS
70 - RCG BASE
25 - SPEAKER
46 - WEIRLESS KEYBOARD PORT - IRDA

FIG. 4

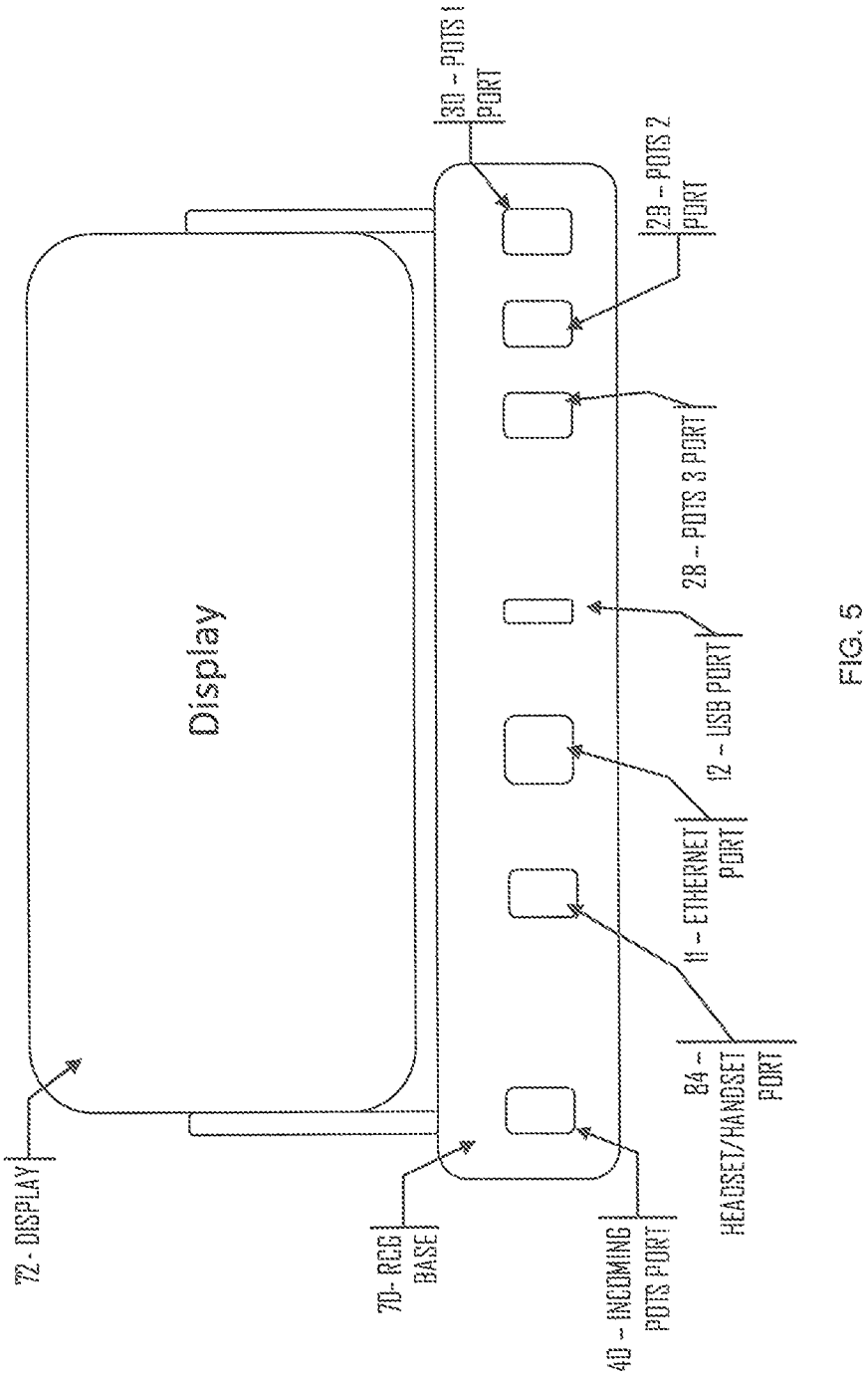

Display
72 - DISPLAY
70 - RCB BASE
40 - INCOMING POTS PORT
84 - HEADSET/HANDSET PORT
11 - ETHERNET PORT
12 - USB PORT
28 - POTS 3 PORT
29 - POTS 2 PORT
30 - POTS 1 PORT

FIG. 5

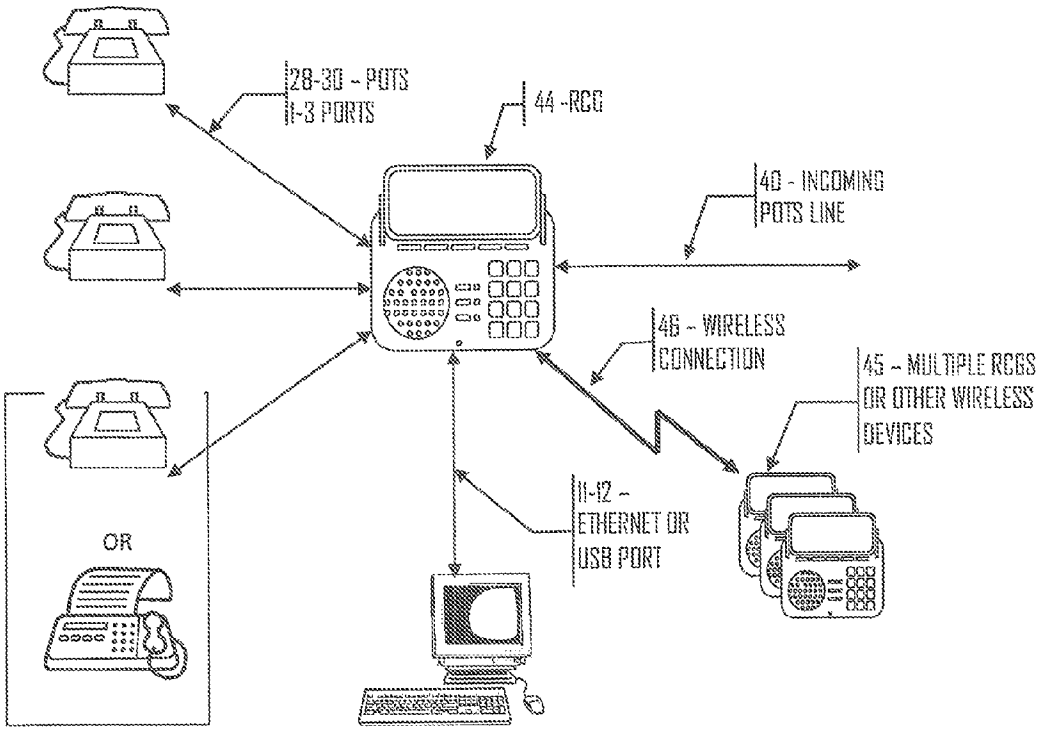

28-30 - POTS
1-3 PORTS
44 -RCG
40 - INCOMING
POTS LINE
46 - WIRELESS
CONNECTION
45 - MULTIPLE RCGS
OR OTHER WIRELESS
DEVICES
11-12 -
ETHERNET OR
USB PORT
OR

FIG. 6

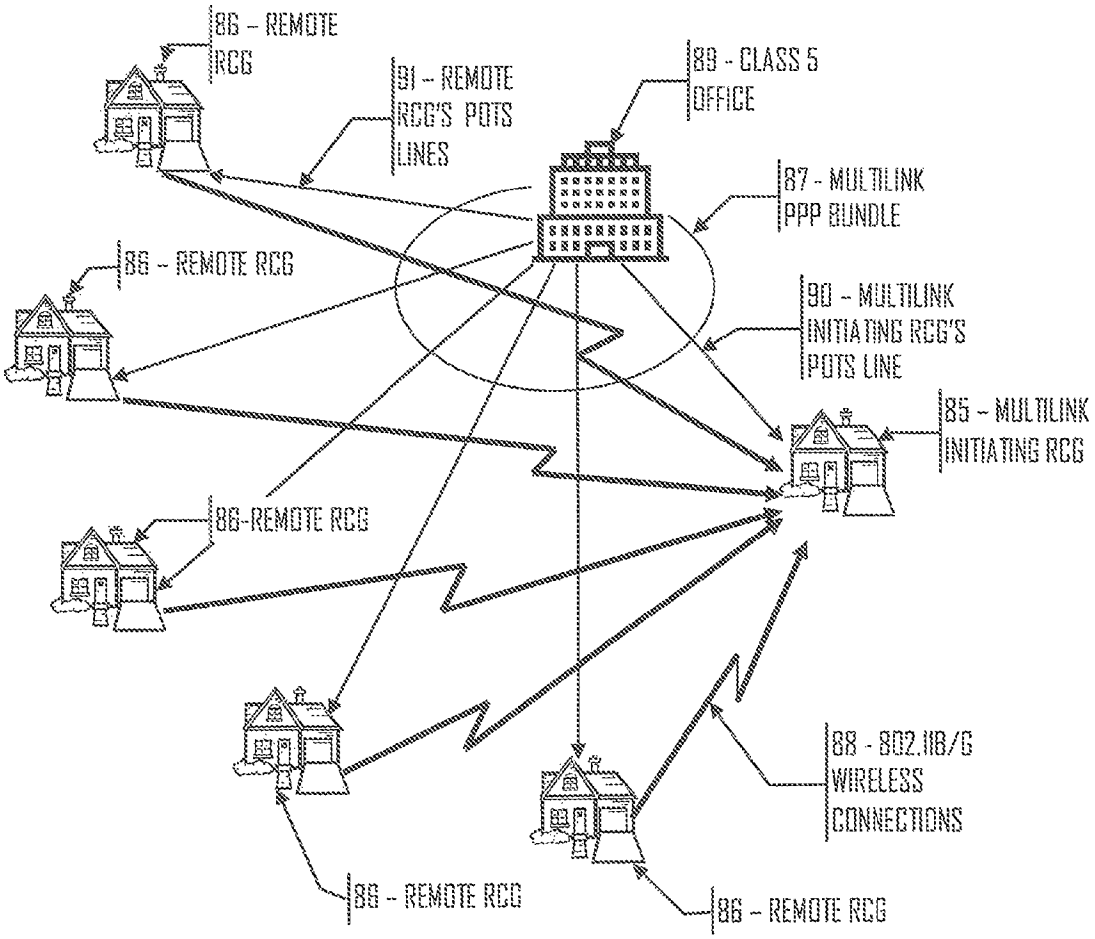

86 – REMOTE RCG
91 – REMOTE RCG'S POTS LINES
89 - CLASS 5 OFFICE
87 - MULTILINK PPP BUNDLE
86 – REMOTE RCG
90 – MULTILINK INITIATING RCG'S POTS LINE
85 – MULTILINK INITIATING RCG
86-REMOTE RCG
88 - 802.11B/G WIRELESS CONNECTIONS
86 – REMOTE RCG
86 – REMOTE RCG

FIG. 7

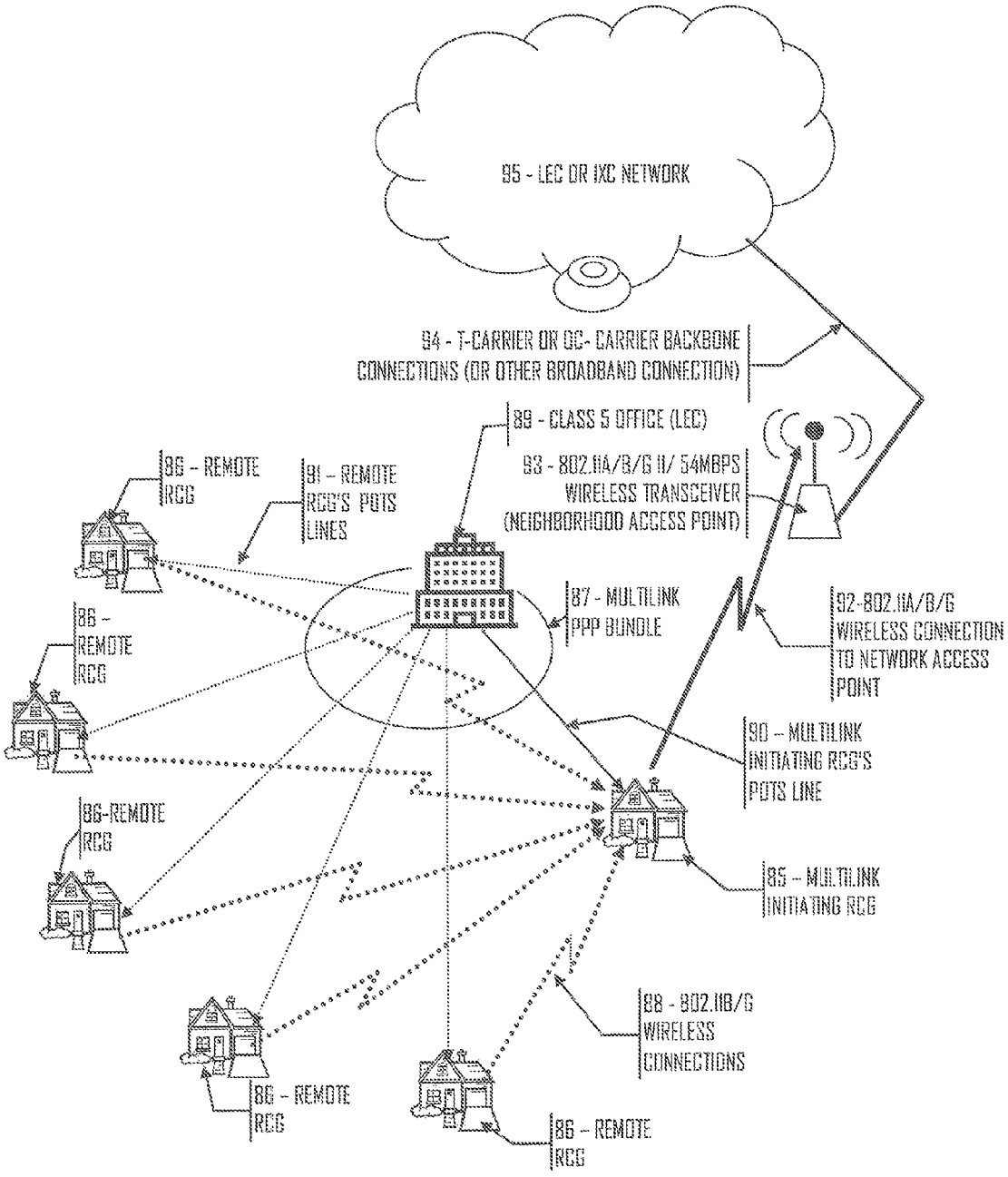

95 - LEC OR IXC NETWORK
94 - T-CARRIER OR OC- CARRIER BACKBONE CONNECTIONS (OR OTHER BROADBAND CONNECTION)
89 - CLASS 5 OFFICE (LEC)
93 - 802.11A/B/G II/ 54MBPS WIRELESS TRANSCEIVER (NEIGHBORHOOD ACCESS POINT)
86 - REMOTE RCG
91 - REMOTE RCG'S POTS LINES
87 - MULTILINK PPP BUNDLE
92-802.11A/B/G WIRELESS CONNECTION TO NETWORK ACCESS POINT
90 - MULTILINK INITIATING RCG'S POTS LINE
85 - MULTILINK INITIATING RCG
88 - 802.11B/G WIRELESS CONNECTIONS

FIG. 8

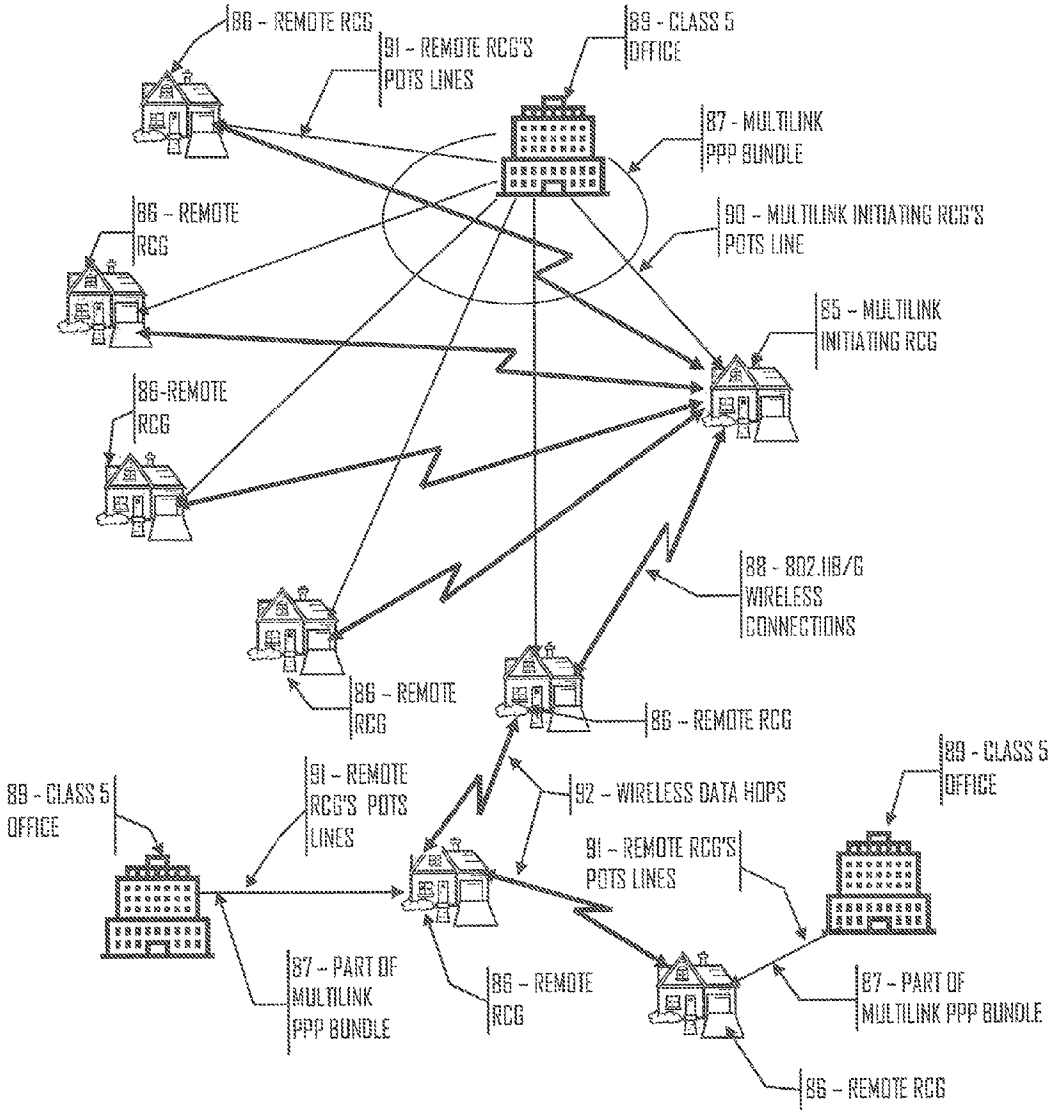

86 - REMOTE RCG
91 - REMOTE RCG'S POTS LINES
89 - CLASS 5 OFFICE
87 - MULTILINK PPP BUNDLE
86 - REMOTE RCG
90 - MULTILINK INITIATING RCG'S POTS LINE
85 - MULTILINK INITIATING RCG
86-REMOTE RCG
88 - 802.11B/G WIRELESS CONNECTIONS
86 - REMOTE RCG
86 - REMOTE RCG
89 - CLASS 5 OFFICE
91 - REMOTE RCG'S POTS LINES
92 - WIRELESS DATA HOPS
89 - CLASS 5 OFFICE
91 - REMOTE RCG'S POTS LINES
87 - PART OF MULTILINK PPP BUNDLE
86 - REMOTE RCG
87 - PART OF MULTILINK PPP BUNDLE
86 - REMOTE RCG

FIG. 9

BROADBAND COMMUNICATIONS DEVICE

RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 12/581,852 filed Oct. 19, 2009, now U.S. Pat. No. 8,228,801, which is a continuation of U.S. patent application Ser. No. 10/686,375 filed Oct. 14, 2003, now U.S. Pat. No. 7,606,156, which claims priority to U.S. Provisional Application Ser. No. 60/418,521, filed Oct. 15, 2002, all which are incorporated by reference herein.

BACKGROUND OF INVENTION

The primary function of the RCG is to provide a platform for Competitive Local Exchange Companies (CLECs) to compete with the Local Exchange Companies (LECs) for residential voice and data services. The LECs have a strangle hold on the "last mile" of copper over which almost all residential customers receive their communications services. Today, most CLECs resell the existing services that are offered by the LECs. CLECs make their money by purchasing these services from the LECs at a discount and marking them up to the customer. Since these services are regulated and controlled by the Public Utilities Commission (PUC) the pricing for these services to the CLECs is set. The monthly CLEC discount is approximately $5 to $6 per line per month for basic rate services. This means, in practicality, that a CLEC can only charge an additional $5 or $6 to the residential customer for basic rate services otherwise they would be more expensive than the LEC, and no one would buy the services from them; telephone customers would simply stay with the LEC.

To be competitive then, CLECs try to sell additional services such as call waiting, caller ID, etc. where they have as much as a 50% margin. Some CLECs also bundle long distance services with their packages as additional incentive to get residential customers to buy local telephone service from them. Since long distance fees are as low as pennies per minute to the customer, there is little profit in long distance for the CLECs. As it is, the pricing structure is such that the LECs will stay in control of the residential market, and the CLECs are nothing more than a marketing arm of the LEC. This structure also keeps the CLECs at an equal competitive advantage, or disadvantage, with respect to each other. The only thing that one CLEC could do to gain more customers is to be a better marketier. Since the CLECs are unable to discount their services because their margins are too slim as it is, the net effect is that the consumer looses by not really getting competition in the residential markets, and prices are kept artificially high.

For the CLECs to be truly competitive in the local telecommunications markets, they must be able to do more than simply resell the LECs services. CLECs must be able to offer many more features or services than those that the LEC provides, and they must be able to do this at a lower cost, in order to attract new customers.

So, what new services can the CLECs offer? As things stand today there are none, with the exception of DSL or Cable services which require tremendous infrastructure costs on behalf of the CLEC. However, by deploying an RCG in a residence, CLECs can offer advanced new calling features and services over the existing POTS line. Their costs for the POTS line from the LEC remains the same, but they can now charge for high bandwidth data services as well as additional calling and messaging features that the LECs cannot offer. This is their competitive advantage.

Competition:

Many companies are currently trying to provide VoIP services to residential customers over high-speed or broadband backbones such as DSL and cable modems, over Internet connections via a computer. The high-speed services require expensive infrastructure enhancements to the local telephone companies' facilities and cable plants, as well as expensive modems at the customer's end. These services are also difficult to deploy and too complicated for the average user. Internet based VoIP services suffer from Internet delays caused by a lack of true Quality of Service (QOS) capabilities across the Internet. Existing VoIP services also require access to a computer and a technical knowledge to be able to make it work. Because of these problems, VoIP services are primarily targeted at the corporate market place where private IP networks that can carry VoIP services with a true guaranteed QOS exist, or can be controlled.

The only available alternatives for the residential user for high speed services are DSL and cable modems. DSL and Cable based communications reach only a small segment of the population, and growth has failed to live up to initial expectations. The recent collapse of the internet boom has led to the failure of many DSL service providers and has effectively eliminated DSL as a potential service for most POTS users for the immediate future.

SUMMARY OF THE INVENTION

The RCG combines the capabilities and features of IP routers, Class 5 circuit switches and wireless LANs in a small stand-alone external modem like device. Additional capabilities for a hands-free speakerphone device with a large touch display are also detailed. The RCG can employ a large display with sufficient resolution to provide a functional user interface to access all of the advanced features offered by the RCG, but also to be able to provide video telephone services.

The device is placed in a residence and connected to the primary POTS line coming from the LEC. Up to three standard telephones or FAX machines (or any combination) are typically connected into the RCG. It also has a Universal Serial Bus (USB) and/or a 10-100 Ethernet interface for connection to a computer or a Local Area Network (LAN). In addition, it has an 802.11b/g wireless interface for wireless home networking as well as broadband-to-the-home services.

The system is installed in a customer's home by simply plugging it into the existing incoming telephone line that provides POTS services from the LEC. One or more standard telephones are then plugged into its three line-output jacks. This is the simplest and most basic usage. In this implementation, the user only is interested in gaining additional telephone lines into the household. No computer connection is required in order to use the system. However, if data communications are desired, then there are three additional interfaces for computer connectivity. Typically either an Ethernet port, USB port or firewire (IEEE 1394) port is used to connect to a PC or LAN. The 802.11b/g interface is for wireless communications between the RCG and PCs, other RCGs as well as any other types of compatible wireless devices. A version of the RCG includes a speakerphone and video camera to provided for video telephone services.

Services Provided by the RCG:

The following discussion refers to FIG. **1**. The RCG has a main system processor that is responsible for all house keeping and traffic routing tasks. The Main CPU **19** routes data to and from the Ethernet Port **11**, USB Port **12**, Modem/DAA **41**, DSP Engine **33**, 802.11b/g Module **36** and the Display and Keypad **10**.

The RCG provides a total telecommunications communications services package for residential and small business customers. With the RCG, a CLEC can offer its customers dialtone for up to three separate telephone numbers per residence (the limit of three telephone numbers is an arbitrary number based upon typical residential usage and is not a limit imposed by the system), all local and long distance services, 24/7 always-on Internet access, a host of custom messaging and calling features, as well as Broadband access and lifeline service. All of these services can be offered over a customer's existing POTS line, and it doesn't require any network infrastructure build out like DSL and Cable services. Because there is no expensive network equipment required, it can be readily deployed throughout the country to expand the CLECs customer base quickly.

The RCG is designed to enhance, not replace, the existing telephone line, enabling it to provide new combined packetized voice and data services. Meanwhile, all existing telecommunications infrastructure and equipment will continue to work seamlessly with the RCG. Aside from simply installing the low cost RCG device in the home telephone wiring, no other equipment needs to be purchased by either the home owner or telephone companies. This eliminates the tremendously expensive infrastructure costs for communications companies that are trying to provide voice services using DSL or cable modems.

The RCG VIP Home Gateway Features:

Up to three telephone lines i.e. numbers, over a single POTS line and/or wireless connection.

Ethernet, USB and IEEE 1394 computer interfaces.

Full G1, G2 and G3 FAX support.

Full support for all CLASS services.

Broadband networking for home computers and appliances as well as wide area networking using a combination of a plurality POTS lines connected to a plurality of RCGs and/or a direct wireless connection to a wireless access point. (These interfaces allow smart devices to communicate to other devices within the home, or over the Internet through the RCG.)

Automated, remote upgradability and configuration. (Requires the customer to do nothing.)

Transparent user operation. (User doesn't have to know that any new technology is being employed)

100% compatible with existing public telephone system.

Video Telephone capabilities.

No local or long distance usage charges.

No Internet access fees.

Lower monthly communication costs.

Multiple telephone calls at the same time.

Voice messaging, follow me features, call forwarding, automatic call back, conferencing, custom call routing. Home networking capabilities, all CLASS calling features, high speed broadband networking, continuous 24/7 internet access, and many others.

All of these features are available even while connected to the Internet.

Very low cost of entry into the market, especially as compared to broadband alternatives.

New calling features that are not currently available to home users.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows the RCG functional block diagram with the preferred embodiment of an 802.11 wireless connection.

FIG. **2** shows the network topology for native RCG to RCG communications.

FIG. **3** shows the network topology for an RCG to PSTN call.

FIG. **4** shows the RCG top view with associated functions.

FIG. **5** shows the RCG rear view and associated connections.

FIG. **6** shows a typical application with peripheral equipment connections.

FIG. **7** shows an ad-hoc wireless LAN configuration with ppp multilink data distribution and wireless connectivity.

FIG. **8** shows an ad-hoc wireless LAN configuration with ppp multilink data distribution and wireless connectivity with connection to a broadband neighborhood access point (Wi-Fi hot spot).

FIG. **9** shows an ad-hoc wireless LAN configuration with ppp multilink data distribution and wireless connectivity with wireless data hopping with POTS connections through numerous different Class 5 offices.

DETAILED DESCRIPTION OF THE INVENTION

The preferred embodiment is detailed herein using the ubiquitous 802.11 wireless protocol. It is by no means insinuated that this is the only wireless scheme that can be used by this device; rather, it is intended that any wireless transmission scheme can be used for wireless communications between this device and other wireless devices as various applications may dictate.

System Initialization

Refer to FIGS. **1**, **2** and **3** for the following discussion. When the RCG is first plugged into an AC power outlet the Main CPU **19**, performs a Power-on Self Test (POST) routine. Once the POST completes and the RCG is connected to an active POTS line, connected to the LEC, by means of the Incoming POTS Port **40**, the RCG automatically initiates a modem connection via the Modem/DAA **41**, to a registration service via a toll free 800 telephone number. The registration service connects directly to the service provider's sales or customer service offices via a VoIP connection. An operator or an automated service answers the call and sets up a new account for the customer. Once the account is set up, the service provider's network automatically sends control information to the device to store the required routing and feature/service information in its non-volatile memory of its Main CPU **19**. As part of this information, a local dialup telephone number is sent to the device that it will use for local network access in the same fashion as a standard ISP connection is made from a home computer. The URL of the Softswitch/SIP Proxy Server and Registrar **51** that will be controlling this particular device is also stored at this time. During the service activation and configuration process, the customer service operator can send test requests to the device, as well as call into it on another telephone number (assuming an additional telephone number is part of the users class of service) or the speakerphone to verify that it is configured and working properly. The final step of the configuration and initialization process is to register the device with the appropriate Softswitch/SIP Proxy Server and Registrar **51** so that the Softswitch/SIP Proxy Server and Registrar **51** knows that it is the controlling SIP Proxy for this RCG. Also configured at this time is the username/password verification server (this is a standard network device and is not shown) that is used to allow the RCG's modem to make a connection onto the service provider's network. Once the RCG configuration is completed, it disconnects the call by hanging up the Modem/DAA **41**, then dials the new local network access number that had been sent during the configuration process and establishes a constant local network connection. This connection is

maintained continuously on a 24/7 basis, and is immediately reestablished whenever it drops. Should the RCG become unable to reestablish this connection after several tries, it will switch over to failsafe mode and inform the user via the Display and Keypad **10**. The RCG will try to reestablish the connection every few minutes until it finally succeeds.

By default, the first telephone port, POTS 1 Port **30**, is assigned as the termination port for the existing POTS service that is connected to Incoming POTS Port **40**. This is the existing telephone service that the user already has as his primary telephone service from his LEC. POTS 1 Port **30**, typically has connected to it a standard telephone set that does not require any power (other than that derived over the POTS interface) to operate properly. POTS 1 Port **30** is the Lifeline telephone port for the user. In the case that all power is lost to the RCG, POTS 1 Port **30** will fail to a direct connection to the Incoming POTS Port **40** telephone line that comes into the RCG from the LEC to provide uninterrupted telephone services to the user. In this state, however, none of the enhanced VoIP services of the RCG are available to the user since the user simply has a stand POTS telephone service to the LEC.

Two additional and unique telephone numbers can be assigned to the other two telephone ports, POTS 2 Port **29** and POTS 3 Port **28**, by the service provider at any time. These numbers are drawn from a pool of available telephone numbers assigned to the service provider. POTS 2 Port **29** and POTS 3 Port **28** must to have standard telephone numbers assigned to them so that the PSTN is able to route calls from its network to these ports. For calls originating from IP based telephones, these numbers are not necessarily needed since POTS 1 Port **30**, POTS 2 Port **29** and POTS 3 Port **28** are uniquely identifiable to IP networks via their IP addresses assigned through the Dynamic Host Configuration Protocol (DHCP) at the time that the RCG establishes a connection to the service provider's network. Since POTS 2 Port **29** and POTS 3 Port **28** must have a telephone number assigned to them, it is a matter of convenience to use the assigned telephone numbers as part of their SIP address for IP routing of their data. In this way, all three user POTS ports, POTS 1 Port **30**, POTS 2 Port **29** and POTS 3 Port **28** are all addressed the same manor.

At this point, the user is able to take advantage of all of the RCG's features that have been activated according to his service agreement. The user can at any time connect additional telephones, a computer or a computer network to the RCG. The user will only be able to use those telephone ports (POTS 1 Port **30**, POTS 2 Port **29** or POTS 3 Port **28**) that have been activated, and assigned unique telephone numbers by the service provider. Any type of standard telephone can be connected to the three POTS ports, POTS 1 Port **30**, POTS 2 Port **29** and POTS 3 Port **28**. In the event that a cordless telephone or a telephone that derives its power from an AC outlet is connected to POTS 1 Port **30**, the lifeline functionality of this port will be ineffective since the telephone itself will not operate once power is lost.

The speaker phone feature of the RCG, comprised of Speakerphone Drivers **22**, Microphone **24**, Speaker **25** and DSP Engine **33**, can be used on any of the activated telephone numbers and is by default enabled to operate on POTS 1 Port **30**. Once either of the other two telephone ports, POTS 2 Port **29** or POTS 3 Port **28**, is activated, the speakerphone function is activated for those lines as well. To use the speakerphone for any assigned telephone number, the user simply presses either the Line Select Button **79-81** for Line 1, Line2 or Line 3 on the face of the RCG, and the speakerphone function is activated on that line. This is convenient for answering any call directly at the RCG. The RCG may or may not have a number keypad for originating calls. This feature may be added or removed based upon the target market price points.

The determination as to which Inter Exchange Carrier (IXC) the RCG will route its data through is determined by any of a number of criteria including, but not limited to, whether the RCG is a private labeled product, or which carrier has the lowest cost routing, or if a specific carrier is specified by the customer, or and number of other considerations. The RCG can be programmed to change its routing path to any IXC at any time by the service provider. Complicated routing algorithms can be programmed into the RCG to control which IXC it will use at any time.

Failsafe Mode

During any time that the RCG is in failsafe mode i.e. Lifeline failsafe logic **39** is activated, the RCG will only be able to receive or initiate telephone calls via the telephone connected to its primary telephone port, POTS 1 Port **30** or through its speakerphone feature. In this condition, all activated telephone numbers are ported via the PSTN to the primary (first) telephone number for delivery to the user's telephone that is connected to POTS 1 Port **30**. While in failsafe mode, the modem is not activated, and the RCG appears to the local Class 5 office as a standard telephone, and the PSTN will route all incoming calls to the RCG as it normally would to any standard telephone.

Call Flow 1:

Dialed call origination from a telephone connected to an RCG POTS port and terminating at another user's RCG POTS port:

When a user picks up a telephone connected to any of the three POTS ports, POTS 1 Port **30**, POTS 2 Port **29** and POTS 3 Port **28**, an off hook condition is detected by the SLIC/CODEC Interface **27** that is connected to the DSP Engine **33** by way of the DSP Audio Interface **31**. The DSP Engine **33** responds by sending digitally generated dialtone to the appropriate POTS interface over the DSP Audio Interface **31**. (Note: all BORSCHT telephony functions are performed by the DSP Engine **33** and the SLIC/CODEC Interface **27**.) Upon hearing the dialtone, the user enters the desired telephone number on his telephone keypad. The Dual Tone Multi-Frequency (DTMF) digits that the user dials are decoded within the DSP Engine **33**. The dialed digits are transferred to the Main CPU **19** via the CPU/DSP Communications Path **34**. The Main CPU **19** polls the DSP Engine **33** approximately every two milliseconds looking for data. The Main CPU **19** polling rate varies according to the process that is being performed. The CPU/DSP Communications path **34** also can generate an interrupt to force data transfer between it and the Main CPU **19**.

The Main CPU **19** generates a SIP Invite IP packet using the dialed digits as the called destination address and the URL of its local controlling SIP Proxy Server which was programmed into the RCG during the configuration process. The Main CPU **19** passes this SIP packet off to the Modem/DAA **41** for transmission over the network. The RCG Modem/DAA **41** is connected to and communicating with a modem in a modem bank located in the Inter Exchange Carrier's (IXCs) facility. This facility may actually be located in the LEC's physical plant or it may be physically located at another location.

Referring to FIG. **2**, User A RCG **44** is connected via its modem to the LEC's local Class 5 Office A **47**. In this example, the service provider's connections to the IXC A Modem Bank & Router **48** are through IXC A Inter-Office Trunks **46**. The service provider may or may not be the IXC. If the service provider does not have its own network, then it will purchase capacity from an IXC and route its traffic to that

IXC's facilities. The SIP Invite IP Packet that is sent from User A RCG **44** transits the LEC's Class 5 Office A **47** facilities and is routed to the IXC A Modem Bank/Router **48** via the IXC A Inter-Office Trunks **46**. It is the job of the router to take the IP packet and route it on to its intended destination, in this case the appropriate SIP proxy server **51**. The router uses the URL for the Softswitch/SIP Proxy Server and Registrar **51** contained in the SIP Invite to know where to route the packet. (Note: The Softswitch, SIP Proxy Server and Registrar are logical devices that may reside in a single computer system, or may be implemented as completely separate devices. In this example, the Softswitch, SIP Proxy Server and Registrar are all shown as a single physical device running these three separate processes.) The IXC A Modem Bank/Router **48** sends the SIP Invite IP packet on to Softswitch/SIP Proxy Server and Registrar **51** via an IP based network route **52**.

The SIP Proxy Server process running on Softswitch/SIP Proxy Server and Registrar **51** performs a look up to determine the termination destination for the call using the dialed digits passed along in the SIP Invite IP packet. In this example, the terminating device for User B RCG **56** is via IXC B's Modem Bank/Router **49** then through Class 5 Office B **50** and over User B POTS line **55** and finally to User B RCG **56**. Not covered in detail here is the SIP message handling since it is completely covered in IETF RFC2543. This example shows that both the originating and terminating ends of this call are controlled by the same Softswitch/SIP Proxy Server and Registrar **51** device. Where the originating and terminating ends of a call are controlled by different Softswitch/SIP Proxy Server and Registrar devices, an additional level of SIP messaging is used between the two SIP Proxy Server processes of each of the Softswitch/SIP Proxy Server and Registrar devices to locate and control the terminating location of the call. Again, that information is covered in IETF RFC2543 and is repeated here.

After the call routing is setup using SIP, and User B answers the call, the Softswitch/SIP Proxy Server and Registrar **51** device sends IP address of the originating User A RCG **44** to the User B RCG **56** and the IP address of User B RCG **56** to User A RCG **44**. Once both RCG's have the other's IP address, they then communicate directly to each other using Real Time Protocol (RTP), and the Softswitch/SIP Proxy Server and Registrar **51** device is no longer part of the connection. This direct communication is shown as IP based RTP Stream **57** between IXC A Modem Bank/Router **48** and IXC B Modem Bank/Router **49**.

On the receiving end of the call, referring back to FIG. **2**, User B RCG **56** receives the SIP Invite data stream through its Modem/DAA **41** and passes it on to the Main CPU **19**. The Main CPU **19** reassembles the SIP IP packet and interrogates the header information to determine which POTS port, POTS 1 Port **30**, POTS 2 Port **29** and POTS 3 Port **28** the call is destined for based upon the dialed number contained in the SIP Invite message. The Main CPU **19** commands the DSP Engine **33** to control the SLIC/CODEC Interface **27** to apply ringing voltage to the selected POTS port to ring the phone. A corresponding SIP **180** (ringing) message is sent back to User A RCG **44** in the reverse direction. When the phone attached to the selected POTS port is answered, the off hook condition detected by the SLIC/CODEC Interface **27** is sent through the DSP Engine **33** to the Main CPU **19** that sends the SIP 200 OK message back to User A RCG **44** to let the RCG know that the call was answered by User B RCG **56** and to turn off the audible ringing tone for User B. Once the call is established, User A RCG **44** sends and ACK F12 SIP message to User B RCG **56** indicating that User A RCG **44** understands that the call setup has been completed.

The two RCGs now exchange SIP messages that include the type of voice encoding that will be used such as G.729, G.723.1, G.711 etc to configure their RTP streams so that they can reliably transfer the user information between them. At this point the call (voice data) is sent between both RCGs and a normal telephone conversation takes place between the user A and user B.

Call teardown is accomplished by either user hanging up their telephone. The RCG of the terminating end (the end that hangs up the phone first) detects the on-hook condition and sends a SIP Bye message to the other end. The other end upon receiving the SIP Bye message responds with an OK 200 SIP message and disables the appropriate POTS port that the user was using.

The Speakerphone interface can be used for either end of a telephone conversation in exactly the same way as described above except that the corresponding POTS port that the call was intended for is disabled if the call is answered via the speakerphone.

Call Flow 2:

Calls between an RCG device and a PSTN telephone:

Refer to FIG. **3** for the following discussion.

In the previous call example, the PSTN network had nothing to do since the call was over a previously established modem connection between two RCGs. In the cases where a call originates or terminates to a standard telephone serviced by a Class 5 office, the process is a bit more complicated.

When a call originates from a user via an RCG, such as User A RCG **44**, the call handling practices are exactly the same up to the point that the SIP Proxy Server process in the Softswitch, SIP Proxy Server and Registrar **51** performs a lookup to determine how to route the call. In this case, the SIP Proxy Server process determines that the call terminates at a standard PSTN telephone attached to the Class 5 Office B **50**. Since the call originates as a native VoIP service, it must be converted to a standard switched circuit based service to be able to be delivered to User B's telephone **61**. The conversion is performed by the IXC's Media Gateway **60** device. In this example, the SIP Proxy Server process routes the call via the IXC's Media Gateway **60** device instead of through the IXC B Modem Bank/Router **49** as before. The SIP Proxy Server process sends a SIP Invite to the IXC's Media Gateway **60** device, as well as other control information, to direct the Media Gateway **60** device to terminate the call and to apply the appropriate voice compression algorithm to the media stream to convert it between switched circuit PCM format and the selected VoIP protocol. At the same time, the Softswitch process of the Softswitch, SIP Proxy Server and Registrar **51** device sends commands to the Media Gateway **60** device to cause it to route the call's PCM data to a specific channel on the IXC B Interoffice Trunk **54**. The Softswitch process then generates an SS7 ISUP message that is sent over the PSTN SS7 signaling network to the Class 5 Office B informing it of the incoming call and on which circuit the call has been placed. It is up to the PSTN at this point to ring the User B telephone **61** and process the call between the IXC's Media Gateway and the User B Telephone **61**. The Softswitch process handles the signaling conversion between the PSTN's SS7 network and the IXC's SIP messaging, as well as any other proprietary signaling schemes utilized by the IXC to control its network. The standard SS7 call control messages, such as ringing, busy, ring back etc., all have a comparable SIP call flow control messages. The Softswitch simply maps the SS7 messages into SIP messages and visa-versa while routing the messages to the appropriate network equipment.

As in the case of a call between two RCGs, the RTP media stream (the actual call data) is routed directly be the IXC A Modem Bank/Router **48** and the IXC's Media Gateway **60** via an IP based RTP Stream **57**.

Again, call teardown is accomplished by either user hanging up their telephone. Depending which end hangs up the phone first, the associated network will generate the appropriate messages which will eventually make it back to the Softswitch process. The Softswitch process will relay the appropriate call control messages between the PSTN and the IXC's SIP based control system.

A telephone call originating from a PSTN telephone is configured and setup in the same fashion as the above description except that the originating messaging begins within the PSTN network instead of the IXC's network.

Personal Computer Based Communications:

Where the RCG is connected to a Personal Computer (PC) through either its USB Port **11** or Ethernet Port **12**, the RCG operates exactly as a cable or DSL type modem device. The RCG is simply a pass through for the computer's data. The RCG receives the IP packets (of whatever type) from the computer and sends the information unchanged to the Modem/DAA **41** interface for transmission over the Internet. Received information from the Internet is processed in the reverse way.

Dynamic Bandwidth Allocation:

When a modem connection is established between the RCG and the "Network", the total available bandwidth of this connection is used in a shared/prioritized fashion. Voice services (calls) take precedence over data services. Therefore, when no calls are in progress all of the available bandwidth is used by data type services such as surfing the Internet or uploading/downloading files. However, when a call is to be passed through the RCG, the required bandwidth for the call is deallocated from the data services and prioritized for the telephone call. This necessary because the Quality Of Service (QOS) is important for effective communications over electronic networks. Since the voice data is carried over a "data centric" network topology (an IP based network), call quality can suffer greatly. Every effort must be taken to eliminate or reduce the packet delay through every network element to be able to provide the best call quality. For data applications such as surfing the Internet or downloading files packet delay is acceptable and expected, and it does not affect the "quality" of the data.

Since all voice and data is transmitted as packets, there are no "time slots" or other type of "channelization" associated with the transmission of this data over either the POTS line or the wireless interface. Channelization of the voice data does occur within the SLIC/Codec Interface—**27** but is converted into IP packets by the DSP engine—**33** and is handled as packets from that point on.

Regardless of whether the call is originating or terminating at the RCG, the bandwidth allocation process is the same. When the SIP call setup messages are processed, the type of voice compression that will be used is defined. The RCG Main CPU **19** handles the IP packet flow between the DSP Engine **33**, USB Port **12**, Ethernet Port **11**, 802.11b/g Module **36** and the Modem/DAA **41** devices giving priority to the voice packets to and from the DSP Engine **33** and the Modem/DAA **41** interfaces. Voice compression algorithms create IP packets at a specified number of packets per second. These packets are handled by a timed process in the RCG. This process is started during call setup so that the packets are handled at the correct rate based upon the compression algorithm's packet generation rate. There is no priority assigned between the voice packets of each of the three different POTS Ports **28-30**. When more than one voice call is in progress, they are handled in a round robin fashion based upon the packet rate for the compression algorithm used. If, for example, two calls are using a compression scheme that generates packets every 2 milliseconds, and the third generates packets every 4 milliseconds, then the calls utilizing the faster packet rate will be polled at twice the rate as the call using a slower packet rate but they are not given priority "over" the other call. Only when there are no voice packets ready for transmission to the Modem/DAA **41**, i.e. during the approximately 2 to 4 millisecond packetization period between packets, will any pending data packets received from the USB Port **12**, Ethernet Port **11** or the 802.11b/g Module **36** be sent to the Modem/DAA **41** for transmission over the network.

Thus, the POTS bandwidth is allocated on a per packet basis, not on a "time slot" or "channelization" or even a "frequency" basis as it the case with T-Carrier, DSL or channelized DSL systems. The same is true for the wireless interface, whether it is carrying pure data or voice.

Security is currently a big concern in today's networks, and especially with wireless 802.11 transmissions. For this reason, the RCG defaults to route voice data over the users POTS connection via Incoming POTS Port **40**. As security concerns regarding wireless communications transmissions are addressed and alleviated, voice call data can, and will, be routed over the wireless interface via the 802.11 b/g Module **36**.

FAX Transmission:

Group 1, 2 and 3 fax transmission is completely supported by the RCG. Fax transmission has the same priority as other voice communications. That is to say that FAX transmission is treated the same as a voice call and takes precedence over native IP data traffic.

Broadband Over POTS:

One of the primary functions of the RCG is to be able to transfer large files such as video files over the POTS lines to a residence. The ability to do this is limited by the maximum of 56 Kbps due to the design of the digital Class 5 office linecards and network transmission schemes based upon T carriers. Typical Class 5 linecard design samples the POTS lines at a rate of 8,000 samples per second. Typically, each sample is digitized into 12 to 16 bits by a codec device. The digitized sample is then companded to an 8 bit sample (1 byte) which makes up the PCM data stream that is transferred over the PSTN. Therefore, each POTS line is sampled at an effective rate of 64 Kbps. Since legacy T1 transmission equipment uses robbed-bit signaling, the maximum guaranteed transmission rate for the PSTN as a whole is 56 Kbps. Because of this limitation, standard POTS lines can only guarantee a maximum of 56 Kbps transfer rate under the best conditions. DSL equipment gets around this problem by installing DSL Access Multiplexing (DSLAM) equipment at the Class 5 office end of the POTS line. By routing around the linecard, as well as routing the data directly over the Internet or other private IP based networks, and therefore the 64 Kbps sampling rate, DSL is not bandwidth limited like PSTN traffic is. DSL, however, suffers from the very high costs associated with the purchase, installation, maintenance, floor lease costs, etc. DSL also suffers from very high deployment costs resulting from the labor intensive process to turn up each line. Each DSL "POTS" line must be inspected, conditioned and all load coils removed.

The RCG gets around the 56 Kbps POTS limitation as well as the DSL problems by using the standard POTS lines as they are, and not requiring any additional equipment to be installed at the Class 5 end of the POTS line. This technique simplifies deployment and drastically cuts costs.

Multilink PPP Connections:

Referring to FIG. **7**, the RCG implements broadband over POTS by employing an 802.11 b/g wireless interface to configure a multilink PPP bundle—**87** (per RFC 1990) comprised of the POTS lines connected to up to 32 RCGs. The limitation of 32 RCGs in a multilink PPP bundle is an arbitrary number and can be scaled up or down as required to support changes in network equipment capabilities. An 802.11b/g interface—**87** is shown as the preferred embodiment, since its 11/54 Mbps interface is considered sufficient bandwidth at this time also, its transmission distances are sufficient for implementation of this device, as opposed to other shorter ranged wireless transmission schemes. However as time goes on, some other wireless interface may be more desirable. There is nothing special or specific to the 802.11 wireless interface that makes it particularly suited to this application. Any wireless interface scheme can be used to implement this device.

The 802.11b/g interface—**88** on an individual RCG is also used to provide a peer-to-peer wireless home networking environment to other 802.11 compatible wireless component within the residence (such as a hand-held computer device) while acting as an always on dialup Internet gateway over the POTS line—**40** for the other wireless devices. An RCG that is transferring a very large file can request the services of 31 (in this embodiment) other RCGs to assist in the file transfer using their respective POTS lines. A single RCG can therefore gain the combined bandwidth of up to 32 POTS lines transferring data at as much as 56 Kbps each to transfer information. This is roughly equivalent to a transfer rate of 1.79 Mpbs in the inbound direction (towards the RCG) and approximately 1.075 Mbps in the outbound direction (towards the PSTN).

The multilink PPP connection—**87** is initiated by an RCG when it determines that the file (or streaming service) that it is to download (receive) is of sufficient size or requires a minimum amount of bandwidth to justify the use of a multilink PPP connection. This determination can be made on many different criteria such as the file size, type of data being transmitted, the type of compression if any, a Quality-of-Service requirement or any other pertinent information. (Since a certain amount of overhead is required to set up a Multilink PPP connection, it doesn't make sense to use it for small or low data rate transfers.)

Multilink PPP bandwidth Allocation and Initialization:

Referring to FIG. **7**, an RCG—**85** that decides to initiate a multilink PPP session with a remote computer i.e. internet URL, requests a multilink PPP session with that URL resource via Link Control Protocol (LCP) session management. The initiating RCG—**85** and the remote server computer (not shown) will negotiate the pertinent multilink parameters such as compression, packet size, sync/async, link quality monitoring, bit stuffing etc. As part of a successful multilink PPP session setup, the initiating RCG—**85** receives a multilink PPP session ID, or "magic number", which is used to identify this particular multilink PPP session and is also used for adding or removing links from the multilink bundle—**87**. Once the multilink bundle is setup, the initiating RCG—**85** begins data transfer across its POTS interface—**90** with the far end computer system. The initiating RCG—**85** then looks up the addresses of up to 31 (in this embodiment) other RCGs in its router tables to use for the multilink PPP transfer. (If a Neighborhood Access Point is available the RCG could request service through it instead of setting up a Multilink PPP connection—see FIG. **8**.) The initiating RCG—**85** determines the number of remote RCGs—**86** that it wants to use to get the desired bandwidth for the transfer and sends multilink PPP service requests via the 802.11 b/g wireless connections—**88** to the selected remote RCGs—**86**. The selected remote RCGs—**86** respond back to the initiating RCG with either an acceptance or denial of multilink PPP service request. This decision is made based upon the remote RCG's currently available POTS bandwidth and the current local demands for that bandwidth. The remote RCG—**86** makes a decision to participate in a multilink PPP service for an initiating RCG if its POTS line—**91** has a current average bandwidth utilization of less than some arbitrary limit such as 8 Kbps to 16 Kbps. This 8 Kbps to 16 Kbps bandwidth utilization represents about two concurrent voice conversations using standard voice compression techniques, or some small amount of data transmission occurring on the remote RCG's POTS interface—**91** or a combination thereof. Assuming that the remote RCG—**86** has a modem connection speed somewhere between 33 Kbps to 56 Kbps, this would leave approximately 17 Kbps to 40 Kbps of POTS bandwidth that the remote RCG—**86** could offer to the initiating RCG—**85** for use in its multilink PPP bundle—**87**. Of course, if there is no activity on the remote RCG—**86** POTS line, then the entire bandwidth will be used for the multilink transfer. If the remote RCG—**86** accepts the multilink PPP service request from the initiating RCG—**85** it also sends its currently available bandwidth on its POTS line—**91** that the initiating RCG **85** will have available to it for the multilink PPP transfers. The initiating RCG then selects which of the responding remote RCGs—**86** it will use for the multilink PPP bundle—**87** and sends them a multilink initialization packet containing the URL of the destination as well as the multilink PPP session ID (magic number) and any other pertinent information required for the remote RCG to join in the existing multilink PPP bundle—**87**. Each remote RCG POTS interface—**91** participating in a multilink PPP bundle, represents a logical "link" in the initiating RCG's multilink PPP bundle—**87**. The remote RCGs—**86** then send a multilink PPP packet (over their respective POTS lines—**91**) to the destination URL with the multilink PPP session ID and request to be added to that multilink PPP bundle—**87**. The destination URL accepts the request of each of the remote RCGs—**86** and begins sending data packets to each over their respective POTS lines—**91**. When the remote RCGs—**86** receive data packets sent over their respective POTS lines—**91**, that are destined for the multilink PPP bundle—**87**, they simply relay the data packets over their 802.11b/g interface—**88** to the initiating RCG—**85**. It is the responsibility of the initiating RCG—**85** to perform all housekeeping tasks associated with the multilink transfer such as detection of lost packets and data packet reassembly, if those functions are required. Typically, lost packet detection and retransmission and reassembly are performed at higher OSI layers by the requesting software such as a browser. The remote RCGs—**86** are simply data transport nodes and do not perform any data processing on data received over a multilink PPP bundle destined for another RCG.

The initiating RCG—**85** of the multilink PPP bundle—**87** continually monitors the bandwidth of each remote RCG's—**86** multilink link which together comprise its multilink bundle—**87**. When the available bandwidth for the multilink PPP link of an individual remote RCG—**86** falls below an arbitrary minimum set by the initiating RCG—**85**, the initiating RCG—**85** instructs the offending remote RCG, via its 802.11b/g wireless interface—**88**, to remove itself from the multilink bundle. The remote RCG—**86** will then notify the remote computer (URL) to be removed as a link in the current multilink bundle on which it is participating. Alternatively, a remote RCG—**86** can inform the initiating RCG—**85** of local

demands on its POTS bandwidth, and request that the initiating RCG—**85** remove it (the remote RCG—**86**) from the participation in the initiating RCG's multilink bundle—**87**. The remote RCG—**86** will not unilaterally remove itself from participation in a multilink bundle without prior notification to the Initiating RCG—**85**. The remote RCG—**86** must get authorization from the initiating RCG—**85** to remove itself from the bundle, since the initiating RCG—**85** will have no way of knowing if the loss of data from that remote RCG is due to some sort of failure or from the remote RCG simply removing itself from participation in the multilink bundle—**87**. Also, for services that require a minimum Quality of Service (QOS) such as streaming video, the initiating RCG—**85** needs to control the multilink bundle—**87** bandwidth, and it can not do that if remote RCGs—**86** drop out of the multilink bundle—**87** at will. When a remote RCG—**86** requests to be removed from participation in a multilink bundle—**87**, the initiating RCG—**85** must immediately grant the request. If the initiating RCG—**85** were to not grant the request, then the remote RCG—**86** could, in worst case, delay or drop incoming multilink packets destined for the initiating RCG—**85**. If this were to happen, the initiating RCG—**85** will have missing packets and could over run its reassembly buffer (if reassembly is being performed by the RCG) causing catastrophic data loss and potentially have to restart the entire transmission. In the least case, the initiating RCG **85** would have to initiate retransmission of potentially many packets which it assumes to be lost, but may simply be delayed by the remote RCG—**86**. Once a remote RCG—**86** has been removed from participating in a multilink bundle—**87**, the initiating RCG—**85** will then look up another remote RCG in its router tables that can be used to participate in the multilink PPP bundle—**87**, and request that the new remote RCG—**86** to join the existing multilink bundle—**87**. This is necessary to maintain a minimum Quality of Service. Since RCGs prioritize their bandwidth requirements based upon their own "local" service requirements, their participation in any multilink PPP service is available only to bandwidth that is not required for its own current local demands. Therefore, a remote RCG's—**86** bandwidth that is available for multilink services can change at any time. The dynamic reassignment of remote RCGs that participate in a multilink bundle is also required to prevent a remote RCG—**86** from receiving packets so slowly that the originating RCG—**85** interprets this delay as lost packets. When the initiating RCG—**85** determines that a packet has been lost, and it is performing packet reassembly, it will, itself, request that the remote computer retransmit the lost packet. The initiating RCG will not ask any remote RCG—**86** to perform retransmissions or any other kind of data computations or manipulations.

Refer to FIG. **8** for the following discussion. In areas where there are existing 802.11 network equipment such as Neighborhood Access Point—**93**, or where there is sufficient bandwidth requirements from an installed base of RCGs to warrant the deployment of a Neighborhood Access Point—**93**, the RCGs will automatically detect the presence of the compatible neighborhood access points and register with that equipment for transport services. In this case, an RCG has an alternative broadband service route in addition to the multilink option. An RCG can communicate directly with a local 802.11 Network Access Point—**93** that is connected to the PSTN or another carrier's network via some sort of high bandwidth backbone such as a T-Carrier or optical carrier connection (T1, T3, OC3, OC12 etc.). The RCGs can communicate directly with neighborhood access points at their full 11/54 Mbps data rates to provide up to that full bandwidth to the user. This functionality is, of course, subject to the Network Access Point—**93** allowing access to its resources to the RCG according to the 802.11 wireless protocol.

This architecture is important since it provides an avenue to relieve the local class 5 offices of congestion that can be caused by a wide spread deployment of RCGs within the class 5 service area. Since each RCG requires a constant 24/7 modem connection, this ties up the class 5 switch in a fashion that it was not designed for. This could lead to wholesale class 5 office expansions which would be extremely expensive, and potentially prohibitive for the Local Exchange Carriers (LECs). By deploying neighborhood access points that operate at 54 Mbps (802.11a/g), in areas where the RCG concentration starts placing too high of a demand on the local class 5 office, the bandwidth from the RCGs can be aggregated by the neighborhood access points into large capacity backbones to relieve the switch congestion. In this case, the RCG POTS interface—**40** can be used solely as a lifeline connection, or when the 802.11 wireless LAN in which the RCG resides is congested. With this implementation, voice calls will be carried over the wireless interface as opposed to the POTS interface on which they would normally be carried. Also, the RCG modem—**41** connected to the POTS interface—**40** would not need to maintain a constant always on connection, it could be a dialed on demand connection and thereby relieving the local class 5 office switch.

Bouncing or Hopping Traffic:

Refer to FIG. **9**. In areas where the density of RCGs is less than the arbitrary number of 32 RCGs within its transmission radius for multilink connections, the RCGs can bounce, or relay, the data traffic between each other to reach other RCGs located farther than the RCGs wireless transmission area. Since the POTS data rate of 56 Kbps is miniscule as compared to the 11/54 Mbps 802.11b/g transfer rate, the overhead associated with bouncing data traffic is not a concern. This will allow for the fastest possible data transfer across POTS lines for every RCG user.

RCGs can also communicate directly with an 802.11a Neighborhood Access Point—**93** device (such as that used in WI-FI networks) that is connected to a data network connection such as a DS3 or OC3 service via a Metro Access Point. Where an RCG has access to a broadband device such as an 802.11a type device, either directly or via a bounced signal across several RCGs, a direct high speed data connection can be used to transfer large files. When an RCG is communicating directly with an 802.11a device, data transfer speeds up to the full 11/54 Mbps can be achieved to speed video transfers for such applications as video on demand.

RCG Router Tables:

The RCG continually monitors its 802.11b/g wireless interface for transmissions from other RCGs or 802.11a Access Points as well as other 802.11b/g wireless devices within the residence. The RCG provides a means to identify and store the addresses of other RCGs and Neighborhood Access Points within its local area. The RCG creates routing tables, much like an IP router device, so that it knows which RCGs are local to itself, and how many hops will be needed to reach the maximum of 32 POTS lines or a Neighborhood Access Point. The RCG can then determine how to route its data transfers to gain the most efficient routing and network efficiencies.

The router tables in each RCG are continually updated by monitoring the 802.11 frames received from other RCGs or Network Access Points. The number of entries in the router tables can be limited to an arbitrary number of other RCGs but contains room for at least 32 entries. For each RCG listed in the router tables, certain information is kept such as signal strength, if the other device is another RCG or some other

802.11 compatible device, if the other RCG is reachable directly, or if it is accessed via another RCGs by hopping. In the case there RCG hopping is used, the address of each RCG that is hopped is stored in the routing table. When an RCG is first powered up, it monitors its 802.11 interface for a period of time to identify other RCGs or Neighborhood Access Point devices, or other Wi-Fi devices within its transmission area. When first deployed, the RCG will not have any entries in its routing tables. This condition can persist for some time, until another RCG or other 802.11 device is deployed within the former RCGs transmission range. In this state, the RCG can be used for wireless networking within the residence, connecting the local computer to the RCGs always on Internet connection as well as to other wireless devices within the home. When an 802.11 frame is received by an RCG that contains the address of an RCG whose address does not exist in the receiving RCG's router table (as is the case when a new RCG is first installed), the receiving RCG polls the transmitting RCG for its router table information. The received router information is reviewed for other RCG's or other 802.11 compatible devices that are not listed in its own router tables. A decision is made to use some, all, or none of the new route information in its router tables. There is no real limitation on the number of RCGs that can be "hopped" in order to build a complete router table or to reach many more RCGs, Neighborhood Access Points or Metro Access Points.

Equipment and Services Priorities:

Just as voice has priority over data transfers within a single RCG, local RCG traffic (both voice and data) has priority over remote transfer requests by other RCGs. If an RCG is currently using all of its available POTS bandwidth for its own purposes, it will deny any remote RCG's request for access to its POTS line. Only when there is available POTS bandwidth available will an RCG allow other RCGs access to its POTS line. It will, however, bounce the traffic to other RCGs within its transmission area if requested by the originating RCG. In this case, available wireless bandwidth of any RCG (that amount of the 11/54 Mbps not currently used for its own traffic) can be used to relay traffic between other RCGs that do have available POTS bandwidth. In the same fashion, excess wireless bandwidth of any RCG can be by other RCGs to access high speed backbones via Neighborhood or Metro Access Points.

RCGs can also access other 802.11 wireless networks (Wi-Fi for example) that happen to be deployed within their service areas. In this case, access agreements between the RCG service provider and the wireless network operator must be put into place. By remaining compatible with the 802.11 standards, the RCGs capabilities will benefit by the growing WI-FI network infrastructure, an the WI-FI network will benefit by the RCG network.

Voice Over POTS and Data Over Wireless:

Normally. all communications from an RCG will be transmitted over the local POTS line, or a multilink bundle made up of many remote RCG POTS lines. By default, all voice calls will be carried over the "local" POTS line—**40** to alleviate security/privacy concerns and only "data" will be transmitted via multilink bundles. Generally, since voice "data" is compressed locally by the RCG, the required bandwidth for a voice call is so small that it does not make for a good choice to route it over a multilink connection. However, it is possible to route voice calls entirely over another RCGs POTS line. It is also possible for an RCG to transmit voice data over POTS lines connected to other RCGs via multilink bundles or directly over its 802.11 wireless interface, and since the 802.11 specification does support the Wired Equivalent Privacy (WEP) specification, a secured connection can be made in this fashion.

Remote Upgradability

The RCG is designed with the capability for unassisted remote upgradability. The remote upgradability feature is not the same as the storing of operational parameters during the configuration process. This feature allows the system operator to add new features as they are developed, or to correct bugs remotely and without the users knowledge or involvement. This feature can also be used to install a complete new operating system (OS).

Key to the successful implementation of the Remote upgradability feature is that a completely fail-safe routine be implemented that can recover from any failure during the upgrade process and to re-initiate and monitor the upgrade process until it has successfully completed. This process is carried out by loading a boot loader program that is stored in non-volatile memory. The boot loader program provides the minimum capabilities to start up the RCG and connect into the system operator's diagnostics network to download fixes or a new OS. The boot loader program is technically part of the OS, but it cannot be over written by any upgrade process. It is responsible for detecting failure of the RCG and initiating a connection to the diagnostics network. Once connected with the diagnostics network, the boot loader will provide diagnostics support to help correct the RCG's operation and reconfigure the OS.

What is claimed is:

1. A method for increasing bandwidth and data throughput comprising the steps of:

sending a multilink request from a first device to a second device to join a multilink connection, the first device being connected at a first location to a network, the second device being connected at a second location to the network, the second location being geographically separate from the first location, the first device and the second device being configured for accessing the network; and

when the multilink request is accepted by the second device, receiving at the first device first data from the network at the first location and during the multilink connection, concurrently receiving second data over a wireless connection from the second device, the second data being received at the second location from the network.

2. The method of claim **1**, wherein the first location and the second location are physically isolated from each other.

3. The method of claim **1**, further comprising the step of aggregating the second data received over the wireless connection and the first data received over the connection at the first location.

4. The method of claim **1**, wherein a connection at the first location and a connection at the second location are network connection points.

5. The method of claim **1**, wherein the first device and the second device are consumer networking devices.

6. The method of claim **1**, further comprising the steps of: sending another multilink request from the first device to a third device, the third device being connected at a third location to the network, the third location being geographically different than the first location and the second location; and

when the another multilink request is accepted by the third device, concurrently receiving third data during the multilink connection over a second wireless connection between the first device and the third device.

7. The method of claim 6, further comprising the step of aggregating the first data, the second data and the third data.

8. The method of claim 1, wherein the first data and the second data are received as data packets.

9. The method of claim 1, wherein the network is the Internet.

10. The method of claim 1, wherein the second device is a wireless device.

11. The method of claim 1, wherein the network is one or a combination of a cable network, a telecommunication network, an optical network and a communications network.

12. The method of claim 1, wherein the wireless connection is a cellular connection, a satellite connection, a Wi-Fi connection, a WiMax connection or a Bluetooth connection.

13. A device comprising:

an interface that establishes a network connection at a first location to a first network and receives first data packets over the network connection;

a wireless interface that is configured to establish a wireless connection to a remote communications device, the remote communications device being connected at a second location to a second network; and

a processor that sends a multilink request over the wireless interface to the remote communications device to join the multilink connection, receives from the interface the first data packets from the first network and when the multilink request is accepted by the remote communications device, concurrently receives from the wireless interface second data packets from the second network, the second data packets being received at the second location from the second network.

14. The device of claim 13, wherein the device is one of a modem, cellular phone, a router, a computer, hotspot device and a tablet.

15. The device of claim 13, wherein the device is part of a home-based network system.

16. A method for providing broadband communications services, comprising:

sending to a remote host an inquiry in whether the remote host is able to support a multilink connection;

receiving first data packets over a first connection to the Internet;

when the remote host indicates that the multilink connection is supported, receiving second data packets over a second connection, the first data packets being concurrently received with the second data packets during the multilink connection; and

wherein the first data packets create a first data stream and the second data packets create a second data stream.

17. The method of claim 16, wherein the first data packets are received at a home-based network system, and wherein the second packets are received over the second connection at the home-based network system.

18. The method of claim 16, wherein the first data packets are received by a consumer-based network system, and wherein the second packets are received over the second connection at the consumer-based network system.

19. The method of claim 16, further comprising:

during the multilink connection, receiving data packets over a plurality of wireless connections, the data packets being concurrently received with the first data packets; and

aggregating the first data packets with the data packets.

20. A method for increasing bandwidth and data throughput comprising the steps of:

sending a multilink request from a first device to a second device to join a multilink connection the first device being connected at a first location to a first network, the wireless device being connected at a second location to the first network or a second network, the second location being geographically separate from the first location; and

when the multilink request is accepted by the second device, receiving at the first device first data from the first network at the first location and during the multilink connection, concurrently receiving second data over a wireless connection from the wireless device, the second data being received at the second location from the first network or the second network.

* * * * *

EXHIBIT B

US009350649B2

(12) **United States Patent**
Delangis

(10) **Patent No.: US 9,350,649 B2**
(45) **Date of Patent: May 24, 2016**

(54) **MULTIPATH COMMUNICATION DEVICES AND METHODS**

(71) Applicant: **Eric M. Delangis**, Huntsville, AL (US)

(72) Inventor: **Eric M. Delangis**, Huntsville, AL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/512,414**

(22) Filed: **Oct. 11, 2014**

(65) **Prior Publication Data**

US 2015/0032860 A1 Jan. 29, 2015

Related U.S. Application Data

(63) Continuation of application No. 13/531,294, filed on Jun. 22, 2012, now Pat. No. 8,861,349, which is a continuation of application No. 12/581,852, filed on Oct. 19, 2009, now Pat. No. 8,228,801, which is a continuation of application No. 10/686,375, filed on Oct. 14, 2003, now Pat. No. 7,606,156.

(60) Provisional application No. 60/418,521, filed on Oct. 15, 2002.

(51) **Int. Cl.**

H04L 12/54	(2013.01)
H04W 88/16	(2009.01)
H04W 28/06	(2009.01)
H04L 12/707	(2013.01)
H04W 8/26	(2009.01)
H04W 40/02	(2009.01)
H04W 72/04	(2009.01)
H04W 80/00	(2009.01)
H04W 84/12	(2009.01)
H04W 84/18	(2009.01)

(52) **U.S. Cl.**

CPC ***H04L 45/24*** (2013.01); ***H04L 12/5692*** (2013.01); ***H04W 88/16*** (2013.01); *H04W 8/26* (2013.01); *H04W 28/06* (2013.01); *H04W 40/02* (2013.01); *H04W 72/04* (2013.01); *H04W 80/00* (2013.01); *H04W 84/12* (2013.01); *H04W 84/18* (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,483,522 A * 1/1996 Derby et al. 370/400
5,487,069 A 1/1996 O'Sullivan et al.

(Continued)

OTHER PUBLICATIONS

Fisk et al., "Dynamic Right-Sizing in TCP, Proceedings of the Los Alamos Computer Science Institute Symposium", pp. 01-5460 (2001).

(Continued)

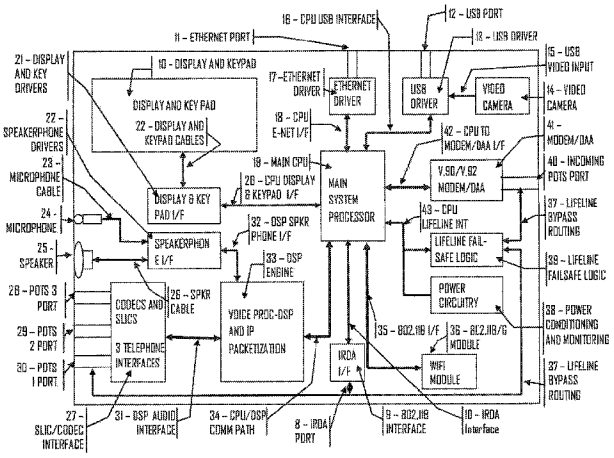
Primary Examiner — Hong Cho

(74) *Attorney, Agent, or Firm* — Clay McGurk; The Law Office of Clay McGurk

(57) **ABSTRACT**

The Residential Communications Gateway (RCG) is a broadband communications device that combines all voice, data and video communications to and from a typical residence or small business for transmission over a single, or a plurality of Plain Old Telephone Service (POTS) lines separately or in conjunction with, a wireless broadband backbone. The RCG does this by employing packetized data with Voice over Internet Protocol (VoIP) technologies combined with RF communications technologies. A key consideration to the design of the RCG is that no additional or special transmission equipment must be installed at the Central Office or anywhere else in the network to enable new calling features provided by the RCG as is the case with DSL and Cable systems. By eliminating the requirement for costly infrastructure enhancements, ubiquitous high speed communications and services can be deployed to every POTS subscriber.

23 Claims, 9 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

6,249,669	B1 *	6/2001	Ogino et al.	455/63.1
6,496,477	B1 *	12/2002	Perkins et al.	370/228
7,068,623	B1 *	6/2006	Barany et al.	370/329
7,224,964	B2	5/2007	Souissi et al.	
7,257,106	B2 *	8/2007	Chen et al.	370/338
7,917,129	B2	3/2011	Souisse et al.	
8,370,507	B1 *	2/2013	Cain	H04N 21/25816 709/225
8,442,504	B2	5/2013	Souissi et al.	
8,521,142	B2	8/2013	Souissi et al.	
2001/0037472	A1 *	11/2001	Li	H04L 12/66 714/4.1
2002/0150099	A1 *	10/2002	Pung et al.	370/390
2003/0137959	A1 *	7/2003	Nebiker et al.	370/338

OTHER PUBLICATIONS

Hsieh et al., "pTCP: An End-to-End Transport Layer Protocol for Striped Connections", ICNP, pp. 24-33 IEEE Computer Society (2002).

"End-to-End Approach to Host Mobility", by Alex C. Snoeren and Had Balakrishnan, MIT Laboratory for Computer Science, MobiCom (2000).

"Multi-homed TCP", by Huitema, C. (Internet Draft) IETF, (1995).

"TCP extensions for high performance", by Jacobson V., Braden R., and Borman D., RFC 1323, IETF, (1992).

"A New Multicasting-based Architecture for Internet Host Mobility", by Mysore, J., and Bharghavan, V., Proc. ACM/IEEE Mobicom '97 (1997).

"Mobile IPv4 Challenge/Response Extensions", by Perkins, C., and Calhoun, P., RFC 3012, IETF, (2000).

"Mobility Support in IPv6", by Perkins, C., and Johnson, D, Proc. ACM/IEEE Mobicom '96 (1996).

"Route Optimization in Mobile IP", by Perkins C., and Johnson, D., Cluster Computing 1, (1998).

"IP Mobility Support", by Perkins, C., RFC 2002, IETF, (1996).

"Transmission Control Protocol", RFC 793, IETF (1981).

"Multiple Paths Protocol for a Cluster Type Network", Hiroshi Mineno et al., 7 pages (1999).

"The PPP Multilink Protocol (MP)", RFC 1990, 24 pages (1996).

* cited by examiner

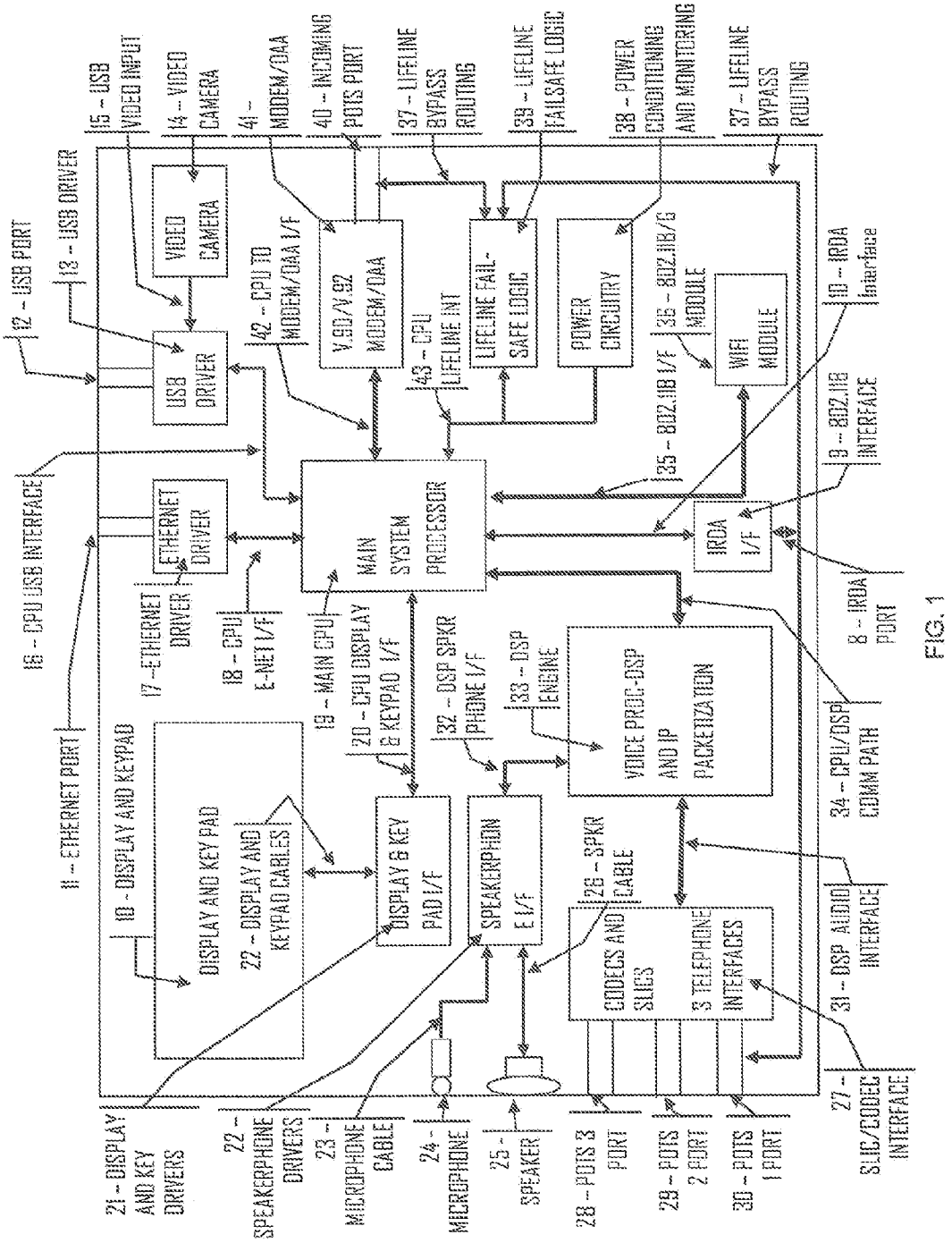

11 – ETHERNET PORT
10 – DISPLAY AND KEYPAD
DISPLAY AND KEY PAD
22 – DISPLAY AND KEYPAD CABLES
16 – CPU USB INTERFACE
12 – USB PORT
13 – USB DRIVER
15 – USB VIDEO INPUT
14 – VIDEO CAMERA
41 – MODEM/DAA
40 – INCOMING POTS PORT
37 – LIFELINE BYPASS ROUTING
39 – LIFELINE FAILSAFE LOGIC
38 – POWER CONDITIONING AND MONITORING
37 – LIFELINE BYPASS ROUTING
USB DRIVER
VIDEO CAMERA
42 – CPU TO MODEM/DAA I/F
V.90/V.92 MODEM/DAA
43 – CPU LIFELINE INT
LIFELINE FAIL-SAFE LOGIC
POWER CIRCUITRY
35 – 802.11B I/F
36 – 802.11B/G MODULE
WIFI MODULE
9 – 802.11B INTERFACE
17 – ETHERNET DRIVER
ETHERNET DRIVER
18 – CPU E-NET I/F
19 – MAIN CPU
MAIN SYSTEM PROCESSOR
IRDA I/F
10 – IRDA Interface
8 – IRDA PORT
20 – CPU DISPLAY & KEYPAD I/F
32 – DSP SPKR PHONE I/F
33 – DSP ENGINE
VOICE PROC-DSP AND IP PACKETIZATION
34 – CPU/DSP COMM PATH
DISPLAY & KEY PAD I/F
SPEAKERPHONE E I/F
26 – SPKR CABLE
CODECS AND SLICS
3 TELEPHONE INTERFACES
31 – DSP AUDIO INTERFACE
21 – DISPLAY AND KEY DRIVERS
22 – SPEAKERPHONE DRIVERS
23 – MICROPHONE CABLE
24 – MICROPHONE
25 – SPEAKER
28 – POTS 3 PORT
29 – POTS 2 PORT
30 – POTS 1 PORT
27 – SLIC/CODEC INTERFACE

FIG. 1

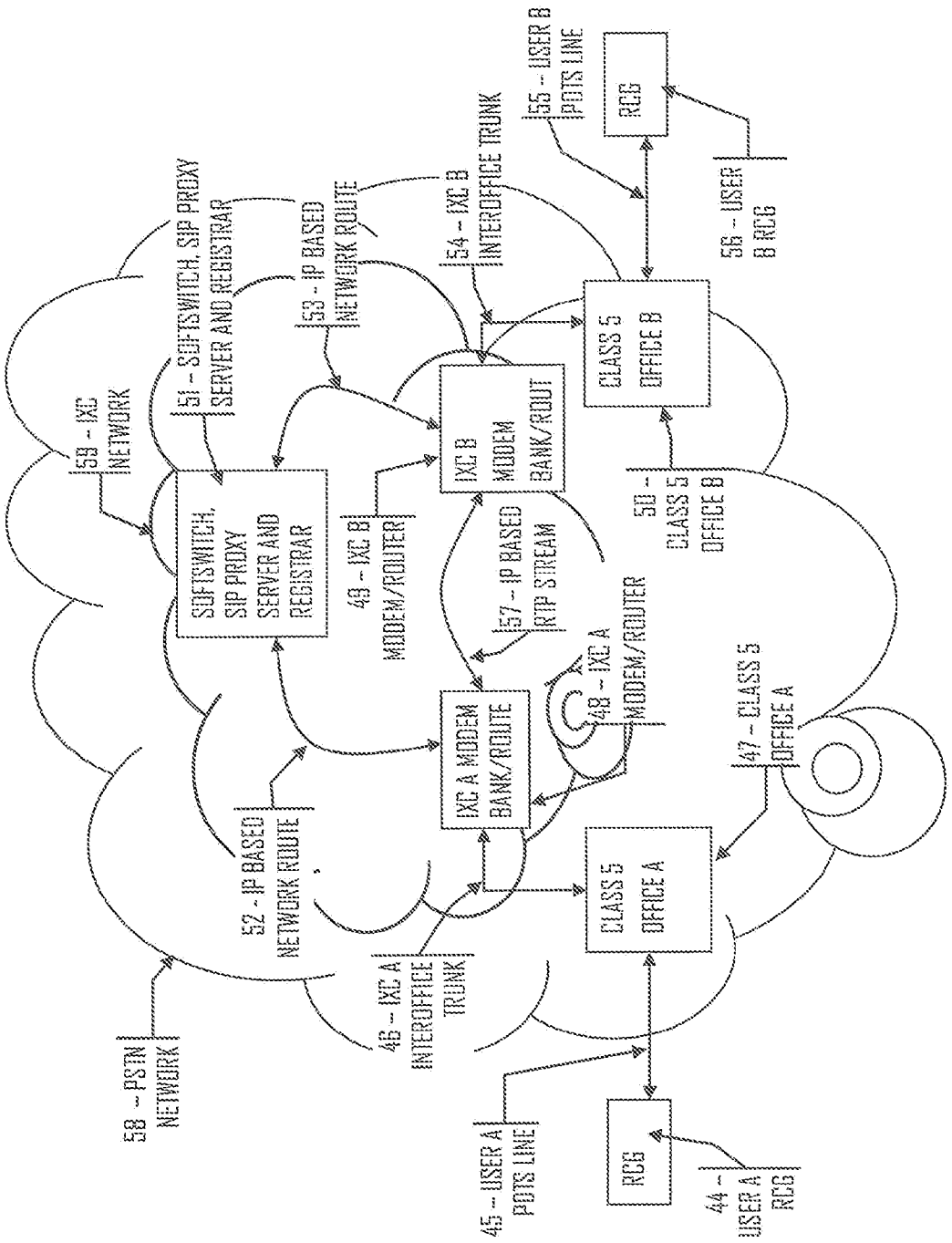

58 – PSTN NETWORK
45 – USER A POTS LINE
RCG
44 – USER A RCG
46 – IXC A INTEROFFICE TRUNK
52 – IP BASED NETWORK ROUTE
IXC A MODEM BANK/ROUTE
CLASS 5 OFFICE A
47 – CLASS 5 OFFICE A
48 – IXC A MODEM/ROUTER
57 – IP BASED RTP STREAM
49 – IXC B MODEM/ROUTER
SOFTSWITCH, SIP PROXY SERVER AND REGISTRAR
59 – IXC NETWORK
51 – SOFTSWITCH, SIP PROXY SERVER AND REGISTRAR
53 – IP BASED NETWORK ROUTE
IXC B MODEM BANK/ROUT
54 – IXC B INTEROFFICE TRUNK
50 – CLASS 5 OFFICE B
CLASS 5 OFFICE B
55 – USER B POTS LINE
RCG
56 – USER B RCG

FIG. 2

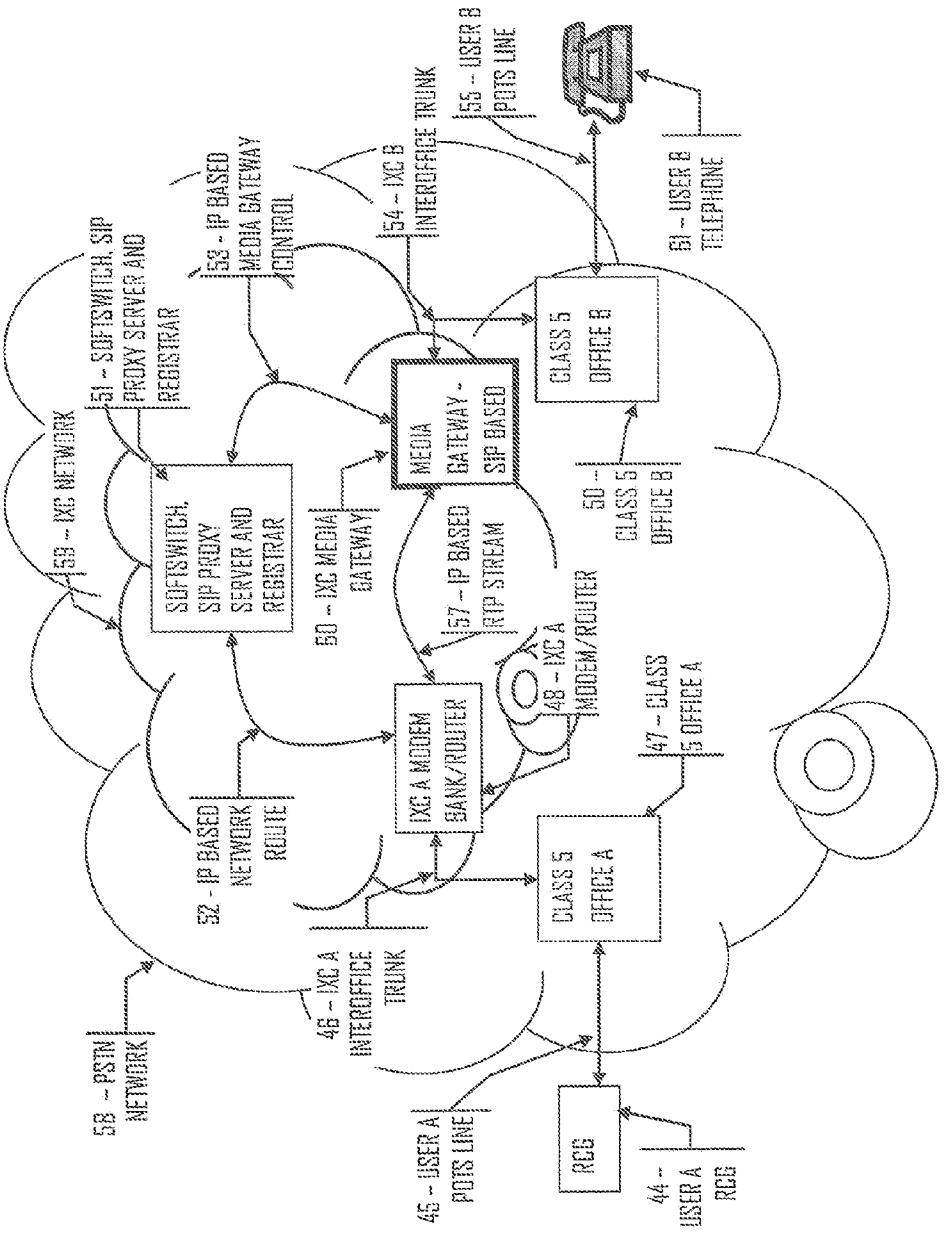

58 – PSTN NETWORK
46 – IXC A INTEROFFICE TRUNK
45 – USER A POTS LINE
RCG
44 – USER A RCG
52 – IP BASED NETWORK ROUTE
IXC A MODEM BANK/ROUTER
CLASS 5 OFFICE A
47 – CLASS 5 OFFICE A
48 – IXC A MODEM/ROUTER
57 – IP BASED RTP STREAM
59 – IXC NETWORK
51 – SOFTSWITCH, SIP PROXY SERVER AND REGISTRAR
SOFTSWITCH, SIP PROXY SERVER AND REGISTRAR
60 – IXC MEDIA GATEWAY
MEDIA GATEWAY - SIP BASED
53 – IP BASED MEDIA GATEWAY CONTROL
54 – IXC B INTEROFFICE TRUNK
55 – USER B POTS LINE
CLASS 5 OFFICE B
50 – CLASS 5 OFFICE B
61 – USER B TELEPHONE

FIG. 3

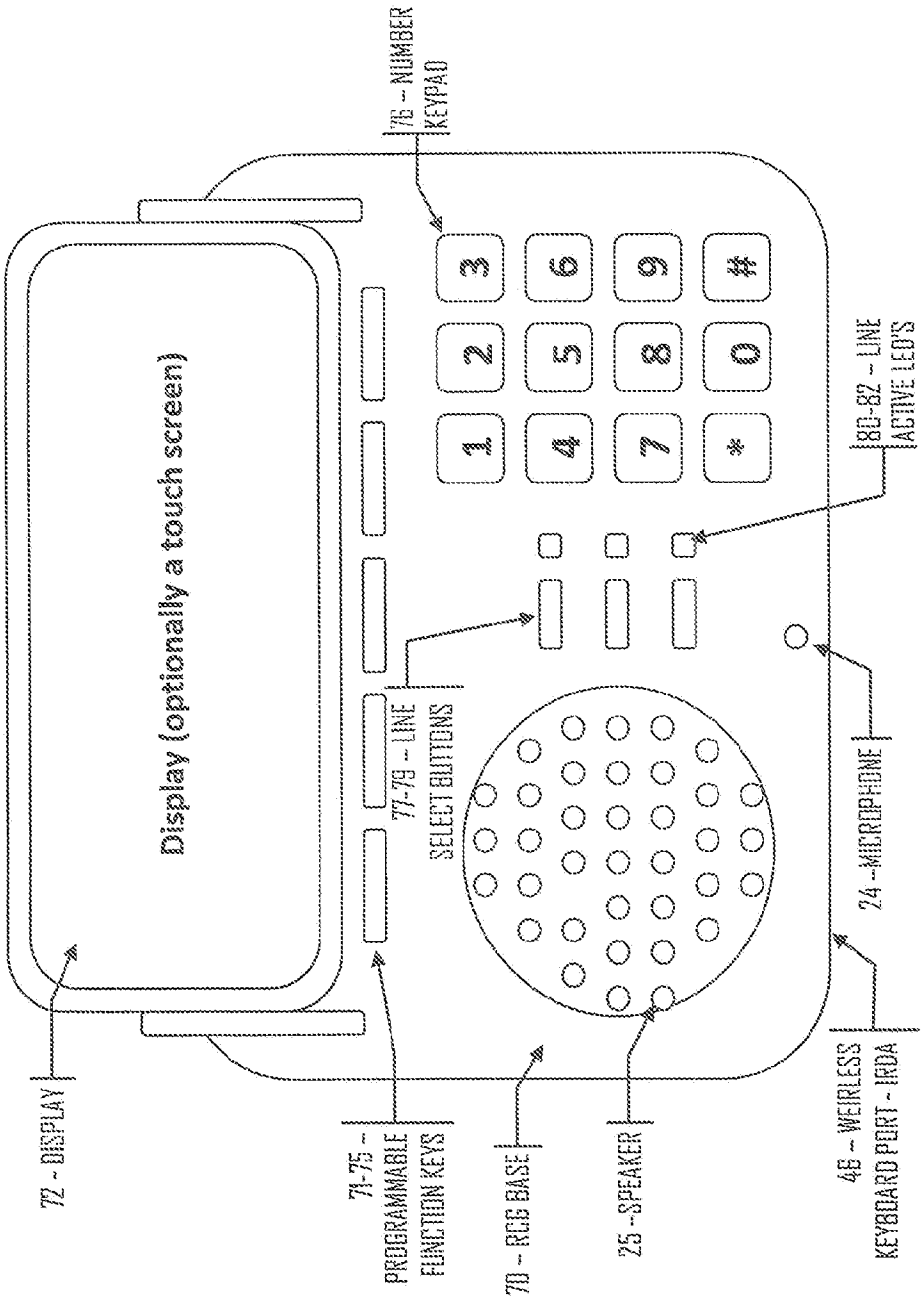

76 – NUMBER KEYPAD
Display (optionally a touch screen)
80-82 – LINE ACTIVE LED'S
77-79 – LINE SELECT BUTTONS
24 – MICROPHONE
72 – DISPLAY
71-75 – PROGRAMMABLE FUNCTION KEYS
70 – RCG BASE
25 – SPEAKER
48 – WEIRLESS KEYBOARD PORT - IRDA

FIG. 4

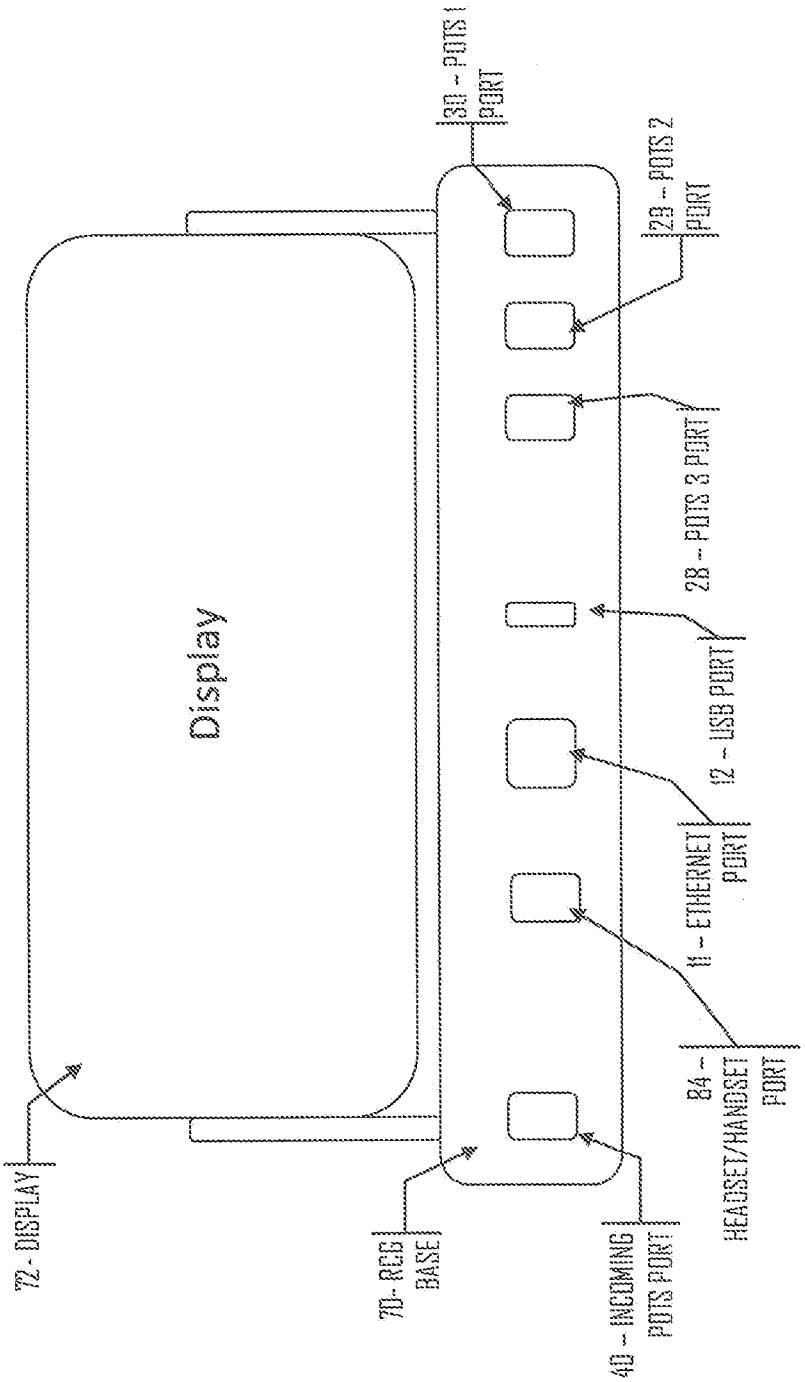

Display
72 - DISPLAY
70 - REG BASE
40 - INCOMING POTS PORT
84 - HEADSET/HANDSET PORT
14 - ETHERNET PORT
12 - USB PORT
28 - POTS 3 PORT
23 - POTS 2 PORT
30 - POTS 1 PORT

FIG. 5

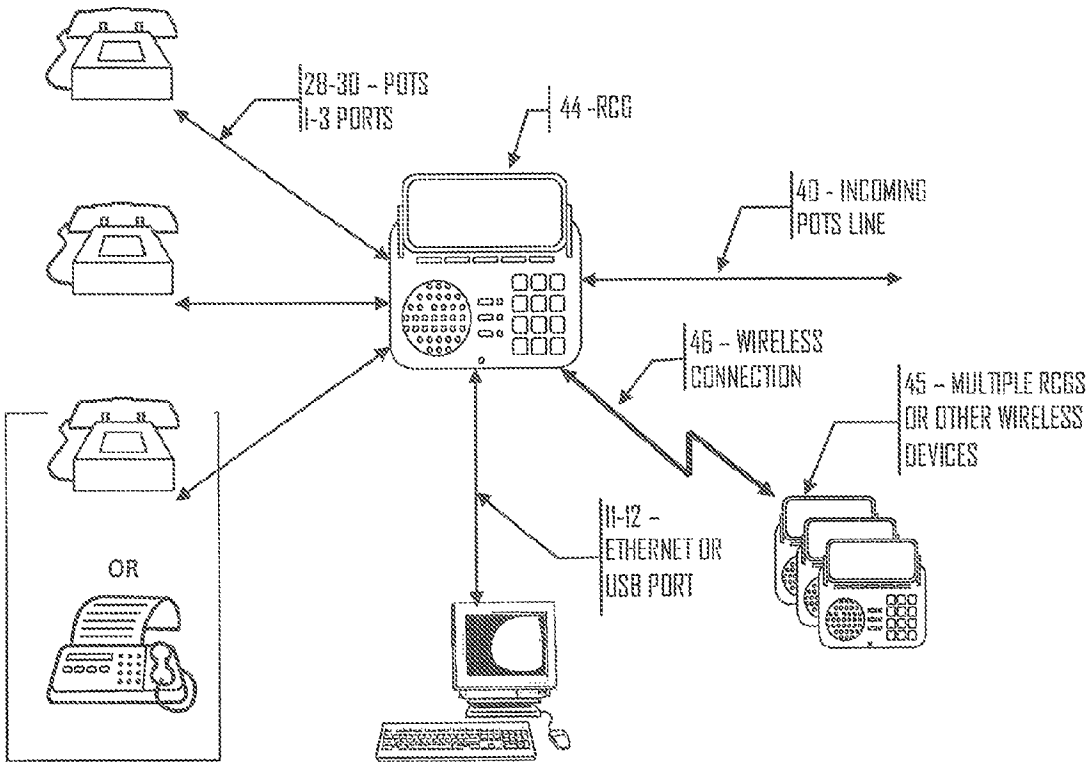

28-30 ~ POTS
1-3 PORTS
44 -RCG
40 - INCOMING
POTS LINE
46 ~ WIRELESS
CONNECTION
45 ~ MULTIPLE RCGS
OR OTHER WIRELESS
DEVICES
11-12 ~
ETHERNET OR
USB PORT
OR

FIG. 6

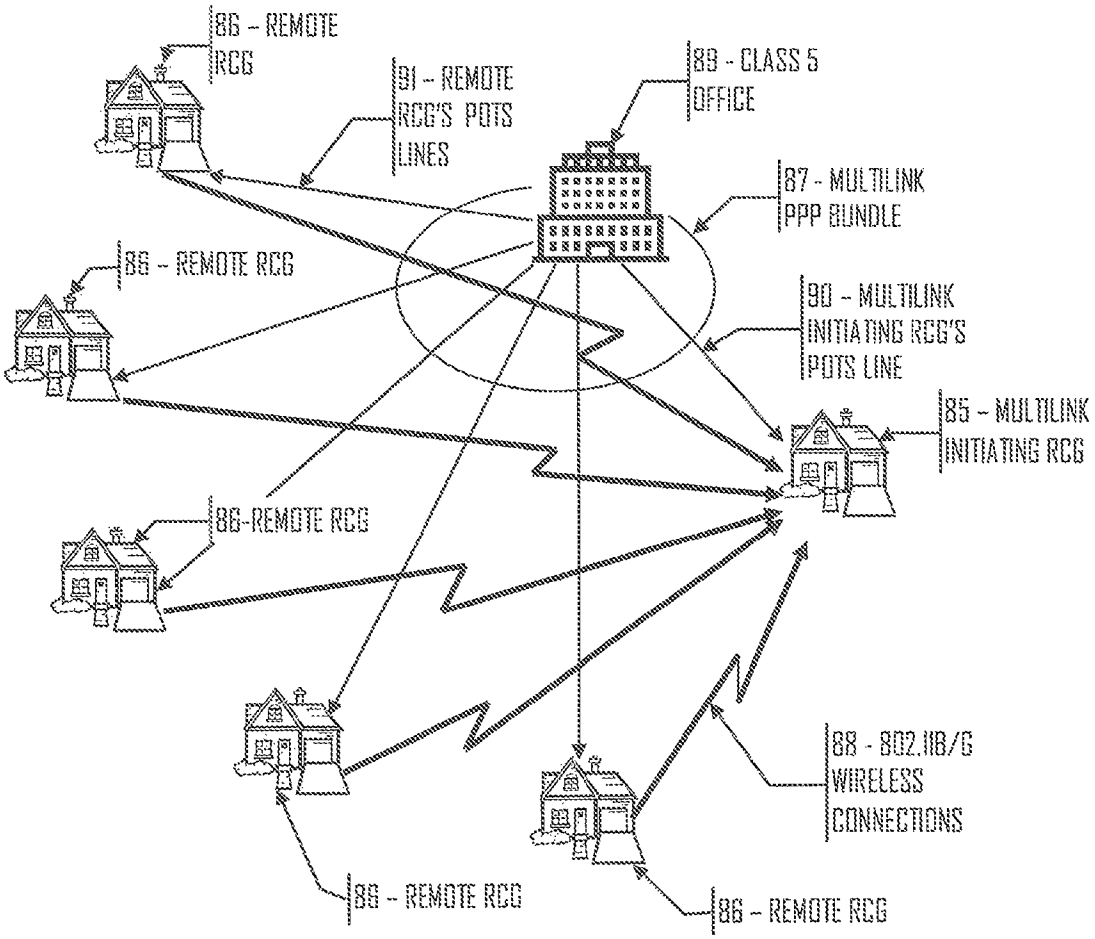

86 – REMOTE RCG
91 – REMOTE RCG'S POTS LINES
89 - CLASS 5 OFFICE
87 - MULTILINK PPP BUNDLE
86 – REMOTE RCG
90 – MULTILINK INITIATING RCG'S POTS LINE
85 – MULTILINK INITIATING RCG
86-REMOTE RCG
88 - 802.11B/G WIRELESS CONNECTIONS
86 – REMOTE RCG
86 – REMOTE RCG

FIG. 7

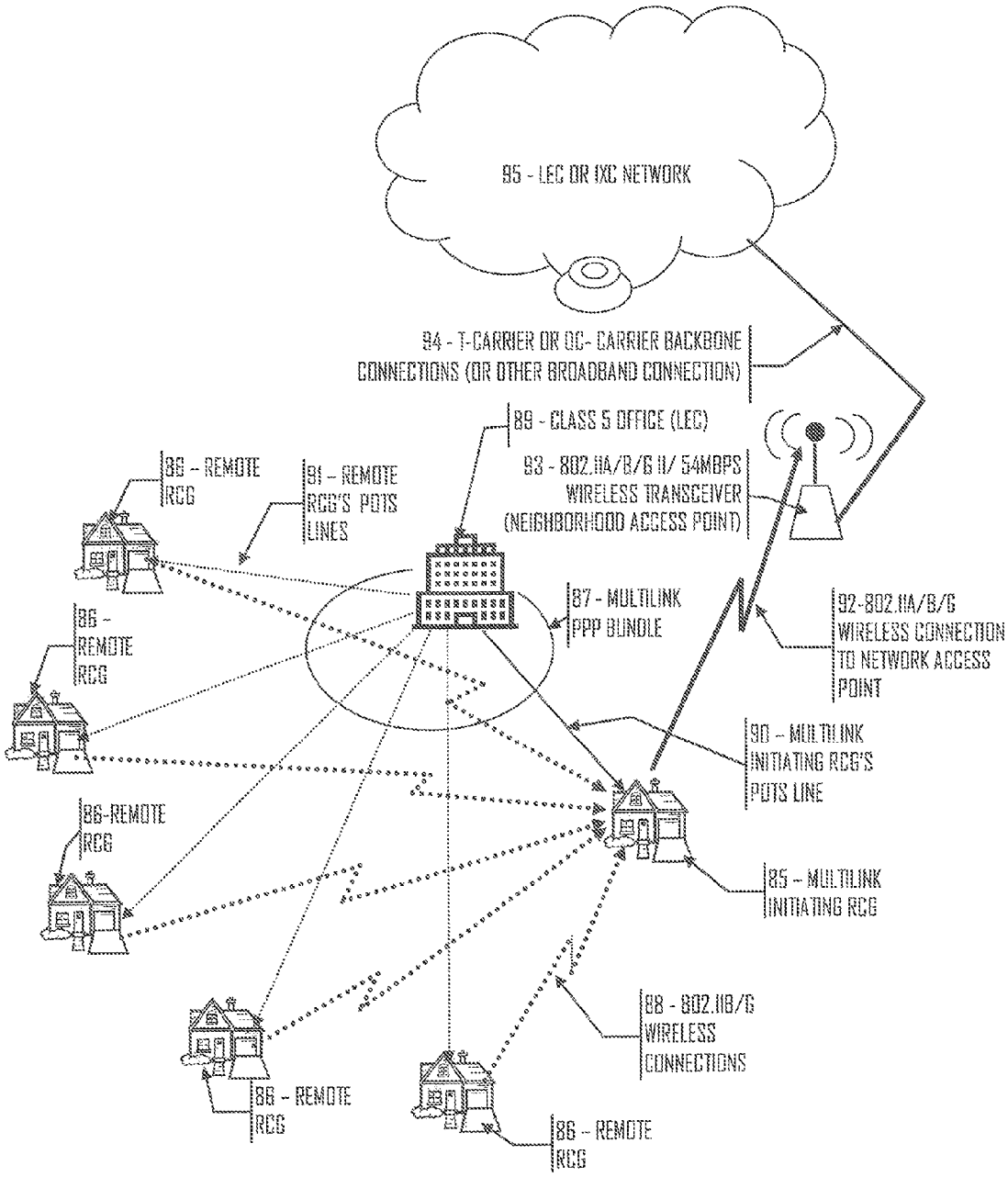

95 - LEC OR IXC NETWORK
94 - T-CARRIER OR OC- CARRIER BACKBONE CONNECTIONS (OR OTHER BROADBAND CONNECTION)
89 - CLASS 5 OFFICE (LEC)
93 - 802.11A/B/G II/ 54MBPS WIRELESS TRANSCEIVER (NEIGHBORHOOD ACCESS POINT)
86 - REMOTE RCG
91 - REMOTE RCG'S POTS LINES
87 - MULTILINK PPP BUNDLE
92-802.11A/B/G WIRELESS CONNECTION TO NETWORK ACCESS POINT
90 - MULTILINK INITIATING RCG'S POTS LINE
85 - MULTILINK INITIATING RCG
88 - 802.11B/G WIRELESS CONNECTIONS

FIG. 8

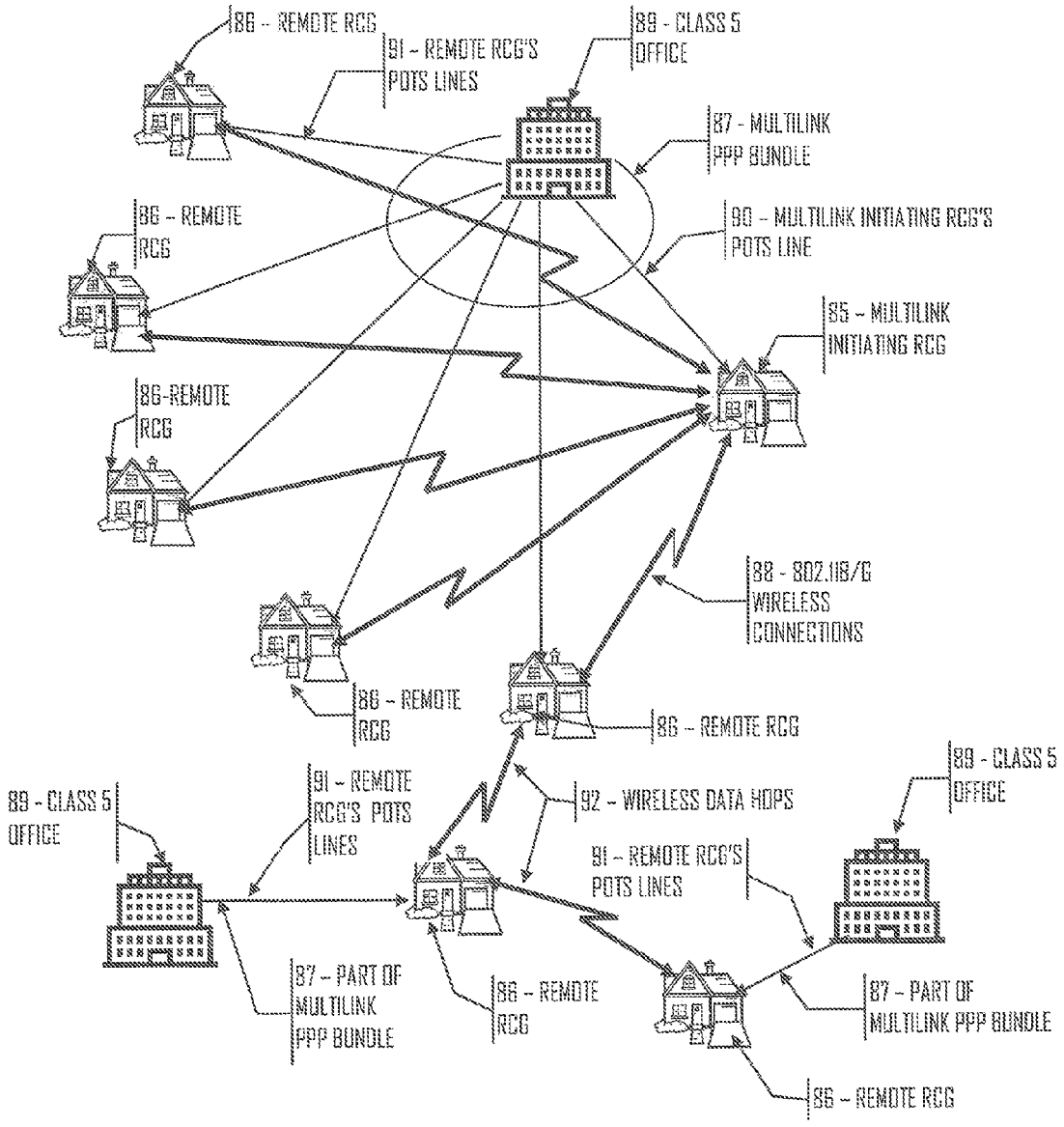

86 – REMOTE RCG
91 – REMOTE RCG'S POTS LINES
89 - CLASS 5 OFFICE
87 - MULTILINK PPP BUNDLE
86 – REMOTE RCG
90 – MULTILINK INITIATING RCG'S POTS LINE
85 – MULTILINK INITIATING RCG
86-REMOTE RCG
88 - 802.11B/G WIRELESS CONNECTIONS
86 – REMOTE RCG
86 – REMOTE RCG
89 - CLASS 5 OFFICE
91 – REMOTE RCG'S POTS LINES
92 – WIRELESS DATA HOPS
89 - CLASS 5 OFFICE
91 – REMOTE RCG'S POTS LINES
87 – PART OF MULTILINK PPP BUNDLE
86 – REMOTE RCG
87 – PART OF MULTILINK PPP BUNDLE
86 – REMOTE RCG

FIG. 9

MULTIPATH COMMUNICATION DEVICES AND METHODS

RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 13/531,294 filed Jun. 12, 2012, which is a continuation of U.S. patent application Ser. No. 12/581,852 filed Oct. 19, 2009, which is a continuation of U.S. patent application Ser. No. 10/686,375 filed Oct. 14, 2003, which claims priority to U.S. Provisional Application Ser. No. 60/418,521, filed Oct. 15, 2002, all of which are incorporated by reference herein.

BACKGROUND OF INVENTION

The primary function of the RCG is to provide a platform for Competitive Local Exchange Companies (CLECs) to compete with the Local Exchange Companies (LECs) for residential voice and data services. The LECs have a strangle hold on the "last mile" of copper over which almost all residential customers receive their communications services. Today, most CLECs resell the existing services that are offered by the LECs. CLECs make their money by purchasing these services from the LECs at a discount and marking them up to the customer. Since these services are regulated and controlled by the Public Utilities Commission (PUC) the pricing for these services to the CLECs is set. The monthly CLEC discount is approximately $5 to $6 per line per month for basic rate services. This means, in practicality, that a CLEC can only charge an additional $5 or $6 to the residential customer for basic rate services otherwise they would be more expensive than the LEC, and no one would buy the services from them; telephone customers would simply stay with the LEC.

To be competitive then, CLECs try to sell additional services such as call waiting, caller ID, etc. where they have as much as a 50% margin. Some CLECs also bundle long distance services with their packages as additional incentive to get residential customers to buy local telephone service from them. Since long distance fees are as low as pennies per minute to the customer, there is little profit in long distance for the CLECs. As it is, the pricing structure is such that the LECs will stay in control of the residential market, and the CLECs are nothing more than a marketing arm of the LEC. This structure also keeps the CLECs at an equal competitive advantage, or disadvantage, with respect to each other. The only thing that one CLEC could do to gain more customers is to be a better marketier. Since the CLECs are unable to discount their services because their margins are too slim as it is, the net effect is that the consumer looses by not really getting competition in the residential markets, and prices are kept artificially high.

For the CLECs to be truly competitive in the local telecommunications markets, they must be able to do more than simply resell the LECs services. CLECs must be able to offer many more features or services than those that the LEC provides, and they must be able to do this at a lower cost, in order to attract new customers.

So, what new services can the CLECs offer? As things stand today there are none, with the exception of DSL or Cable services which require tremendous infrastructure costs on behalf of the CLEC. However, by deploying an RCG in a residence, CLECs can offer advanced new calling features and services over the existing POTS line. Their costs for the POTS line from the LEC remains the same, but they can now charge for high bandwidth data services as well as additional calling and messaging features that the LECs cannot offer. This is their competitive advantage.

Competition:

Many companies are currently trying to provide VoIP services to residential customers over high-speed or broadband backbones such as DSL and cable modems, over Internet connections via a computer. The high-speed services require expensive infrastructure enhancements to the local telephone companies' facilities and cable plants, as well as expensive modems at the customer's end. These services are also difficult to deploy and too complicated for the average user. Internet based VoIP services suffer from Internet delays caused by a lack of true Quality of Service (QOS) capabilities across the Internet. Existing VoIP services also require access to a computer and a technical knowledge to be able to make it work. Because of these problems, VoIP services are primarily targeted at the corporate market place where private IP networks that can carry VoIP services with a true guaranteed QOS exist, or can be controlled.

The only available alternatives for the residential user for high speed services are DSL and cable modems. DSL and Cable based communications reach only a small segment of the population, and growth has failed to live up to initial expectations. The recent collapse of the internet boom has led to the failure of many DSL service providers and has effectively eliminated DSL as a potential service for most POTS users for the immediate future.

SUMMARY OF THE INVENTION

The RCG combines the capabilities and features of IP routers, Class 5 circuit switches and wireless LANs in a small stand-alone external modem like device. Additional capabilities for a hands-free speakerphone device with a large touch display are also detailed. The RCG can employ a large display with sufficient resolution to provide a functional user interface to access all of the advanced features offered by the RCG, but also to be able to provide video telephone services.

The device is placed in a residence and connected to the primary POTS line coming from the LEC. Up to three standard telephones or FAX machines (or any combination) are typically connected into the RCG. It also has a Universal Serial Bus (USB) and/or a 10-100 Ethernet interface for connection to a computer or a Local Area Network (LAN). In addition, it has an 802.11b/g wireless interface for wireless home networking as well as broadband-to-the-home services.

The system is installed in a customer's home by simply plugging it into the existing incoming telephone line that provides POTS services from the LEC. One or more standard telephones are then plugged into its three line-output jacks. This is the simplest and most basic usage. In this implementation, the user only is interested in gaining additional telephone lines into the household. No computer connection is required in order to use the system. However, if data communications are desired, then there are three additional interfaces for computer connectivity. Typically either an Ethernet port, USB port or firewire (IEEE 1394) port is used to connect to a PC or LAN. The 802.11b/g interface is for wireless communications between the RCG and PCs, other RCGs as well as any other types of compatible wireless devices. A version of the RCG includes a speakerphone and video camera to provided for video telephone services.

Services Provided by the RCG:

The following discussion refers to FIG. **1**. The RCG has a main system processor that is responsible for all house keeping and traffic routing tasks. The Main CPU **19** routes data to

and from the Ethernet Port **11**, USB Port **12**, Modem/DAA **41**, DSP Engine **33**, 802.11b/g Module **36** and the Display and Keypad **10**.

The RCG provides a total telecommunications communications services package for residential and small business customers. With the RCG, a CLEC can offer its customers dialtone for up to three separate telephone numbers per residence (the limit of three telephone numbers is an arbitrary number based upon typical residential usage and is not a limit imposed by the system), all local and long distance services, 24/7 always-on Internet access, a host of custom messaging and calling features, as well as Broadband access and lifeline service. All of these services can be offered over a customer's existing POTS line, and it doesn't require any network infrastructure build out like DSL and Cable services. Because there is no expensive network equipment required, it can be readily deployed throughout the country to expand the CLECs customer base quickly.

The RCG is designed to enhance, not replace, the existing telephone line, enabling it to provide new combined packetized voice and data services. Meanwhile, all existing telecommunications infrastructure and equipment will continue to work seamlessly with the RCG. Aside from simply installing the low cost RCG device in the home telephone wiring, no other equipment needs to be purchased by either the home owner or telephone companies. This eliminates the tremendously expensive infrastructure costs for communications companies that are trying to provide voice services using DSL or cable modems.

The RCG VIP Home Gateway Features:

Up to three telephone lines i.e. numbers, over a single POTS line and/or wireless connection.

Ethernet, USB and IEEE 1394 computer interfaces.

Full G1, G2 and G3 FAX support.

Full support for all CLASS services.

Broadband networking for home computers and appliances as well as wide area networking using a combination of a plurality POTS lines connected to a plurality of RCGs and/or a direct wireless connection to a wireless access point. (These interfaces allow smart devices to communicate to other devices within the home, or over the Internet through the RCG.)

Automated, remote upgradability and configuration. (Requires the customer to do nothing.)

Transparent user operation. (User doesn't have to know that any new technology is being employed)

100% compatible with existing public telephone system.

Video Telephone capabilities.

No local or long distance usage charges.

No Internet access fees.

Lower monthly communication costs.

Multiple telephone calls at the same time.

Voice messaging, follow me features, call forwarding, automatic call back, conferencing, custom call routing. Home networking capabilities, all CLASS calling features, high speed broadband networking, continuous 24/7 internet access. and many others.

All of these features are available even while connected to the Internet.

Very low cost of entry into the market, especially as compared to broadband alternatives.

New calling features that are not currently available to home users.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows the RCG functional block diagram with the preferred embodiment of an 802.11 wireless connection.

FIG. **2** shows the network topology for native RCG to RCG communications.

FIG. **3** shows the network topology for an RCG to PSTN call.

FIG. **4** shows the RCG top view with associated functions.

FIG. **5** shows the RCG rear view and associated connections.

FIG. **6** shows a typical application with peripheral equipment connections.

FIG. **7** shows an ad-hoc wireless LAN configuration with ppp multilink data distribution and wireless connectivity.

FIG. **8** shows an ad-hoc wireless LAN configuration with ppp multilink data distribution and wireless connectivity with connection to a broadband neighborhood access point (Wi-Fi hot spot).

FIG. **9** shows an ad-hoc wireless LAN configuration with ppp multilink data distribution and wireless connectivity with wireless data hopping with POTS connections through numerous different Class 5 offices.

DETAILED DESCRIPTION OF THE INVENTION

The preferred embodiment is detailed herein using the ubiquitous 802.11 wireless protocol. It is by no means insinuated that this is the only wireless scheme that can be used by this device; rather, it is intended that any wireless transmission scheme can be used for wireless communications between this device and other wireless devices as various applications may dictate.

System Initialization

Refer to FIGS. **1**, **2** and **3** for the following discussion. When the RCG is first plugged into an AC power outlet the Main CPU **19**, performs a Power-on Self Test (POST) routine. Once the POST completes and the RCG is connected to an active POTS line, connected to the LEC, by means of the Incoming POTS Port **40**, the RCG automatically initiates a modem connection via the Modem/DAA **41**, to a registration service via a toll free 800 telephone number. The registration service connects directly to the service provider's sales or customer service offices via a VoIP connection. An operator or an automated service answers the call and sets up a new account for the customer. Once the account is set up, the service provider's network automatically sends control information to the device to store the required routing and feature/service information in its non-volatile memory of its Main CPU **19**. As part of this information, a local dialup telephone number is sent to the device that it will use for local network access in the same fashion as a standard ISP connection is made from a home computer. The URL of the Softswitch/SIP Proxy Server and Registrar **51** that will be controlling this particular device is also stored at this time. During the service activation and configuration process, the customer service operator can send test requests to the device, as well as call into it on another telephone number (assuming an additional telephone number is part of the users class of service) or the speakerphone to verify that it is configured and working properly. The final step of the configuration and initialization process is to register the device with the appropriate Softswitch/SIP Proxy Server and Registrar **51** so that the Softswitch/SIP Proxy Server and Registrar **51** knows that it is the controlling SIP Proxy for this RCG. Also configured at this time is the username/password verification server (this is a standard network device and is not shown) that is used to allow the RCG's modem to make a connection onto the service provider's network. Once the RCG configuration is completed, it disconnects the call by hanging up the Modem/DAA **41**, then dials the new local network access number that

had been sent during the configuration process and establishes a constant local network connection. This connection is maintained continuously on a 24/7 basis, and is immediately reestablished whenever it drops. Should the RCG become unable to reestablish this connection after several tries, it will switch over to failsafe mode and inform the user via the Display and Keypad **10**. The RCG will try to reestablish the connection every few minutes until it finally succeeds.

By default, the first telephone port, POTS 1 Port **30**, is assigned as the termination port for the existing POTS service that is connected to Incoming POTS Port **40**. This is the existing telephone service that the user already has as his primary telephone service from his LEC. POTS 1 Port **30**, typically has connected to it a standard telephone set that does not require any power (other than that derived over the POTS interface) to operate properly. POTS 1 Port **30** is the Lifeline telephone port for the user. In the case that all power is lost to the RCG, POTS 1 Port **30** will fail to a direct connection to the Incoming POTS Port **40** telephone line that comes into the RCG from the LEC to provide uninterrupted telephone services to the user. In this state, however, none of the enhanced VoIP services of the RCG are available to the user since the user simply has a stand POTS telephone service to the LEC.

Two additional and unique telephone numbers can be assigned to the other two telephone ports, POTS 2 Port **29** and POTS 3 Port **28**, by the service provider at any time. These numbers are drawn from a pool of available telephone numbers assigned to the service provider. POTS 2 Port **29** and POTS 3 Port **28** must to have standard telephone numbers assigned to them so that the PSTN is able to route calls from its network to these ports. For calls originating from IP based telephones, these numbers are not necessarily needed since POTS 1 Port **30**, POTS 2 Port **29** and POTS 3 Port **28** are uniquely identifiable to IP networks via their IP addresses assigned through the Dynamic Host Configuration Protocol (DHCP) at the time that the RCG establishes a connection to the service provider's network. Since POTS 2 Port **29** and POTS 3 Port **28** must have a telephone number assigned to them, it is a matter of convenience to use the assigned telephone numbers as part of their SIP address for IP routing of their data. In this way, all three user POTS ports, POTS 1 Port **30**, POTS 2 Port **29** and POTS 3 Port **28** are all addressed the same manor.

At this point, the user is able to take advantage of all of the RCG's features that have been activated according to his service agreement. The user can at any time connect additional telephones, a computer or a computer network to the RCG. The user will only be able to use those telephone ports (POTS 1 Port **30**, POTS 2 Port **29** or POTS 3 Port **28**) that have been activated, and assigned unique telephone numbers by the service provider. Any type of standard telephone can be connected to the three POTS ports, POTS 1 Port **30**, POTS 2 Port **29** and POTS 3 Port **28**. In the event that a cordless telephone or a telephone that derives its power from an AC outlet is connected to POTS 1 Port **30**, the lifeline functionality of this port will be ineffective since the telephone itself will not operate once power is lost.

The speaker phone feature of the RCG, comprised of Speakerphone Drivers **22**, Microphone **24**, Speaker **25** and DSP Engine **33**, can be used on any of the activated telephone numbers and is by default enabled to operate on POTS 1 Port **30**. Once either of the other two telephone ports, POTS 2 Port **29** or POTS 3 Port **28**, is activated, the speakerphone function is activated for those lines as well. To use the speakerphone for any assigned telephone number, the user simply presses either the Line Select Button **79-81** for Line 1, Line 2 or Line 3 on the face of the RCG, and the speakerphone function is activated on that line. This is convenient for answering any call directly at the RCG. The RCG may or may not have a number keypad for originating calls. This feature may be added or removed based upon the target market price points.

The determination as to which Inter Exchange Carrier (IXC) the RCG will route its data through is determined by any of a number of criteria including, but not limited to, whether the RCG is a private labeled product, or which carrier has the lowest cost routing, or if a specific carrier is specified by the customer, or and number of other considerations. The RCG can be programmed to change its routing path to any IXC at any time by the service provider. Complicated routing algorithms can be programmed into the RCG to control which IXC it will use at any time.

Failsafe Mode

During any time that the RCG is in failsafe mode i.e. Lifeline failsafe logic **39** is activated, the RCG will only be able to receive or initiate telephone calls via the telephone connected to its primary telephone port, POTS 1 Port **30** or through its speakerphone feature. In this condition, all activated telephone numbers are ported via the PSTN to the primary (first) telephone number for delivery to the user's telephone that is connected to POTS 1 Port **30**. While in failsafe mode, the modem is not activated, and the RCG appears to the local Class 5 office as a standard telephone, and the PSTN will route all incoming calls to the RCG as it normally would to any standard telephone.

Call Flow 1:

Dialed call origination from a telephone connected to an RCG POTS port and terminating at another user's RCG POTS port:

When a user picks up a telephone connected to any of the three POTS ports, POTS 1 Port **30**, POTS 2 Port **29** and POTS 3 Port **28**, an off hook condition is detected by the SLIC/CODEC Interface **27** that is connected to the DSP Engine **33** by way of the DSP Audio Interface **31**. The DSP Engine **33** responds by sending digitally generated dialtone to the appropriate POTS interface over the DSP Audio Interface **31**. (Note: all BORSCHT telephony functions are performed by the DSP Engine **33** and the SLIC/CODEC Interface **27**.) Upon hearing the dialtone, the user enters the desired telephone number on his telephone keypad. The Dual Tone Multi-Frequency (DTMF) digits that the user dials are decoded within the DSP Engine **33**. The dialed digits are transferred to the Main CPU **19** via the CPU/DSP Communications Path **34**. The Main CPU **19** polls the DSP Engine **33** approximately every two milliseconds looking for data. The Main CPU **19** polling rate varies according to the process that is being performed. The CPU/DSP Communications path **34** also can generate an interrupt to force data transfer between it and the Main CPU **19**.

The Main CPU **19** generates a SIP Invite IP packet using the dialed digits as the called destination address and the URL of its local controlling SIP Proxy Server which was programmed into the RCG during the configuration process. The Main CPU **19** passes this SIP packet off to the Modem/DAA **41** for transmission over the network. The RCG Modem/DAA **41** is connected to and communicating with a modem in a modem bank located in the Inter Exchange Carrier's (IXCs) facility. This facility may actually be located in the LEC's physical plant or it may be physically located at another location.

Referring to FIG. **2**, User A RCG **44** is connected via its modem to the LEC's local Class 5 Office A **47**. In this example, the service provider's connections to the IXC A Modem Bank & Router **48** are through IXC A Inter-Office Trunks **46**. The service provider may or may not be the IXC.

If the service provider does not have its own network, then it will purchase capacity from an IXC and route its traffic to that IXC's facilities. The SIP Invite IP Packet that is sent from User A RCG **44** transits the LEC's Class 5 Office A **47** facilities and is routed to the IXC A Modem Bank/Router **48** via the IXC A Inter-Office Trunks **46**. It is the job of the router to take the IP packet and route it on to its intended destination, in this case the appropriate SIP proxy server **51**. The router uses the URL for the Softswitch/SIP Proxy Server and Registrar **51** contained in the SIP Invite to know where to route the packet. (Note: The Softswitch, SIP Proxy Server and Registrar are logical devices that may reside in a single computer system, or may be implemented as completely separate devices. In this example, the Softswitch, SIP Proxy Server and Registrar are all shown as a single physical device running these three separate processes.) The IXC A Modem Bank/Router **48** sends the SIP Invite IP packet on to Softswitch/SIP Proxy Server and Registrar **51** via an IP based network route **52**.

The SIP Proxy Server process running on Softswitch/SIP Proxy Server and Registrar **51** performs a look up to determine the termination destination for the call using the dialed digits passed along in the SIP Invite IP packet. In this example, the terminating device for User B RCG **56** is via IXC B's Modem Bank/Router **49** then through Class 5 Office B **50** and over User B POTS line **55** and finally to User B RCG **56**. Not covered in detail here is the SIP message handling since it is completely covered in IETF RFC2543. This example shows that both the originating and terminating ends of this call are controlled by the same Softswitch/SIP Proxy Server and Registrar **51** device. Where the originating and terminating ends of a call are controlled by different Softswitch/SIP Proxy Server and Registrar devices, an additional level of SIP messaging is used between the two SIP Proxy Server processes of each of the Softswitch/SIP Proxy Server and Registrar devices to locate and control the terminating location of the call. Again, that information is covered in IETF RFC2543 and is repeated here.

After the call routing is setup using SIP, and User B answers the call, the Softswitch/SIP Proxy Server and Registrar **51** device sends IP address of the originating User A RCG **44** to the User B RCG **56** and the IP address of User B RCG **56** to User A RCG **44**. Once both RCG's have the other's IP address, they then communicate directly to each other using Real Time Protocol (RTP), and the Softswitch/SIP Proxy Server and Registrar **51** device is no longer part of the connection. This direct communication is shown as IP based RTP Stream **57** between IXC A Modem Bank/Router **48** and IXC B Modem Bank/Router **49**.

On the receiving end of the call, referring back to FIG. **2**, User B RCG **56** receives the SIP Invite data stream through its Modem/DAA **41** and passes it on to the Main CPU **19**. The Main CPU **19** reassembles the SIP IP packet and interrogates the header information to determine which POTS port, POTS 1 Port **30**, POTS 2 Port **29** and POTS 3 Port **28** the call is destined for based upon the dialed number contained in the SIP Invite message. The Main CPU **19** commands the DSP Engine **33** to control the SLIC/CODEC Interface **27** to apply ringing voltage to the selected POTS port to ring the phone. A corresponding SIP 180 (ringing) message is sent back to User A RCG **44** in the reverse direction. When the phone attached to the selected POTS port is answered, the off hook condition detected by the SLIC/CODEC Interface **27** is sent through the DSP Engine **33** to the Main CPU **19** that sends the SIP 200 OK message back to User A RCG **44** to let the RCG know that the call was answered by User B RCG **56** and to turn off the audible ringing tone for User B. Once the call is established, User A RCG **44** sends and ACK F12 SIP message to User B RCG **56** indicating that User A RCG **44** understands that the call setup has been completed.

The two RCGs now exchange SIP messages that include the type of voice encoding that will be used such as G.729, G.723.1, G.711 etc to configure their RTP streams so that they can reliably transfer the user information between them. At this point the call (voice data) is sent between both RCGs and a normal telephone conversation takes place between the user A and user B.

Call teardown is accomplished by either user hanging up their telephone. The RCG of the terminating end (the end that hangs up the phone first) detects the on-hook condition and sends a SIP Bye message to the other end. The other end upon receiving the SIP Bye message responds with an OK 200 SIP message and disables the appropriate POTS port that the user was using.

The Speakerphone interface can be used for either end of a telephone conversation in exactly the same way as described above except that the corresponding POTS port that the call was intended for is disabled if the call is answered via the speakerphone.

Call Flow 2:

Calls between an RCG device and a PSTN telephone:

Refer to FIG. **3** for the following discussion.

In the previous call example, the PSTN network had nothing to do since the call was over a previously established modem connection between two RCGs. In the cases where a call originates or terminates to a standard telephone serviced by a Class 5 office, the process is a bit more complicated.

When a call originates from a user via an RCG, such as User A RCG **44**, the call handling practices are exactly the same up to the point that the SIP Proxy Server process in the Softswitch, SIP Proxy Server and Registrar **51** performs a lookup to determine how to route the call. In this case, the SIP Proxy Server process determines that the call terminates at a standard PSTN telephone attached to the Class 5 Office B **50**. Since the call originates as a native VoIP service, it must be converted to a standard switched circuit based service to be able to be delivered to User B's telephone **61**. The conversion is performed by the IXC's Media Gateway **60** device. In this example, the SIP Proxy Server process routes the call via the IXC's Media Gateway **60** device instead of through the IXC B Modem Bank/Router **49** as before. The SIP Proxy Server process sends a SIP Invite to the IXC's Media Gateway **60** device, as well as other control information, to direct the Media Gateway **60** device to terminate the call and to apply the appropriate voice compression algorithm to the media stream to convert it between switched circuit PCM format and the selected VoIP protocol. At the same time, the Softswitch process of the Softswitch, SIP Proxy Server and Registrar **51** device sends commands to the Media Gateway **60** device to cause it to route the call's PCM data to a specific channel on the IXC B Interoffice Trunk **54**. The Softswitch process then generates an SS7 ISUP message that is sent over the PSTN SS7 signaling network to the Class 5 Office B informing it of the incoming call and on which circuit the call has been placed. It is up to the PSTN at this point to ring the User B telephone **61** and process the call between the IXC's Media Gateway and the User B Telephone **61**. The Softswitch process handles the signaling conversion between the PSTN's SS7 network and the IXC's SIP messaging, as well as any other proprietary signaling schemes utilized by the IXC to control its network. The standard SS7 call control messages, such as ringing, busy, ring back etc., all have a comparable SIP call flow control messages. The Softswitch simply maps

the SS7 messages into SIP messages and visa-versa while routing the messages to the appropriate network equipment.

As in the case of a call between two RCGs, the RTP media stream (the actual call data) is routed directly be the IXC A Modem Bank/Router **48** and the IXC's Media Gateway **60** via an IP based RTP Stream **57**.

Again, call teardown is accomplished by either user hanging up their telephone. Depending which end hangs up the phone first, the associated network will generate the appropriate messages which will eventually make it back to the Softswitch process. The Softswitch process will relay the appropriate call control messages between the PSTN and the IXC's SIP based control system.

A telephone call originating from a PSTN telephone is configured and setup in the same fashion as the above description except that the originating messaging begins within the PSTN network instead of the IXC's network.

Personal Computer based communications:

Where the RCG is connected to a Personal Computer (PC) through either its USB Port **11** or Ethernet Port **12**, the RCG operates exactly as a cable or DSL type modem device. The RCG is simply a pass through for the computer's data. The RCG receives the IP packets (of whatever type) from the computer and sends the information unchanged to the Modem/DAA **41** interface for transmission over the Internet. Received information from the Internet is processed in the reverse way.

Dynamic Bandwidth Allocation:

When a modem connection is established between the RCG and the "Network", the total available bandwidth of this connection is used in a shared/prioritized fashion. Voice services (calls) take precedence over data services. Therefore, when no calls are in progress all of the available bandwidth is used by data type services such as surfing the Internet or uploading/downloading files. However, when a call is to be passed through the RCG, the required bandwidth for the call is deallocated from the data services and prioritized for the telephone call. This necessary because the Quality Of Service (QOS) is important for effective communications over electronic networks. Since the voice data is carried over a "data centric" network topology (an IP based network), call quality can suffer greatly. Every effort must be taken to eliminate or reduce the packet delay through every network element to be able to provide the best call quality. For data applications such as surfing the Internet or downloading files packet delay is acceptable and expected, and it does not affect the "quality" of the data.

Since all voice and data is transmitted as packets, there are no "time slots" or other type of "channelization" associated with the transmission of this data over either the POTS line or the wireless interface. Channelization of the voice data does occur within the SLIC/Codec Interface—**27** but is converted into IP packets by the DSP engine—**33** and is handled as packets from that point on.

Regardless of whether the call is originating or terminating at the RCG, the bandwidth allocation process is the same. When the SIP call setup messages are processed, the type of voice compression that will be used is defined. The RCG Main CPU **19** handles the IP packet flow between the DSP Engine **33**, USB Port **12**, Ethernet Port **11**, 802.11b/g Module **36** and the Modem/DAA **41** devices giving priority to the voice packets to and from the DSP Engine **33** and the Modem/DAA **41** interfaces. Voice compression algorithms create IP packets at a specified number of packets per second. These packets are handled by a timed process in the RCG. This process is started during call setup so that the packets are handled at the correct rate based upon the compression algorithm's packet generation rate. There is no priority assigned between the voice packets of each of the three different POTS Ports **28-30**. When more than one voice call is in progress, they are handled in a round robin fashion based upon the packet rate for the compression algorithm used. If, for example, two calls are using a compression scheme that generates packets every 2 milliseconds, and the third generates packets every 4 milliseconds, then the calls utilizing the faster packet rate will be polled at twice the rate as the call using a slower packet rate but they are not given priority "over" the other call. Only when there are no voice packets ready for transmission to the Modem/DAA **41**, i.e. during the approximately 2 to 4 millisecond packetization period between packets, will any pending data packets received from the USB Port **12**, Ethernet Port **11** or the 802.11b/g Module **36** be sent to the Modem/DAA **41** for transmission over the network.

Thus, the POTS bandwidth is allocated on a per packet basis, not on a "time slot" or "channelization" or even a "frequency" basis as it the case with T-Carrier, DSL or channelized DSL systems. The same is true for the wireless interface, whether it is carrying pure data or voice.

Security is currently a big concern in today's networks, and especially with wireless 802.11 transmissions. For this reason, the RCG defaults to route voice data over the users POTS connection via Incoming POTS Port **40**. As security concerns regarding wireless communications transmissions are addressed and alleviated, voice call data can, and will, be routed over the wireless interface via the 802.11b/g Module **36**.

FAX Transmission:

Group I, 2 and 3 fax transmission is completely supported by the RCG. Fax transmission has the same priority as other voice communications. That is to say that FAX transmission is treated the same as a voice call and takes precedence over native IP data traffic.

Broadband Over POTS:

One of the primary functions of the RCG is to be able to transfer large files such as video files over the POTS lines to a residence. The ability to do this is limited by the maximum of 56 Kbps due to the design of the digital Class 5 office linecards and network transmission schemes based upon T carriers. Typical Class 5 linecard design samples the POTS lines at a rate of 8,000 samples per second. Typically, each sample is digitized into 12 to 16 bits by a codec device. The digitized sample is then companded to an 8 bit sample (1 byte) which makes up the PCM data stream that is transferred over the PSTN. Therefore, each POTS line is sampled at an effective rate of 64 Kbps. Since legacy T1 transmission equipment uses robbed-bit signaling, the maximum guaranteed transmission rate for the PSTN as a whole is 56 Kbps. Because of this limitation, standard POTS lines can only guarantee a maximum of 56 Kbps transfer rate under the best conditions. DSL equipment gets around this problem by installing DSL Access Multiplexing (DSLAM) equipment at the Class 5 office end of the POTS line. By routing around the linecard, as well as routing the data directly over the Internet or other private IP based networks, and therefore the 64 Kbps sampling rate, DSL is not bandwidth limited like PSTN traffic is. DSL, however, suffers from the very high costs associated with the purchase, installation, maintenance, floor lease costs, etc. DSL also suffers from very high deployment costs resulting from the labor intensive process to turn up each line. Each DSL "POTS" line must be inspected, conditioned and all load coils removed.

The RCG gets around the 56 Kbps POTS limitation as well as the DSL problems by using the standard POTS lines as they are, and not requiring any additional equipment to be installed

at the Class 5 end of the POTS line. This technique simplifies deployment and drastically cuts costs.

Multilink PPP Connections:

Referring to FIG. **7**, the RCG implements broadband over POTS by employing an 802.11b/g wireless interface to configure a multilink PPP bundle—**87** (per RFC 1990) comprised of the POTS lines connected to up to 32 RCGs. The limitation of 32 RCGs in a multilink PPP bundle is an arbitrary number and can be scaled up or down as required to support changes in network equipment capabilities. An 802.11b/g interface—**87** is shown as the preferred embodiment, since its 11/54 Mbps interface is considered sufficient bandwidth at this time also, its transmission distances are sufficient for implementation of this device, as opposed to other shorter ranged wireless transmission schemes. However as time goes on, some other wireless interface may be more desirable. There is nothing special or specific to the 802.11 wireless interface that makes it particularly suited to this application. Any wireless interface scheme can be used to implement this device.

The 802.11b/g interface—**88** on an individual RCG is also used to provide a peer-to-peer wireless home networking environment to other 802.11 compatible wireless component within the residence (such as a hand-held computer device) while acting as an always on dialup Internet gateway over the POTS line **40** for the other wireless devices. An RCG that is transferring a very large file can request the services of 31 (in this embodiment) other RCGs to assist in the file transfer using their respective POTS lines. A single RCG can therefore gain the combined bandwidth of up to 32 POTS lines transferring data at as much as 56 Kbps each to transfer information. This is roughly equivalent to a transfer rate of 1.79 Mpbs in the inbound direction (towards the RCG) and approximately 1.075 Mbps in the outbound direction (towards the PSTN).

The multilink PPP connection—**87** is initiated by an RCG when it determines that the file (or streaming service) that it is to download (receive) is of sufficient size or requires a minimum amount of bandwidth to justify the use of a multilink PPP connection. This determination can be made on many different criteria such as the file size, type of data being transmitted, the type of compression if any, a Quality-of-Service requirement or any other pertinent information. (Since a certain amount of overhead is required to set up a Multilink PPP connection, it doesn't make sense to use it for small or low data rate transfers.)

Multilink PPP Bandwidth Allocation and Initialization:

Referring to FIG. **7**, an RCG—**85** that decides to initiate a multilink PPP session with a remote computer i.e. internet URL, requests a multilink PPP session with that URL resource via Link Control Protocol (LCP) session management. The initiating RCG—**85** and the remote server computer (not shown) will negotiate the pertinent multilink parameters such as compression, packet size, sync/async, link quality monitoring, bit stuffing etc. As part of a successful multilink PPP session setup, the initiating RCG—**85** receives a multilink PPP session ID, or "magic number", which is used to identify this particular multilink PPP session and is also used for adding or removing links from the multilink bundle—**87**. Once the multilink bundle is setup, the initiating RCG—**85** begins data transfer across its POTS interface—**90** with the far end computer system. The initiating RCG—**85** then looks up the addresses of up to 31 (in this embodiment) other RCGs in its router tables to use for the multilink PPP transfer. (If a Neighborhood Access Point is available the RCG could request service through it instead of setting up a Multilink PPP connection—see FIG. **8**.) The initiating RCG—**85** determines the number of remote RCGs—**86** that it wants to use to get the desired bandwidth for the transfer and sends multilink PPP service requests via the 802.11b/g wireless connections—**88** to the selected remote RCGs—**86**. The selected remote RCGs—**86** respond back to the initiating RCG with either an acceptance or denial of multilink PPP service request. This decision is made based upon the remote RCG's currently available POTS bandwidth and the current local demands for that bandwidth. The remote RCG—**86** makes a decision to participate in a multilink PPP service for an initiating RCG if its POTS line—**91** has a current average bandwidth utilization of less than some arbitrary limit such as 8 Kbps to 16 Kbps. This 8 Kbps to 16 Kbps bandwidth utilization represents about two concurrent voice conversations using standard voice compression techniques, or some small amount of data transmission occurring on the remote RCG's POTS interface—**91** or a combination thereof. Assuming that the remote RCG—**86** has a modem connection speed somewhere between 33 Kbps to 56 Kbps, this would leave approximately 17 Kbps to 40 Kbps of POTS bandwidth that the remote RCG—**86** could offer to the initiating RCG—**85** for use in its multilink PPP bundle—**87**. Of course, if there is no activity on the remote RCG—**86** POTS line, then the entire bandwidth will be used for the multilink transfer. If the remote RCG—**86** accepts the multilink PPP service request from the initiating RCG **85** it also sends its currently available bandwidth on its POTS line—**91** that the initiating RCG—**85** will have available to it for the multilink PPP transfers. The initiating RCG then selects which of the responding remote RCGs—**86** it will use for the multilink PPP bundle—**87** and sends them a multilink initialization packet containing the URL of the destination as well as the multilink PPP session ID (magic number) and any other pertinent information required for the remote RCG to join in the existing multilink PPP bundle—**87**. Each remote RCG POTS interface—**91** participating in a multilink PPP bundle, represents a logical "link" in the initiating RCG's multilink PPP bundle—**87**. The remote RCGs—**86** then send a multilink PPP packet (over their respective POTS lines—**91**) to the destination URL with the multilink PPP session ID and request to be added to that multilink PPP bundle—**87**. The destination URL accepts the request of each of the remote RCGs—**86** and begins sending data packets to each over their respective POTS lines—**91**. When the remote RCGs—**86** receive data packets sent over their respective POTS lines—**91**, that are destined for the multilink PPP bundle—**87**, they simply relay the data packets over their 802.11b/g interface—**88** to the initiating RCG—**85**. It is the responsibility of the initiating RCG—**85** to perform all housekeeping tasks associated with the multilink transfer such as detection of lost packets and data packet reassembly, if those functions are required. Typically, lost packet detection and retransmission and reassembly are performed at higher OSI layers by the requesting software such as a browser. The remote RCGs—**86** are simply data transport nodes and do not perform any data processing on data received over a multilink PPP bundle destined for another RCG.

The initiating RCG—**85** of the multilink PPP bundle—**87** continually monitors the bandwidth of each remote RCG's—**86** multilink link which together comprise its multilink bundle—**87**. When the available bandwidth for the multilink PPP link of an individual remote RCG—**86** falls below an arbitrary minimum set by the initiating RCG—**85**, the initiating RCG—**85** instructs the offending remote RCG, via its 802.11b/g wireless interface—**88**, to remove itself from the multilink bundle. The remote RCG—**86** will then notify the remote computer (URL) to be removed as a link in the current

multilink bundle on which it is participating. Alternatively, a remote RCG—**86** can inform the initiating RCG—**85** of local demands on its POTS bandwidth, and request that the initiating RCG—**85** remove it (the remote RCG—**86**) from the participation in the initiating RCG's multilink bundle—**87**. The remote RCG—**86** will not unilaterally remove itself from participation in a multilink bundle without prior notification to the Initiating RCG—**85**. The remote RCG—**86** must get authorization from the initiating RCG—**85** to remove itself from the bundle, since the initiating RCG—**85** will have no way of knowing if the loss of data from that remote RCG is due to some sort of failure or from the remote RCG simply removing itself from participation in the multilink bundle—**87**. Also, for services that require a minimum Quality of Service (QOS) such as streaming video, the initiating RCG—**85** needs to control the multilink bundle—**87** bandwidth, and it can not do that if remote RCGs—**86** drop out of the multilink bundle—**87** at will. When a remote RCG—**86** requests to be removed from participation in a multilink bundle—**87**, the initiating RCG—**85** must immediately grant the request. If the initiating RCG—**85** were to not grant the request, then the remote RCG—**86** could, in worst case, delay or drop incoming multilink packets destined for the initiating RCG—**85**. If this were to happen, the initiating RCG—**85** will have missing packets and could over run its reassembly buffer (if reassembly is being performed by the RCG) causing catastrophic data loss and potentially have to restart the entire transmission. In the least case, the initiating RCG—**85** would have to initiate retransmission of potentially many packets which it assumes to be lost, but may simply be delayed by the remote RCG—**86**. Once a remote RCG—**86** has been removed from participating in a multilink bundle—**87**, the initiating RCG—**85** will then look up another remote RCG in its router tables that can be used to participate in the multilink PPP bundle—**87**, and request that the new remote RCG—**86** to join the existing multilink bundle—**87**. This is necessary to maintain a minimum Quality of Service. Since RCGs prioritize their bandwidth requirements based upon their own "local" service requirements, their participation in any multilink PPP service is available only to bandwidth that is not required for its own current local demands. Therefore, a remote RCG's—**86** bandwidth that is available for multilink services can change at any time. The dynamic reassignment of remote RCGs that participate in a multilink bundle is also required to prevent a remote RCG—**86** from receiving packets so slowly that the originating RCG—**85** interprets this delay as lost packets. When the initiating RCG—**85** determines that a packet has been lost, and it is performing packet reassembly, it will, itself, request that the remote computer retransmit the lost packet. The initiating RCG will not ask any remote RCG—**86** to perform retransmissions or any other kind of data computations or manipulations.

Refer to FIG. **8** for the following discussion. In areas where there are existing 802.11 network equipment such as Neighborhood Access Point—**93**, or where there is sufficient bandwidth requirements from an installed base of RCGs to warrant the deployment of a Neighborhood Access Point—**93**, the RCGs will automatically detect the presence of the compatible neighborhood access points and register with that equipment for transport services. In this case, an RCG has an alternative broadband service route in addition to the multilink option. An RCG can communicate directly with a local 802.11 Network Access Point—**93** that is connected to the PSTN or another carrier's network via some sort of high bandwidth backbone such as a T-Carrier or optical carrier connection (T1, T3, OC3, OC12 etc.). The RCGs can communicate directly with neighborhood access points at their full 11/54 Mbps data rates to provide up to that full bandwidth to the user. This functionality is, of course, subject to the Network Access Point—**93** allowing access to its resources to the RCG according to the 802.11 wireless protocol.

This architecture is important since it provides an avenue to relieve the local class 5 offices of congestion that can be caused by a wide spread deployment of RCGs within the class 5 service area. Since each RCG requires a constant 24/7 modem connection, this ties up the class 5 switch in a fashion that it was not designed for. This could lead to wholesale class 5 office expansions which would be extremely expensive, and potentially prohibitive for the Local Exchange Carriers (LECs). By deploying neighborhood access points that operate at 54 Mbps (802.11a/g), in areas where the RCG concentration starts placing too high of a demand on the local class 5 office, the bandwidth from the RCGs can be aggregated by the neighborhood access points into large capacity backbones to relieve the switch congestion. In this case, the RCG POTS interface—**40** can be used solely as a lifeline connection, or when the 802.11 wireless LAN in which the RCG resides is congested. With this implementation, voice calls will be carried over the wireless interface as opposed to the POTS interface on which they would normally be carried. Also, the RCG modem—**41** connected to the POTS interface—**40** would not need to maintain a constant always on connection, it could be a dialed on demand connection and thereby relieving the local class 5 office switch.

Bouncing or Hopping Traffic:

Refer to FIG. **9**. In areas where the density of RCGs is less than the arbitrary number of 32 RCGs within its transmission radius for multilink connections, the RCGs can bounce, or relay, the data traffic between each other to reach other RCGs located farther than the RCGs wireless transmission area. Since the POTS data rate of 56 Kbps is miniscule as compared to the 11/54 Mbps 802.11b/g transfer rate, the overhead associated with bouncing data traffic is not a concern. This will allow for the fastest possible data transfer across POTS lines for every RCG user.

RCGs can also communicate directly with an 802.11a Neighborhood Access Point—**93** device (such as that used in WI-FI networks) that is connected to a data network connection such as a DS3 or OC3 service via a Metro Access Point. Where an RCG has access to a broadband device such as an 802.11a type device, either directly or via a bounced signal across several RCGs, a direct high speed data connection can be used to transfer large files. When an RCG is communicating directly with an 802.11a device, data transfer speeds up to the full 11/54 Mbps can be achieved to speed video transfers for such applications as video on demand.

RCG Router Tables:

The RCG continually monitors its 802.11b/g wireless interface for transmissions from other RCGs or 802.11a Access Points as well as other 802.11b/g wireless devices within the residence. The RCG provides a means to identify and store the addresses of other RCGs and Neighborhood Access Points within its local area. The RCG creates routing tables, much like an IP router device, so that it knows which RCGs are local to itself, and how many hops will be needed to reach the maximum of 32 POTS lines or a Neighborhood Access Point. The RCG can then determine how to route its data transfers to gain the most efficient routing and network efficiencies.

The router tables in each RCG are continually updated by monitoring the 802.11 frames received from other RCGs or Network Access Points. The number of entries in the router tables can be limited to an arbitrary number of other RCGs but contains room for at least 32 entries. For each RCG listed in

the router tables, certain information is kept such as signal strength, if the other device is another RCG or some other 802.11 compatible device, if the other RCG is reachable directly, or if it is accessed via another RCGs by hopping. In the case there RCG hopping is used, the address of each RCG that is hopped is stored in the routing table. When an RCG is first powered up, it monitors its 802.11 interface for a period of time to identify other RCGs or Neighborhood Access Point devices, or other Wi-Fi devices within its transmission area. When first deployed, the RCG will not have any entries in its routing tables. This condition can persist for some time, until another RCG or other 802.11 device is deployed within the former RCGs transmission range. In this state, the RCG can be used for wireless networking within the residence, connecting the local computer to the RCGs always on Internet connection as well as to other wireless devices within the home. When an 802.11 frame is received by an RCG that contains the address of an RCG whose address does not exist in the receiving RCG's router table (as is the case when a new RCG is first installed), the receiving RCG polls the transmitting RCG for its router table information. The received router information is reviewed for other RCG's or other 802.11 compatible devices that are not listed in its own router tables. A decision is made to use some, all, or none of the new route information in its router tables. There is no real limitation on the number of RCGs that can be "hopped" in order to build a complete router table or to reach many more RCGs, Neighborhood Access Points or Metro Access Points.

Equipment and Services Priorities:

Just as voice has priority over data transfers within a single RCG, local RCG traffic (both voice and data) has priority over remote transfer requests by other RCGs. If an RCG is currently using all of its available POTS bandwidth for its own purposes, it will deny any remote RCG's request for access to its POTS line. Only when there is available POTS bandwidth available will an RCG allow other RCGs access to its POTS line. It will, however, bounce the traffic to other RCGs within its transmission area if requested by the originating RCG. In this case, available wireless bandwidth of any RCG (that amount of the 11/54 Mbps not currently used for its own traffic) can be used to relay traffic between other RCGs that do have available POTS bandwidth. In the same fashion, excess wireless bandwidth of any RCG can be by other RCGs to access high speed backbones via Neighborhood or Metro Access Points.

RCGs can also access other 802.11 wireless networks (Wi-Fi for example) that happen to be deployed within their service areas. In this case, access agreements between the RCG service provider and the wireless network operator must be put into place. By remaining compatible with the 802.11 standards, the RCGs capabilities will benefit by the growing WI-FI network infrastructure, an the WI-FI network will benefit by the RCG network.

Voice Over POTS and Data Over Wireless:

Normally. all communications from an RCG will be transmitted over the local POTS line, or a multilink bundle made up of many remote RCG POTS lines. By default, all voice calls will be carried over the "local" POTS line—**40** to alleviate security/privacy concerns and only "data" will be transmitted via multilink bundles. Generally, since voice "data" is compressed locally by the RCG, the required bandwidth for a voice call is so small that it does not make for a good choice to route it over a multilink connection. However, it is possible to route voice calls entirely over another RCGs POTS line. It is also possible for an RCG to transmit voice data over POTS lines connected to other RCGs via multilink bundles or directly over its 802.11 wireless interface, and since the 802.11 specification does support the Wired Equivalent Privacy (WEP) specification, a secured connection can be made in this fashion.

Remote Upgradability

The RCG is designed with the capability for unassisted remote upgradability. The remote upgradability feature is not the same as the storing of operational parameters during the configuration process. This feature allows the system operator to add new features as they are developed, or to correct bugs remotely and without the users knowledge or involvement. This feature can also be used to install a complete new operating system (OS).

Key to the successful implementation of the Remote upgradability feature is that a completely fail-safe routine be implemented that can recover from any failure during the upgrade process and to re-initiate and monitor the upgrade process until it has successfully completed. This process is carried out by loading a boot loader program that is stored in non-volatile memory. The boot loader program provides the minimum capabilities to start up the RCG and connect into the system operator's diagnostics network to download fixes or a new OS. The boot loader program is technically part of the OS, but it cannot be over written by any upgrade process. It is responsible for detecting failure of the RCG and initiating a connection to the diagnostics network. Once connected with the diagnostics network, the boot loader will provide diagnostics support to help correct the RCG's operation and reconfigure the OS.

What is claimed is:

1. A method for establishing and sending data during a multipath connection comprising:

a data-source device receiving multipath information about each of a plurality of network-edge devices that is capable of joining a multipath connection with a data-requesting device, each of the network-edge devices being connected to one or more networks, and each of the network-edge devices being connected to the data-requesting device over a different connection; and

the data-source device performing at least one of (i) sending different groups of data packets to different network-edge devices that are participating in the multipath connection, (ii) sending different streams of data to one or more of the network-edge devices that are participating in the multipath connection, and (iii) sending combinations of different streams and different groups of data packets to one or more of the network-edge devices that are participating in the multipath connection.

2. The method of claim **1**, wherein the multipath information includes a connection ID that is generated by one of the data-source device, one of the plurality of network-edge devices, the data-requesting device and a network device.

3. The method of claim **1**, further comprising:

the data-source device receiving second multipath information about a second network-edge device that is capable of joining the multipath connection; and

the data-source device joining the second network-edge device to the multipath connection.

4. The method of claim **1**, further comprising:

the data-source device receiving multipath information about which network-edge devices are to be removed from the multipath connection; and

the data-source device removing the network-edge devices from being associated with the multipath connection.

5. The method of claim **1**, further comprising at least one of the data-source device, the network-edge devices and the

data-requesting device determining which of the network-edge devices are to be removed from the multipath connection.

6. The method of claim **1**, wherein the data-source device is one of a multipath link aggregator, a network relay, a multipath link server, a server, a network switch, a network router and a device capable of providing multipath services.

7. A method for establishing and sending data during a multipath connection, comprising:

the data-source device receiving multipath connection requests from a plurality of data-requesting devices, each of the multipath connection requests involving a particular multipath connection to a data-requesting device;

the data-source device associating a connection ID to each multipath connection request;

the data-source device using multipath information about each of a plurality of network-edge devices that is capable of joining in a particular multipath connection to a particular data-requesting device, the particular multipath connection having a particular connection ID;

the data-source device notifying each of the network-edge devices that is participating in the particular multipath connection associated with the particular connection ID; and

the data-source device sending data associated with the particular connection ID to the network-edge devices participating in the particular multipath connection associated with the particular connection ID.

8. The method of claim **7**, further comprising: the data-source device sending different groups of data packets to different network-edge devices that are participating in the particular multipath connection associated with the particular connection ID.

9. The method of claim **7**, further comprising:

the data-source device receiving identification of the network-edge devices to be removed from the particular multipath connection; and

the data-source device removing the identified network-edge devices from the particular multipath connection.

10. The method of claim **7**, further comprising the data-source device notifying the data-requesting device when all data has been sent over the particular multilink connection.

11. The method of claim **7**, wherein the data-source device is one of a multipath link aggregator, a network relay, a multipath link server, a server, a network switch, a network router and a device capable of providing multipath services.

12. The method of claim **7**, wherein the connection ID is generated by one of the data-source device, one of the plurality of network-edge devices, the data-requesting device, and a network device.

13. A method for establishing and sending data during a multipath connection, comprising:

a data-requesting device sending a multipath request to a network-edge device where the multipath request indicates that the network-edge device will join a multipath connection associated with the data-requesting device, the data-requesting device being connected over a first connection to a network and over a second connection to the network-edge device, the multipath connection comprising the first connection and the second connection which are capable of receiving data at the same time;

the data-requesting device receiving first data over the first connection from the network; and

after the network-edge device joins the multipath connection, the data-requesting device receiving second data over the second connection from the network-edge device.

14. The method of claim **13**, wherein the first connection and the second connection are each a wireless connection, a wired connection or a combination of wired and wireless connections.

15. The method of claim **13**, wherein the data-requesting device is one of a cell phone, a tablet, a switch, a network device, a router, a computer, a Wi-Fi device, a Wi-Max device, a communications device, a mobile communications device, a near-field communications device, and a Bluetooth device.

16. The method of claim **13**, wherein the network-edge device comprises one or more routers, modems, cell phones, tablets, computers, cellular towers, wireless towers, base stations, wireless base stations, repeaters, wireless repeaters, Wi-Fi devices, networking devices, hot spot devices, Wi-MAX devices, LTE devices, GSM devices, consumer electronic devices, an Internet-ready device, a network switch, a network router, a multipath server and a device capable of providing multipath services.

17. The method of claim **13**, wherein the data-requesting device is capable of connecting to another network device which is capable of joining the multipath connection, and further comprising the data-requesting device receiving data from the another network device after the another network device joins the multipath connection.

18. A data-requesting device comprising:

at least one interface capable of connecting concurrently to a plurality of network-edge devices during a multipath connection, the multipath connection comprising the connections between the data-requesting device and each of the network-edge devices; and

at least one processor coupled to the at least one interface that

sends multipath information to each of the network-edge devices that is capable of joining the multipath connection; and

receives different data at the data-requesting device from different ones of the network-edge devices that are able to join the multipath connection.

19. The data-requesting device of claim **18**, wherein the data-requesting device is one of a cell phone, a tablet, a switch, a network device, a router, a computer, a Wi-Fi device, a Wi-Max device, a mobile communications device, a near-field communications device, and a Bluetooth device.

20. The data-requesting device of claim **18**, wherein each of the network-edge devices comprises one or more network devices, communications devices, cellular devices, tablet devices, router devices, computer devices, satellite devices, Wi-MAX devices, wireless devices, mobile communications devices, Bluetooth devices, and Wi-Fi devices, a network switch, a network router, a multipath server and a device capable of providing multipath services.

21. A method for creating and using a multipath connection, comprising the steps of:

a data-requesting device sending first multipath control information to or through a first network-edge device, the first multipath control information indicates that the first network-edge device will join the multipath connection, the data-requesting device being connected over a first connection to the first network-edge device;

the data-requesting device sending a second multipath control information to or through a second network-edge device, the second multipath control information indicates that the second network-edge device will join the

multipath connection, the data-requesting device being connected over a second connection to the second network-edge device, the data-requesting device capable of receiving different data over the first connection and the second connection at the same time; and

after the first network-edge device joins the multipath connection, the data-requesting device receiving first data over the first connection from the first network-edge device; and

after the second network-edge device joins the multipath connection, receiving second data at the data-requesting device over the second path from the second network-edge device.

22. The method as in claim **21**, wherein the first network-edge device is connected to a network, and wherein the second network-edge device is connected to the network or a different network.

23. The method as in claim **21**, wherein the first connection and the second connection are wireless connections, a wired connection or a combination of wired and wireless connections.

* * * * *

EXHIBIT C

US011418641B2

(12) **United States Patent**
Delangis

(10) **Patent No.: US 11,418,641 B2**
(45) **Date of Patent: Aug. 16, 2022**

(54) **DEVICES AND METHODS FOR MULTIPATH COMMUNICATIONS**

(71) Applicant: **Eric M. Delangis**, Wylie, TX (US)

(72) Inventor: **Eric M. Delangis**, Wylie, TX (US)

(73) Assignee: **Competitive Access Systems, Inc.**, Wylie, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 58 days.

(21) Appl. No.: **17/120,549**

(22) Filed: **Dec. 14, 2020**

(65) **Prior Publication Data**

US 2021/0099572 A1 Apr. 1, 2021

Related U.S. Application Data

(63) Continuation of application No. 15/161,787, filed on May 23, 2016, now Pat. No. 10,868,908, which is a (Continued)

(51) **Int. Cl.**

H04M 3/00	(2006.01)
H04L 12/54	(2022.01)
H04L 45/24	(2022.01)
H04W 88/16	(2009.01)
H04L 45/00	(2022.01)
H04L 47/70	(2022.01)
H04L 61/5014	(2022.01)
H04L 69/168	(2022.01)
H04M 1/60	(2006.01)
H04W 8/26	(2009.01)
H04W 28/06	(2009.01)
H04W 40/02	(2009.01)
H04W 72/04	(2009.01)
H04W 80/00	(2009.01)

(Continued)

(52) **U.S. Cl.**

CPC ***H04M 3/007*** (2013.01); ***H04L 12/5692*** (2013.01); ***H04L 45/24*** (2013.01); ***H04L 45/54*** (2013.01); ***H04L 47/821*** (2013.01); ***H04L 61/2015*** (2013.01); ***H04L 69/168*** (2013.01); ***H04M 1/6033*** (2013.01); ***H04W 88/16*** (2013.01); *H04M 2203/052* (2013.01); *H04M 2203/60* (2013.01); *H04M 2250/06* (2013.01); *H04W 8/26* (2013.01); *H04W 28/06* (2013.01); *H04W 40/02* (2013.01); *H04W 72/04* (2013.01); *H04W 80/00* (2013.01); *H04W 84/12* (2013.01); *H04W 84/18* (2013.01); *Y02D 30/70* (2020.08)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,315,900	B1 *	1/2008	Ofelt	H04L 47/624 709/245
2002/0150099	A1 *	10/2002	Pung	H04L 47/70 370/432

* cited by examiner

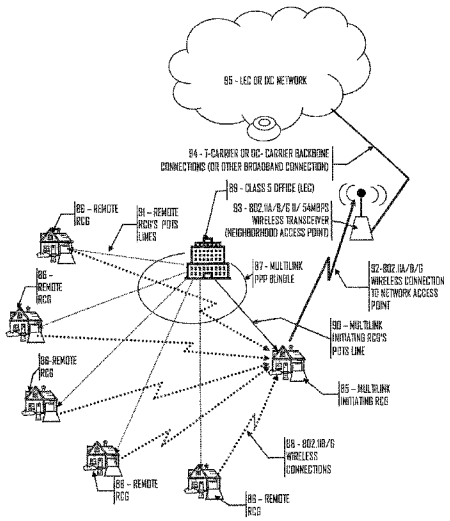
Primary Examiner — Hong S Cho

(74) *Attorney, Agent, or Firm* — Clay McGurk; The Law Office of Clay McGurk

(57) **ABSTRACT**

Broadband communications devices and methods operate with at least two separate communication paths between the devices and the network, such as the Internet. The broadband devices and methods receive data concurrently over the communication paths or separately. The bandwidth is increased when the separate communication paths are combined. The broadband devices employ packetized data with Voice over Internet Protocol (VoIP) technologies combined with RF communications technologies.

3 Claims, 9 Drawing Sheets



Related U.S. Application Data

continuation of application No. 14/512,414, filed on Oct. 11, 2014, now Pat. No. 9,350,649, which is a continuation of application No. 13/531,294, filed on Jun. 22, 2012, now Pat. No. 8,861,349, which is a continuation of application No. 12/581,852, filed on Oct. 19, 2009, now Pat. No. 8,228,801, which is a continuation of application No. 10/686,375, filed on Oct. 14, 2003, now Pat. No. 7,606,156.

(60) Provisional application No. 60/418,521, filed on Oct. 15, 2002.

(51) **Int. Cl.**

H04W 84/12	(2009.01)
H04W 84/18	(2009.01)

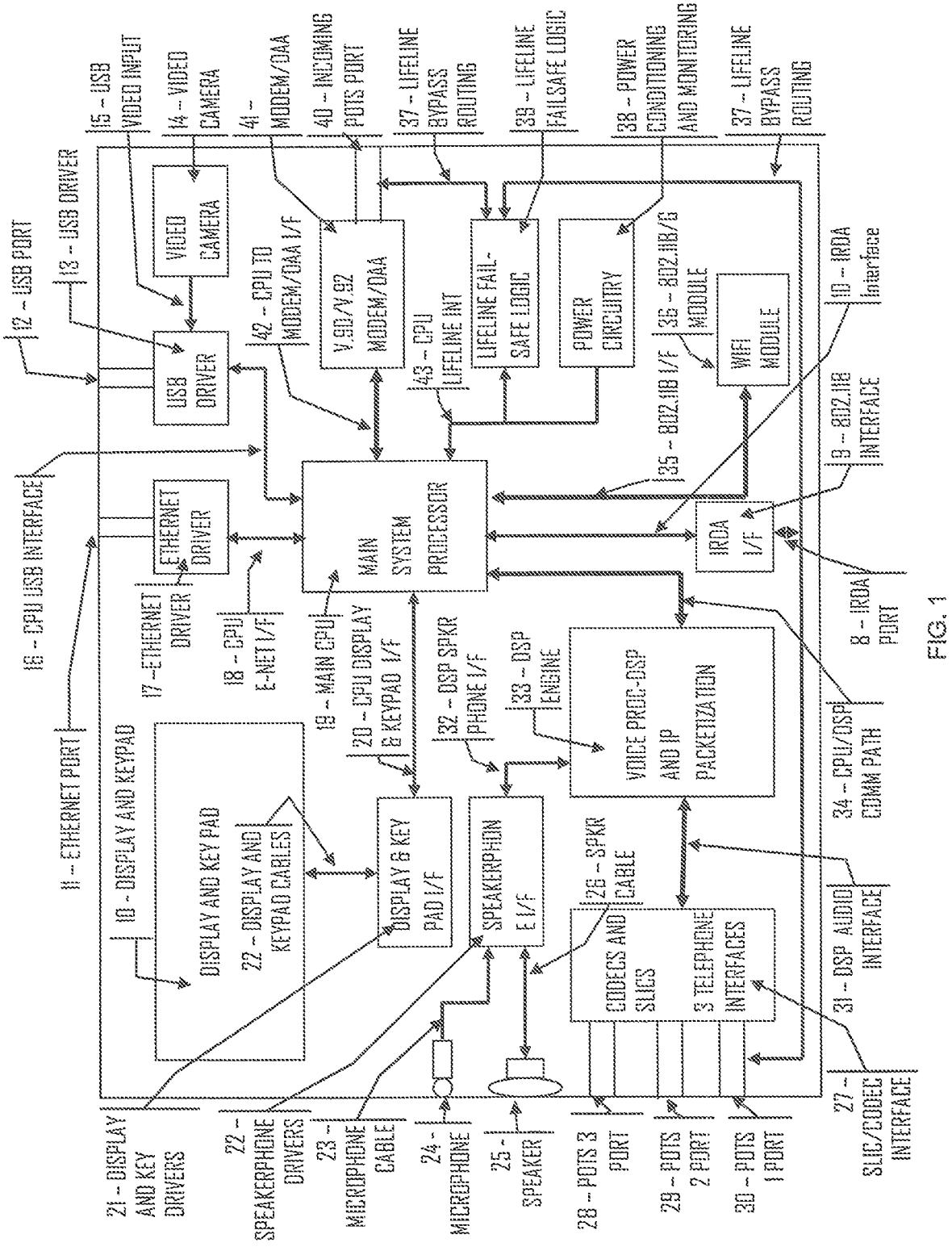

12 – USB PORT
13 – USB DRIVER
15 – USB VIDEO INPUT
14 – VIDEO CAMERA
41 – MODEM/DAA
40 – INCOMING POTS PORT
37 – LIFELINE BYPASS ROUTING
33 – LIFELINE FAILSAFE LOGIC
38 – POWER CONDITIONING AND MONITORING
37 – LIFELINE BYPASS ROUTING
USB DRIVER
VIDEO CAMERA
42 – CPU TO MODEM/DAA I/F
V.90/V.92 MODEM/DAA
43 – CPU LIFELINE INT
LIFELINE FAIL-SAFE LOGIC
POWER CIRCUITRY
35 – 802.11B I/F
36 – 802.11B/G MODULE
WIFI MODULE
10 – IRDA interface
9 – 802.11B INTERFACE
16 – CPU USB INTERFACE
ETHERNET DRIVER
17 – ETHERNET DRIVER
18 – CPU E-NET I/F
MAIN SYSTEM PROCESSOR
IRDA I/F
11 – ETHERNET PORT
10 – DISPLAY AND KEYPAD
DISPLAY AND KEY PAD
22 – DISPLAY AND KEYPAD CABLES
19 – MAIN CPU
20 – CPU DISPLAY & KEYPAD I/F
32 – DSP SPKR PHONE I/F
33 – DSP ENGINE
VOICE PROC-DSP AND IP PACKETIZATION
8 – IRDA PORT
DISPLAY & KEY PAD I/F
SPEAKERPHONE E I/F
26 – SPKR CABLE
34 – CPU/DSP COMM PATH
CODECS AND SLICS
3 TELEPHONE INTERFACES
31 – DSP AUDIO INTERFACE
21 – DISPLAY AND KEY DRIVERS
22 – SPEAKERPHONE DRIVERS
23 – MICROPHONE CABLE
24 – MICROPHONE
25 – SPEAKER
28 – POTS 3 PORT
29 – POTS 2 PORT
30 – POTS 1 PORT
27 – SLIC/CODEC INTERFACE

FIG. 1

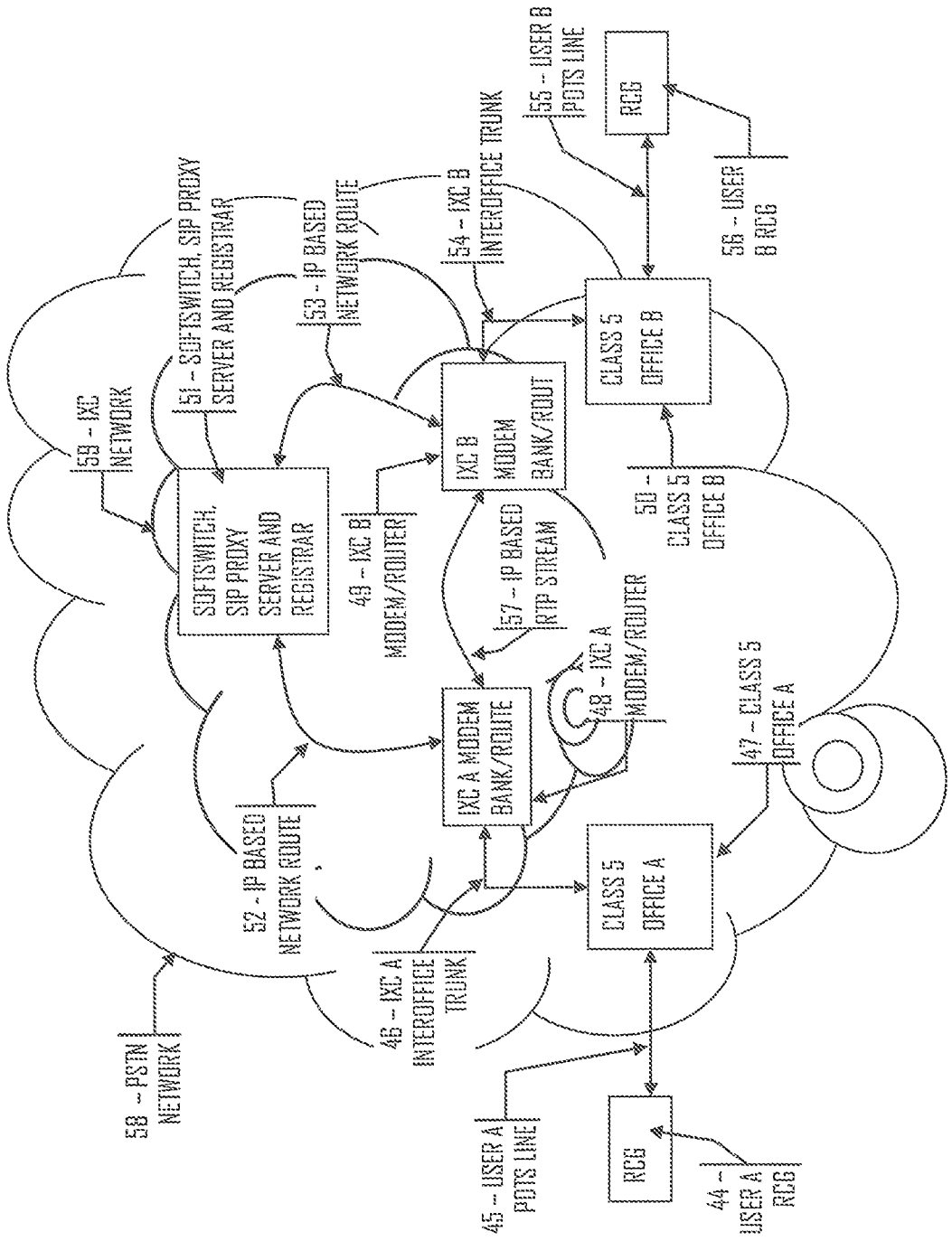

58 – PSTN NETWORK
45 – USER A POTS LINE
44 – USER A RCG
RCG
46 – IXC A INTEROFFICE TRUNK
52 – IP BASED NETWORK ROUTE
SOFTSWITCH, SIP PROXY SERVER AND REGISTRAR
59 – IXC NETWORK
51 – SOFTSWITCH, SIP PROXY SERVER AND REGISTRAR
53 – IP BASED NETWORK ROUTE
49 – IXC B MODEM/ROUTER
IXC A MODEM BANK/ROUTE
IXC B MODEM BANK/ROUT
57 – IP BASED RTP STREAM
48 – IXC A MODEM/ROUTER
54 – IXC B INTEROFFICE TRUNK
CLASS 5 OFFICE A
47 – CLASS 5 OFFICE A
CLASS 5 OFFICE B
50 – CLASS 5 OFFICE B
55 – USER B POTS LINE
RCG
56 – USER B RCG

FIG. 2

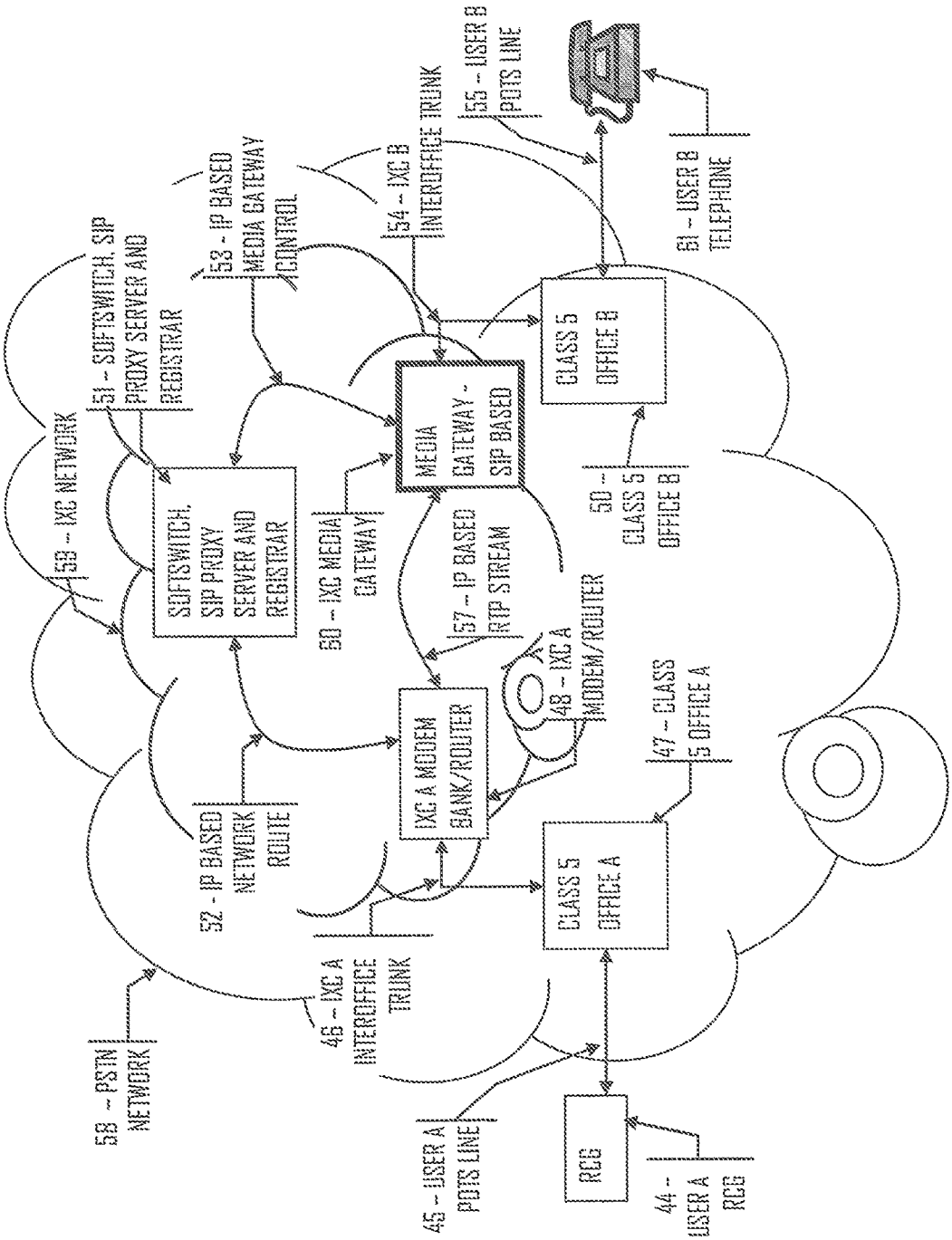

58 – PSTN NETWORK
46 – IXC A INTEROFFICE TRUNK
52 - IP BASED NETWORK ROUTE
SOFTSWITCH, SIP PROXY SERVER AND REGISTRAR
59 – IXC NETWORK
51 – SOFTSWITCH, SIP PROXY SERVER AND REGISTRAR
53 - IP BASED MEDIA GATEWAY CONTROL
54 – IXC B INTEROFFICE TRUNK
55 – USER B POTS LINE
61 – USER B TELEPHONE
CLASS 5 OFFICE B
MEDIA GATEWAY - SIP BASED
60 – IXC MEDIA GATEWAY
57 – IP BASED RTP STREAM
50 – CLASS 5 OFFICE B
48 – IXC A MODEM/ROUTER
IXC A MODEM BANK/ROUTER
47 – CLASS 5 OFFICE A
CLASS 5 OFFICE A
45 – USER A POTS LINE
RGB
44 – USER A RGB

FIG. 3

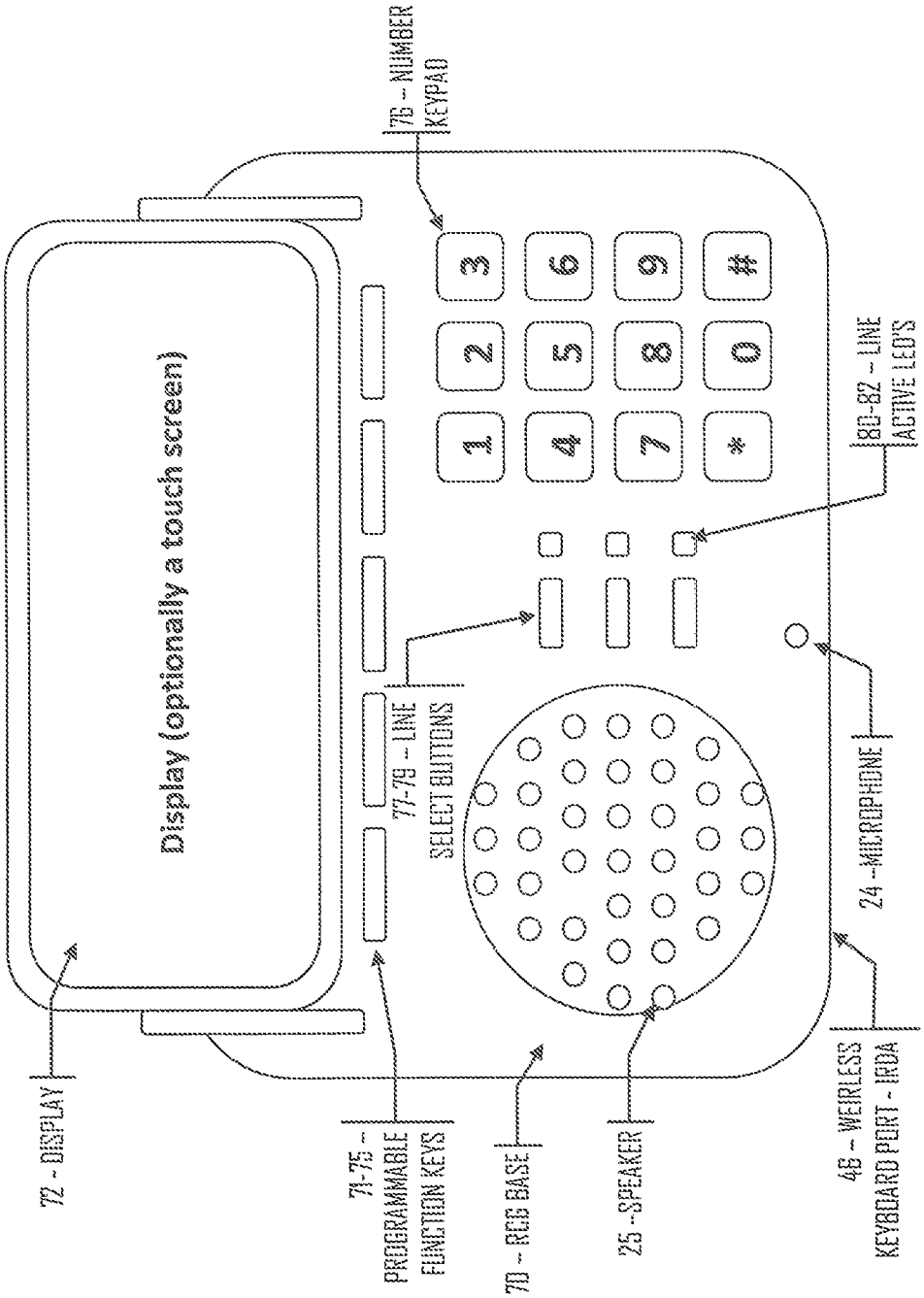

76 – NUMBER KEYPAD
Display (optionally a touch screen)
1
2
3
4
5
6
7
8
9
*
0
#
80-82 – LINE ACTIVE LED'S
77-79 – LINE SELECT BUTTONS
24 – MICROPHONE
72 – DISPLAY
71-75 – PROGRAMMABLE FUNCTION KEYS
70 – REG BASE
25 – SPEAKER
46 – WEIRLESS KEYBOARD PORT – IRDA

FIG. 4

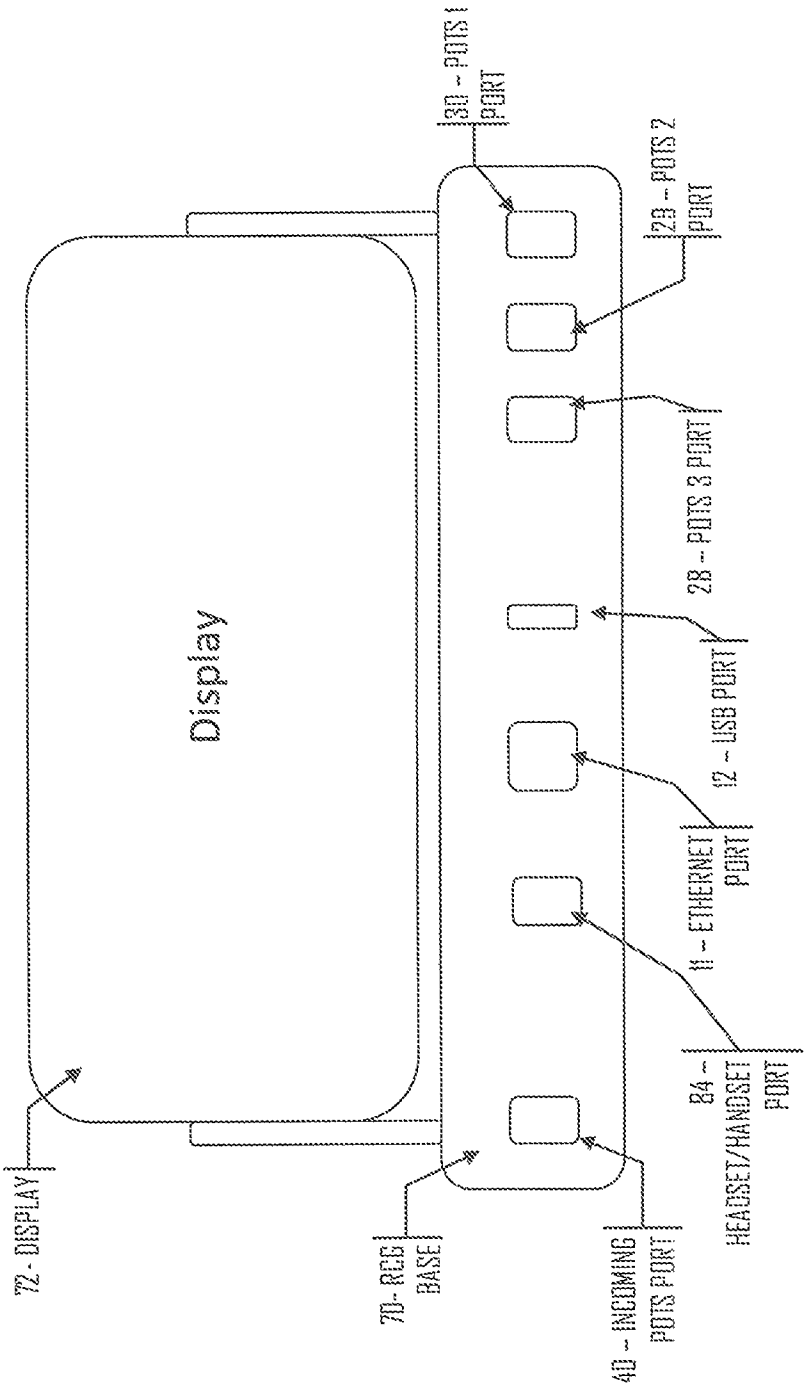

Display
72 - DISPLAY
70 - REG BASE
40 - INCOMING POTS PORT
84 - HEADSET/HANDSET PORT
11 - ETHERNET PORT
12 - USB PORT
28 - POTS 3 PORT
29 - POTS 2 PORT
30 - POTS 1 PORT

FIG. 5

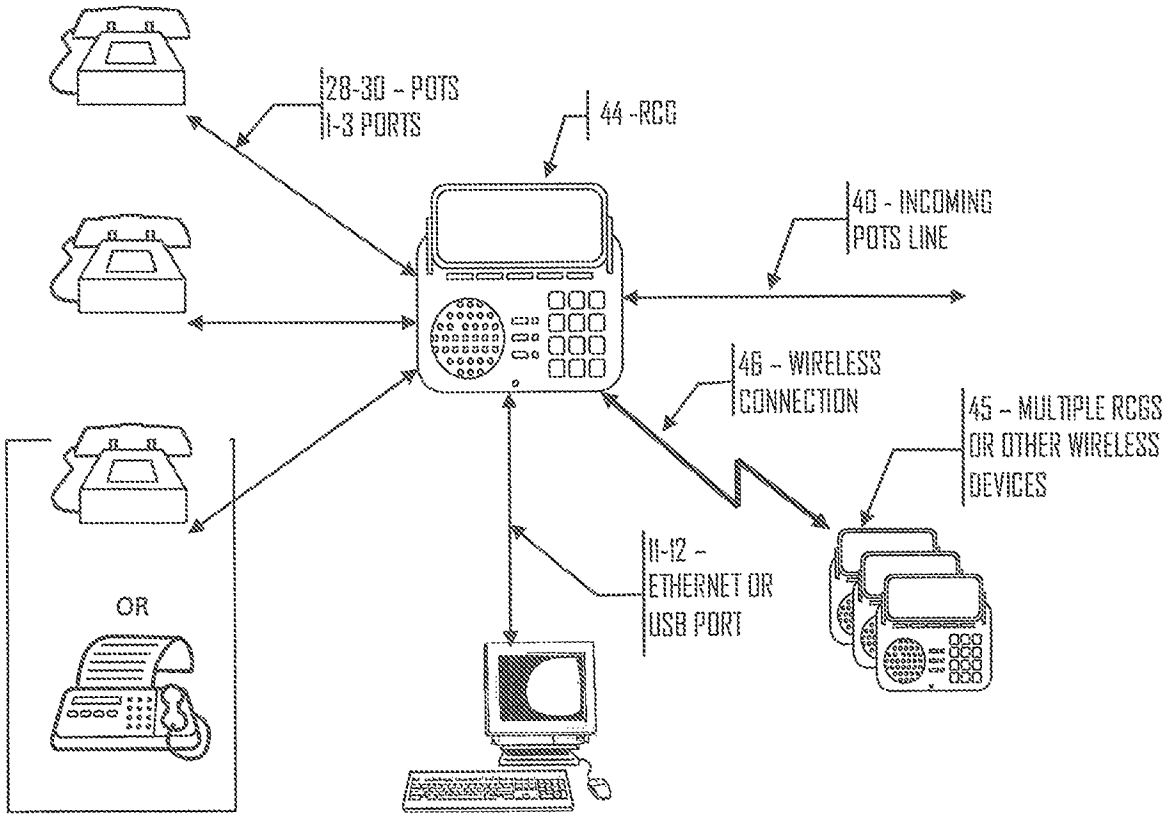

28-30 - POTS
1-3 PORTS
44 -RCG
40 - INCOMING
POTS LINE
46 - WIRELESS
CONNECTION
45 - MULTIPLE RCGS
OR OTHER WIRELESS
DEVICES
11-12 -
ETHERNET OR
USB PORT
OR

FIG. 6

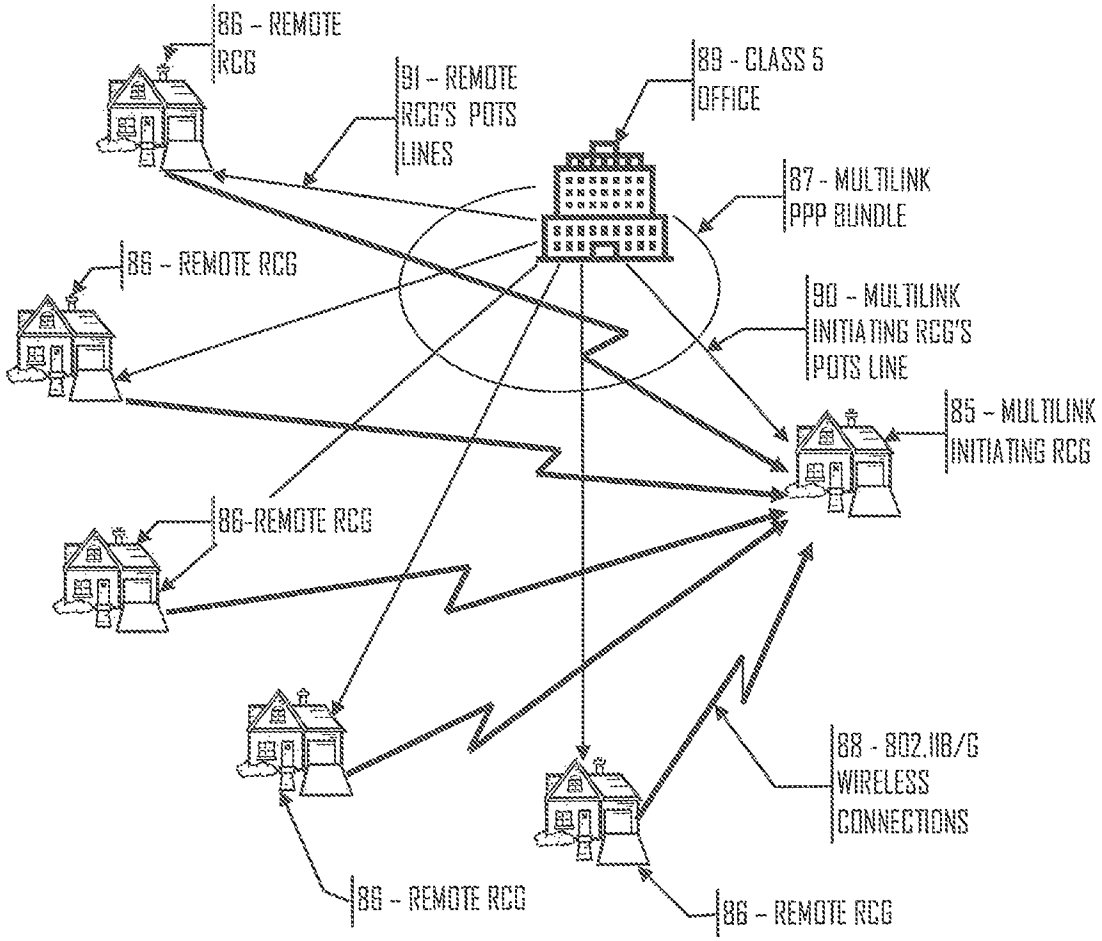

86 – REMOTE RCG
81 – REMOTE RCG'S POTS LINES
88 - CLASS 5 OFFICE
87 - MULTILINK PPP BUNDLE
86 – REMOTE RCG
90 – MULTILINK INITIATING RCG'S POTS LINE
85 – MULTILINK INITIATING RCG
86-REMOTE RCG
88 - 802.11B/G WIRELESS CONNECTIONS
86 – REMOTE RCG
86 – REMOTE RCG

FIG. 7

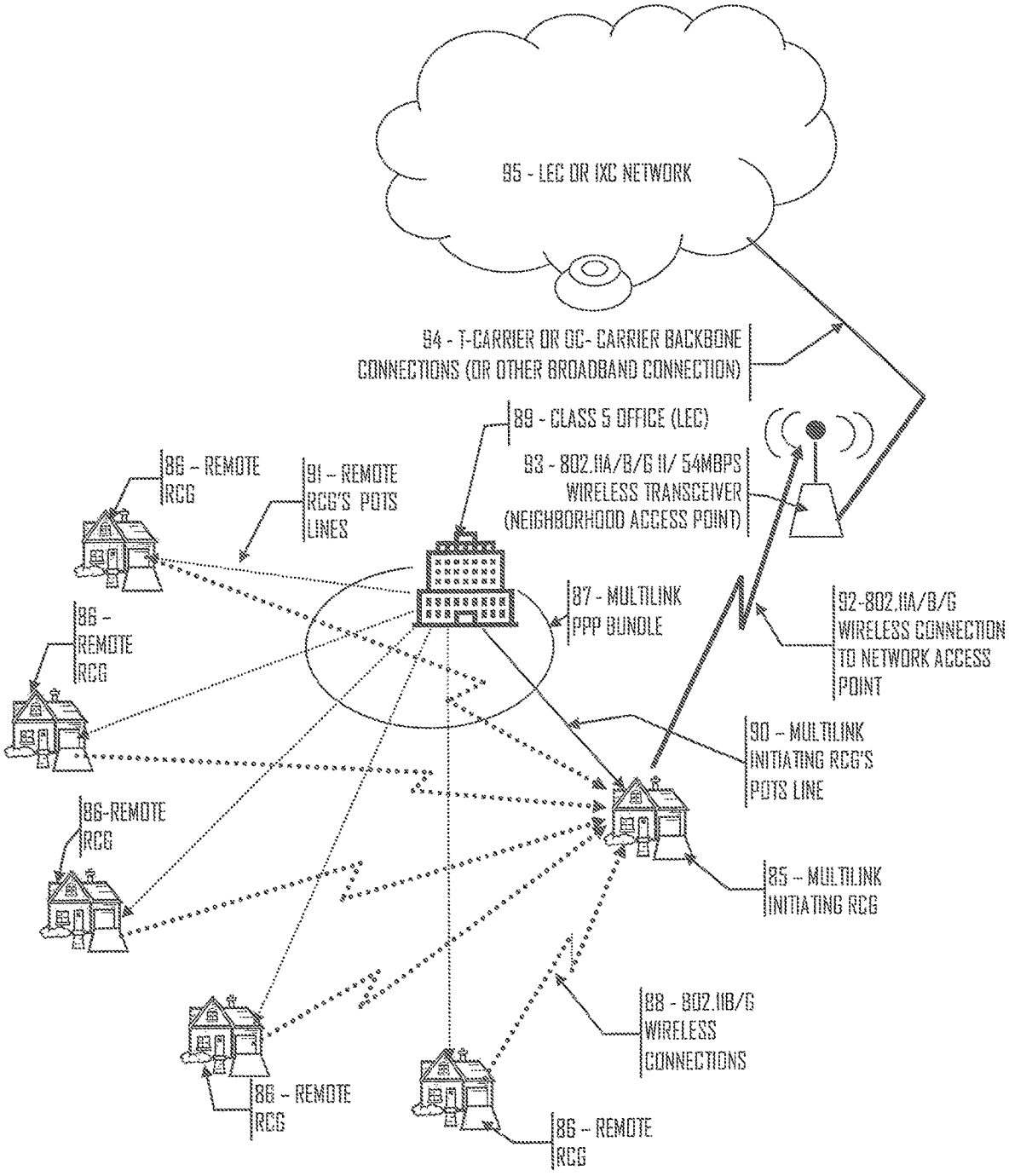

95 - LEC OR IXC NETWORK
94 - T-CARRIER OR OC- CARRIER BACKBONE CONNECTIONS (OR OTHER BROADBAND CONNECTION)
89 - CLASS 5 OFFICE (LEC)
93 - 802.11A/B/G II/ 54MBPS WIRELESS TRANSCEIVER (NEIGHBORHOOD ACCESS POINT)
86 – REMOTE RCG
91 – REMOTE RCG'S POTS LINES
87 - MULTILINK PPP BUNDLE
92-802.11A/B/G WIRELESS CONNECTION TO NETWORK ACCESS POINT
86 – REMOTE RCG
90 – MULTILINK INITIATING RCG'S POTS LINE
86-REMOTE RCG
85 – MULTILINK INITIATING RCG
88 - 802.11B/G WIRELESS CONNECTIONS
86 – REMOTE RCG
86 – REMOTE RCG

FIG. 8

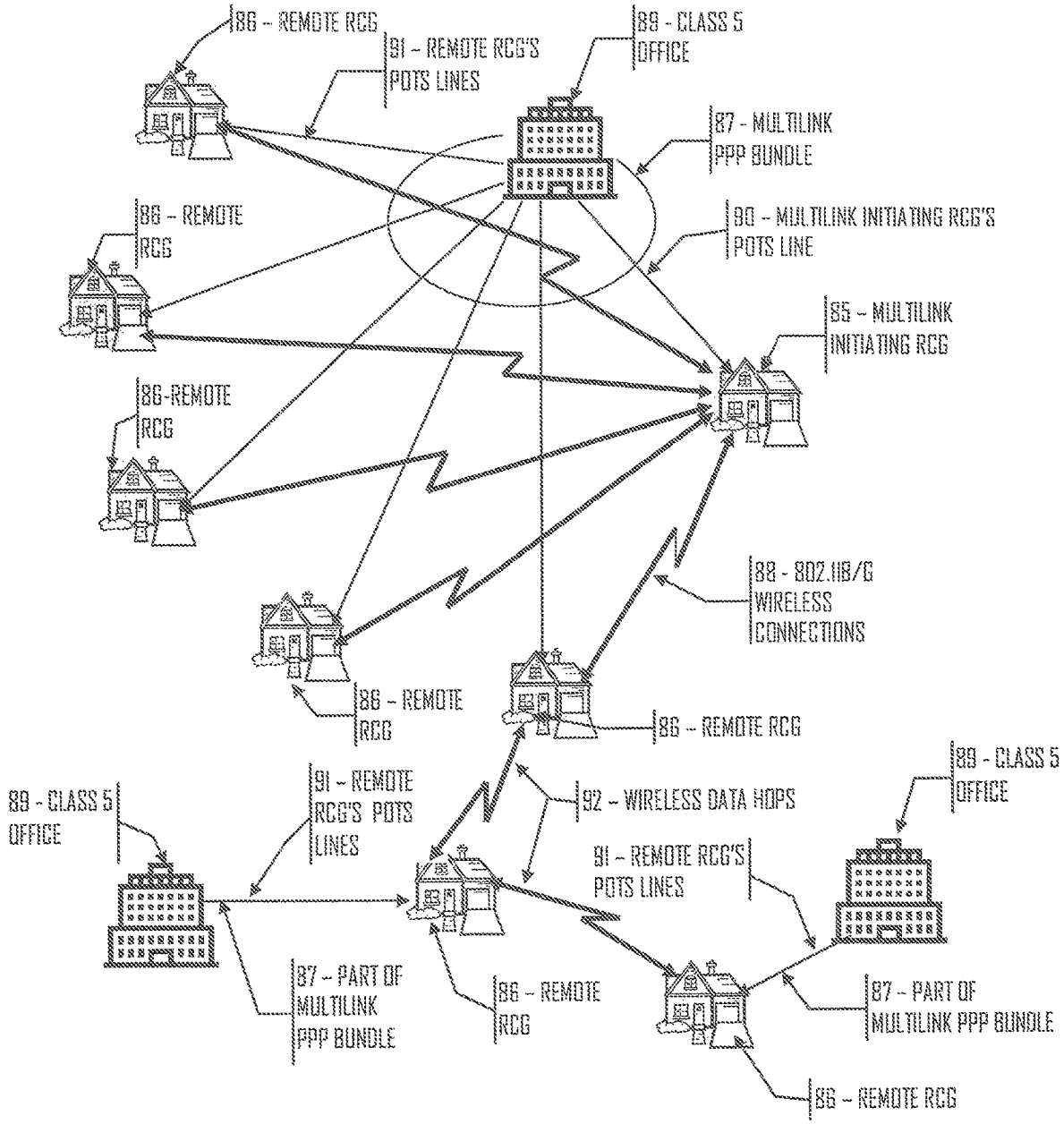

86 – REMOTE RCG
91 – REMOTE RCG'S POTS LINES
89 - CLASS 5 OFFICE
87 - MULTILINK PPP BUNDLE
86 – REMOTE RCG
90 – MULTILINK INITIATING RCG'S POTS LINE
85 – MULTILINK INITIATING RCG
86-REMOTE RCG
88 - 802.11B/G WIRELESS CONNECTIONS
86 – REMOTE RCG
86 – REMOTE RCG
89 - CLASS 5 OFFICE
91 – REMOTE RCG'S POTS LINES
92 – WIRELESS DATA HOPS
89 - CLASS 5 OFFICE
91 – REMOTE RCG'S POTS LINES
87 – PART OF MULTILINK PPP BUNDLE
86 – REMOTE RCG
87 – PART OF MULTILINK PPP BUNDLE
86 – REMOTE RCG

FIG. 9

DEVICES AND METHODS FOR MULTIPATH COMMUNICATIONS

RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 15/161,787 filed May 23, 2016, soon to be patented as U.S. Pat. No. 10,868,908, which is a continuation of U.S. patent application Ser. No. 14/512,414 filed Oct. 11, 2014, now patented as U.S. Pat. No. 9,350,649, which is a continuation of U.S. patent application Ser. No. 13/531,294 filed Jun. 12, 2012, now patented as U.S. Pat. No. 8,861,349, which is a continuation of U.S. patent application Ser. No. 12/581,852 filed Oct. 19, 2009, now patented as U.S. Pat. No. 8,228,801, which is a continuation of U.S. patent application Ser. No. 10/686,375 filed Oct. 14, 2003, now patented as U.S. Pat. No. 7,606,156, which claims priority to U.S. Provisional Application Ser. No. 60/418,521, filed Oct. 15, 2002, all of which are incorporated by reference herein.

BACKGROUND OF INVENTION

The primary function of the RCG is to provide a platform for Competitive Local Exchange Companies (CLECs) to compete with the Local Exchange Companies (LECs) for residential voice and data services. The LECs have a strangle hold on the "last mile" of copper over which almost all residential customers receive their communications services. Today, most CLECs resell the existing services that are offered by the LECs. CLECs make their money by purchasing these services from the LECs at a discount and marking them up to the customer. Since these services are regulated and controlled by the Public Utilities Commission (PUC) the pricing for these services to the CLECs is set. The monthly CLEC discount is approximately $5 to $6 per line per month for basic rate services. This means, in practicality, that a CLEC can only charge an additional $5 or $6 to the residential customer for basic rate services otherwise they would be more expensive than the LEC, and no one would buy the services from them; telephone customers would simply stay with the LEC.

To be competitive then, CLECs try to sell additional services such as call waiting, caller ID, etc. where they have as much as a 50% margin. Some CLECs also bundle long distance services with their packages as additional incentive to get residential customers to buy local telephone service from them. Since long distance fees are as low as pennies per minute to the customer, there is little profit in long distance for the CLECs. As it is, the pricing structure is such that the LECs will stay in control of the residential market, and the CLECs are nothing more than a marketing arm of the LEC. This structure also keeps the CLECs at an equal competitive advantage, or disadvantage, with respect to each other. The only thing that one CLEC could do to gain more customers is to be a better marketier. Since the CLECs are unable to discount their services because their margins are too slim as it is, the net effect is that the consumer looses by not really getting competition in the residential markets, and prices are kept artificially high.

For the CLECs to be truly competitive in the local telecommunications markets, they must be able to do more than simply resell the LECs services. CLECs must be able to offer many more features or services than those that the LEC provides, and they must be able to do this at a lower cost, in order to attract new customers.

So, what new services can the CLECs offer? As things stand today there are none, with the exception of DSL or Cable services which require tremendous infrastructure costs on behalf of the CLEC. However, by deploying an RCG in a residence, CLECs can offer advanced new calling features and services over the existing POTS line. Their costs for the POTS line from the LEC remains the same, but they can now charge for high bandwidth data services as well as additional calling and messaging features that the LECs cannot offer. This is their competitive advantage.

Competition:

Many companies are currently trying to provide VoIP services to residential customers over high-speed or broadband backbones such as DSL and cable modems, over Internet connections via a computer. The high-speed services require expensive infrastructure enhancements to the local telephone companies' facilities and cable plants, as well as expensive modems at the customer's end. These services are also difficult to deploy and too complicated for the average user. Internet based VoIP services suffer from Internet delays caused by a lack of true Quality of Service (QOS) capabilities across the Internet. Existing VoIP services also require access to a computer and a technical knowledge to be able to make it work. Because of these problems, VoIP services are primarily targeted at the corporate market place where private IP networks that can carry VoIP services with a true guaranteed QOS exist, or can be controlled.

The only available alternatives for the residential user for high speed services are DSL and cable modems. DSL and Cable based communications reach only a small segment of the population, and growth has failed to live up to initial expectations. The recent collapse of the internet boom has led to the failure of many DSL service providers and has effectively eliminated DSL as a potential service for most POTS users for the immediate future.

SUMMARY OF THE INVENTION

The RCG combines the capabilities and features of IP routers, Class 5 circuit switches and wireless LANs in a small stand-alone external modem like device. Additional capabilities for a hands-free speakerphone device with a large touch display are also detailed. The RCG can employ a large display with sufficient resolution to provide a functional user interface to access all of the advanced features offered by the RCG, but also to be able to provide video telephone services.

The device is placed in a residence and connected to the primary POTS line coming from the LEC. Up to three standard telephones or FAX machines (or any combination) are typically connected into the RCG. It also has a Universal Serial Bus (USB) and/or a 10-100 Ethernet interface for connection to a computer or a Local Area Network (LAN). In addition, it has an 802.11b/g wireless interface for wireless home networking as well as broadband-to-the-home services.

The system is installed in a customer's home by simply plugging it into the existing incoming telephone line that provides POTS services from the LEC. One or more standard telephones are then plugged into its three line-output jacks. This is the simplest and most basic usage. In this implementation, the user only is interested in gaining additional telephone lines into the household. No computer connection is required in order to use the system. However, if data communications are desired, then there are three additional interfaces for computer connectivity. Typically

either an Ethernet port, USB port or firewire (IEEE 1394) port is used to connect to a PC or LAN. The 802.11b/g interface is for wireless communications between the RCG and PCs, other RCGs as well as any other types of compatible wireless devices. A version of the RCG includes a speakerphone and video camera to provided for video telephone services.

Services Provided by the RCG:

The following discussion refers to FIG. **1**. The RCG has a main system processor that is responsible for all house keeping and traffic routing tasks. The Main CPU **19** routes data to and from the Ethernet Port **11**, USB Port **12**, Modem/DAA **41**, DSP Engine **33**, 802.11b/g Module **36** and the Display and Keypad **10**.

The RCG provides a total telecommunications communications services package for residential and small business customers. With the RCG, a CLEC can offer its customers dialtone for up to three separate telephone numbers per residence (the limit of three telephone numbers is an arbitrary number based upon typical residential usage and is not a limit imposed by the system), all local and long distance services, 24/7 always-on Internet access, a host of custom messaging and calling features, as well as Broadband access and lifeline service. All of these services can be offered over a customer's existing POTS line, and it doesn't require any network infrastructure build out like DSL and Cable services. Because there is no expensive network equipment required, it can be readily deployed throughout the country to expand the CLECs customer base quickly.

The RCG is designed to enhance, not replace, the existing telephone line, enabling it to provide new combined packetized voice and data services. Meanwhile, all existing telecommunications infrastructure and equipment will continue to work seamlessly with the RCG. Aside from simply installing the low cost RCG device in the home telephone wiring, no other equipment needs to be purchased by either the home owner or telephone companies. This eliminates the tremendously expensive infrastructure costs for communications companies that are trying to provide voice services using DSL or cable modems.

The RCG VIP Home Gateway Features:

Up to three telephone lines i.e. numbers, over a single POTS line and/or wireless connection.

Ethernet, USB and IEEE 1394 computer interfaces.

Full G1, G2 and G3 FAX support.

Full support for all CLASS services.

Broadband networking for home computers and appliances as well as wide area networking using a combination of a plurality POTS lines connected to a plurality of RCGs and/or a direct wireless connection to a wireless access point. (These interfaces allow smart devices to communicate to other devices within the home, or over the Internet through the RCG.)

Automated, remote upgradability and configuration. (Requires the customer to do nothing.)

Transparent user operation. (User doesn't have to know that any new technology is being employed)

100% compatible with existing public telephone system.

Video Telephone capabilities.

No local or long distance usage charges.

No Internet access fees.

Lower monthly communication costs.

Multiple telephone calls at the same time.

Voice messaging, follow me features, call forwarding, automatic call back, conferencing, custom call routing.

Home networking capabilities, all CLASS calling features, high speed broadband networking, continuous 24/7 internet access. and many others.

All of these features are available even while connected to the Internet.

Very low cost of entry into the market, especially as compared to broadband alternatives.

New calling features that are not currently available to home users.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows the RCG functional block diagram with the preferred embodiment of an 802.11 wireless connection.

FIG. **2** shows the network topology for native RCG to RCG communications.

FIG. **3** shows the network topology for an RCG to PSTN call.

FIG. **4** shows the RCG top view with associated functions.

FIG. **5** shows the RCG rear view and associated connections.

FIG. **6** shows a typical application with peripheral equipment connections.

FIG. **7** shows an ad-hoc wireless LAN configuration with ppp multilink data distribution and wireless connectivity.

FIG. **8** shows an ad-hoc wireless LAN configuration with ppp multilink data distribution and wireless connectivity with connection to a broadband neighborhood access point (Wi-Fi hot spot).

FIG. **9** shows an ad-hoc wireless LAN configuration with ppp multilink data distribution and wireless connectivity with wireless data hopping with POTS connections through numerous different Class 5 offices.

DETAILED DESCRIPTION OF THE INVENTION

The preferred embodiment is detailed herein using the ubiquitous 802.11 wireless protocol. It is by no means insinuated that this is the only wireless scheme that can be used by this device; rather, it is intended that any wireless transmission scheme can be used for wireless communications between this device and other wireless devices as various applications may dictate.

System Initialization

Refer to FIGS. **1**, **2** and **3** for the following discussion. When the RCG is first plugged into an AC power outlet the Main CPU **19**, performs a Power-on Self Test (POST) routine. Once the POST completes and the RCG is connected to an active POTS line, connected to the LEC, by means of the Incoming POTS Port **40**, the RCG automatically initiates a modem connection via the Modem/DAA **41**, to a registration service via a toll free 800 telephone number. The registration service connects directly to the service provider's sales or customer service offices via a VoIP connection. An operator or an automated service answers the call and sets up a new account for the customer. Once the account is set up, the service provider's network automatically sends control information to the device to store the required routing and feature/service information in its non-volatile memory of its Main CPU **19**. As part of this information, a local dialup telephone number is sent to the device that it will use for local network access in the same fashion as a standard ISP connection is made from a home computer. The URL of the Softswitch/SIP Proxy Server and Registrar **51** that will be controlling this particular device is

also stored at this time. During the service activation and configuration process, the customer service operator can send test requests to the device, as well as call into it on another telephone number (assuming an additional telephone number is part of the users class of service) or the speakerphone to verify that it is configured and working properly. The final step of the configuration and initialization process is to register the device with the appropriate Softswitch/SIP Proxy Server and Registrar **51** so that the Softswitch/SIP Proxy Server and Registrar **51** knows that it is the controlling SIP Proxy for this RCG. Also configured at this time is the username/password verification server (this is a standard network device and is not shown) that is used to allow the RCG's modem to make a connection onto the service provider's network. Once the RCG configuration is completed, it disconnects the call by hanging up the Modem/DAA **41**, then dials the new local network access number that had been sent during the configuration process and establishes a constant local network connection. This connection is maintained continuously on a 24/7 basis, and is immediately reestablished whenever it drops. Should the RCG become unable to reestablish this connection after several tries, it will switch over to failsafe mode and inform the user via the Display and Keypad **10**. The RCG will try to reestablish the connection every few minutes until it finally succeeds.

By default, the first telephone port, POTS **1** Port **30**, is assigned as the termination port for the existing POTS service that is connected to Incoming POTS Port **40**. This is the existing telephone service that the user already has as his primary telephone service from his LEC. POTS **1** Port **30**, typically has connected to it a standard telephone set that does not require any power (other than that derived over the POTS interface) to operate properly. POTS **1** Port **30** is the Lifeline telephone port for the user. In the case that all power is lost to the RCG, POTS **1** Port **30** will fail to a direct connection to the Incoming POTS Port **40** telephone line that comes into the RCG from the LEC to provide uninterrupted telephone services to the user. In this state, however, none of the enhanced VoIP services of the RCG are available to the user since the user simply has a stand POTS telephone service to the LEC.

Two additional and unique telephone numbers can be assigned to the other two telephone ports, POTS **2** Port **29** and POTS **3** Port **28**, by the service provider at any time. These numbers are drawn from a pool of available telephone numbers assigned to the service provider. POTS **2** Port **29** and POTS **3** Port **28** must to have standard telephone numbers assigned to them so that the PSTN is able to route calls from its network to these ports. For calls originating from IP based telephones, these numbers are not necessarily needed since POTS **1** Port **30**, POTS **2** Port **29** and POTS **3** Port **28** are uniquely identifiable to IP networks via their IP addresses assigned through the Dynamic Host Configuration Protocol (DHCP) at the time that the RCG establishes a connection to the service provider's network. Since POTS **2** Port **29** and POTS **3** Port **28** must have a telephone number assigned to them, it is a matter of convenience to use the assigned telephone numbers as part of their SIP address for IP routing of their data. In this way, all three user POTS ports, POTS **1** Port **30**, POTS **2** Port **29** and POTS **3** Port **28** are all addressed the same manor.

At this point, the user is able to take advantage of all of the RCG's features that have been activated according to his service agreement. The user can at any time connect additional telephones, a computer or a computer network to the RCG. The user will only be able to use those telephone ports (POTS **1** Port **30**, POTS **2** Port **29** or POTS **3** Port **28**) that have been activated, and assigned unique telephone numbers by the service provider. Any type of standard telephone can be connected to the three POTS ports, POTS **1** Port **30**, POTS **2** Port **29** and POTS **3** Port **28**. In the event that a cordless telephone or a telephone that derives its power from an AC outlet is connected to POTS **1** Port **30**, the lifeline functionality of this port will be ineffective since the telephone itself will not operate once power is lost.

The speaker phone feature of the RCG, comprised of Speakerphone Drivers **22**, Microphone **24**, Speaker **25** and DSP Engine **33**, can be used on any of the activated telephone numbers and is by default enabled to operate on POTS **1** Port **30**. Once either of the other two telephone ports, POTS **2** Port **29** or POTS **3** Port **28**, is activated, the speakerphone function is activated for those lines as well. To use the speakerphone for any assigned telephone number, the user simply presses either the Line Select Button 79-81 for Line 1, Line2 or Line 3 on the face of the RCG, and the speakerphone function is activated on that line. This is convenient for answering any call directly at the RCG. The RCG may or may not have a number keypad for originating calls. This feature may be added or removed based upon the target market price points.

The determination as to which Inter Exchange Carrier (IXC) the RCG will route its data through is determined by any of a number of criteria including, but not limited to, whether the RCG is a private labeled product, or which carrier has the lowest cost routing, or if a specific carrier is specified by the customer, or and number of other considerations. The RCG can be programmed to change its routing path to any IXC at any time by the service provider. Complicated routing algorithms can be programmed into the RCG to control which IXC it will use at any time.

Failsafe Mode

During any time that the RCG is in failsafe mode i.e. Lifeline failsafe logic **39** is activated, the RCG will only be able to receive or initiate telephone calls via the telephone connected to its primary telephone port, POTS **1** Port **30** or through its speakerphone feature. In this condition, all activated telephone numbers are ported via the PSTN to the primary (first) telephone number for delivery to the user's telephone that is connected to POTS **1** Port **30**. While in failsafe mode, the modem is not activated, and the RCG appears to the local Class 5 office as a standard telephone, and the PSTN will route all incoming calls to the RCG as it normally would to any standard telephone.

Call Flow 1:

Dialed call origination from a telephone connected to an RCG POTS port and terminating at another user's RCG POTS port:

When a user picks up a telephone connected to any of the three POTS ports, POTS **1** Port **30**, POTS **2** Port **29** and POTS **3** Port **28**, an off hook condition is detected by the SLIC/CODEC Interface **27** that is connected to the DSP Engine **33** by way of the DSP Audio Interface **31**. The DSP Engine **33** responds by sending digitally generated dialtone to the appropriate POTS interface over the DSP Audio Interface **31**. (Note: all BORSCHT telephony functions are performed by the DSP Engine **33** and the SLIC/CODEC Interface **27**.) Upon hearing the dialtone, the user enters the desired telephone number on his telephone keypad. The Dual Tone Multi-Frequency (DTMF) digits that the user dials are decoded within the DSP Engine **33**. The dialed digits are transferred to the Main CPU **19** via the CPU/DSP Communications Path **34**. The Main CPU **19** polls the DSP Engine **33** approximately every two milliseconds looking for

data. The Main CPU **19** polling rate varies according to the process that is being performed. The CPU/DSP Communications path **34** also can generate an interrupt to force data transfer between it and the Main CPU **19**.

The Main CPU **19** generates a SIP Invite IP packet using the dialed digits as the called destination address and the URL of its local controlling SIP Proxy Server which was programmed into the RCG during the configuration process. The Main CPU **19** passes this SIP packet off to the Modem/DAA **41** for transmission over the network. The RCG Modem/DAA **41** is connected to and communicating with a modem in a modem bank located in the Inter Exchange Carrier's (IXCs) facility. This facility may actually be located in the LEC's physical plant or it may be physically located at another location.

Referring to FIG. **2**, User A RCG **44** is connected via its modem to the LEC's local Class 5 Office A **47**. In this example, the service provider's connections to the IXC A Modem Bank & Router **48** are through IXC A Inter-Office Trunks **46**. The service provider may or may not be the IXC. If the service provider does not have its own network, then it will purchase capacity from an IXC and route its traffic to that IXC's facilities. The SIP Invite IP Packet that is sent from User A RCG **44** transits the LEC's Class 5 Office A **47** facilities and is routed to the IXC A Modem Bank/Router **48** via the IXC A Inter-Office Trunks **46**. It is the job of the router to take the IP packet and route it on to its intended destination, in this case the appropriate SIP proxy server **51**. The router uses the URL for the Softswitch/SIP Proxy Server and Registrar **51** contained in the SIP Invite to know where to route the packet. (Note: The Softswitch, SIP Proxy Server and Registrar are logical devices that may reside in a single computer system, or may be implemented as completely separate devices. In this example, the Softswitch, SIP Proxy Server and Registrar are all shown as a single physical device running these three separate processes.) The IXC A Modem Bank/Router **48** sends the SIP Invite IP packet on to Softswitch/SIP Proxy Server and Registrar **51** via an IP based network route **52**.

The SIP Proxy Server process running on Softswitch/SIP Proxy Server and Registrar **51** performs a look up to determine the termination destination for the call using the dialed digits passed along in the SIP Invite IP packet. In this example, the terminating device for User B RCG **56** is via IXC B's Modem Bank/Router **49** then through Class 5 Office B **50** and over User B POTS line **55** and finally to User B RCG **56**. Not covered in detail here is the SIP message handling since it is completely covered in IETF RFC2543. This example shows that both the originating and terminating ends of this call are controlled by the same Softswitch/SIP Proxy Server and Registrar **51** device. Where the originating and terminating ends of a call are controlled by different Softswitch/SIP Proxy Server and Registrar devices, an additional level of SIP messaging is used between the two SIP Proxy Server processes of each of the Softswitch/SIP Proxy Server and Registrar devices to locate and control the terminating location of the call. Again, that information is covered in IETF RFC2543 and is repeated here.

After the call routing is setup using SIP, and User B answers the call, the Softswitch/SIP Proxy Server and Registrar **51** device sends IP address of the originating User A RCG **44** to the User B RCG **56** and the IP address of User B RCG **56** to User A RCG **44**. Once both RCG's have the other's IP address, they then communicate directly to each other using Real Time Protocol (RTP), and the Softswitch/SIP Proxy Server and Registrar **51** device is no longer part of the connection. This direct communication is shown as IP based RTP Stream **57** between IXC A Modem Bank/Router **48** and IXC B Modem Bank/Router **49**.

On the receiving end of the call, referring back to FIG. **2**, User B RCG **56** receives the SIP Invite data stream through its Modem/DAA **41** and passes it on to the Main CPU **19**. The Main CPU **19** reassembles the SIP IP packet and interrogates the header information to determine which POTS port, POTS **1** Port **30**, POTS **2** Port **29** and POTS **3** Port **28** the call is destined for based upon the dialed number contained in the SIP Invite message. The Main CPU **19** commands the DSP Engine **33** to control the SLIC/CODEC Interface **27** to apply ringing voltage to the selected POTS port to ring the phone. A corresponding SIP 180 (ringing) message is sent back to User A RCG **44** in the reverse direction. When the phone attached to the selected POTS port is answered, the off hook condition detected by the SLIC/CODEC Interface **27** is sent through the DSP Engine **33** to the Main CPU **19** that sends the SIP 200 OK message back to User A RCG **44** to let the RCG know that the call was answered by User B RCG **56** and to turn off the audible ringing tone for User B. Once the call is established, User A RCG **44** sends and ACK F12 SIP message to User B RCG **56** indicating that User A RCG **44** understands that the call setup has been completed.

The two RCGs now exchange SIP messages that include the type of voice encoding that will be used such as G.729, G.723.1, G.711 etc to configure their RTP streams so that they can reliably transfer the user information between them. At this point the call (voice data) is sent between both RCGs and a normal telephone conversation takes place between the user A and user B.

Call teardown is accomplished by either user hanging up their telephone. The RCG of the terminating end (the end that hangs up the phone first) detects the on-hook condition and sends a SIP Bye message to the other end. The other end upon receiving the SIP Bye message responds with an OK 200 SIP message and disables the appropriate POTS port that the user was using.

The Speakerphone interface can be used for either end of a telephone conversation in exactly the same way as described above except that the corresponding POTS port that the call was intended for is disabled if the call is answered via the speakerphone.

Call Flow 2:

Calls between an RCG device and a PSTN telephone:

Refer to FIG. **3** for the following discussion.

In the previous call example, the PSTN network had nothing to do since the call was over a previously established modem connection between two RCGs. In the cases where a call originates or terminates to a standard telephone serviced by a Class 5 office, the process is a bit more complicated.

When a call originates from a user via an RCG, such as User A RCG **44**, the call handling practices are exactly the same up to the point that the SIP Proxy Server process in the Softswitch, SIP Proxy Server and Registrar **51** performs a lookup to determine how to route the call. In this case, the SIP Proxy Server process determines that the call terminates at a standard PSTN telephone attached to the Class 5 Office B **50**. Since the call originates as a native VoIP service, it must be converted to a standard switched circuit based service to be able to be delivered to User B's telephone **61**. The conversion is performed by the IXC's Media Gateway **60** device. In this example, the SIP Proxy Server process routes the call via the IXC's Media Gateway **60** device instead of through the IXC B Modem Bank/Router **49** as

before. The SIP Proxy Server process sends a SIP Invite to the IXC's Media Gateway **60** device, as well as other control information, to direct the Media Gateway **60** device to terminate the call and to apply the appropriate voice compression algorithm to the media stream to convert it between switched circuit PCM format and the selected VoIP protocol. At the same time, the Softswitch process of the Softswitch, SIP Proxy Server and Registrar **51** device sends commands to the Media Gateway **60** device to cause it to route the call's PCM data to a specific channel on the IXC B Interoffice Trunk **54**. The Softswitch process then generates an SS7 ISUP message that is sent over the PSTN SS7 signaling network to the Class 5 Office B informing it of the incoming call and on which circuit the call has been placed. It is up to the PSTN at this point to ring the User B telephone **61** and process the call between the IXC's Media Gateway and the User B Telephone **61**. The Softswitch process handles the signaling conversion between the PSTN's SS7 network and the IXC's SIP messaging, as well as any other proprietary signaling schemes utilized by the IXC to control its network. The standard SS7 call control messages, such as ringing, busy, ring back etc., all have a comparable SIP call flow control messages. The Softswitch simply maps the SS7 messages into SIP messages and visa-versa while routing the messages to the appropriate network equipment.

As in the case of a call between two RCGs, the RTP media stream (the actual call data) is routed directly be the IXC A Modem Bank/Router **48** and the IXC's Media Gateway **60** via an IP based RTP Stream **57**.

Again, call teardown is accomplished by either user hanging up their telephone. Depending which end hangs up the phone first, the associated network will generate the appropriate messages which will eventually make it back to the Softswitch process. The Softswitch process will relay the appropriate call control messages between the PSTN and the IXC's SIP based control system.

A telephone call originating from a PSTN telephone is configured and setup in the same fashion as the above description except that the originating messaging begins within the PSTN network instead of the IXC's network.

Personal Computer Based Communications:

Where the RCG is connected to a Personal Computer (PC) through either its USB Port **11** or Ethernet Port **12**, the RCG operates exactly as a cable or DSL type modem device. The RCG is simply a pass through for the computer's data. The RCG receives the IP packets (of whatever type) from the computer and sends the information unchanged to the Modem/DAA **41** interface for transmission over the Internet. Received information from the Internet is processed in the reverse way.

Dynamic Bandwidth Allocation:

When a modem connection is established between the RCG and the "Network", the total available bandwidth of this connection is used in a shared/prioritized fashion. Voice services (calls) take precedence over data services. Therefore, when no calls are in progress all of the available bandwidth is used by data type services such as surfing the Internet or uploading/downloading files. However, when a call is to be passed through the RCG, the required bandwidth for the call is deallocated from the data services and prioritized for the telephone call. This necessary because the Quality Of Service (QOS) is important for effective communications over electronic networks. Since the voice data is carried over a "data centric" network topology (an IP based network), call quality can suffer greatly. Every effort must be taken to eliminate or reduce the packet delay through every network element to be able to provide the best call quality. For data applications such as surfing the Internet or downloading files packet delay is acceptable and expected, and it does not affect the "quality" of the data.

Since all voice and data is transmitted as packets, there are no "time slots" or other type of "channelization" associated with the transmission of this data over either the POTS line or the wireless interface. Channelization of the voice data does occur within the SLIC/Codec Interface—**27** but is converted into IP packets by the DSP engine—**33** and is handled as packets from that point on.

Regardless of whether the call is originating or terminating at the RCG, the bandwidth allocation process is the same. When the SIP call setup messages are processed, the type of voice compression that will be used is defined. The RCG Main CPU **19** handles the IP packet flow between the DSP Engine **33**, USB Port **12**, Ethernet Port **11**, 802.11b/g Module **36** and the Modem/DAA **41** devices giving priority to the voice packets to and from the DSP Engine **33** and the Modem/DAA **41** interfaces. Voice compression algorithms create IP packets at a specified number of packets per second. These packets are handled by a timed process in the RCG. This process is started during call setup so that the packets are handled at the correct rate based upon the compression algorithm's packet generation rate. There is no priority assigned between the voice packets of each of the three different POTS Ports **28-30**. When more than one voice call is in progress, they are handled in a round robin fashion based upon the packet rate for the compression algorithm used. If, for example, two calls are using a compression scheme that generates packets every 2 milliseconds, and the third generates packets every 4 milliseconds, then the calls utilizing the faster packet rate will be polled at twice the rate as the call using a slower packet rate but they are not given priority "over" the other call. Only when there are no voice packets ready for transmission to the Modem/DAA **41**, i.e. during the approximately 2 to 4 millisecond packetization period between packets, will any pending data packets received from the USB Port **12**, Ethernet Port **11** or the 802.11b/g Module **36** be sent to the Modem/DAA **41** for transmission over the network.

Thus, the POTS bandwidth is allocated on a per packet basis, not on a "time slot" or "channelization" or even a "frequency" basis as it the case with T-Carrier, DSL or channelized DSL systems. The same is true for the wireless interface, whether it is carrying pure data or voice.

Security is currently a big concern in today's networks, and especially with wireless 802.11 transmissions. For this reason, the RCG defaults to route voice data over the users POTS connection via Incoming POTS Port **40**. As security concerns regarding wireless communications transmissions are addressed and alleviated, voice call data can, and will, be routed over the wireless interface via the 802.11 b/g Module **36**.

FAX Transmission:

Group I, 2 and 3 fax transmission is completely supported by the RCG. Fax transmission has the same priority as other voice communications. That is to say that FAX transmission is treated the same as a voice call and takes precedence over native IP data traffic.

Broadband Over POTS:

One of the primary functions of the RCG is to be able to transfer large files such as video files over the POTS lines to a residence. The ability to do this is limited by the maximum of 56 Kbps due to the design of the digital Class 5 office linecards and network transmission schemes based upon T carriers. Typical Class 5 linecard design samples the POTS lines at a rate of 8,000 samples per second. Typically, each

sample is digitized into 12 to 16 bits by a codec device. The digitized sample is then companded to an 8 bit sample (1 byte) which makes up the PCM data stream that is transferred over the PSTN. Therefore, each POTS line is sampled at an effective rate of 64 Kbps. Since legacy T1 transmission equipment uses robbed-bit signaling, the maximum guaranteed transmission rate for the PSTN as a whole is 56 Kbps. Because of this limitation, standard POTS lines can only guarantee a maximum of 56 Kbps transfer rate under the best conditions. DSL equipment gets around this problem by installing DSL Access Multiplexing (DSLAM) equipment at the Class 5 office end of the POTS line. By routing around the linecard, as well as routing the data directly over the Internet or other private IP based networks, and therefore the 64 Kbps sampling rate, DSL is not bandwidth limited like PSTN traffic is. DSL, however, suffers from the very high costs associated with the purchase, installation, maintenance, floor lease costs, etc. DSL also suffers from very high deployment costs resulting from the labor intensive process to turn up each line. Each DSL "POTS" line must be inspected, conditioned and all load coils removed.

The RCG gets around the 56 Kbps POTS limitation as well as the DSL problems by using the standard POTS lines as they are, and not requiring any additional equipment to be installed at the Class 5 end of the POTS line. This technique simplifies deployment and drastically cuts costs.

Multilink PPP Connections:

Referring to FIG. **7**, the RCG implements broadband over POTS by employing an 802.11 b/g wireless interface to configure a multilink PPP bundle—**87** (per RFC 1990) comprised of the POTS lines connected to up to 32 RCGs. The limitation of 32 RCGs in a multilink PPP bundle is an arbitrary number and can be scaled up or down as required to support changes in network equipment capabilities. An 802.11b/g interface—**87** is shown as the preferred embodiment, since its 11/54 Mbps interface is considered sufficient bandwidth at this time also, its transmission distances are sufficient for implementation of this device, as opposed to other shorter ranged wireless transmission schemes. However as time goes on, some other wireless interface may be more desirable. There is nothing special or specific to the 802.11 wireless interface that makes it particularly suited to this application. Any wireless interface scheme can be used to implement this device.

The 802.11b/g interface—**88** on an individual RCG is also used to provide a peer-to-peer wireless home networking environment to other 802.11 compatible wireless component within the residence (such as a hand-held computer device) while acting as an always on dialup Internet gateway over the POTS line—**40** for the other wireless devices. An RCG that is transferring a very large file can request the services of **31** (in this embodiment) other RCGs to assist in the file transfer using their respective POTS lines. A single RCG can therefore gain the combined bandwidth of up to 32 POTS lines transferring data at as much as 56 Kbps each to transfer information. This is roughly equivalent to a transfer rate of 1.79 Mpbs in the inbound direction (towards the RCG) and approximately 1.075 Mbps in the outbound direction (towards the PSTN).

The multilink PPP connection—**87** is initiated by an RCG when it determines that the file (or streaming service) that it is to download (receive) is of sufficient size or requires a minimum amount of bandwidth to justify the use of a multilink PPP connection. This determination can be made on many different criteria such as the file size, type of data being transmitted, the type of compression if any, a Quality-of-Service requirement or any other pertinent information. (Since a certain amount of overhead is required to set up a Multilink PPP connection, it doesn't make sense to use it for small or low data rate transfers.)

Multilink PPP Bandwidth Allocation and Initialization:

Referring to FIG. **7**, an RCG—**85** that decides to initiate a multilink PPP session with a remote computer i.e. internet URL, requests a multilink PPP session with that URL resource via Link Control Protocol (LCP) session management. The initiating RCG—**85** and the remote server computer (not shown) will negotiate the pertinent multilink parameters such as compression, packet size, sync/async, link quality monitoring, bit stuffing etc. As part of a successful multilink PPP session setup, the initiating RCG—**85** receives a multilink PPP session ID, or "magic number", which is used to identify this particular multilink PPP session and is also used for adding or removing links from the multilink bundle—**87**. Once the multilink bundle is setup, the initiating RCG—**85** begins data transfer across its POTS interface—**90** with the far end computer system. The initiating RCG—**85** then looks up the addresses of up to 31 (in this embodiment) other RCGs in its router tables to use for the multilink PPP transfer. (If a Neighborhood Access Point is available the RCG could request service through it instead of setting up a Multilink PPP connection—see FIG. **8**.) The initiating RCG—**85** determines the number of remote RCGs—**86** that it wants to use to get the desired bandwidth for the transfer and sends multilink PPP service requests via the 802.11 b/g wireless connections—**88** to the selected remote RCGs—**86**. The selected remote RCGs—**86** respond back to the initiating RCG with either an acceptance or denial of multilink PPP service request. This decision is made based upon the remote RCG's currently available POTS bandwidth and the current local demands for that bandwidth. The remote RCG—**86** makes a decision to participate in a multilink PPP service for an initiating RCG if its POTS line—**91** has a current average bandwidth utilization of less than some arbitrary limit such as 8 Kbps to 16 Kbps. This 8 Kbps to 16 Kbps bandwidth utilization represents about two concurrent voice conversations using standard voice compression techniques, or some small amount of data transmission occurring on the remote RCG's POTS interface—**91** or a combination thereof. Assuming that the remote RCG—**86** has a modem connection speed somewhere between 33 Kbps to 56 Kbps, this would leave approximately 17 Kbps to 40 Kbps of POTS bandwidth that the remote RCG—**86** could offer to the initiating RCG—**85** for use in its multilink PPP bundle—**87**. Of course, if there is no activity on the remote RCG—**86** POTS line, then the entire bandwidth will be used for the multilink transfer. If the remote RCG—**86** accepts the multilink PPP service request from the initiating RCG—**85** it also sends its currently available bandwidth on its POTS line—**91** that the initiating RCG—**85** will have available to it for the multilink PPP transfers. The initiating RCG then selects which of the responding remote RCGs—**86** it will use for the multilink PPP bundle—**87** and sends them a multilink initialization packet containing the URL of the destination as well as the multilink PPP session ID (magic number) and any other pertinent information required for the remote RCG to join in the existing multilink PPP bundle—**87**. Each remote RCG POTS interface—**91** participating in a multilink PPP bundle, represents a logical "link" in the initiating RCG's multilink PPP bundle—**87**. The remote RCGs—**86** then send a multilink PPP packet (over their respective POTS lines—**91**) to the destination URL with the multilink PPP session ID and request to be added to that multilink PPP bundle—**87**. The destination URL accepts the request of each of the remote

RCGs—**86** and begins sending data packets to each over their respective POTS lines—**91**. When the remote RCGs—**86** receive data packets sent over their respective POTS lines—**91**, that are destined for the multilink PPP bundle—**87**, they simply relay the data packets over their 802.11b/g interface—**88** to the initiating RCG—**85**. It is the responsibility of the initiating RCG—**85** to perform all housekeeping tasks associated with the multilink transfer such as detection of lost packets and data packet reassembly, if those functions are required. Typically, lost packet detection and retransmission and reassembly are performed at higher OSI layers by the requesting software such as a browser. The remote RCGs—**86** are simply data transport nodes and do not perform any data processing on data received over a multilink PPP bundle destined for another RCG.

The initiating RCG—**85** of the multilink PPP bundle—**87** continually monitors the bandwidth of each remote RCG's—**86** multilink link which together comprise its multilink bundle —**87**. When the available bandwidth for the multilink PPP link of an individual remote RCG—**86** falls below an arbitrary minimum set by the initiating RCG—**85**, the initiating RCG—**85** instructs the offending remote RCG, via its 802.11b/g wireless interface—**88**, to remove itself from the multilink bundle. The remote RCG—**86** will then notify the remote computer (URL) to be removed as a link in the current multilink bundle on which it is participating. Alternatively, a remote RCG—**86** can inform the initiating RCG—**85** of local demands on its POTS bandwidth, and request that the initiating RCG—**85** remove it (the remote RCG—**86**) from the participation in the initiating RCG's multilink bundle—**87**. The remote RCG—**86** will not unilaterally remove itself from participation in a multilink bundle without prior notification to the Initiating RCG—**85**. The remote RCG—**86** must get authorization from the initiating RCG—**85** to remove itself from the bundle, since the initiating RCG—**85** will have no way of knowing if the loss of data from that remote RCG is due to some sort of failure or from the remote RCG simply removing itself from participation in the multilink bundle—**87**. Also, for services that require a minimum Quality of Service (QOS) such as streaming video, the initiating RCG—**85** needs to control the multilink bundle—**87** bandwidth, and it can not do that if remote RCGs—**86** drop out of the multilink bundle—**87** at will. When a remote RCG—**86** requests to be removed from participation in a multilink bundle—**87**, the initiating RCG—**85** must immediately grant the request. If the initiating RCG—**85** were to not grant the request, then the remote RCG—**86** could, in worst case, delay or drop incoming multilink packets destined for the initiating RCG—**85**. If this were to happen, the initiating RCG—**85** will have missing packets and could over run its reassembly buffer (if reassembly is being performed by the RCG) causing catastrophic data loss and potentially have to restart the entire transmission. In the least case, the initiating RCG—**85** would have to initiate retransmission of potentially many packets which it assumes to be lost, but may simply be delayed by the remote RCG—**86**. Once a remote RCG—**86** has been removed from participating in a multilink bundle—**87**, the initiating RCG—**85** will then look up another remote RCG in its router tables that can be used to participate in the multilink PPP bundle—**87**, and request that the new remote RCG—**86** to join the existing multilink bundle—**87**. This is necessary to maintain a minimum Quality of Service. Since RCGs prioritize their bandwidth requirements based upon their own "local" service requirements, their participation in any multilink PPP service is available only to bandwidth that is not required for its own current local demands. Therefore, a remote RCG's—**86** bandwidth that is available for multilink services can change at any time. The dynamic reassignment of remote RCGs that participate in a multilink bundle is also required to prevent a remote RCG—**86** from receiving packets so slowly that the originating RCG—**85** interprets this delay as lost packets. When the initiating RCG—**85** determines that a packet has been lost, and it is performing packet reassembly, it will, itself, request that the remote computer retransmit the lost packet. The initiating RCG will not ask any remote RCG—**86** to perform retransmissions or any other kind of data computations or manipulations.

Refer to FIG. **8** for the following discussion. In areas where there are existing 802.11 network equipment such as Neighborhood Access Point—**93**, or where there is sufficient bandwidth requirements from an installed base of RCGs to warrant the deployment of a Neighborhood Access Point—**93**, the RCGs will automatically detect the presence of the compatible neighborhood access points and register with that equipment for transport services. In this case, an RCG has an alternative broadband service route in addition to the multilink option. An RCG can communicate directly with a local 802.11 Network Access Point—**93** that is connected to the PSTN or another carrier's network via some sort of high bandwidth backbone such as a T-Carrier or optical carrier connection (T1, T3, OC3, OC12 etc.). The RCGs can communicate directly with neighborhood access points at their full 11/54 Mbps data rates to provide up to that full bandwidth to the user. This functionality is, of course, subject to the Network Access Point—**93** allowing access to its resources to the RCG according to the 802.11 wireless protocol.

This architecture is important since it provides an avenue to relieve the local class 5 offices of congestion that can be caused by a wide spread deployment of RCGs within the class 5 service area. Since each RCG requires a constant 24/7 modem connection, this ties up the class 5 switch in a fashion that it was not designed for. This could lead to wholesale class 5 office expansions which would be extremely expensive, and potentially prohibitive for the Local Exchange Carriers (LECs). By deploying neighborhood access points that operate at 54 Mbps (802.11a/g), in areas where the RCG concentration starts placing too high of a demand on the local class 5 office, the bandwidth from the RCGs can be aggregated by the neighborhood access points into large capacity backbones to relieve the switch congestion. In this case, the RCG POTS interface—**40** can be used solely as a lifeline connection, or when the 802.11 wireless LAN in which the RCG resides is congested. With this implementation, voice calls will be carried over the wireless interface as opposed to the POTS interface on which they would normally be carried. Also, the RCG modem—**41** connected to the POTS interface—**40** would not need to maintain a constant always on connection, it could be a dialed on demand connection and thereby relieving the local class 5 office switch.

Bouncing or Hopping Traffic:

Refer to FIG. **9**. In areas where the density of RCGs is less than the arbitrary number of 32 RCGs within its transmission radius for multilink connections, the RCGs can bounce, or relay, the data traffic between each other to reach other RCGs located farther than the RCGs wireless transmission area. Since the POTS data rate of 56 Kbps is miniscule as compared to the 11/54 Mbps 802.11b/g transfer rate, the overhead associated with bouncing data traffic is not a concern. This will allow for the fastest possible data transfer across POTS lines for every RCG user.

RCGs can also communicate directly with an 802.11a Neighborhood Access Point—**93** device (such as that used in WI-FI networks) that is connected to a data network connection such as a DS3 or OC3 service via a Metro Access Point. Where an RCG has access to a broadband device such as an 802.11a type device, either directly or via a bounced signal across several RCGs, a direct high speed data connection can be used to transfer large files. When an RCG is communicating directly with an 802.11a device, data transfer speeds up to the full 11/54 Mbps can be achieved to speed video transfers for such applications as video on demand.

RCG Router Tables:

The RCG continually monitors its 802.11b/g wireless interface for transmissions from other RCGs or 802.11a Access Points as well as other 802.11b/g wireless devices within the residence. The RCG provides a means to identify and store the addresses of other RCGs and Neighborhood Access Points within its local area. The RCG creates routing tables, much like an IP router device, so that it knows which RCGs are local to itself, and how many hops will be needed to reach the maximum of 32 POTS lines or a Neighborhood Access Point. The RCG can then determine how to route its data transfers to gain the most efficient routing and network efficiencies.

The router tables in each RCG are continually updated by monitoring the 802.11 frames received from other RCGs or Network Access Points. The number of entries in the router tables can be limited to an arbitrary number of other RCGs but contains room for at least 32 entries. For each RCG listed in the router tables, certain information is kept such as signal strength, if the other device is another RCG or some other 802.11 compatible device, if the other RCG is reachable directly, or if it is accessed via another RCGs by hopping. In the case there RCG hopping is used, the address of each RCG that is hopped is stored in the routing table. When an RCG is first powered up, it monitors its 802.11 interface for a period of time to identify other RCGs or Neighborhood Access Point devices, or other Wi-Fi devices within its transmission area. When first deployed, the RCG will not have any entries in its routing tables. This condition can persist for some time, until another RCG or other 802.11 device is deployed within the former RCGs transmission range. In this state, the RCG can be used for wireless networking within the residence, connecting the local computer to the RCGs always on Internet connection as well as to other wireless devices within the home. When an 802.11 frame is received by an RCG that contains the address of an RCG whose address does not exist in the receiving RCG's router table (as is the case when a new RCG is first installed), the receiving RCG polls the transmitting RCG for its router table information. The received router information is reviewed for other RCG's or other 802.11 compatible devices that are not listed in its own router tables. A decision is made to use some, all, or none of the new route information in its router tables. There is no real limitation on the number of RCGs that can be "hopped" in order to build a complete router table or to reach many more RCGs, Neighborhood Access Points or Metro Access Points.

Equipment and Services Priorities:

Just as voice has priority over data transfers within a single RCG, local RCG traffic (both voice and data) has priority over remote transfer requests by other RCGs. If an RCG is currently using all of its available POTS bandwidth for its own purposes, it will deny any remote RCG's request for access to its POTS line. Only when there is available POTS bandwidth available will an RCG allow other RCGs access to its POTS line. It will, however, bounce the traffic to other RCGs within its transmission area if requested by the originating RCG. In this case, available wireless bandwidth of any RCG (that amount of the 11/54 Mbps not currently used for its own traffic) can be used to relay traffic between other RCGs that do have available POTS bandwidth. In the same fashion, excess wireless bandwidth of any RCG can be by other RCGs to access high speed backbones via Neighborhood or Metro Access Points.

RCGs can also access other 802.11 wireless networks (Wi-Fi for example) that happen to be deployed within their service areas. In this case, access agreements between the RCG service provider and the wireless network operator must be put into place. By remaining compatible with the 802.11 standards, the RCGs capabilities will benefit by the growing WI-FI network infrastructure, an the WI-FI network will benefit by the RCG network.

Voice Over POTS and Data Over Wireless:

Normally, all communications from an RCG will be transmitted over the local POTS line, or a multilink bundle made up of many remote RCG POTS lines. By default, all voice calls will be carried over the "local" POTS line—**40** to alleviate security/privacy concerns and only "data" will be transmitted via multilink bundles. Generally, since voice "data" is compressed locally by the RCG, the required bandwidth for a voice call is so small that it does not make for a good choice to route it over a multilink connection. However, it is possible to route voice calls entirely over another RCGs POTS line. It is also possible for an RCG to transmit voice data over POTS lines connected to other RCGs via multilink bundles or directly over its 802.11 wireless interface, and since the 802.11 specification does support the Wired Equivalent Privacy (WEP) specification, a secured connection can be made in this fashion.

Remote Upgradability

The RCG is designed with the capability for unassisted remote upgradability. The remote upgradability feature is not the same as the storing of operational parameters during the configuration process. This feature allows the system operator to add new features as they are developed, or to correct bugs remotely and without the users knowledge or involvement. This feature can also be used to install a complete new operating system (OS).

Key to the successful implementation of the Remote upgradability feature is that a completely fail-safe routine be implemented that can recover from any failure during the upgrade process and to re-initiate and monitor the upgrade process until it has successfully completed. This process is carried out by loading a boot loader program that is stored in non-volatile memory. The boot loader program provides the minimum capabilities to start up the RCG and connect into the system operator's diagnostics network to download fixes or a new OS. The boot loader program is technically part of the OS, but it cannot be over written by any upgrade process. It is responsible for detecting failure of the RCG and initiating a connection to the diagnostics network. Once connected with the diagnostics network, the boot loader will provide diagnostics support to help correct the RCG's operation and reconfigure the OS.

What is claimed is:

1. A communications device that is capable of providing broadband communications services, comprising:

at least one connection for connecting to a communications network;

at least one wireless interface for connecting wirelessly to at least one remote communications device; and

a processor that

requests the at least one remote communications device to assist in transferring data,

sends a request to the at least one remote communications device for availability for participating in a multilink communication,

if available, sends control information through the at least one remote communications device for participating in a multilink connection,

receives packets from the at least one remote communications device, and

aggregates the data from the at least one remote communications device with data transfers from the at least one connection to increase data bandwidth for the communications device.

2. The communications device of claim **1**, wherein the at least one remote communications device is at least one of a residential communications gateway, a cable modem, a digital subscriber line, a wireless device, a neighborhood access point device, a Wi-Fi device and a cellular phone.

3. The communications device of claim **1**, wherein the communications network is at least one of a public wired network, a private wired network, a public wireless network, and a private wireless network.

* * * * *

EXHIBIT D

US011582343B2

(12) **United States Patent**
Delangis

(10) **Patent No.: US 11,582,343 B2**
(45) **Date of Patent: Feb. 14, 2023**

(54) **DEVICES AND METHODS FOR MULTIPATH COMMUNICATIONS**

(71) Applicant: **Eric M. Delangis**, Wylie, TX (US)

(72) Inventor: **Eric M. Delangis**, Wylie, TX (US)

(73) Assignee: **Competitive Access Systems, Inc.**

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **17/887,922**

(22) Filed: **Aug. 15, 2022**

(65) **Prior Publication Data**

US 2022/0394124 A1 Dec. 8, 2022

Related U.S. Application Data

(63) Continuation of application No. 17/120,549, filed on Dec. 14, 2020, now Pat. No. 11,418,641, which is a (Continued)

(51) **Int. Cl.**

H04L 45/24	(2022.01)
H04M 3/00	(2006.01)
H04L 12/54	(2022.01)
H04L 61/5014	(2022.01)
H04W 88/16	(2009.01)
H04L 45/00	(2022.01)
H04L 47/70	(2022.01)
H04L 69/168	(2022.01)
H04M 1/60	(2006.01)
H04W 8/26	(2009.01)
H04W 28/06	(2009.01)
H04W 40/02	(2009.01)

(Continued)

(52) **U.S. Cl.**

CPC ***H04M 3/007*** (2013.01); ***H04L 12/5692*** (2013.01); ***H04L 45/24*** (2013.01); ***H04L 45/54*** (2013.01); ***H04L 47/821*** (2013.01); ***H04L 61/5014*** (2022.05); ***H04L 69/168*** (2013.01); ***H04M 1/6033*** (2013.01); ***H04W 88/16*** (2013.01); *H04M 2203/052* (2013.01); *H04M 2203/60* (2013.01); *H04M 2250/06* (2013.01); *H04W 8/26* (2013.01); *H04W 28/06* (2013.01); *H04W 40/02* (2013.01); *H04W 72/04* (2013.01); *H04W 80/00* (2013.01); *H04W 84/12* (2013.01); *H04W 84/18* (2013.01); *Y02D 30/70* (2020.08)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,496,477 B1 * 12/2002 Perkins H04L 47/2416 370/228

7,315,900 B1 1/2008 Ofelt et al.

(Continued)

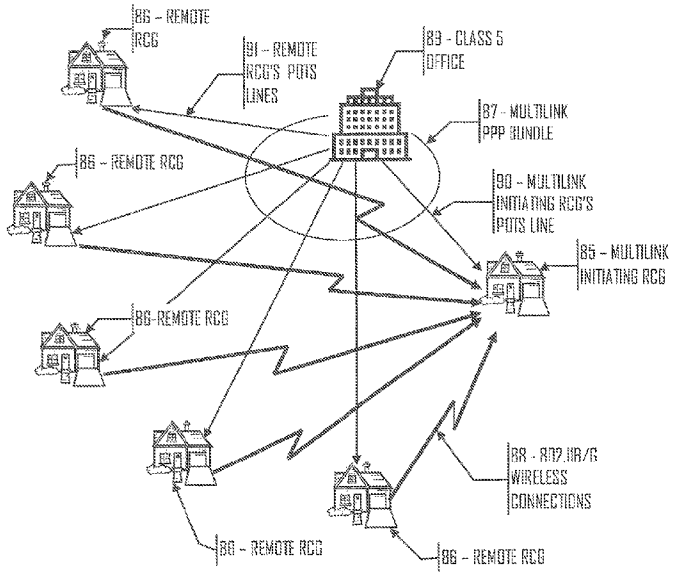
Primary Examiner — Hong S Cho

(74) *Attorney, Agent, or Firm* — Clay McGurk; The Law Office of Clay McGurk

(57) **ABSTRACT**

Broadband communications devices and methods operate with at least two separate communication paths between the devices and the network, such as the Internet. The broadband devices and methods receive data concurrently over the communication paths or separately. The bandwidth is increased when the separate communication paths are combined. The broadband devices employ packetized data with Voice over Internet Protocol (VoIP) technologies combined with RF communications technologies.

20 Claims, 9 Drawing Sheets



Related U.S. Application Data

continuation of application No. 15/161,787, filed on May 23, 2016, now Pat. No. 10,868,908, which is a continuation of application No. 14/512,414, filed on Oct. 11, 2014, now Pat. No. 9,350,649, which is a continuation of application No. 13/531,294, filed on Jun. 22, 2012, now Pat. No. 8,861,349, which is a continuation of application No. 12/581,852, filed on Oct. 19, 2009, now Pat. No. 8,228,801, which is a continuation of application No. 10/686,375, filed on Oct. 14, 2003, now Pat. No. 7,606,156.

(60) Provisional application No. 60/418,521, filed on Oct. 15, 2002.

(51) **Int. Cl.**

H04W 72/04	(2023.01)
H04W 80/00	(2009.01)
H04W 84/12	(2009.01)
H04W 84/18	(2009.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

2001/0007557	A1*	7/2001	Yamada	H04L 45/00 370/389
2003/0016664	A1*	1/2003	MeLampy	H04L 61/2557 370/389

* cited by examiner

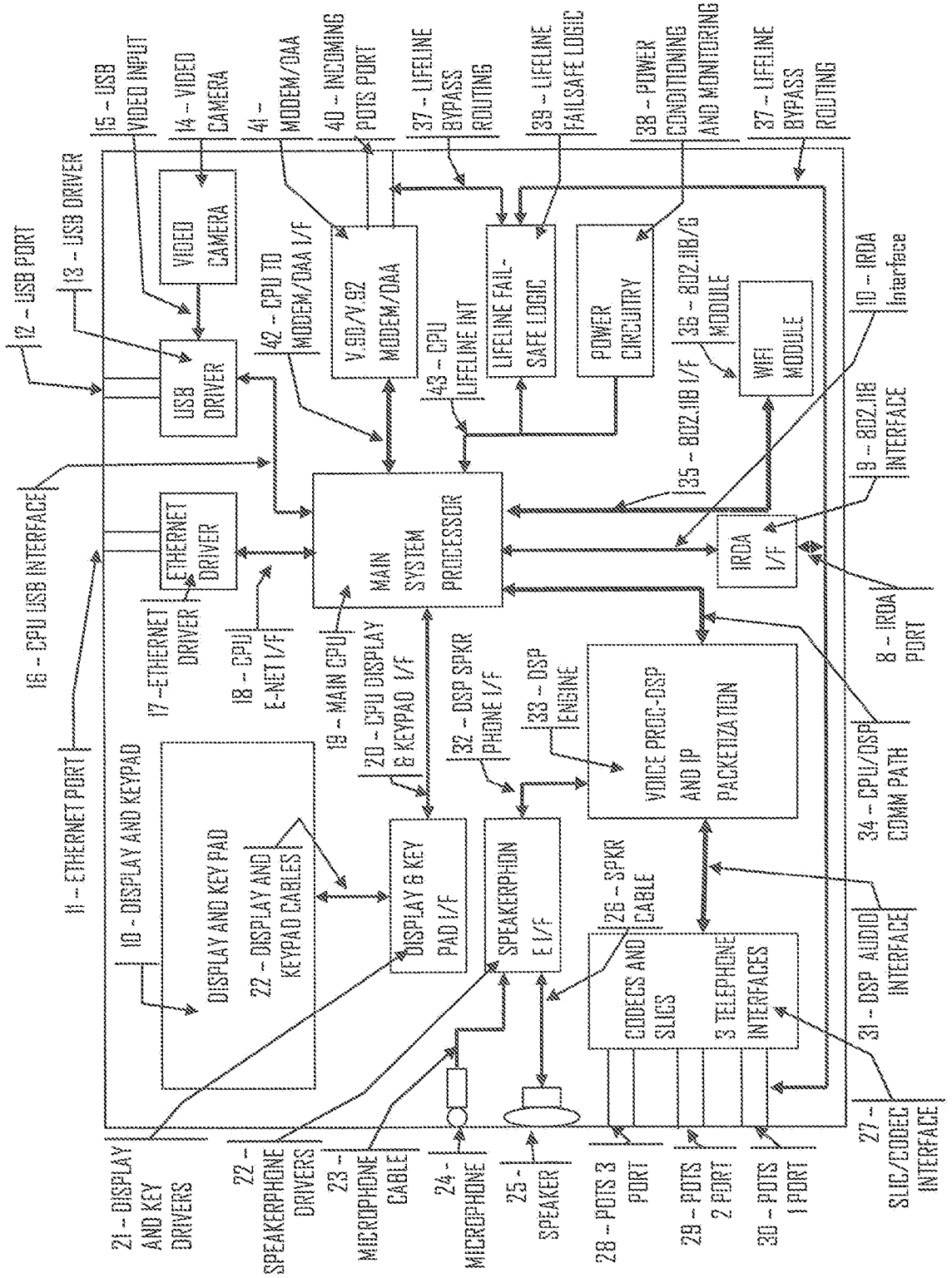

MAIN SYSTEM PROCESSOR
USB DRIVER
ETHERNET DRIVER
VIDEO CAMERA
V.90/V.92 MODEM/DAA
LIFELINE FAIL-SAFE LOGIC
POWER CIRCUITRY
WIFI MODULE
IRDA I/F
DISPLAY AND KEY PAD
DISPLAY & KEY PAD I/F
SPEAKERPHONE E I/F
VOICE PROC-DSP AND IP PACKETIZATION
CODECS AND SLICS
5 TELEPHONE INTERFACES
12 - USB PORT
13 - USB DRIVER
14 - VIDEO CAMERA
15 - USB VIDEO INPUT
16 - CPU USB INTERFACE
17 - ETHERNET DRIVER
18 - CPU E-NET I/F
19 - MAIN CPU
20 - CPU DISPLAY & KEYPAD I/F
21 - DISPLAY AND KEY DRIVERS
22 - SPEAKERPHONE DRIVERS
23 - MICROPHONE CABLE
24 - MICROPHONE
25 - SPEAKER
26 - SPKR CABLE
27 - SLIC/CODEC INTERFACE
28 - POTS 3 PORT
29 - POTS 2 PORT
30 - POTS 1 PORT
31 - DSP AUDIO INTERFACE
32 - DSP SPKR PHONE I/F
33 - DSP ENGINE
34 - CPU/DSP COMM PATH
35 - 802.11B I/F
36 - 802.11B/G MODULE
37 - LIFELINE BYPASS ROUTING
38 - POWER CONDITIONING AND MONITORING
39 - LIFELINE FAILSAFE LOGIC
40 - INCOMING POTS PORT
41 - MODEM/DAA
42 - CPU TO MODEM/DAA I/F
43 - CPU LIFELINE INT
8 - IRDA PORT
9 - 802.11B INTERFACE
10 - IRDA interface
11 - ETHERNET PORT
18 - DISPLAY AND KEYPAD
22 - DISPLAY AND KEYPAD CABLES

FIG. 1

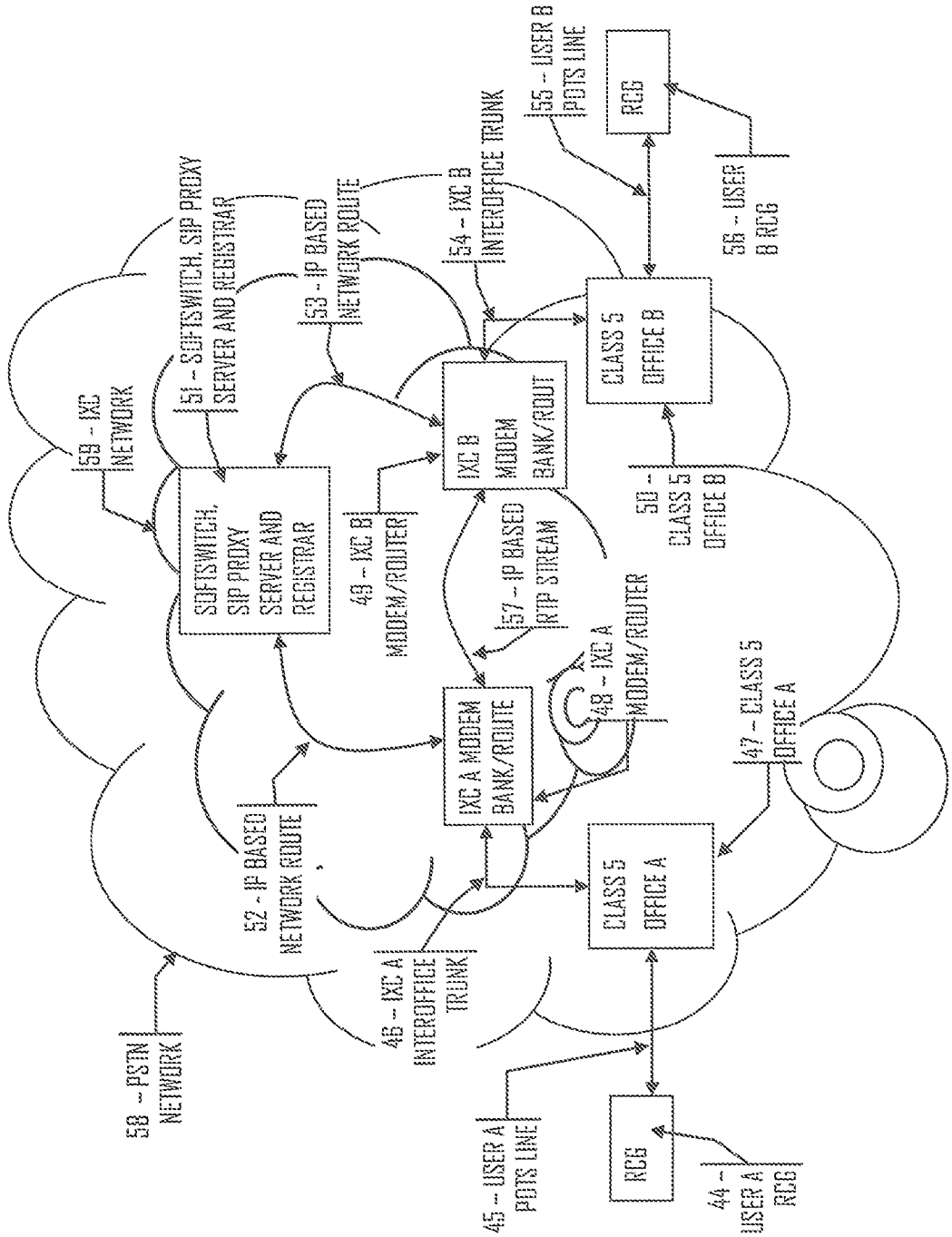

58 – PSTN NETWORK
45 – USER A POTS LINE
44 – USER A RCG
RCG
46 – IXC A INTEROFFICE TRUNK
52 – IP BASED NETWORK ROUTE
IXC A MODEM BANK/ROUTE
CLASS 5 OFFICE A
48 – IXC A MODEM/ROUTER
47 – CLASS 5 OFFICE A
57 – IP BASED RTP STREAM
49 – IXC B MODEM/ROUTER
SOFTSWITCH, SIP PROXY SERVER AND REGISTRAR
59 – IXC NETWORK
51 – SOFTSWITCH, SIP PROXY SERVER AND REGISTRAR
53 – IP BASED NETWORK ROUTE
IXC B MODEM BANK/ROUT
54 – IXC B INTEROFFICE TRUNK
50 – CLASS 5 OFFICE B
CLASS 5 OFFICE B
55 – USER B POTS LINE
RCG
56 – USER B RCG

FIG. 2

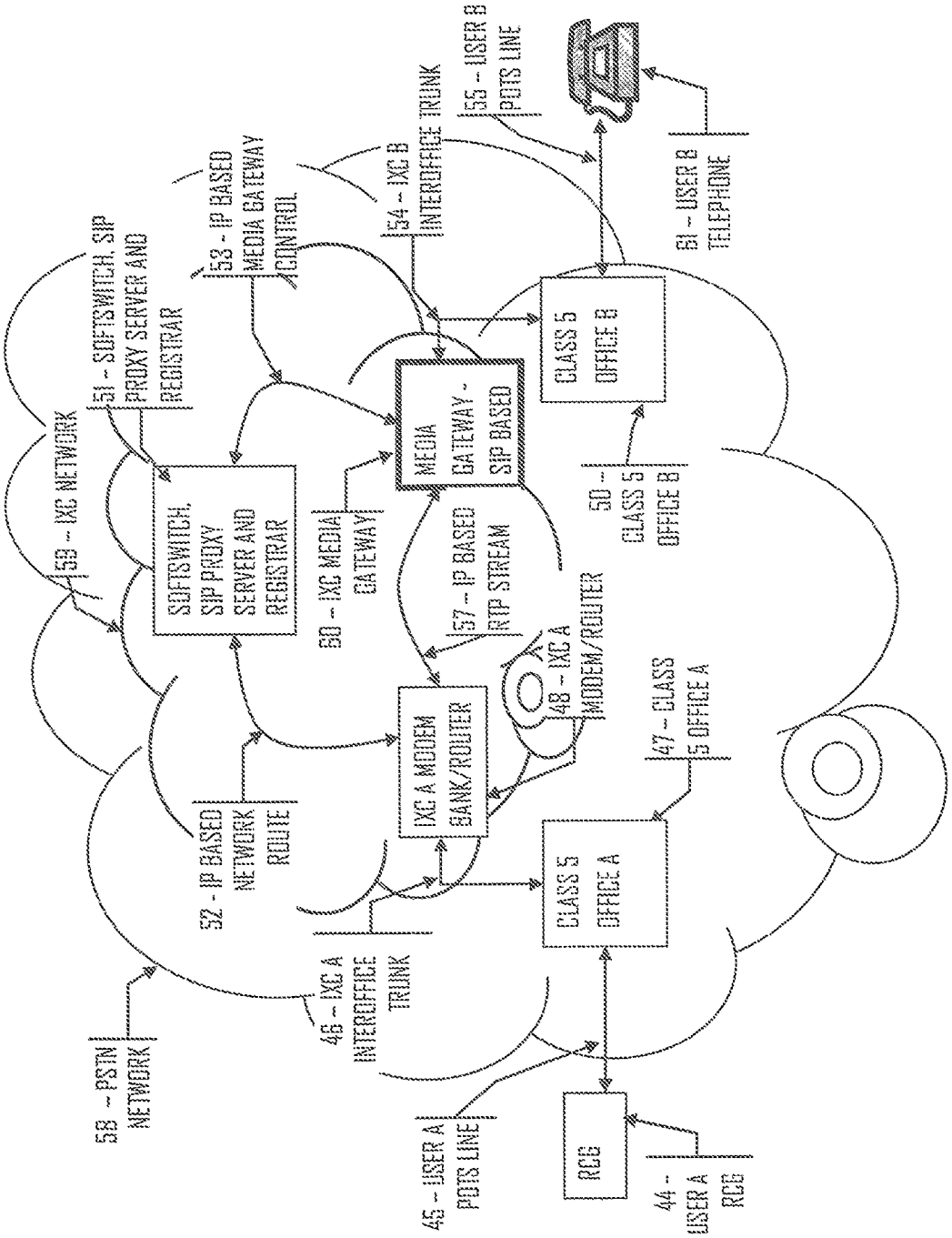

58 – PSTN NETWORK
46 – IXC A INTEROFFICE TRUNK
45 – USER A POTS LINE
RCG
44 – USER A RCG
52 – IP BASED NETWORK ROUTE
IXC A MODEM BANK/ROUTER
CLASS 5 OFFICE A
47 – CLASS 5 OFFICE A
48 – IXC A MODEM/ROUTER
57 – IP BASED RTP STREAM
MEDIA GATEWAY - SIP BASED
50 – CLASS 5 OFFICE B
CLASS 5 OFFICE B
61 – USER B TELEPHONE
55 – USER B POTS LINE
54 – IXC B INTEROFFICE TRUNK
53 – IP BASED MEDIA GATEWAY CONTROL
60 – IXC MEDIA GATEWAY
SOFTSWITCH, SIP PROXY SERVER AND REGISTRAR
51 – SOFTSWITCH, SIP PROXY SERVER AND REGISTRAR
59 – IXC NETWORK

FIG. 3

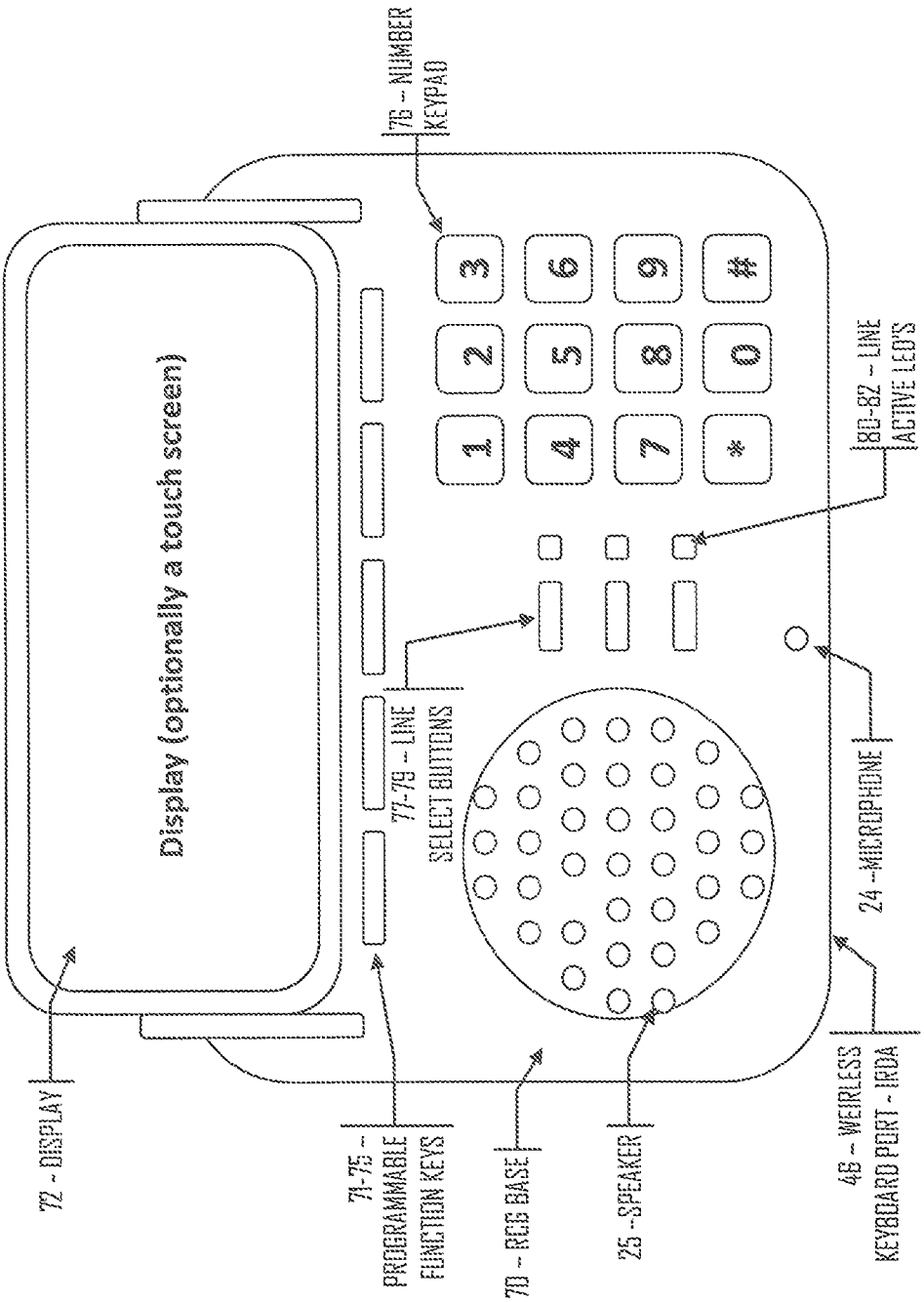

76 – NUMBER KEYPAD
Display (optionally a touch screen)
1
2
3
4
5
6
7
8
9
*
0
#
80-82 – LINE ACTIVE LED'S
77-79 – LINE SELECT BUTTONS
24 – MICROPHONE
72 – DISPLAY
71-75 – PROGRAMMABLE FUNCTION KEYS
78 – RCG BASE
25 – SPEAKER
46 – WEIRLESS KEYBOARD PORT - IRDA

FIG. 4

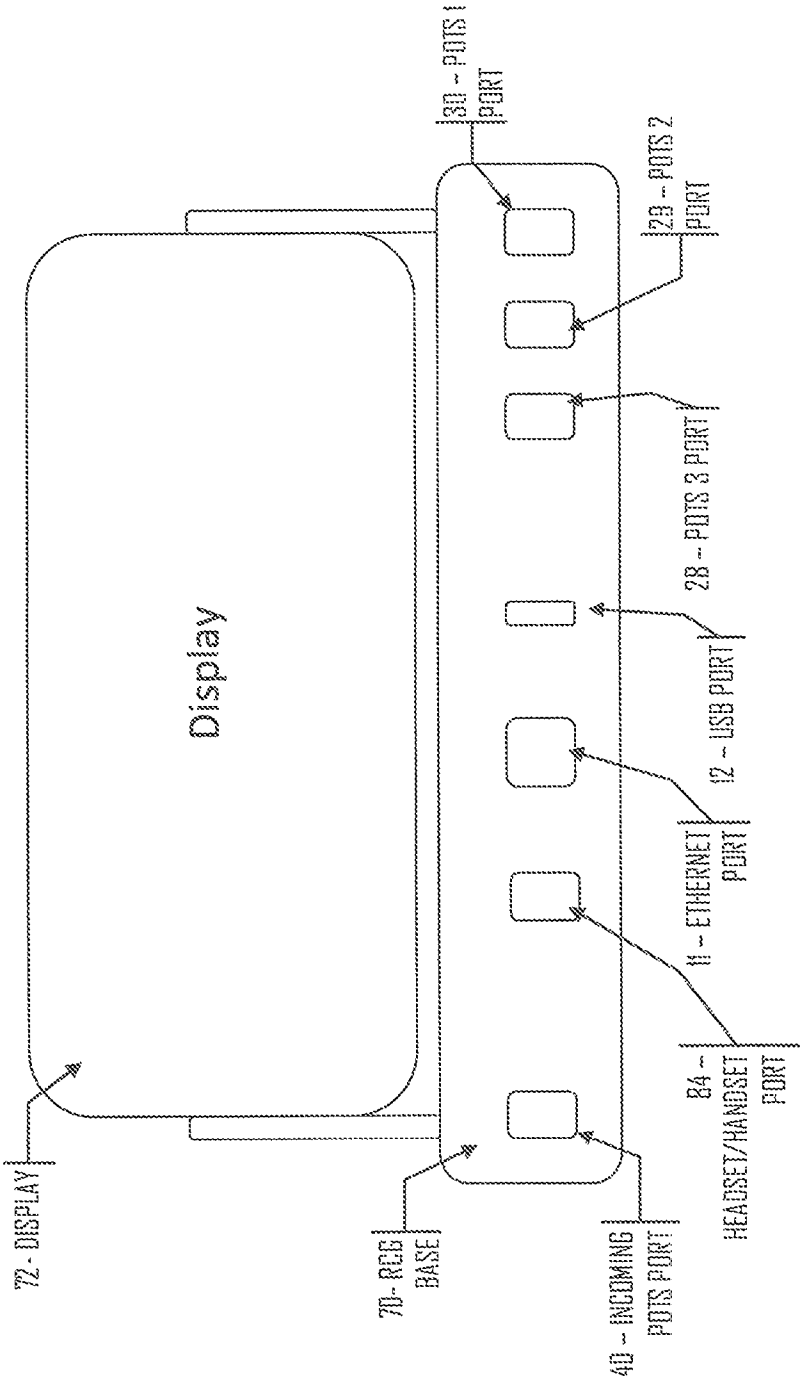

Display
72 - DISPLAY
70 - REG BASE
40 - INCOMING POTS PORT
84 - HEADSET/HANDSET PORT
11 - ETHERNET PORT
12 - USB PORT
28 - POTS 3 PORT
29 - POTS 2 PORT
30 - POTS 1 PORT

FIG. 5

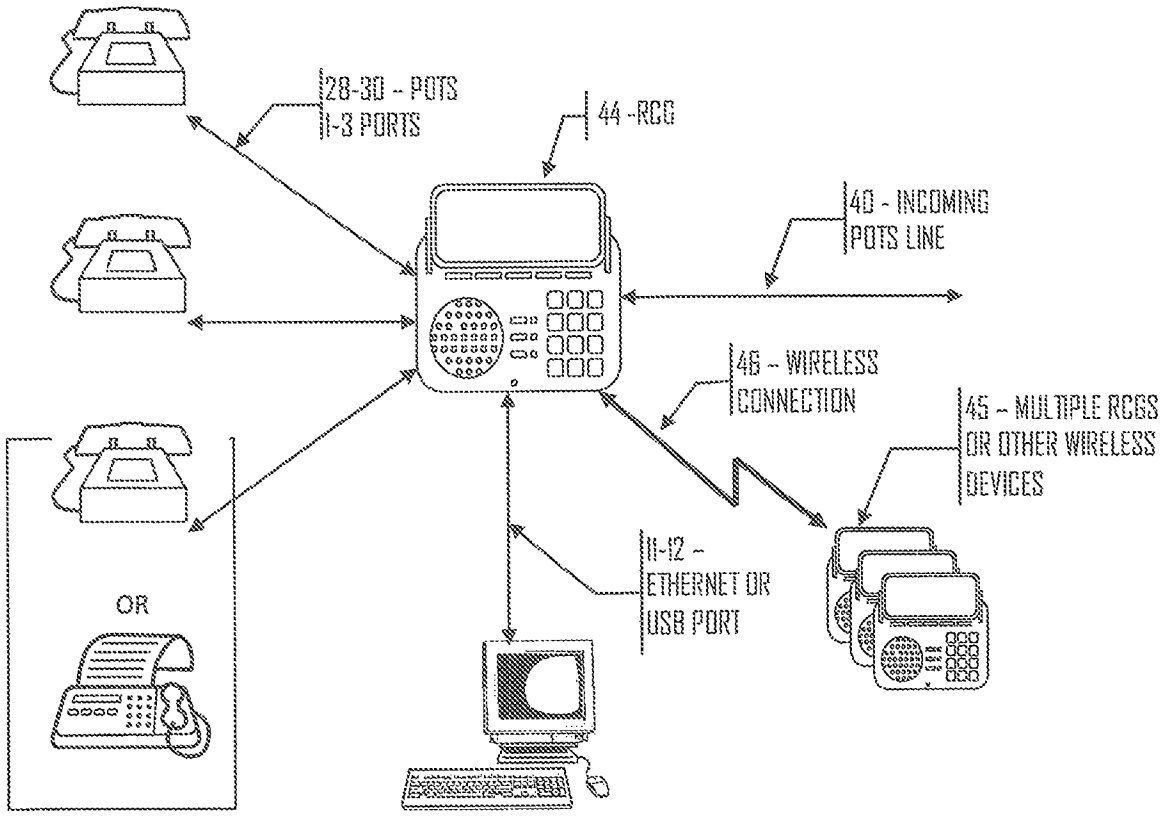

28-30 - POTS
1-3 PORTS
44 -RCG
40 - INCOMING
POTS LINE
46 - WIRELESS
CONNECTION
45 - MULTIPLE RCSS
OR OTHER WIRELESS
DEVICES
11-12 -
ETHERNET OR
USB PORT
OR

FIG. 6

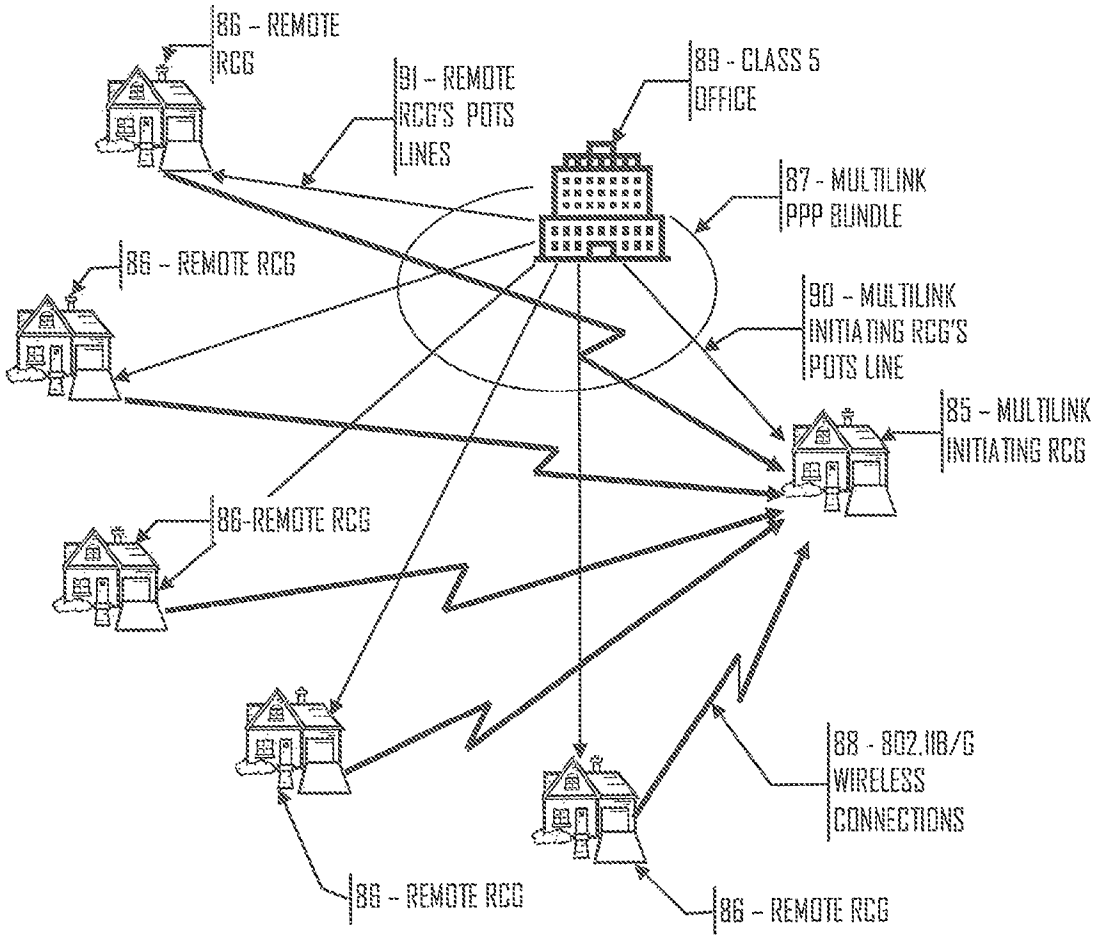

86 – REMOTE RCG
91 – REMOTE RCG'S POTS LINES
89 - CLASS 5 OFFICE
87 - MULTILINK PPP BUNDLE
86 – REMOTE RCG
90 – MULTILINK INITIATING RCG'S POTS LINE
85 – MULTILINK INITIATING RCG
86-REMOTE RCG
88 - 802.11B/G WIRELESS CONNECTIONS
86 – REMOTE RCG
86 – REMOTE RCG

FIG. 7

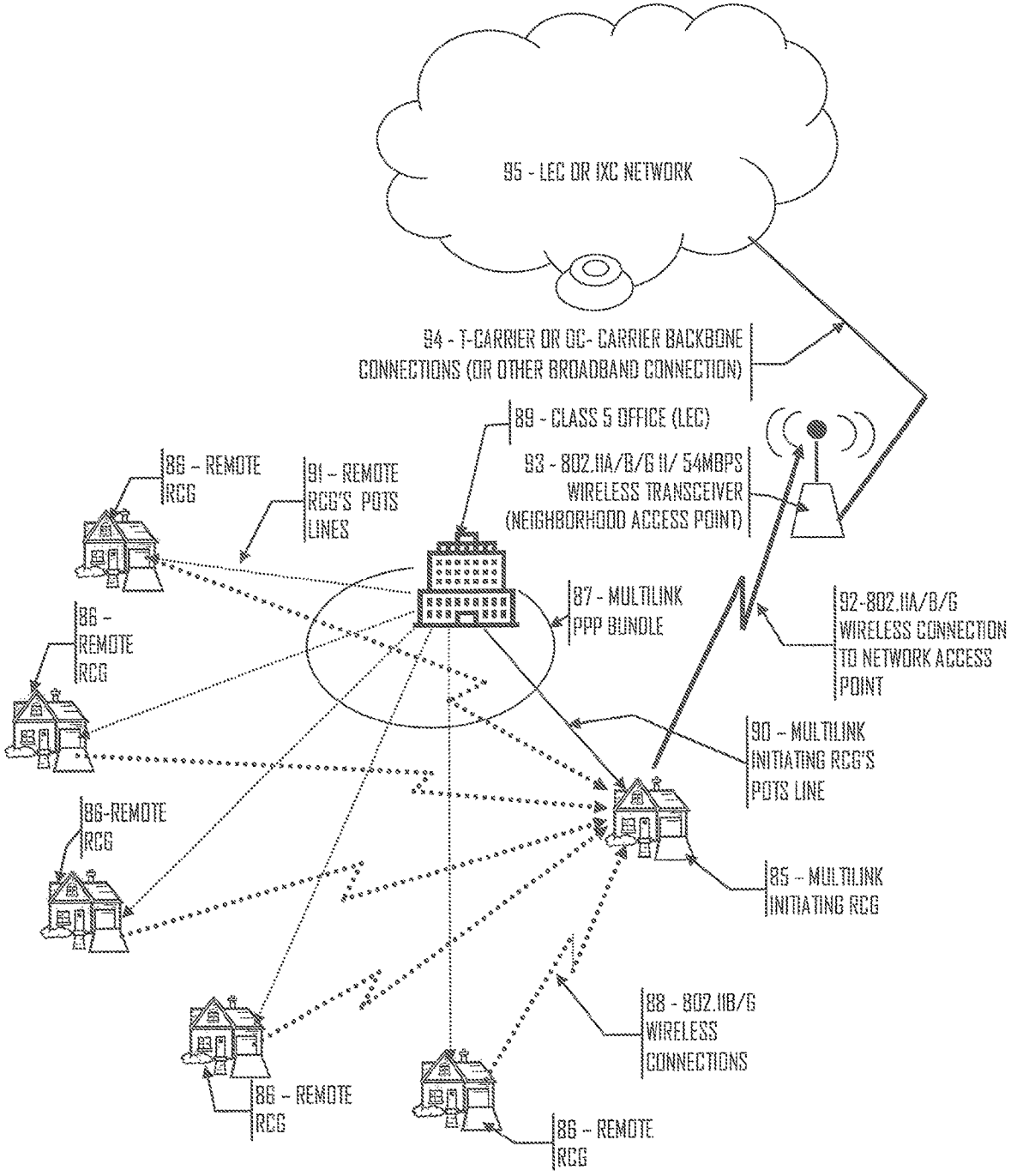

95 - LEC OR IXC NETWORK
94 - T-CARRIER OR OC- CARRIER BACKBONE CONNECTIONS (OR OTHER BROADBAND CONNECTION)
89 - CLASS 5 OFFICE (LEC)
93 - 802.11A/B/G N/ 54MBPS WIRELESS TRANSCEIVER (NEIGHBORHOOD ACCESS POINT)
86 – REMOTE RCG
91 – REMOTE RCG'S POTS LINES
87 - MULTILINK PPP BUNDLE
92-802.11A/B/G WIRELESS CONNECTION TO NETWORK ACCESS POINT
86 – REMOTE RCG
90 – MULTILINK INITIATING RCG'S POTS LINE
86-REMOTE RCG
85 – MULTILINK INITIATING RCG
88 - 802.11B/G WIRELESS CONNECTIONS
86 – REMOTE RCG
86 – REMOTE RCG

FIG. 8

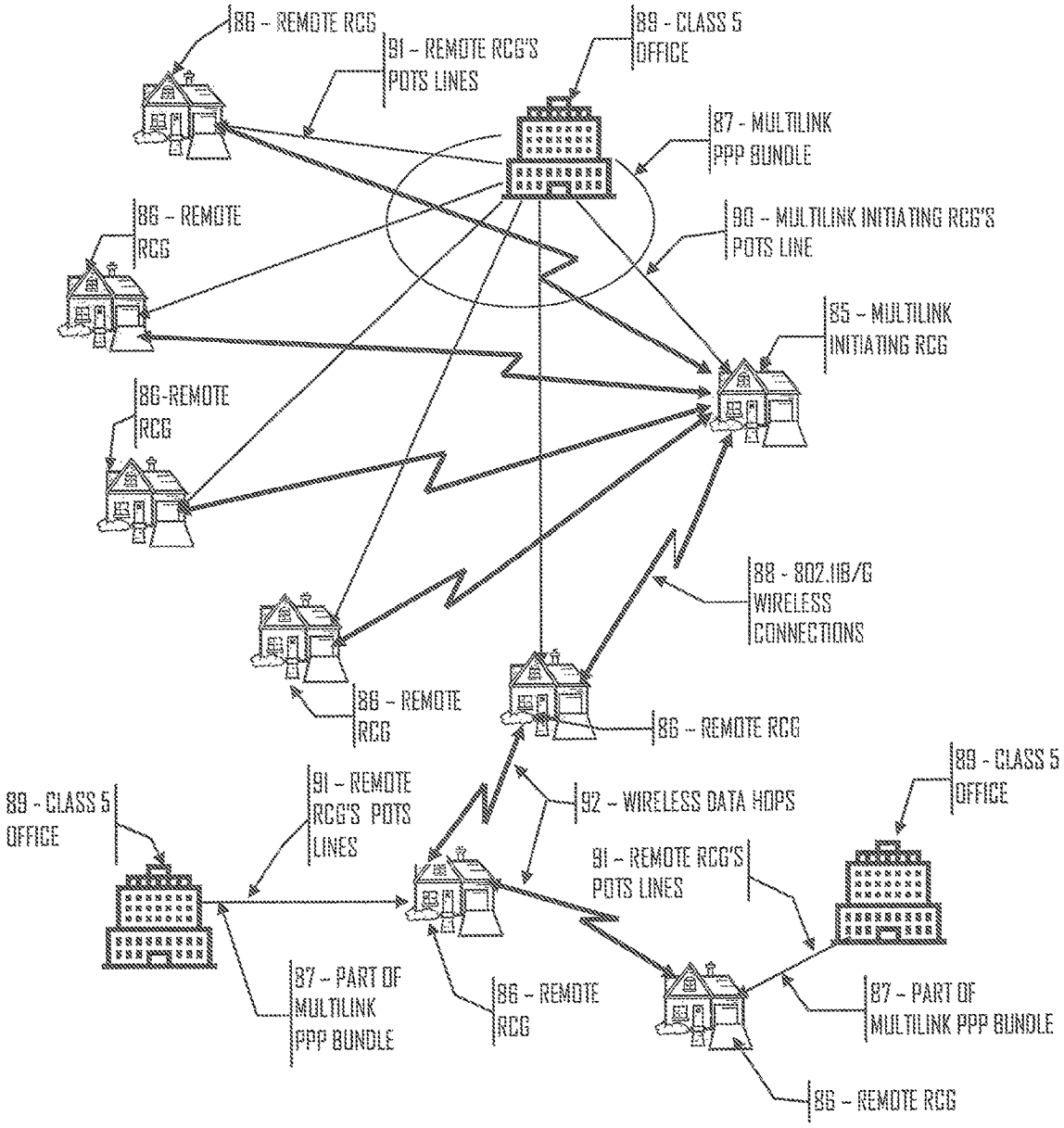

86 – REMOTE RCG
91 – REMOTE RCG'S POTS LINES
89 - CLASS 5 OFFICE
87 - MULTILINK PPP BUNDLE
86 – REMOTE RCG
90 – MULTILINK INITIATING RCG'S POTS LINE
85 – MULTILINK INITIATING RCG
86-REMOTE RCG
88 - 802.11B/G WIRELESS CONNECTIONS
86 – REMOTE RCG
86 – REMOTE RCG
89 - CLASS 5 OFFICE
91 – REMOTE RCG'S POTS LINES
92 – WIRELESS DATA HOPS
89 - CLASS 5 OFFICE
91 – REMOTE RCG'S POTS LINES
87 – PART OF MULTILINK PPP BUNDLE
86 – REMOTE RCG
87 – PART OF MULTILINK PPP BUNDLE
86 – REMOTE RCG

FIG. 9

DEVICES AND METHODS FOR MULTIPATH COMMUNICATIONS

RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 17/120,549 filed on Dec. 14, 2020, soon to be patented as U.S. Pat. No. 11,418,641, which is a continuation of U.S. patent application Ser. No. 15/161,787 filed May 23, 2016, now patented as U.S. Pat. No. 10,868,908, which is a continuation of U.S. patent application Ser. No. 14/512,414 filed Oct. 11, 2014, now patented as U.S. Pat. No. 9,350,649, which is a continuation of U.S. patent application Ser. No. 13/531,294 filed Jun. 12, 2012, now patented as U.S. Pat. No. 8,861,349, which is a continuation of U.S. patent application Ser. No. 12/581,852 filed Oct. 19, 2009, now patented as U.S. Pat. No. 8,228,801, which is a continuation of U.S. patent application Ser. No. 10/686,375 filed Oct. 14, 2003, now patented as U.S. Pat. No. 7,606,156, which claims priority to U.S. Provisional Application Ser. No. 60/418,521, filed Oct. 15, 2002, all of which are incorporated by reference herein.

BACKGROUND OF INVENTION

The primary function of the RCG is to provide a platform for Competitive Local Exchange Companies (CLECs) to compete with the Local Exchange Companies (LECs) for residential voice and data services. The LECs have a strangle hold on the "last mile" of copper over which almost all residential customers receive their communications services. Today, most CLECs resell the existing services that are offered by the LECs. CLECs make their money by purchasing these services from the LECs at a discount and marking them up to the customer. Since these services are regulated and controlled by the Public Utilities Commission (PUC) the pricing for these services to the CLECs is set. The monthly CLEC discount is approximately $5 to $6 per line per month for basic rate services. This means, in practicality, that a CLEC can only charge an additional $5 or $6 to the residential customer for basic rate services otherwise they would be more expensive than the LEC, and no one would buy the services from them; telephone customers would simply stay with the LEC.

To be competitive then, CLECs try to sell additional services such as call waiting, caller ID, etc. where they have as much as a 50% margin. Some CLECs also bundle long distance services with their packages as additional incentive to get residential customers to buy local telephone service from them. Since long distance fees are as low as pennies per minute to the customer, there is little profit in long distance for the CLECs. As it is, the pricing structure is such that the LECs will stay in control of the residential market, and the CLECs are nothing more than a marketing arm of the LEC. This structure also keeps the CLECs at an equal competitive advantage, or disadvantage, with respect to each other. The only thing that one CLEC could do to gain more customers is to be a better marketier. Since the CLECs are unable to discount their services because their margins are too slim as it is, the net effect is that the consumer looses by not really getting competition in the residential markets, and prices are kept artificially high.

For the CLECs to be truly competitive in the local telecommunications markets, they must be able to do more than simply resell the LECs services. CLECs must be able to offer many more features or services than those that the LEC provides, and they must be able to do this at a lower cost, in order to attract new customers.

So, what new services can the CLECs offer? As things stand today there are none, with the exception of DSL or Cable services which require tremendous infrastructure costs on behalf of the CLEC. However, by deploying an RCG in a residence, CLECs can offer advanced new calling features and services over the existing POTS line. Their costs for the POTS line from the LEC remains the same, but they can now charge for high bandwidth data services as well as additional calling and messaging features that the LECs cannot offer. This is their competitive advantage.

Competition:

Many companies are currently trying to provide VoIP services to residential customers over high-speed or broadband backbones such as DSL and cable modems, over Internet connections via a computer. The high-speed services require expensive infrastructure enhancements to the local telephone companies' facilities and cable plants, as well as expensive modems at the customer's end. These services are also difficult to deploy and too complicated for the average user. Internet based VoIP services suffer from Internet delays caused by a lack of true Quality of Service (QOS) capabilities across the Internet. Existing VoIP services also require access to a computer and a technical knowledge to be able to make it work. Because of these problems, VoIP services are primarily targeted at the corporate market place where private IP networks that can carry VoIP services with a true guaranteed QOS exist, or can be controlled.

The only available alternatives for the residential user for high speed services are DSL and cable modems. DSL and Cable based communications reach only a small segment of the population, and growth has failed to live up to initial expectations. The recent collapse of the internet boom has led to the failure of many DSL service providers and has effectively eliminated DSL as a potential service for most POTS users for the immediate future.

SUMMARY OF THE INVENTION

The RCG combines the capabilities and features of IP routers, Class 5 circuit switches and wireless LANs in a small stand-alone external modem like device. Additional capabilities for a hands-free speakerphone device with a large touch display are also detailed. The RCG can employ a large display with sufficient resolution to provide a functional user interface to access all of the advanced features offered by the RCG, but also to be able to provide video telephone services.

The device is placed in a residence and connected to the primary POTS line coming from the LEC. Up to three standard telephones or FAX machines (or any combination) are typically connected into the RCG. It also has a Universal Serial Bus (USB) and/or a 10-100 Ethernet interface for connection to a computer or a Local Area Network (LAN). In addition, it has an 802.11b/g wireless interface for wireless home networking as well as broadband-to-the-home services.

The system is installed in a customer's home by simply plugging it into the existing incoming telephone line that provides POTS services from the LEC. One or more standard telephones are then plugged into its three line-output jacks. This is the simplest and most basic usage. In this implementation, the user only is interested in gaining additional telephone lines into the household. No computer connection is required in order to use the system. However,

if data communications are desired, then there are three additional interfaces for computer connectivity. Typically either an Ethernet port, USB port or firewire (IEEE 1394) port is used to connect to a PC or LAN. The 802.11b/g interface is for wireless communications between the RCG and PCs, other RCGs as well as any other types of compatible wireless devices. A version of the RCG includes a speakerphone and video camera to provided for video telephone services.

Services Provided by the RCG:

The following discussion refers to FIG. **1**. The RCG has a main system processor that is responsible for all house keeping and traffic routing tasks. The Main CPU **19** routes data to and from the Ethernet Port **11**, USB Port **12**, Modem/DAA **41**, DSP Engine **33**, 802.11b/g Module **36** and the Display and Keypad **10**.

The RCG provides a total telecommunications communications services package for residential and small business customers. With the RCG, a CLEC can offer its customers dialtone for up to three separate telephone numbers per residence (the limit of three telephone numbers is an arbitrary number based upon typical residential usage and is not a limit imposed by the system), all local and long distance services, 24/7 always-on Internet access, a host of custom messaging and calling features, as well as Broadband access and lifeline service. All of these services can be offered over a customer's existing POTS line, and it doesn't require any network infrastructure build out like DSL and Cable services. Because there is no expensive network equipment required, it can be readily deployed throughout the country to expand the CLECs customer base quickly.

The RCG is designed to enhance, not replace, the existing telephone line, enabling it to provide new combined packetized voice and data services. Meanwhile, all existing telecommunications infrastructure and equipment will continue to work seamlessly with the RCG. Aside from simply installing the low cost RCG device in the home telephone wiring, no other equipment needs to be purchased by either the home owner or telephone companies. This eliminates the tremendously expensive infrastructure costs for communications companies that are trying to provide voice services using DSL or cable modems.

The RCG VIP Home Gateway Features:

Up to three telephone lines i.e. numbers, over a single POTS line and/or wireless connection.

Ethernet, USB and IEEE 1394 computer interfaces.

Full G1, G2 and G3 FAX support.

Full support for all CLASS services.

Broadband networking for home computers and appliances as well as wide area networking using a combination of a plurality POTS lines connected to a plurality of RCGs and/or a direct wireless connection to a wireless access point. (These interfaces allow smart devices to communicate to other devices within the home, or over the Internet through the RCG.)

Automated, remote upgradability and configuration. (Requires the customer to do nothing.)

Transparent user operation. (User doesn't have to know that any new technology is being employed)

100% compatible with existing public telephone system.

Video Telephone capabilities.

No local or long distance usage charges.

No Internet access fees.

Lower monthly communication costs.

Multiple telephone calls at the same time.

Voice messaging, follow me features, call forwarding, automatic call back, conferencing, custom call routing.

Home networking capabilities, all CLASS calling features, high speed broadband networking, continuous 24/7 internet access. and many others.

All of these features are available even while connected to the Internet.

Very low cost of entry into the market, especially as compared to broadband alternatives.

New calling features that are not currently available to home users.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows the RCG functional block diagram with the preferred embodiment of an 802.11 wireless connection.

FIG. **2** shows the network topology for native RCG to RCG communications.

FIG. **3** shows the network topology for an RCG to PSTN call.

FIG. **4** shows the RCG top view with associated functions.

FIG. **5** shows the RCG rear view and associated connections.

FIG. **6** shows a typical application with peripheral equipment connections.

FIG. **7** shows an ad-hoc wireless LAN configuration with ppp multilink data distribution and wireless connectivity.

FIG. **8** shows an ad-hoc wireless LAN configuration with ppp multilink data distribution and wireless connectivity with connection to a broadband neighborhood access point (Wi-Fi hot spot).

FIG. **9** shows an ad-hoc wireless LAN configuration with ppp multilink data distribution and wireless connectivity with wireless data hopping with POTS connections through numerous different Class 5 offices.

DETAILED DESCRIPTION OF THE INVENTION

The preferred embodiment is detailed herein using the ubiquitous 802.11 wireless protocol. It is by no means insinuated that this is the only wireless scheme that can be used by this device; rather, it is intended that any wireless transmission scheme can be used for wireless communications between this device and other wireless devices as various applications may dictate.

System Initialization

Refer to FIGS. **1**, **2** and **3** for the following discussion. When the RCG is first plugged into an AC power outlet the Main CPU **19**, performs a Power-on Self Test (POST) routine. Once the POST completes and the RCG is connected to an active POTS line, connected to the LEC, by means of the Incoming POTS Port **40**, the RCG automatically initiates a modem connection via the Modem/DAA **41**, to a registration service via a toll free 800 telephone number. The registration service connects directly to the service provider's sales or customer service offices via a VoIP connection. An operator or an automated service answers the call and sets up a new account for the customer. Once the account is set up, the service provider's network automatically sends control information to the device to store the required routing and feature/service information in its non-volatile memory of its Main CPU **19**. As part of this information, a local dialup telephone number is sent to the device that it will use for local network access in the same fashion as a standard ISP connection is made from a home computer. The URL of the Softswitch/SIP Proxy Server and Registrar **51** that will be controlling this particular device is

also stored at this time. During the service activation and configuration process, the customer service operator can send test requests to the device, as well as call into it on another telephone number (assuming an additional telephone number is part of the users class of service) or the speakerphone to verify that it is configured and working properly. The final step of the configuration and initialization process is to register the device with the appropriate Softswitch/SIP Proxy Server and Registrar **51** so that the Softswitch/SIP Proxy Server and Registrar **51** knows that it is the controlling SIP Proxy for this RCG. Also configured at this time is the username/password verification server (this is a standard network device and is not shown) that is used to allow the RCG's modem to make a connection onto the service provider's network. Once the RCG configuration is completed, it disconnects the call by hanging up the Modem/DAA **41**, then dials the new local network access number that had been sent during the configuration process and establishes a constant local network connection. This connection is maintained continuously on a 24/7 basis, and is immediately reestablished whenever it drops. Should the RCG become unable to reestablish this connection after several tries, it will switch over to failsafe mode and inform the user via the Display and Keypad **10**. The RCG will try to reestablish the connection every few minutes until it finally succeeds.

By default, the first telephone port, POTS **1** Port **30**, is assigned as the termination port for the existing POTS service that is connected to Incoming POTS Port **40**. This is the existing telephone service that the user already has as his primary telephone service from his LEC. POTS **1** Port **30**, typically has connected to it a standard telephone set that does not require any power (other than that derived over the POTS interface) to operate properly. POTS **1** Port **30** is the Lifeline telephone port for the user. In the case that all power is lost to the RCG, POTS **1** Port **30** will fail to a direct connection to the Incoming POTS Port **40** telephone line that comes into the RCG from the LEC to provide uninterrupted telephone services to the user. In this state, however, none of the enhanced VoIP services of the RCG are available to the user since the user simply has a stand POTS telephone service to the LEC.

Two additional and unique telephone numbers can be assigned to the other two telephone ports, POTS **2** Port **29** and POTS **3** Port **28**, by the service provider at any time. These numbers are drawn from a pool of available telephone numbers assigned to the service provider. POTS **2** Port **29** and POTS **3** Port **28** must to have standard telephone numbers assigned to them so that the PSTN is able to route calls from its network to these ports. For calls originating from IP based telephones, these numbers are not necessarily needed since POTS **1** Port **30**, POTS **2** Port **29** and POTS **3** Port **28** are uniquely identifiable to IP networks via their IP addresses assigned through the Dynamic Host Configuration Protocol (DHCP) at the time that the RCG establishes a connection to the service provider's network. Since POTS **2** Port **29** and POTS **3** Port **28** must have a telephone number assigned to them, it is a matter of convenience to use the assigned telephone numbers as part of their SIP address for IP routing of their data. In this way, all three user POTS ports, POTS **1** Port **30**, POTS **2** Port **29** and POTS **3** Port **28** are all addressed the same manor.

At this point, the user is able to take advantage of all of the RCG's features that have been activated according to his service agreement. The user can at any time connect additional telephones, a computer or a computer network to the RCG. The user will only be able to use those telephone ports (POTS **1** Port **30**, POTS **2** Port **29** or POTS **3** Port **28**) that have been activated, and assigned unique telephone numbers by the service provider. Any type of standard telephone can be connected to the three POTS ports, POTS **1** Port **30**, POTS **2** Port **29** and POTS **3** Port **28**. In the event that a cordless telephone or a telephone that derives its power from an AC outlet is connected to POTS **1** Port **30**, the lifeline functionality of this port will be ineffective since the telephone itself will not operate once power is lost.

The speaker phone feature of the RCG, comprised of Speakerphone Drivers **22**, Microphone **24**, Speaker **25** and DSP Engine **33**, can be used on any of the activated telephone numbers and is by default enabled to operate on POTS **1** Port **30**. Once either of the other two telephone ports, POTS **2** Port **29** or POTS **3** Port **28**, is activated, the speakerphone function is activated for those lines as well. To use the speakerphone for any assigned telephone number, the user simply presses either the Line Select Button **79-81** for Line **1**, Line **2** or Line **3** on the face of the RCG, and the speakerphone function is activated on that line. This is convenient for answering any call directly at the RCG. The RCG may or may not have a number keypad for originating calls. This feature may be added or removed based upon the target market price points.

The determination as to which Inter Exchange Carrier (IXC) the RCG will route its data through is determined by any of a number of criteria including, but not limited to, whether the RCG is a private labeled product, or which carrier has the lowest cost routing, or if a specific carrier is specified by the customer, or and number of other considerations. The RCG can be programmed to change its routing path to any IXC at any time by the service provider. Complicated routing algorithms can be programmed into the RCG to control which IXC it will use at any time.

Failsafe Mode

During any time that the RCG is in failsafe mode i.e. Lifeline failsafe logic **39** is activated, the RCG will only be able to receive or initiate telephone calls via the telephone connected to its primary telephone port, POTS **1** Port **30** or through its speakerphone feature. In this condition, all activated telephone numbers are ported via the PSTN to the primary (first) telephone number for delivery to the user's telephone that is connected to POTS **1** Port **30**. While in failsafe mode, the modem is not activated, and the RCG appears to the local Class 5 office as a standard telephone, and the PSTN will route all incoming calls to the RCG as it normally would to any standard telephone.

Call Flow 1:

Dialed call origination from a telephone connected to an RCG POTS port and terminating at another user's RCG POTS port:

When a user picks up a telephone connected to any of the three POTS ports, POTS **1** Port **30**, POTS **2** Port **29** and POTS **3** Port **28**, an off hook condition is detected by the SLIC/CODEC Interface **27** that is connected to the DSP Engine **33** by way of the DSP Audio Interface **31**. The DSP Engine **33** responds by sending digitally generated dialtone to the appropriate POTS interface over the DSP Audio Interface **31**. (Note: all BORSCHT telephony functions are performed by the DSP Engine **33** and the SLIC/CODEC Interface **27**.) Upon hearing the dialtone, the user enters the desired telephone number on his telephone keypad. The Dual Tone Multi-Frequency (DTMF) digits that the user dials are decoded within the DSP Engine **33**. The dialed digits are transferred to the Main CPU **19** via the CPU/DSP Communications Path **34**. The Main CPU **19** polls the DSP Engine **33** approximately every two milliseconds looking for

data. The Main CPU **19** polling rate varies according to the process that is being performed. The CPU/DSP Communications path **34** also can generate an interrupt to force data transfer between it and the Main CPU **19**.

The Main CPU **19** generates a SIP Invite IP packet using the dialed digits as the called destination address and the URL of its local controlling SIP Proxy Server which was programmed into the RCG during the configuration process. The Main CPU **19** passes this SIP packet off to the Modem/DAA **41** for transmission over the network. The RCG Modem/DAA **41** is connected to and communicating with a modem in a modem bank located in the Inter Exchange Carrier's (IXCs) facility. This facility may actually be located in the LEC's physical plant or it may be physically located at another location.

Referring to FIG. **2**, User A RCG **44** is connected via its modem to the LEC's local Class 5 Office A **47**. In this example, the service provider's connections to the IXC A Modem Bank & Router **48** are through IXC A Inter-Office Trunks **46**. The service provider may or may not be the IXC. If the service provider does not have its own network, then it will purchase capacity from an IXC and route its traffic to that IXC's facilities. The SIP Invite IP Packet that is sent from User A RCG **44** transits the LEC's Class 5 Office A **47** facilities and is routed to the IXC A Modem Bank/Router **48** via the IXC A Inter-Office Trunks **46**. It is the job of the router to take the IP packet and route it on to its intended destination, in this case the appropriate SIP proxy server **51**. The router uses the URL for the Softswitch/SIP Proxy Server and Registrar **51** contained in the SIP Invite to know where to route the packet. (Note: The Softswitch, SIP Proxy Server and Registrar are logical devices that may reside in a single computer system, or may be implemented as completely separate devices. In this example, the Softswitch, SIP Proxy Server and Registrar are all shown as a single physical device running these three separate processes.) The IXC A Modem Bank/Router **48** sends the SIP Invite IP packet on to Softswitch/SIP Proxy Server and Registrar **51** via an IP based network route **52**.

The SIP Proxy Server process running on Softswitch/SIP Proxy Server and Registrar **51** performs a look up to determine the termination destination for the call using the dialed digits passed along in the SIP Invite IP packet. In this example, the terminating device for User B RCG **56** is via IXC B's Modem Bank/Router **49** then through Class 5 Office B **50** and over User B POTS line **55** and finally to User B RCG **56**. Not covered in detail here is the SIP message handling since it is completely covered in IETF RFC2543. This example shows that both the originating and terminating ends of this call are controlled by the same Softswitch/SIP Proxy Server and Registrar **51** device. Where the originating and terminating ends of a call are controlled by different Softswitch/SIP Proxy Server and Registrar devices, an additional level of SIP messaging is used between the two SIP Proxy Server processes of each of the Softswitch/SIP Proxy Server and Registrar devices to locate and control the terminating location of the call. Again, that information is covered in IETF RFC2543 and is repeated here.

After the call routing is setup using SIP, and User B answers the call, the Softswitch/SIP Proxy Server and Registrar **51** device sends IP address of the originating User A RCG **44** to the User B RCG **56** and the IP address of User B RCG **56** to User A RCG **44**. Once both RCG's have the other's IP address, they then communicate directly to each other using Real Time Protocol (RTP), and the Softswitch/SIP Proxy Server and Registrar **51** device is no longer part of the connection. This direct communication is shown as IP based RTP Stream **57** between IXC A Modem Bank/Router **48** and IXC B Modem Bank/Router **49**.

On the receiving end of the call, referring back to FIG. **2**, User B RCG **56** receives the SIP Invite data stream through its Modem/DAA **41** and passes it on to the Main CPU **19**. The Main CPU **19** reassembles the SIP IP packet and interrogates the header information to determine which POTS port, POTS **1** Port **30**, POTS **2** Port **29** and POTS **3** Port **28** the call is destined for based upon the dialed number contained in the SIP Invite message. The Main CPU **19** commands the DSP Engine **33** to control the SLIC/CODEC Interface **27** to apply ringing voltage to the selected POTS port to ring the phone. A corresponding SIP 180 (ringing) message is sent back to User A RCG **44** in the reverse direction. When the phone attached to the selected POTS port is answered, the off hook condition detected by the SLIC/CODEC Interface **27** is sent through the DSP Engine **33** to the Main CPU **19** that sends the SIP 200 OK message back to User A RCG **44** to let the RCG know that the call was answered by User B RCG **56** and to turn off the audible ringing tone for User B. Once the call is established, User A RCG **44** sends and ACK F12 SIP message to User B RCG **56** indicating that User A RCG **44** understands that the call setup has been completed.

The two RCGs now exchange SIP messages that include the type of voice encoding that will be used such as G.729, G.723.1, G.711 etc to configure their RTP streams so that they can reliably transfer the user information between them. At this point the call (voice data) is sent between both RCGs and a normal telephone conversation takes place between the user A and user B.

Call teardown is accomplished by either user hanging up their telephone. The RCG of the terminating end (the end that hangs up the phone first) detects the on-hook condition and sends a SIP Bye message to the other end. The other end upon receiving the SIP Bye message responds with an OK 200 SIP message and disables the appropriate POTS port that the user was using.

The Speakerphone interface can be used for either end of a telephone conversation in exactly the same way as described above except that the corresponding POTS port that the call was intended for is disabled if the call is answered via the speakerphone.

Call Flow 2:

Calls between an RCG device and a PSTN telephone:

Refer to FIG. **3** for the following discussion.

In the previous call example, the PSTN network had nothing to do since the call was over a previously established modem connection between two RCGs. In the cases where a call originates or terminates to a standard telephone serviced by a Class 5 office, the process is a bit more complicated.

When a call originates from a user via an RCG, such as User A RCG **44**, the call handling practices are exactly the same up to the point that the SIP Proxy Server process in the Softswitch, SIP Proxy Server and Registrar **51** performs a lookup to determine how to route the call. In this case, the SIP Proxy Server process determines that the call terminates at a standard PSTN telephone attached to the Class 5 Office B **50**. Since the call originates as a native VoIP service, it must be converted to a standard switched circuit based service to be able to be delivered to User B's telephone **61**. The conversion is performed by the IXC's Media Gateway **60** device. In this example, the SIP Proxy Server process routes the call via the IXC's Media Gateway **60** device instead of through the IXC B Modem Bank/Router **49** as

before. The SIP Proxy Server process sends a SIP Invite to the IXC's Media Gateway **60** device, as well as other control information, to direct the Media Gateway **60** device to terminate the call and to apply the appropriate voice compression algorithm to the media stream to convert it between switched circuit PCM format and the selected VoIP protocol. At the same time, the Softswitch process of the Softswitch, SIP Proxy Server and Registrar **51** device sends commands to the Media Gateway **60** device to cause it to route the call's PCM data to a specific channel on the IXC B Interoffice Trunk **54**. The Softswitch process then generates an SS7 ISUP message that is sent over the PSTN SS7 signaling network to the Class 5 Office B informing it of the incoming call and on which circuit the call has been placed. It is up to the PSTN at this point to ring the User B telephone **61** and process the call between the IXC's Media Gateway and the User B Telephone **61**. The Softswitch process handles the signaling conversion between the PSTN's SS7 network and the IXC's SIP messaging, as well as any other proprietary signaling schemes utilized by the IXC to control its network. The standard SS7 call control messages, such as ringing, busy, ring back etc., all have a comparable SIP call flow control messages. The Softswitch simply maps the SS7 messages into SIP messages and visa-versa while routing the messages to the appropriate network equipment.

As in the case of a call between two RCGs, the RTP media stream (the actual call data) is routed directly be the IXC A Modem Bank/Router **48** and the IXC's Media Gateway **60** via an IP based RTP Stream **57**.

Again, call teardown is accomplished by either user hanging up their telephone. Depending which end hangs up the phone first, the associated network will generate the appropriate messages which will eventually make it back to the Softswitch process. The Softswitch process will relay the appropriate call control messages between the PSTN and the IXC's SIP based control system.

A telephone call originating from a PSTN telephone is configured and setup in the same fashion as the above description except that the originating messaging begins within the PSTN network instead of the IXC's network.

Personal Computer Based Communications:

Where the RCG is connected to a Personal Computer (PC) through either its USB Port **11** or Ethernet Port **12**, the RCG operates exactly as a cable or DSL type modem device. The RCG is simply a pass through for the computer's data. The RCG receives the IP packets (of whatever type) from the computer and sends the information unchanged to the Modem/DAA **41** interface for transmission over the Internet. Received information from the Internet is processed in the reverse way.

Dynamic Bandwidth Allocation:

When a modem connection is established between the RCG and the "Network", the total available bandwidth of this connection is used in a shared/prioritized fashion. Voice services (calls) take precedence over data services. Therefore, when no calls are in progress all of the available bandwidth is used by data type services such as surfing the Internet or uploading/downloading files. However, when a call is to be passed through the RCG, the required bandwidth for the call is deallocated from the data services and prioritized for the telephone call. This necessary because the Quality Of Service (QOS) is important for effective communications over electronic networks. Since the voice data is carried over a "data centric" network topology (an IP based network), call quality can suffer greatly. Every effort must be taken to eliminate or reduce the packet delay through every network element to be able to provide the best call quality. For data applications such as surfing the Internet or downloading files packet delay is acceptable and expected, and it does not affect the "quality" of the data.

Since all voice and data is transmitted as packets, there are no "time slots" or other type of "channelization" associated with the transmission of this data over either the POTS line or the wireless interface. Channelization of the voice data does occur within the SLIC/Codec Interface—**27** but is converted into IP packets by the DSP engine—**33** and is handled as packets from that point on.

Regardless of whether the call is originating or terminating at the RCG, the bandwidth allocation process is the same. When the SIP call setup messages are processed, the type of voice compression that will be used is defined. The RCG Main CPU **19** handles the IP packet flow between the DSP Engine **33**, USB Port **12**, Ethernet Port **11**, 802.11 b/g Module **36** and the Modem/DAA **41** devices giving priority to the voice packets to and from the DSP Engine **33** and the Modem/DAA **41** interfaces. Voice compression algorithms create IP packets at a specified number of packets per second. These packets are handled by a timed process in the RCG. This process is started during call setup so that the packets are handled at the correct rate based upon the compression algorithm's packet generation rate. There is no priority assigned between the voice packets of each of the three different POTS Ports **28**-**30**. When more than one voice call is in progress, they are handled in a round robin fashion based upon the packet rate for the compression algorithm used. If, for example, two calls are using a compression scheme that generates packets every 2 milliseconds, and the third generates packets every 4 milliseconds, then the calls utilizing the faster packet rate will be polled at twice the rate as the call using a slower packet rate but they are not given priority "over" the other call. Only when there are no voice packets ready for transmission to the Modem/DAA **41**, i.e. during the approximately 2 to 4 millisecond packetization period between packets, will any pending data packets received from the USB Port **12**, Ethernet Port **11** or the 802.11b/g Module **36** be sent to the Modem/DAA **41** for transmission over the network.

Thus, the POTS bandwidth is allocated on a per packet basis, not on a "time slot" or "channelization" or even a "frequency" basis as it the case with T-Carrier, DSL or channelized DSL systems. The same is true for the wireless interface, whether it is carrying pure data or voice.

Security is currently a big concern in today's networks, and especially with wireless 802.11 transmissions. For this reason, the RCG defaults to route voice data over the users POTS connection via Incoming POTS Port **40**. As security concerns regarding wireless communications transmissions are addressed and alleviated, voice call data can, and will, be routed over the wireless interface via the 802.11 b/g Module **36**.

FAX Transmission:

Group I, 2 and 3 fax transmission is completely supported by the RCG. Fax transmission has the same priority as other voice communications. That is to say that FAX transmission is treated the same as a voice call and takes precedence over native IP data traffic.

Broadband Over POTS:

One of the primary functions of the RCG is to be able to transfer large files such as video files over the POTS lines to a residence. The ability to do this is limited by the maximum of 56 Kbps due to the design of the digital Class 5 office linecards and network transmission schemes based upon T carriers. Typical Class 5 linecard design samples the POTS lines at a rate of 8,000 samples per second. Typically, each

sample is digitized into 12 to 16 bits by a codec device. The digitized sample is then companded to an 8 bit sample (1 byte) which makes up the PCM data stream that is transferred over the PSTN. Therefore, each POTS line is sampled at an effective rate of 64 Kbps. Since legacy T1 transmission equipment uses robbed-bit signaling, the maximum guaranteed transmission rate for the PSTN as a whole is 56 Kbps. Because of this limitation, standard POTS lines can only guarantee a maximum of 56 Kbps transfer rate under the best conditions. DSL equipment gets around this problem by installing DSL Access Multiplexing (DSLAM) equipment at the Class 5 office end of the POTS line. By routing around the linecard, as well as routing the data directly over the Internet or other private IP based networks, and therefore the 64 Kbps sampling rate, DSL is not bandwidth limited like PSTN traffic is. DSL, however, suffers from the very high costs associated with the purchase, installation, maintenance, floor lease costs, etc. DSL also suffers from very high deployment costs resulting from the labor intensive process to turn up each line. Each DSL "POTS" line must be inspected, conditioned and all load coils removed.

The RCG gets around the 56 Kbps POTS limitation as well as the DSL problems by using the standard POTS lines as they are, and not requiring any additional equipment to be installed at the Class 5 end of the POTS line. This technique simplifies deployment and drastically cuts costs.

Multilink PPP Connections:

Referring to FIG. **7**, the RCG implements broadband over POTS by employing an 802.11 b/g wireless interface to configure a multilink PPP bundle—**87** (per RFC 1990) comprised of the POTS lines connected to up to 32 RCGs. The limitation of 32 RCGs in a multilink PPP bundle is an arbitrary number and can be scaled up or down as required to support changes in network equipment capabilities. An 802.11b/g interface—**87** is shown as the preferred embodiment, since its 11/54 Mbps interface is considered sufficient bandwidth at this time also, its transmission distances are sufficient for implementation of this device, as opposed to other shorter ranged wireless transmission schemes. However as time goes on, some other wireless interface may be more desirable. There is nothing special or specific to the 802.11 wireless interface that makes it particularly suited to this application. Any wireless interface scheme can be used to implement this device.

The 802.11 b/g interface—**88** on an individual RCG is also used to provide a peer-to-peer wireless home networking environment to other 802.11 compatible wireless component within the residence (such as a hand-held computer device) while acting as an always on dialup Internet gateway over the POTS line—**40** for the other wireless devices. An RCG that is transferring a very large file can request the services of 31 (in this embodiment) other RCGs to assist in the file transfer using their respective POTS lines. A single RCG can therefore gain the combined bandwidth of up to 32 POTS lines transferring data at as much as 56 Kbps each to transfer information. This is roughly equivalent to a transfer rate of 1.79 Mpbs in the inbound direction (towards the RCG) and approximately 1.075 Mbps in the outbound direction (towards the PSTN).

The multilink PPP connection—**87** is initiated by an RCG when it determines that the file (or streaming service) that it is to download (receive) is of sufficient size or requires a minimum amount of bandwidth to justify the use of a multilink PPP connection. This determination can be made on many different criteria such as the file size, type of data being transmitted, the type of compression if any, a Quality-of-Service requirement or any other pertinent information. (Since a certain amount of overhead is required to set up a Multilink PPP connection, it doesn't make sense to use it for small or low data rate transfers.)

Multilink PPP Bandwidth Allocation and Initialization:

Referring to FIG. **7**, an RCG—**85** that decides to initiate a multilink PPP session with a remote computer i.e. internet URL, requests a multilink PPP session with that URL resource via Link Control Protocol (LCP) session management. The initiating RCG—**85** and the remote server computer (not shown) will negotiate the pertinent multilink parameters such as compression, packet size, sync/async, link quality monitoring, bit stuffing etc. As part of a successful multilink PPP session setup, the initiating RCG—**85** receives a multilink PPP session ID, or "magic number", which is used to identify this particular multilink PPP session and is also used for adding or removing links from the multilink bundle—**87**. Once the multilink bundle is setup, the initiating RCG—**85** begins data transfer across its POTS interface—**90** with the far end computer system. The initiating RCG—**85** then looks up the addresses of up to 31 (in this embodiment) other RCGs in its router tables to use for the multilink PPP transfer. (If a Neighborhood Access Point is available the RCG could request service through it instead of setting up a Multilink PPP connection—see FIG. **8**.) The initiating RCG—**85** determines the number of remote RCGs **86** that it wants to use to get the desired bandwidth for the transfer and sends multilink PPP service requests via the 802.11 b/g wireless connections—**88** to the selected remote RCGs—**86**. The selected remote RCGs—**86** respond back to the initiating RCG with either an acceptance or denial of multilink PPP service request. This decision is made based upon the remote RCG's currently available POTS bandwidth and the current local demands for that bandwidth. The remote RCG—**86** makes a decision to participate in a multilink PPP service for an initiating RCG if its POTS line—**91** has a current average bandwidth utilization of less than some arbitrary limit such as 8 Kbps to 16 Kbps. This 8 Kbps to 16 Kbps bandwidth utilization represents about two concurrent voice conversations using standard voice compression techniques, or some small amount of data transmission occurring on the remote RCG's POTS interface—**91** or a combination thereof. Assuming that the remote RCG—**86** has a modem connection speed somewhere between 33 Kbps to 56 Kbps, this would leave approximately 17 Kbps to 40 Kbps of POTS bandwidth that the remote RCG—**86** could offer to the initiating RCG—**85** for use in its multilink PPP bundle—**87**. Of course, if there is no activity on the remote RCG—**86** POTS line, then the entire bandwidth will be used for the multilink transfer. If the remote RCG—**86** accepts the multilink PPP service request from the initiating RCG—**85** it also sends its currently available bandwidth on its POTS line—**91** that the initiating RCG—**85** will have available to it for the multilink PPP transfers. The initiating RCG then selects which of the responding remote RCGs—**86** it will use for the multilink PPP bundle—**87** and sends them a multilink initialization packet containing the URL of the destination as well as the multilink PPP session ID (magic number) and any other pertinent information required for the remote RCG to join in the existing multilink PPP bundle—**87**. Each remote RCG POTS interface—**91** participating in a multilink PPP bundle, represents a logical "link" in the initiating RCG's multilink PPP bundle—**87**. The remote RCGs—**86** then send a multilink PPP packet (over their respective POTS lines—**91**) to the destination URL with the multilink PPP session ID and request to be added to that multilink PPP bundle—**87**. The destination URL accepts the request of each of the remote

RCGs—**86** and begins sending data packets to each over their respective POTS lines—**91**. When the remote RCGs—**86** receive data packets sent over their respective POTS lines—**91**, that are destined for the multilink PPP bundle—**87**, they simply relay the data packets over their 802.11b/g interface—**88** to the initiating RCG—**85**. It is the responsibility of the initiating RCG—**85** to perform all housekeeping tasks associated with the multilink transfer such as detection of lost packets and data packet reassembly, if those functions are required. Typically, lost packet detection and retransmission and reassembly are performed at higher OSI layers by the requesting software such as a browser. The remote RCGs—**86** are simply data transport nodes and do not perform any data processing on data received over a multilink PPP bundle destined for another RCG.

The initiating RCG—**85** of the multilink PPP bundle—**87** continually monitors the bandwidth of each remote RCG's—**86** multilink link which together comprise its multilink bundle—**87**. When the available bandwidth for the multilink PPP link of an individual remote RCG—**86** falls below an arbitrary minimum set by the initiating RCG—**85**, the initiating RCG—**85** instructs the offending remote RCG, via its 802.11b/g wireless interface—**88**, to remove itself from the multilink bundle. The remote RCG—**86** will then notify the remote computer (URL) to be removed as a link in the current multilink bundle on which it is participating. Alternatively, a remote RCG—**86** can inform the initiating RCG—**85** of local demands on its POTS bandwidth, and request that the initiating RCG—**85** remove it (the remote RCG—**86**) from the participation in the initiating RCG's multilink bundle—**87**. The remote RCG—**86** will not unilaterally remove itself from participation in a multilink bundle without prior notification to the Initiating RCG—**85**. The remote RCG—**86** must get authorization from the initiating RCG—**85** to remove itself from the bundle, since the initiating RCG—**85** will have no way of knowing if the loss of data from that remote RCG is due to some sort of failure or from the remote RCG simply removing itself from participation in the multilink bundle—**87**. Also, for services that require a minimum Quality of Service (QOS) such as streaming video, the initiating RCG—**85** needs to control the multilink bundle—**87** bandwidth, and it can not do that if remote RCGs—**86** drop out of the multilink bundle—**87** at will. When a remote RCG—**86** requests to be removed from participation in a multilink bundle—**87**, the initiating RCG—**85** must immediately grant the request. If the initiating RCG—**85** were to not grant the request, then the remote RCG—**86** could, in worst case, delay or drop incoming multilink packets destined for the initiating RCG—**85**. If this were to happen, the initiating RCG—**85** will have missing packets and could over run its reassembly buffer (if reassembly is being performed by the RCG) causing catastrophic data loss and potentially have to restart the entire transmission. In the least case, the initiating RCG—**85** would have to initiate retransmission of potentially many packets which it assumes to be lost, but may simply be delayed by the remote RCG—**86**. Once a remote RCG—**86** has been removed from participating in a multilink bundle—**87**, the initiating RCG—**85** will then look up another remote RCG in its router tables that can be used to participate in the multilink PPP bundle—**87**, and request that the new remote RCG—**86** to join the existing multilink bundle—**87**. This is necessary to maintain a minimum Quality of Service. Since RCGs prioritize their bandwidth requirements based upon their own "local" service requirements, their participation in any multilink PPP service is available only to bandwidth that is not required for its own current local demands. Therefore, a remote RCG's—**86** bandwidth that is available for multilink services can change at any time. The dynamic reassignment of remote RCGs that participate in a multilink bundle is also required to prevent a remote RCG—**86** from receiving packets so slowly that the originating RCG—**85** interprets this delay as lost packets. When the initiating RCG—**85** determines that a packet has been lost, and it is performing packet reassembly, it will, itself, request that the remote computer retransmit the lost packet. The initiating RCG will not ask any remote RCG—**86** to perform retransmissions or any other kind of data computations or manipulations.

Refer to FIG. **8** for the following discussion. In areas where there are existing 802.11 network equipment such as Neighborhood Access Point—**93**, or where there is sufficient bandwidth requirements from an installed base of RCGs to warrant the deployment of a Neighborhood Access Point—**93**, the RCGs will automatically detect the presence of the compatible neighborhood access points and register with that equipment for transport services. In this case, an RCG has an alternative broadband service route in addition to the multilink option. An RCG can communicate directly with a local 802.11 Network Access Point—**93** that is connected to the PSTN or another carrier's network via some sort of high bandwidth backbone such as a T-Carrier or optical carrier connection (T1, T3, OC3, OC12 etc.). The RCGs can communicate directly with neighborhood access points at their full 11/54 Mbps data rates to provide up to that full bandwidth to the user. This functionality is, of course, subject to the Network Access Point—**93** allowing access to its resources to the RCG according to the 802.11 wireless protocol.

This architecture is important since it provides an avenue to relieve the local class 5 offices of congestion that can be caused by a wide spread deployment of RCGs within the class 5 service area. Since each RCG requires a constant 24/7 modem connection, this ties up the class 5 switch in a fashion that it was not designed for. This could lead to wholesale class 5 office expansions which would be extremely expensive, and potentially prohibitive for the Local Exchange Carriers (LECs). By deploying neighborhood access points that operate at 54 Mbps (802.11a/g), in areas where the RCG concentration starts placing too high of a demand on the local class 5 office, the bandwidth from the RCGs can be aggregated by the neighborhood access points into large capacity backbones to relieve the switch congestion. In this case, the RCG POTS interface—**40** can be used solely as a lifeline connection, or when the 802.11 wireless LAN in which the RCG resides is congested. With this implementation, voice calls will be carried over the wireless interface as opposed to the POTS interface on which they would normally be carried. Also, the RCG modem—**41** connected to the POTS interface—**40** would not need to maintain a constant always on connection, it could be a dialed on demand connection and thereby relieving the local class 5 office switch.

Bouncing or Hopping Traffic:

Refer to FIG. **9**. In areas where the density of RCGs is less than the arbitrary number of 32 RCGs within its transmission radius for multilink connections, the RCGs can bounce, or relay, the data traffic between each other to reach other RCGs located farther than the RCGs wireless transmission area. Since the POTS data rate of 56 Kbps is miniscule as compared to the 11/54 Mbps 802.11b/g transfer rate, the overhead associated with bouncing data traffic is not a concern. This will allow for the fastest possible data transfer across POTS lines for every RCG user.

RCGs can also communicate directly with an 802.11a Neighborhood Access Point—**93** device (such as that used in WI-FI networks) that is connected to a data network connection such as a DS3 or OC3 service via a Metro Access Point. Where an RCG has access to a broadband device such as an 802.11a type device, either directly or via a bounced signal across several RCGs, a direct high speed data connection can be used to transfer large files. When an RCG is communicating directly with an 802.11a device, data transfer speeds up to the full 11/54 Mbps can be achieved to speed video transfers for such applications as video on demand.

RCG Router Tables:

The RCG continually monitors its 802.11b/g wireless interface for transmissions from other RCGs or 802.11a Access Points as well as other 802.11b/g wireless devices within the residence. The RCG provides a means to identify and store the addresses of other RCGs and Neighborhood Access Points within its local area. The RCG creates routing tables, much like an IP router device, so that it knows which RCGs are local to itself, and how many hops will be needed to reach the maximum of 32 POTS lines or a Neighborhood Access Point. The RCG can then determine how to route its data transfers to gain the most efficient routing and network efficiencies.

The router tables in each RCG are continually updated by monitoring the 802.11 frames received from other RCGs or Network Access Points. The number of entries in the router tables can be limited to an arbitrary number of other RCGs but contains room for at least 32 entries. For each RCG listed in the router tables, certain information is kept such as signal strength, if the other device is another RCG or some other 802.11 compatible device, if the other RCG is reachable directly, or if it is accessed via another RCGs by hopping. In the case there RCG hopping is used, the address of each RCG that is hopped is stored in the routing table. When an RCG is first powered up, it monitors its 802.11 interface for a period of time to identify other RCGs or Neighborhood Access Point devices, or other Wi-Fi devices within its transmission area. When first deployed, the RCG will not have any entries in its routing tables. This condition can persist for some time, until another RCG or other 802.11 device is deployed within the former RCGs transmission range. In this state, the RCG can be used for wireless networking within the residence, connecting the local computer to the RCGs always on Internet connection as well as to other wireless devices within the home. When an 802.11 frame is received by an RCG that contains the address of an RCG whose address does not exist in the receiving RCG's router table (as is the case when a new RCG is first installed), the receiving RCG polls the transmitting RCG for its router table information. The received router information is reviewed for other RCG's or other 802.11 compatible devices that are not listed in its own router tables. A decision is made to use some, all, or none of the new route information in its router tables. There is no real limitation on the number of RCGs that can be "hopped" in order to build a complete router table or to reach many more RCGs, Neighborhood Access Points or Metro Access Points.

Equipment and Services Priorities:

Just as voice has priority over data transfers within a single RCG, local RCG traffic (both voice and data) has priority over remote transfer requests by other RCGs. If an RCG is currently using all of its available POTS bandwidth for its own purposes, it will deny any remote RCG's request for access to its POTS line. Only when there is available POTS bandwidth available will an RCG allow other RCGs access to its POTS line. It will, however, bounce the traffic to other RCGs within its transmission area if requested by the originating RCG. In this case, available wireless bandwidth of any RCG (that amount of the 11/54 Mbps not currently used for its own traffic) can be used to relay traffic between other RCGs that do have available POTS bandwidth. In the same fashion, excess wireless bandwidth of any RCG can be by other RCGs to access high speed backbones via Neighborhood or Metro Access Points.

RCGs can also access other 802.11 wireless networks (Wi-Fi for example) that happen to be deployed within their service areas. In this case, access agreements between the RCG service provider and the wireless network operator must be put into place. By remaining compatible with the 802.11 standards, the RCGs capabilities will benefit by the growing WI-FI network infrastructure, an the WI-FI network will benefit by the RCG network.

Voice Over POTS and Data Over Wireless:

Normally, all communications from an RCG will be transmitted over the local POTS line, or a multilink bundle made up of many remote RCG POTS lines. By default, all voice calls will be carried over the "local" POTS line—**40** to alleviate security/privacy concerns and only "data" will be transmitted via multilink bundles. Generally, since voice "data" is compressed locally by the RCG, the required bandwidth for a voice call is so small that it does not make for a good choice to route it over a multilink connection. However, it is possible to route voice calls entirely over another RCGs POTS line. It is also possible for an RCG to transmit voice data over POTS lines connected to other RCGs via multilink bundles or directly over its 802.11 wireless interface, and since the 802.11 specification does support the Wired Equivalent Privacy (WEP) specification, a secured connection can be made in this fashion.

Remote Upgradability

The RCG is designed with the capability for unassisted remote upgradability. The remote upgradability feature is not the same as the storing of operational parameters during the configuration process. This feature allows the system operator to add new features as they are developed, or to correct bugs remotely and without the users knowledge or involvement. This feature can also be used to install a complete new operating system (OS).

Key to the successful implementation of the Remote upgradability feature is that a completely fail-safe routine be implemented that can recover from any failure during the upgrade process and to re-initiate and monitor the upgrade process until it has successfully completed. This process is carried out by loading a boot loader program that is stored in non-volatile memory. The boot loader program provides the minimum capabilities to start up the RCG and connect into the system operator's diagnostics network to download fixes or a new OS. The boot loader program is technically part of the OS, but it cannot be over written by any upgrade process. It is responsible for detecting failure of the RCG and initiating a connection to the diagnostics network. Once connected with the diagnostics network, the boot loader will provide diagnostics support to help correct the RCG's operation and reconfigure the OS.

What is claimed is:

1. A computer-implemented method for a first device to communicate via a wide area network, comprising the steps of:

connecting the first device to a first network having a first bandwidth via a second device;

connecting the first device to a second network having a second bandwidth via a third device;

establishing a connection through which data may be transferred between the first device and a fourth device by concurrently using a first portion of the first bandwidth and a second portion of the second bandwidth, the connection having an effective bandwidth including the first portion of the first bandwidth and the second portion of the second bandwidth; and

receiving by the first device a data set from the fourth device via the connection, wherein a portion of the data set is received through the first network and a portion of the data is received through the second network.

2. The computer-implemented method of claim **1**, wherein the second network comprises at least one wireless network.

3. The computer-implemented method of claim **2**, wherein the wireless network comprises a cellular network.

4. The computer-implemented method of claim **1**, wherein the first network is selected from the group consisting of a public wired network, a private wired network, a public wireless network, and a private wireless network.

5. The computer-implemented method of claim **1**, wherein the second device is selected from the group consisting of a residential communications gateway, a cable modem, a digital subscriber line modem, a wireless device, a neighborhood access point device, and a cellular modem.

6. The computer-implemented method of claim **1**, wherein the third device is selected from the group consisting of a residential communications gateway, a cable modem, a digital subscriber line modem, a wireless device, a neighborhood access point device, and a cellular modem.

7. The computer-implemented method of claim **1**, wherein the second network comprises the Internet.

8. The computer-implemented method of claim **1**, wherein the first network comprises a private network.

9. The computer-implemented method of claim **1**, wherein the first portion of the first bandwidth comprises substantially all the first bandwidth.

10. The computer-implemented method of claim **1**, wherein the step of connecting the first device to a first network having a first bandwidth via a second device includes the first network having current available bandwidth equal to or in excess of a minimum bandwidth.

11. The computer-implemented method of claim **1**, further comprising the step of assigning a session identifier to the connection.

12. A communication device capable of providing broadband communications services comprising:

a first connection via a first device to a first network having a first bandwidth including an allocated first portion of the first bandwidth;

a second connection via a second device to a second network having a second bandwidth including an allocated second portion of the second bandwidth; and

a third connection to a remote device via the first network and the second network, the third connection having an effective bandwidth including the allocated first portion of the first bandwidth and the allocated second portion of the second bandwidth;

wherein, in response to transmitting a request to the remote device via the third connection, the communication device receives a response from the remote device wherein a portion of the response is received via the first network and a portion of the response is received via the second network.

13. The communication device of claim **12**, wherein the second network comprises at least one wireless network.

14. The communication device of claim **12**, wherein the wireless network comprises a cellular network.

15. The communication device of claim **12**, wherein the first network is selected from the group consisting of a public wired network, a private wired network, a public wireless network, and a private wireless network.

16. The communication device of claim **12**, wherein the first connection is made to a first connection device selected from the group consisting of a residential communications gateway, a cable modem, a digital subscriber line modem, a wireless device, a neighborhood access point device, and a cellular modem and the second connection is made to a second connection device selected from the group consisting of a residential communications gateway, a cable modem, a digital subscriber line modem, a wireless device, a neighborhood access point device, and a cellular modem.

17. The communication device of claim **12**, wherein the first network comprises a private network and the second network comprises the Internet.

18. The communication device of claim **12**, wherein the first portion of the first bandwidth comprises substantially all the first bandwidth.

19. The communication device of claim **12**, wherein the allocated first portion of the first bandwidth meets or exceeds a minimum bandwidth.

20. The communication device of claim **12**, wherein the third connection includes an assigned session identifier.

* * * * *

EXHIBIT E

US008228801B2

(12) **United States Patent**
Delangis

(10) **Patent No.: US 8,228,801 B2**
(45) **Date of Patent: Jul. 24, 2012**

(54) **BROADBAND COMMUNICATIONS DEVICE**

(76) Inventor: **Eric M. Delangis**, Loveland, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 466 days.

(21) Appl. No.: **12/581,852**

(22) Filed: **Oct. 19, 2009**

(65) **Prior Publication Data**

US 2010/0098058 A1 Apr. 22, 2010

Related U.S. Application Data

(63) Continuation of application No. 10/686,375, filed on Oct. 14, 2003, now Pat. No. 7,606,156.

(60) Provisional application No. 60/418,521, filed on Oct. 15, 2002.

(51) **Int. Cl.**
H04L 12/26 (2006.01)
H04L 12/28 (2006.01)

(52) **U.S. Cl.** **370/235**; 370/401

(58) **Field of Classification Search** 370/235, 370/230, 233, 363, 371, 374, 381, 401, 433, 370/465–468, 470–474, 483–486, 493–495, 370/352, 395, 252

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,307,839	B1 *	10/2001	Gerszberg et al.	370/235
7,257,106	B2 *	8/2007	Chen et al.	370/338
7,385,924	B1 *	6/2008	Riddle	370/235
2006/0079274	A1 *	4/2006	Gallagher et al.	455/552.1

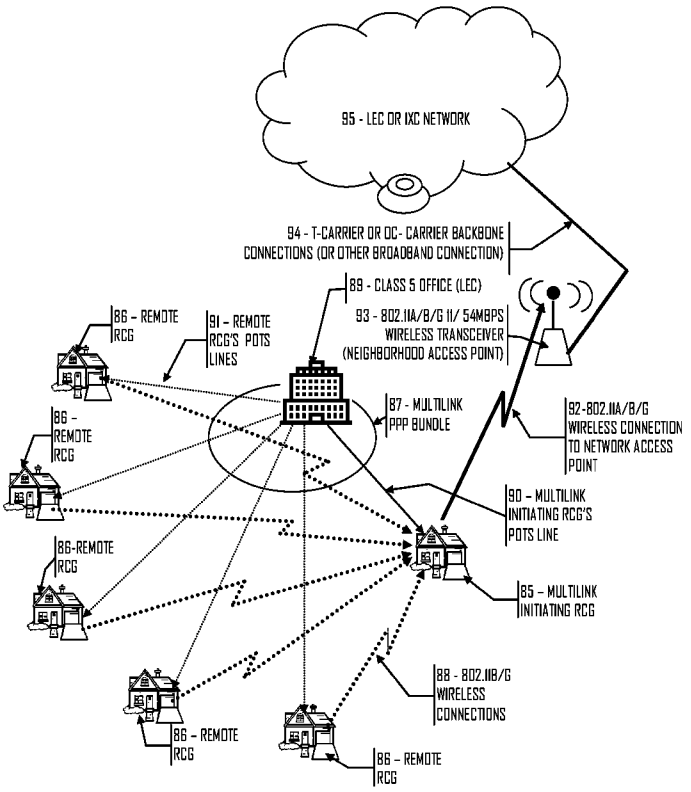
* cited by examiner

Primary Examiner — Hong Cho
(74) *Attorney, Agent, or Firm* — Clay McGurk; The Law Office of Clay McGurk

(57) **ABSTRACT**

The Residential Communications Gateway (RCG) is a broadband communications device that combines all voice, data and video communications to and from a typical residence or small business for transmission over a single, or a plurality of Plain Old Telephone Service (POTS) lines separately or in conjunction with, a wireless broadband backbone. The RCG does this by employing packetized data with Voice over Internet Protocol (VoIP) technologies combined with RF communications technologies. A key consideration to the design of the RCG is that no additional or special transmission equipment must be installed at the Central Office or anywhere else in the network to enable new calling features provided by the RCG as is the case with DSL and Cable systems. By eliminating the requirement for costly infrastructure enhancements, ubiquitous high speed communications and services can be deployed to every POTS subscriber.

17 Claims, 9 Drawing Sheets



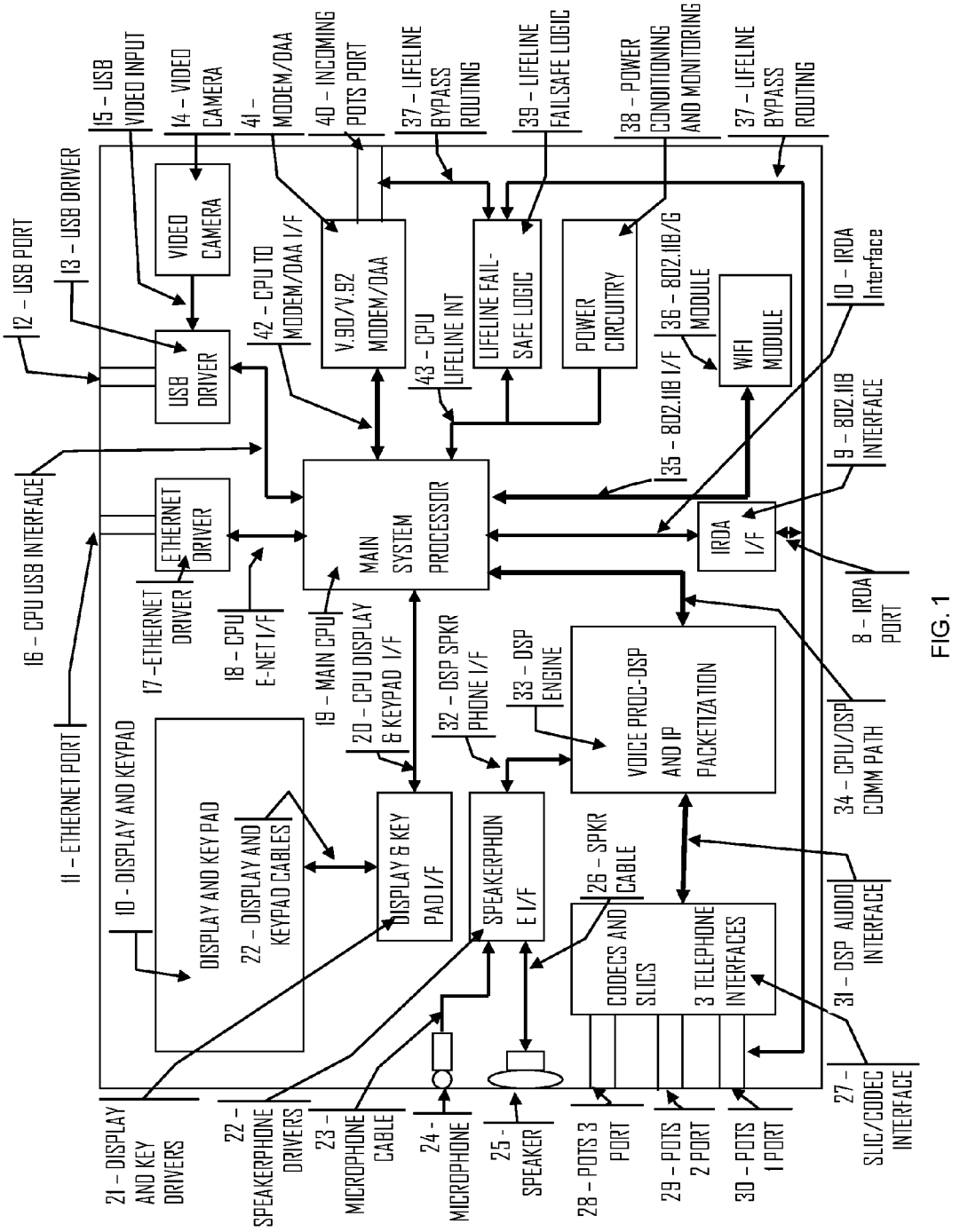

15 – USB VIDEO INPUT
14 – VIDEO CAMERA
41 – MODEM/DAA
40 – INCOMING POTS PORT
37 – LIFELINE BYPASS ROUTING
39 – LIFELINE FAILSAFE LOGIC
38 – POWER CONDITIONING AND MONITORING
37 – LIFELINE BYPASS ROUTING
12 – USB PORT
13 – USB DRIVER
VIDEO CAMERA
42 – CPU TO MODEM/DAA I/F
V.90/V.92 MODEM/DAA
43 – CPU LIFELINE INT
LIFELINE FAIL-SAFE LOGIC
POWER CIRCUITRY
36 – 802.11B/G MODULE
WIFI MODULE
10 – IRDA Interface
USB DRIVER
35 – 802.11B I/F
9 – 802.11B INTERFACE
16 – CPU USB INTERFACE
ETHERNET DRIVER
MAIN SYSTEM PROCESSOR
IRDA I/F
17 – ETHERNET DRIVER
18 – CPU E-NET I/F
19 – MAIN CPU
20 – CPU DISPLAY & KEYPAD I/F
32 – DSP SPKR PHONE I/F
33 – DSP ENGINE
VOICE PROC-DSP AND IP PACKETIZATION
8 – IRDA PORT
11 – ETHERNET PORT
10 - DISPLAY AND KEYPAD
DISPLAY AND KEY PAD
22 – DISPLAY AND KEYPAD CABLES
DISPLAY & KEY PAD I/F
SPEAKERPHON E I/F
26 – SPKR CABLE
34 – CPU/DSP COMM PATH
CODECS AND SLICS
3 TELEPHONE INTERFACES
31 – DSP AUDIO INTERFACE
21 – DISPLAY AND KEY DRIVERS
22 – SPEAKERPHONE DRIVERS
23 – MICROPHONE CABLE
24 – MICROPHONE
25 – SPEAKER
28 – POTS 3 PORT
29 – POTS 2 PORT
30 – POTS 1 PORT
27 – SLIC/CODEC INTERFACE

FIG. 1

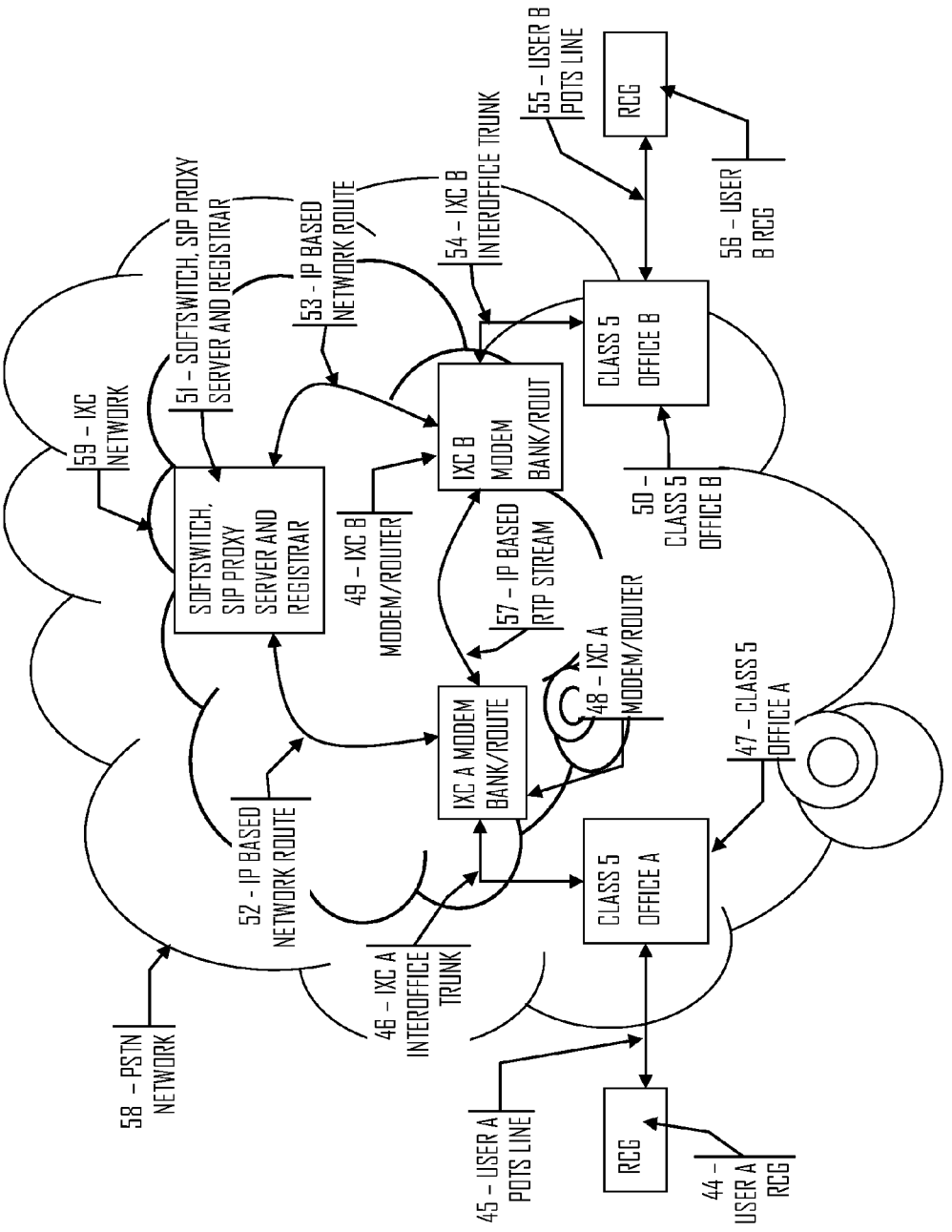

58 – PSTN NETWORK
46 – IXC A INTEROFFICE TRUNK
52 - IP BASED NETWORK ROUTE
45 – USER A POTS LINE
RCG
44 – USER A RCG
CLASS 5 OFFICE A
47 – CLASS 5 OFFICE A
IXC A MODEM BANK/ROUTE
48 – IXC A MODEM/ROUTER
57 – IP BASED RTP STREAM
49 – IXC B MODEM/ROUTER
SOFTSWITCH, SIP PROXY SERVER AND REGISTRAR
59 – IXC NETWORK
51 – SOFTSWITCH, SIP PROXY SERVER AND REGISTRAR
53 - IP BASED NETWORK ROUTE
54 – IXC B INTEROFFICE TRUNK
IXC B MODEM BANK/ROUT
50 – CLASS 5 OFFICE B
CLASS 5 OFFICE B
55 – USER B POTS LINE
RCG
56 – USER B RCG

FIG. 2

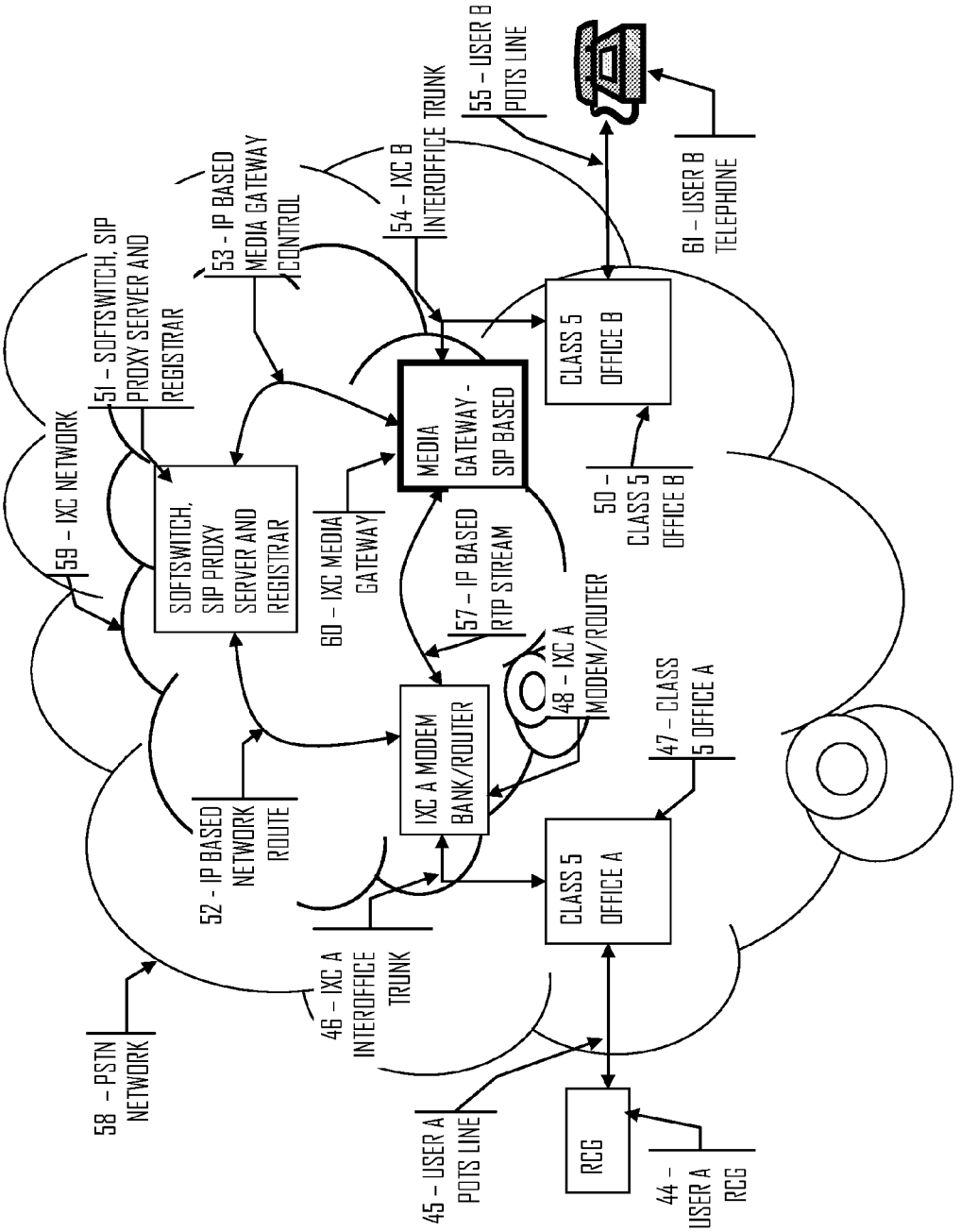

58 – PSTN NETWORK
46 – IXC A INTEROFFICE TRUNK
45 – USER A POTS LINE
RCG
44 – USER A RCG
52 - IP BASED NETWORK ROUTE
IXC A MODEM BANK/ROUTER
CLASS 5 OFFICE A
47 – CLASS 5 OFFICE A
48 – IXC A MODEM/ROUTER
57 – IP BASED RTP STREAM
60 – IXC MEDIA GATEWAY
SOFTSWITCH, SIP PROXY SERVER AND REGISTRAR
59 – IXC NETWORK
51 – SOFTSWITCH, SIP PROXY SERVER AND REGISTRAR
53 - IP BASED MEDIA GATEWAY CONTROL
MEDIA GATEWAY - SIP BASED
54 – IXC B INTEROFFICE TRUNK
50 – CLASS 5 OFFICE B
CLASS 5 OFFICE B
55 – USER B POTS LINE
61 – USER B TELEPHONE

FIG. 3

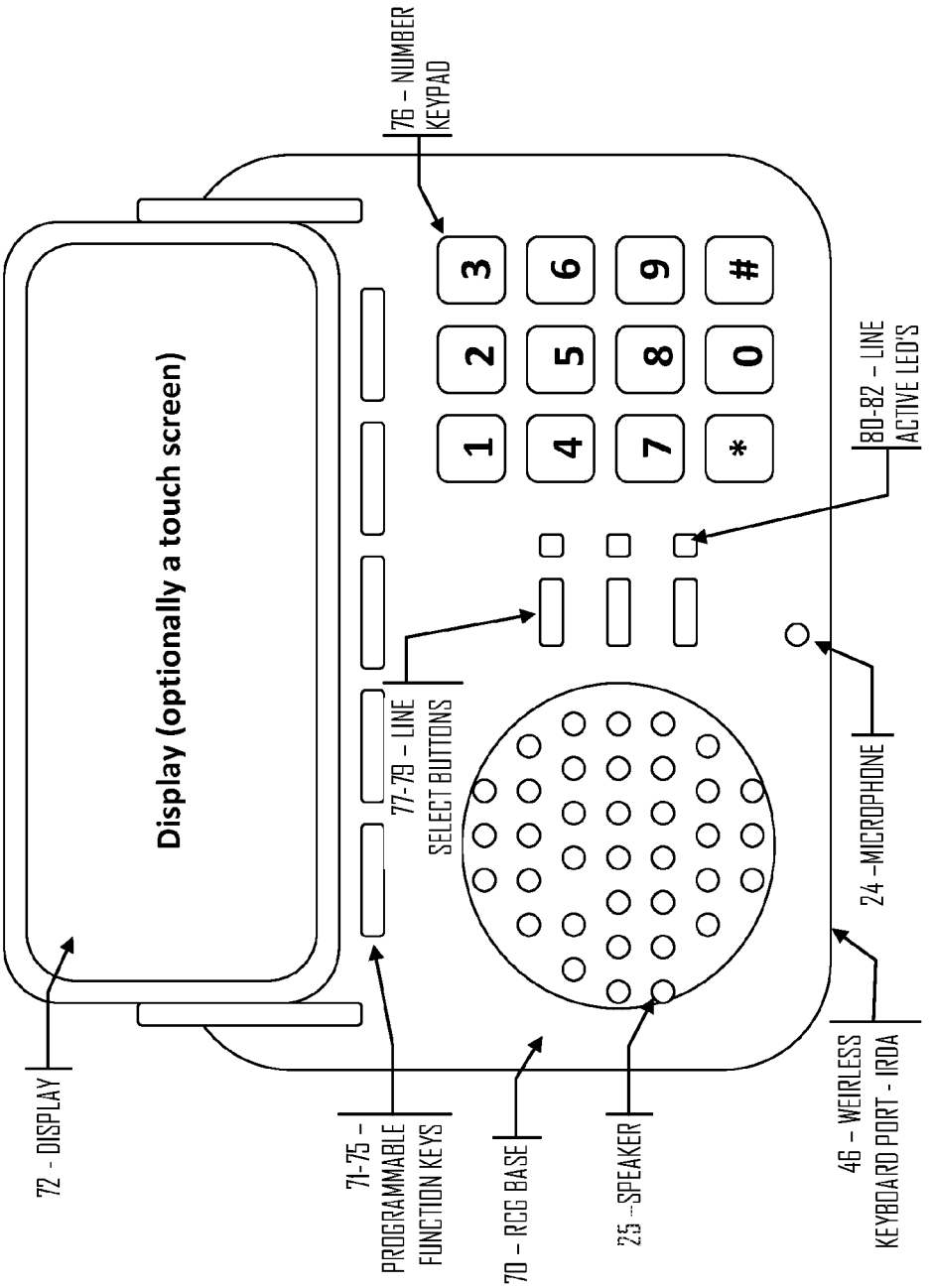

76 – NUMBER KEYPAD
Display (optionally a touch screen)
1
2
3
4
5
6
7
8
9
*
0
#
80-82 – LINE ACTIVE LED'S
77-79 – LINE SELECT BUTTONS
24 –MICROPHONE
72 - DISPLAY
71-75 – PROGRAMMABLE FUNCTION KEYS
70 – RCG BASE
25 –SPEAKER
46 – WEIRLESS KEYBOARD PORT - IRDA

FIG. 4

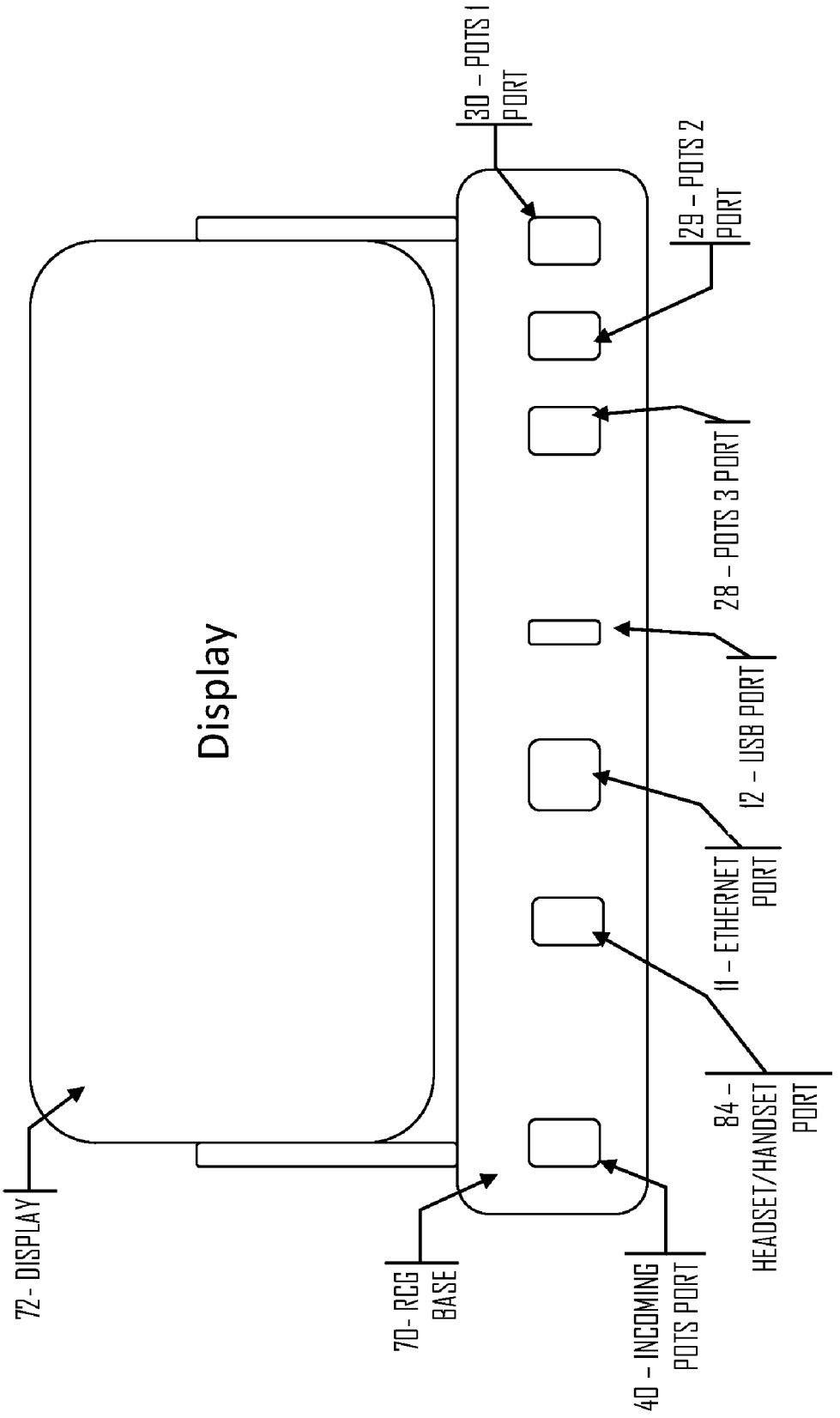

Display
72- DISPLAY
70- RCG BASE
40 – INCOMING POTS PORT
84 – HEADSET/HANDSET PORT
11 – ETHERNET PORT
12 – USB PORT
28 – POTS 3 PORT
29 – POTS 2 PORT
30 – POTS 1 PORT

FIG. 5

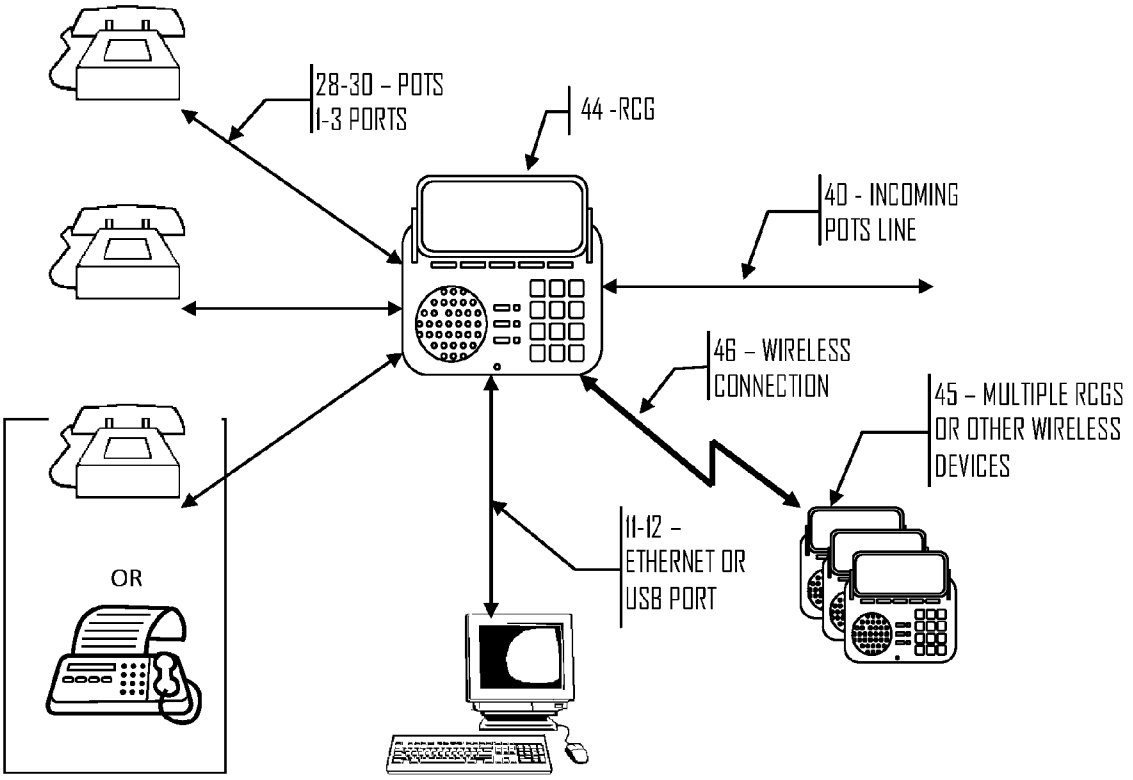

28-30 – POTS
1-3 PORTS
44 -RCG
40 - INCOMING
POTS LINE
46 – WIRELESS
CONNECTION
45 – MULTIPLE RCGS
OR OTHER WIRELESS
DEVICES
11-12 –
ETHERNET OR
USB PORT
OR

FIG. 6

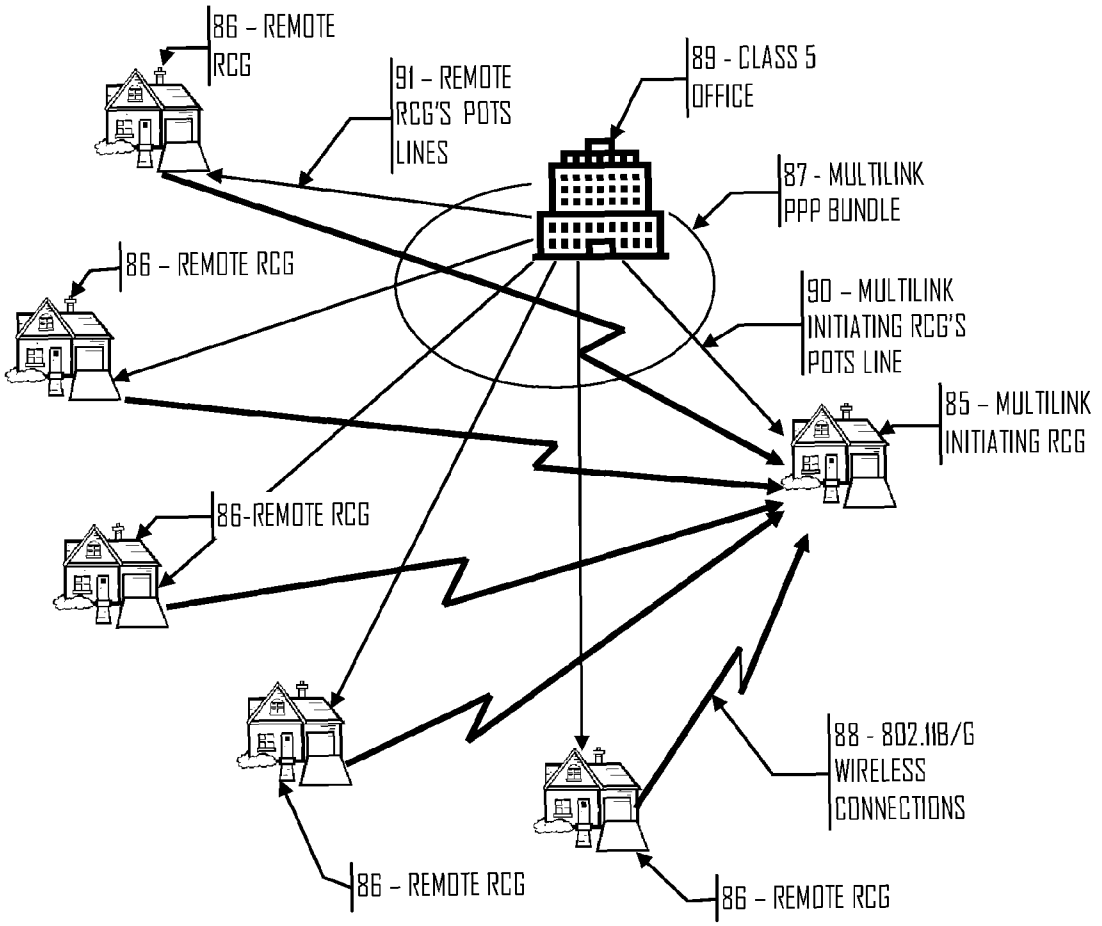

86 – REMOTE RCG
91 – REMOTE RCG'S POTS LINES
89 - CLASS 5 OFFICE
87 - MULTILINK PPP BUNDLE
86 – REMOTE RCG
90 – MULTILINK INITIATING RCG'S POTS LINE
85 – MULTILINK INITIATING RCG
86-REMOTE RCG
88 - 802.11B/G WIRELESS CONNECTIONS
86 – REMOTE RCG
86 – REMOTE RCG

FIG. 7

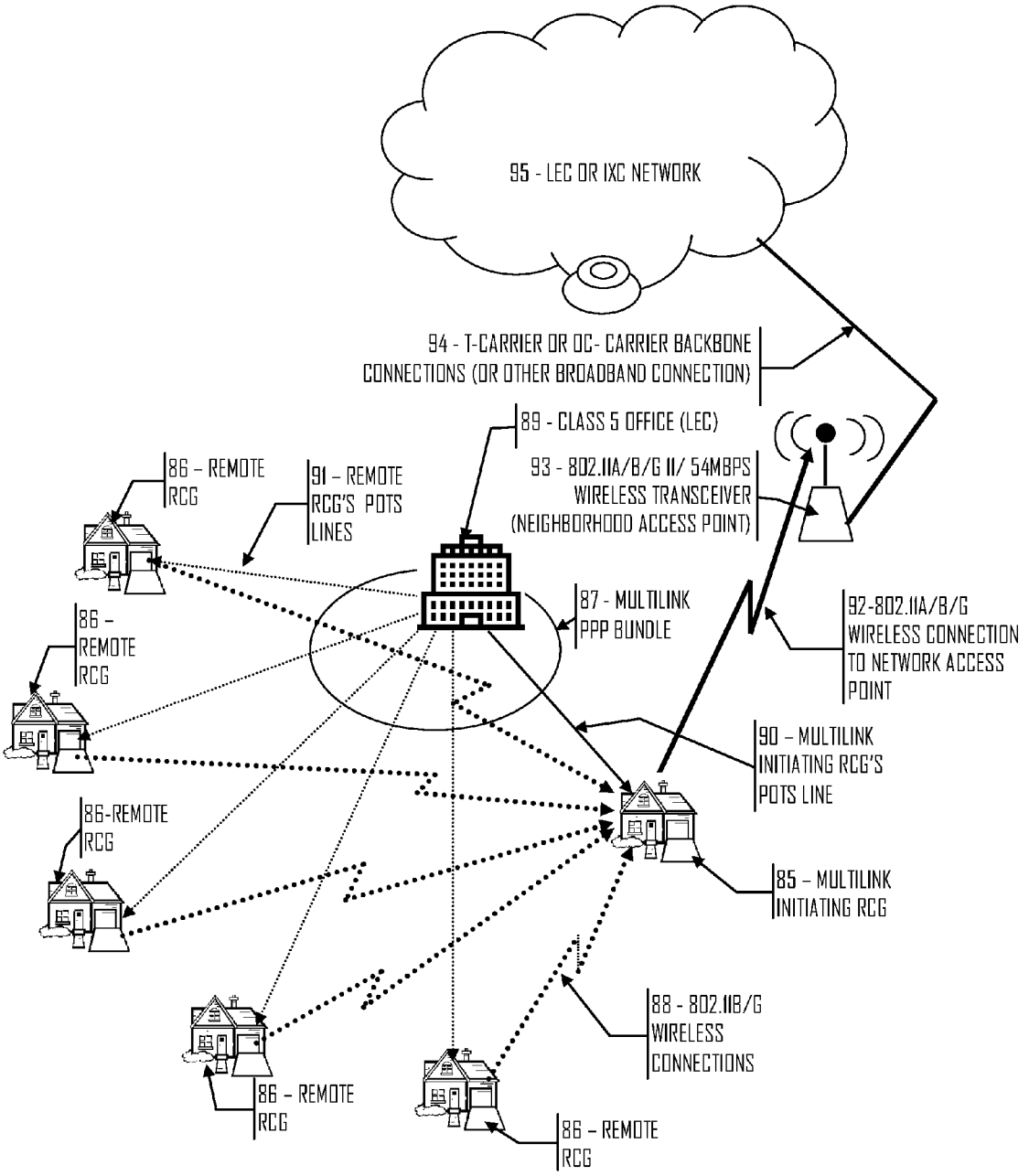

95 - LEC OR IXC NETWORK
94 - T-CARRIER OR OC- CARRIER BACKBONE CONNECTIONS (OR OTHER BROADBAND CONNECTION)
89 - CLASS 5 OFFICE (LEC)
93 - 802.11A/B/G II/ 54MBPS WIRELESS TRANSCEIVER (NEIGHBORHOOD ACCESS POINT)
86 – REMOTE RCG
91 – REMOTE RCG'S POTS LINES
87 - MULTILINK PPP BUNDLE
92-802.11A/B/G WIRELESS CONNECTION TO NETWORK ACCESS POINT
86 – REMOTE RCG
90 – MULTILINK INITIATING RCG'S POTS LINE
86-REMOTE RCG
85 – MULTILINK INITIATING RCG
88 - 802.11B/G WIRELESS CONNECTIONS
86 – REMOTE RCG
86 – REMOTE RCG

FIG. 8

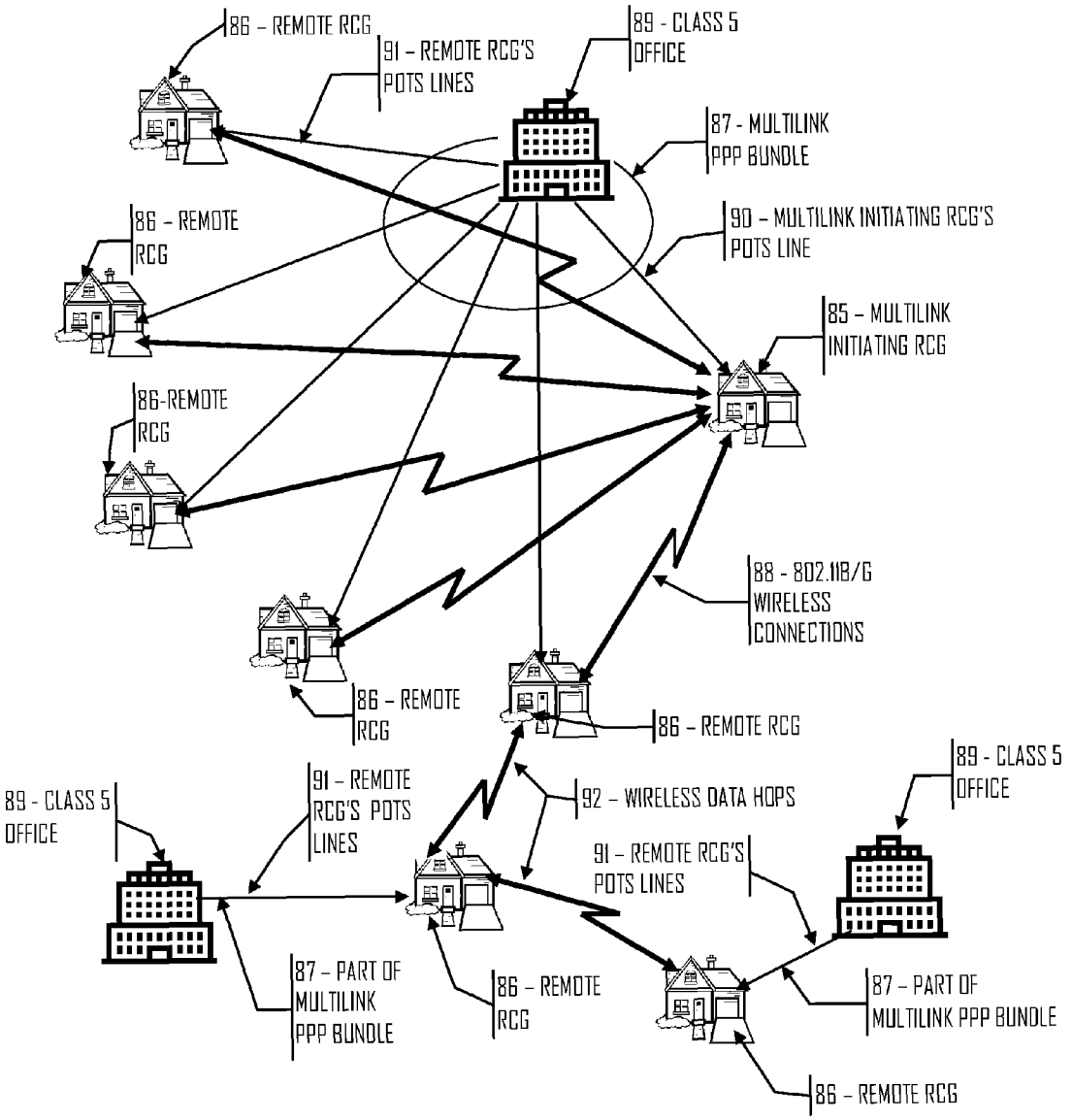

86 – REMOTE RCG
91 – REMOTE RCG'S POTS LINES
89 - CLASS 5 OFFICE
87 - MULTILINK PPP BUNDLE
86 – REMOTE RCG
90 – MULTILINK INITIATING RCG'S POTS LINE
85 – MULTILINK INITIATING RCG
86-REMOTE RCG
88 - 802.11B/G WIRELESS CONNECTIONS
86 – REMOTE RCG
86 – REMOTE RCG
89 - CLASS 5 OFFICE
91 – REMOTE RCG'S POTS LINES
92 – WIRELESS DATA HOPS
89 - CLASS 5 OFFICE
91 – REMOTE RCG'S POTS LINES
87 – PART OF MULTILINK PPP BUNDLE
86 – REMOTE RCG
87 – PART OF MULTILINK PPP BUNDLE
86 – REMOTE RCG

FIG. 9

BROADBAND COMMUNICATIONS DEVICE

RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 10/686,375 filed Oct. 14, 2003, which claims priority to U.S. Provisional Application Ser. No. 60/418,521, filed Oct. 15, 2002, all of which are incorporated by reference herein.

BACKGROUND OF INVENTION

The primary function of the RCG is to provide a platform for Competitive Local Exchange Companies (CLECs) to compete with the Local Exchange Companies (LECs) for residential voice and data services. The LECs have a strangle hold on the "last mile" of copper over which almost all residential customers receive their communications services. Today, most CLECs resell the existing services that are offered by the LECs. CLECs make their money by purchasing these services from the LECs at a discount and marking them up to the customer. Since these services are regulated and controlled by the Public Utilities Commission (PUC) the pricing for these services to the CLECs is set. The monthly CLEC discount is approximately $5 to $6 per line per month for basic rate services. This means, in practicality, that a CLEC can only charge an additional $5 or $6 to the residential customer for basic rate services otherwise they would be more expensive than the LEC, and no one would buy the services from them; telephone customers would simply stay with the LEC.

To be competitive then, CLECs try to sell additional services such as call waiting, caller ID, etc. where they have as much as a 50% margin. Some CLECs also bundle long distance services with their packages as additional incentive to get residential customers to buy local telephone service from them. Since long distance fees are as low as pennies per minute to the customer, there is little profit in long distance for the CLECs. As it is, the pricing structure is such that the LECs will stay in control of the residential market, and the CLECs are nothing more than a marketing arm of the LEC. This structure also keeps the CLECs at an equal competitive advantage, or disadvantage, with respect to each other. The only thing that one CLEC could do to gain more customers is to be a better marketier. Since the CLECs are unable to discount their services because their margins are too slim as it is, the net effect is that the consumer looses by not really getting competition in the residential markets, and prices are kept artificially high.

For the CLECs to be truly competitive in the local telecommunications markets, they must be able to do more than simply resell the LECs services. CLECs must be able to offer many more features or services than those that the LEC provides, and they must be able to do this at a lower cost, in order to attract new customers.

So, what new services can the CLECs offer? As things stand today there are none, with the exception of DSL or Cable services which require tremendous infrastructure costs on behalf of the CLEC. However, by deploying an RCG in a residence, CLECs can offer advanced new calling features and services over the existing POTS line. Their costs for the POTS line from the LEC remains the same, but they can now

charge for high bandwidth data services as well as additional calling and messaging features that the LECs cannot offer. This is their competitive advantage.

Competition:

Many companies are currently trying to provide VoIP services to residential customers over high-speed or broadband backbones such as DSL and cable modems, over Internet connections via a computer. The high-speed services require expensive infrastructure enhancements to the local telephone companies' facilities and cable plants, as well as expensive modems at the customer's end. These services are also difficult to deploy and too complicated for the average user. Internet based VoIP services suffer from Internet delays caused by a lack of true Quality of Service (QOS) capabilities across the Internet. Existing VoIP services also require access to a computer and a technical knowledge to be able to make it work. Because of these problems, VoIP services are primarily targeted at the corporate market place where private IP networks that can carry VoIP services with a true guaranteed QOS exist, or can be controlled.

The only available alternatives for the residential user for high speed services are DSL and cable modems. DSL and Cable based communications reach only a small segment of the population, and growth has failed to live up to initial expectations. The recent collapse of the internet boom has led to the failure of many DSL service providers and has effectively eliminated DSL as a potential service for most POTS users for the immediate future.

SUMMARY OF THE INVENTION

The RCG combines the capabilities and features of IP routers, Class 5 circuit switches and wireless LANs in a small stand-alone external modem like device. Additional capabilities for a hands-free speakerphone device with a large touch display are also detailed. The RCG can employ a large display with sufficient resolution to provide a functional user interface to access all of the advanced features offered by the RCG, but also to be able to provide video telephone services.

The device is placed in a residence and connected to the primary POTS line coming from the LEC. Up to three standard telephones or FAX machines (or any combination) are typically connected into the RCG. It also has a Universal Serial Bus (USB) and/or a 10-100 Ethernet interface for connection to a computer or a Local Area Network (LAN). In addition, it has an 802.11b/g wireless interface for wireless home networking as well as broadband-to-the-home services.

The system is installed in a customer's home by simply plugging it into the existing incoming telephone line that provides POTS services from the LEC. One or more standard telephones are then plugged into its three line-output jacks. This is the simplest and most basic usage. In this implementation, the user only is interested in gaining additional telephone lines into the household. No computer connection is required in order to use the system. However, if data communications are desired, then there are three additional interfaces for computer connectivity. Typically either an Ethernet port, USB port or firewire (IEEE 1394) port is used to connect to a PC or LAN. The 802.11b/g interface is for wireless communications between the RCG and PCs, other RCGs as well as any other types of compatible wireless devices. A version of the RCG includes a speakerphone and video camera to provided for video telephone services.

Services Provided by the RCG:

The following discussion refers to FIG. **1**. The RCG has a main system processor that is responsible for all house keeping and traffic routing tasks. The Main CPU **19** routes data to

and from the Ethernet Port **11**, USB Port **12**, Modem/DAA **41**, DSP Engine **33**, 802.11b/g Module **36** and the Display and Keypad **10**.

The RCG provides a total telecommunications communications services package for residential and small business customers. With the RCG, a CLEC can offer its customers dialtone for up to three separate telephone numbers per residence (the limit of three telephone numbers is an arbitrary number based upon typical residential usage and is not a limit imposed by the system), all local and long distance services, 24/7 always-on Internet access, a host of custom messaging and calling features, as well as Broadband access and lifeline service. All of these services can be offered over a customer's existing POTS line, and it doesn't require any network infrastructure build out like DSL and Cable services. Because there is no expensive network equipment required, it can be readily deployed throughout the country to expand the CLECs customer base quickly.

The RCG is designed to enhance, not replace, the existing telephone line, enabling it to provide new combined packetized voice and data services. Meanwhile, all existing telecommunications infrastructure and equipment will continue to work seamlessly with the RCG. Aside from simply installing the low cost RCG device in the home telephone wiring, no other equipment needs to be purchased by either the home owner or telephone companies. This eliminates the tremendously expensive infrastructure costs for communications companies that are trying to provide voice services using DSL or cable modems.

The RCG VIP Home Gateway Features:

Up to three telephone lines i.e. numbers, over a single POTS line and/or wireless connection.

Ethernet, USB and IEEE 1394 computer interfaces.

Full G1, G2 and G3 FAX support.

Full support for all CLASS services.

Broadband networking for home computers and appliances as well as wide area networking using a combination of a plurality POTS lines connected to a plurality of RCGs and/or a direct wireless connection to a wireless access point. (These interfaces allow smart devices to communicate to other devices within the home, or over the Internet through the RCG.)

Automated, remote upgradability and configuration. (Requires the customer to do nothing.)

Transparent user operation. (User doesn't have to know that any new technology is being employed)

100% compatible with existing public telephone system.

Video Telephone capabilities.

No local or long distance usage charges.

No Internet access fees.

Lower monthly communication costs.

Multiple telephone calls at the same time.

Voice messaging, follow me features, call forwarding, automatic call back, conferencing, custom call routing. Home networking capabilities, all CLASS calling features, high speed broadband networking, continuous 24/7 internet access and many others.

All of these features are available even while connected to the Internet.

Very low cost of entry into the market, especially as compared to broadband alternatives.

New calling features that are not currently available to home users.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows the RCG functional block diagram with the preferred embodiment of an 802.11 wireless connection.

FIG. **2** shows the network topology for native RCG to RCG communications.

FIG. **3** shows the network topology for an RCG to PSTN call.

FIG. **4** shows the RCG top view with associated functions.

FIG. **5** shows the RCG rear view and associated connections.

FIG. **6** shows a typical application with peripheral equipment connections.

FIG. **7** shows an ad-hoc wireless LAN configuration with ppp multilink data distribution and wireless connectivity.

FIG. **8** shows an ad-hoc wireless LAN configuration with ppp multilink data distribution and wireless connectivity with connection to a broadband neighborhood access point (Wi-Fi hot spot).

FIG. **9** shows an ad-hoc wireless LAN configuration with ppp multilink data distribution and wireless connectivity with wireless data hopping with POTS connections through numerous different Class 5 offices.

DETAILED DESCRIPTION OF THE INVENTION

The preferred embodiment is detailed herein using the ubiquitous 802.11 wireless protocol. It is by no means insinuated that this is the only wireless scheme that can be used by this device; rather, it is intended that any wireless transmission scheme can be used for wireless communications between this device and other wireless devices as various applications may dictate.

System Initialization

Refer to FIGS. **1**, **2** and **3** for the following discussion. When the RCG is first plugged into an AC power outlet the Main CPU **19**, performs a Power-on Self Test (POST) routine. Once the POST completes and the RCG is connected to an active POTS line, connected to the LEC, by means of the Incoming POTS Port **40**, the RCG automatically initiates a modem connection via the Modem/DAA **41**, to a registration service via a toll free 800 telephone number. The registration service connects directly to the service provider's sales or customer service offices via a VoIP connection. An operator or an automated service answers the call and sets up a new account for the customer. Once the account is set up, the service provider's network automatically sends control information to the device to store the required routing and feature/service information in its non-volatile memory of its Main CPU **19**. As part of this information, a local dialup telephone number is sent to the device that it will use for local network access in the same fashion as a standard ISP connection is made from a home computer. The URL of the Softswitch/SIP Proxy Server and Registrar **51** that will be controlling this particular device is also stored at this time. During the service activation and configuration process, the customer service operator can send test requests to the device, as well as call into it on another telephone number (assuming an additional telephone number is part of the users class of service) or the speakerphone to verify that it is configured and working properly. The final step of the configuration and initialization process is to register the device with the appropriate Softswitch/SIP Proxy Server and Registrar **51** so that the Softswitch/SIP Proxy Server and Registrar **51** knows that it is the controlling SIP Proxy for this RCG. Also configured at this time is the username/password verification server (this is a standard network device and is not shown) that is used to allow the RCG's modem to make a connection onto the service provider's network. Once the RCG configuration is completed, it disconnects the call by hanging up the Modem/DAA **41**, then dials the new local network access number that

had been sent during the configuration process and establishes a constant local network connection. This connection is maintained continuously on a 24/7 basis, and is immediately reestablished whenever it drops. Should the RCG become unable to reestablish this connection after several tries, it will switch over to failsafe mode and inform the user via the Display and Keypad **10**. The RCG will try to reestablish the connection every few minutes until it finally succeeds.

By default, the first telephone port, POTS **1** Port **30**, is assigned as the termination port for the existing POTS service that is connected to Incoming POTS Port **40**. This is the existing telephone service that the user already has as his primary telephone service from his LEC. POTS **1** Port **30**, typically has connected to it a standard telephone set that does not require any power (other than that derived over the POTS interface) to operate properly. POTS **1** Port **30** is the Lifeline telephone port for the user. In the case that all power is lost to the RCG, POTS **1** Port **30** will fail to a direct connection to the Incoming POTS Port **40** telephone line that comes into the RCG from the LEC to provide uninterrupted telephone services to the user. In this state, however, none of the enhanced VoIP services of the RCG are available to the user since the user simply has a stand POTS telephone service to the LEC.

Two additional and unique telephone numbers can be assigned to the other two telephone ports, POTS **2** Port **29** and POTS **3** Port **28**, by the service provider at any time. These numbers are drawn from a pool of available telephone numbers assigned to the service provider. POTS **2** Port **29** and POTS **3** Port **28** must to have standard telephone numbers assigned to them so that the PSTN is able to route calls from its network to these ports. For calls originating from IP based telephones, these numbers are not necessarily needed since POTS **1** Port **30**, POTS **2** Port **29** and POTS **3** Port **28** are uniquely identifiable to IP networks via their IP addresses assigned through the Dynamic Host Configuration Protocol (DHCP) at the time that the RCG establishes a connection to the service provider's network. Since POTS **2** Port **29** and POTS **3** Port **28** must have a telephone number assigned to them, it is a matter of convenience to use the assigned telephone numbers as part of their SIP address for IP routing of their data. In this way, all three user POTS ports, POTS **1** Port **30**, POTS **2** Port **29** and POTS **3** Port **28** are all addressed the same manor.

At this point, the user is able to take advantage of all of the RCG's features that have been activated according to his service agreement. The user can at any time connect additional telephones, a computer or a computer network to the RCG. The user will only be able to use those telephone ports (POTS **1** Port **30**, POTS **2** Port **29** or POTS **3** Port **28**) that have been activated, and assigned unique telephone numbers by the service provider. Any type of standard telephone can be connected to the three POTS ports, POTS **1** Port **30**, POTS **2** Port **29** and POTS **3** Port **28**. In the event that a cordless telephone or a telephone that derives its power from an AC outlet is connected to POTS **1** Port **30**, the lifeline functionality of this port will be ineffective since the telephone itself will not operate once power is lost.

The speaker phone feature of the RCG, comprised of Speakerphone Drivers **22**, Microphone **24**, Speaker **25** and DSP Engine **33**, can be used on any of the activated telephone numbers and is by default enabled to operate on POTS **1** Port **30**. Once either of the other two telephone ports, POTS **2** Port **29** or POTS **3** Port **28**, is activated, the speakerphone function is activated for those lines as well. To use the speakerphone for any assigned telephone number, the user simply presses either the Line Select Button **79-81** for Line **1**, Line**2** or Line **3** on the face of the RCG, and the speakerphone function is activated on that line. This is convenient for answering any call directly at the RCG. The RCG may or may not have a number keypad for originating calls. This feature may be added or removed based upon the target market price points.

The determination as to which Inter Exchange Carrier (IXC) the RCG will route its data through is determined by any of a number of criteria including, but not limited to, whether the RCG is a private labeled product, or which carrier has the lowest cost routing, or if a specific carrier is specified by the customer, or and number of other considerations. The RCG can be programmed to change its routing path to any IXC at any time by the service provider. Complicated routing algorithms can be programmed into the RCG to control which IXC it will use at any time.

Failsafe Mode

During any time that the RCG is in failsafe mode i.e. Lifeline failsafe logic **39** is activated, the RCG will only be able to receive or initiate telephone calls via the telephone connected to its primary telephone port, POTS **1** Port **30** or through its speakerphone feature. In this condition, all activated telephone numbers are ported via the PSTN to the primary (first) telephone number for delivery to the user's telephone that is connected to POTS **1** Port **30**. While in failsafe mode, the modem is not activated, and the RCG appears to the local Class 5 office as a standard telephone, and the PSTN will route all incoming calls to the RCG as it normally would to any standard telephone.

Call Flow 1:

Dialed call origination from a telephone connected to an RCG POTS port and terminating at another user's RCG POTS port:

When a user picks up a telephone connected to any of the three POTS ports, POTS **1** Port **30**, POTS **2** Port **29** and POTS **3** Port **28**, an off hook condition is detected by the SLIC/CODEC Interface **27** that is connected to the DSP Engine **33** by way of the DSP Audio Interface **31**. The DSP Engine **33** responds by sending digitally generated dialtone to the appropriate POTS interface over the DSP Audio Interface **31**. (Note: all BORSCHT telephony functions are performed by the DSP Engine **33** and the SLIC/CODEC Interface **27**.) Upon hearing the dialtone, the user enters the desired telephone number on his telephone keypad. The Dual Tone Multi-Frequency (DTMF) digits that the user dials are decoded within the DSP Engine **33**. The dialed digits are transferred to the Main CPU **19** via the CPU/DSP Communications Path **34**. The Main CPU **19** polls the DSP Engine **33** approximately every two milliseconds looking for data. The Main CPU **19** polling rate varies according to the process that is being performed. The CPU/DSP Communications path **34** also can generate an interrupt to force data transfer between it and the Main CPU **19**.

The Main CPU **19** generates a SIP Invite IP packet using the dialed digits as the called destination address and the URL of its local controlling SIP Proxy Server which was programmed into the RCG during the configuration process. The Main CPU **19** passes this SIP packet off to the Modem/DAA **41** for transmission over the network. The RCG Modem/DAA **41** is connected to and communicating with a modem in a modem bank located in the Inter Exchange Carrier's (IXCs) facility. This facility may actually be located in the LEC's physical plant or it may be physically located at another location.

Referring to FIG. **2**, User A RCG **44** is connected via its modem to the LEC's local Class 5 Office A **47**. In this example, the service provider's connections to the IXC A Modem Bank & Router **48** are through IXC A Inter-Office Trunks **46**. The service provider may or may not be the IXC.

If the service provider does not have its own network, then it will purchase capacity from an IXC and route its traffic to that IXC's facilities. The SIP Invite IP Packet that is sent from User A RCG **44** transits the LEC's Class 5 Office A **47** facilities and is routed to the IXC A Modem Bank/Router **48** via the IXC A Inter-Office Trunks **46**. It is the job of the router to take the IP packet and route it on to its intended destination, in this case the appropriate SIP proxy server **51**. The router uses the URL for the Softswitch/SIP Proxy Server and Registrar **51** contained in the SIP Invite to know where to route the packet. (Note: The Softswitch, SIP Proxy Server and Registrar are logical devices that may reside in a single computer system, or may be implemented as completely separate devices. In this example, the Softswitch, SIP Proxy Server and Registrar are all shown as a single physical device running these three separate processes.) The IXC A Modem Bank/Router **48** sends the SIP Invite IP packet on to Softswitch/SIP Proxy Server and Registrar **51** via an IP based network route **52**.

The SIP Proxy Server process running on Softswitch/SIP Proxy Server and Registrar **51** performs a look up to determine the termination destination for the call using the dialed digits passed along in the SIP Invite IP packet. In this example, the terminating device for User B RCG **56** is via IXC B's Modem Bank/Router **49** then through Class 5 Office B **50** and over User B POTS line **55** and finally to User B RCG **56**. Not covered in detail here is the SIP message handling since it is completely covered in IETF RFC2543. This example shows that both the originating and terminating ends of this call are controlled by the same Softswitch/SIP Proxy Server and Registrar **51** device. Where the originating and terminating ends of a call are controlled by different Softswitch/SIP Proxy Server and Registrar devices, an additional level of SIP messaging is used between the two SIP Proxy Server processes of each of the Softswitch/SIP Proxy Server and Registrar devices to locate and control the terminating location of the call. Again, that information is covered in IETF RFC2543 and is repeated here.

After the call routing is setup using SIP, and User B answers the call, the Softswitch/SIP Proxy Server and Registrar **51** device sends IP address of the originating User A RCG **44** to the User B RCG **56** and the IP address of User B RCG **56** to User A RCG **44**. Once both RCG's have the other's IP address, they then communicate directly to each other using Real Time Protocol (RTP), and the Softswitch/SIP Proxy Server and Registrar **51** device is no longer part of the connection. This direct communication is shown as IP based RTP Stream **57** between IXC A Modem Bank/Router **48** and IXC B Modem Bank/Router **49**.

On the receiving end of the call, referring back to FIG. **2**, User B RCG **56** receives the SIP Invite data stream through its Modem/DAA **41** and passes it on to the Main CPU **19**. The Main CPU **19** reassembles the SIP IP packet and interrogates the header information to determine which POTS port, POTS **1** Port **30**, POTS **2** Port **29** and POTS **3** Port **28** the call is destined for based upon the dialed number contained in the SIP Invite message. The Main CPU **19** commands the DSP Engine **33** to control the SLIC/CODEC Interface **27** to apply ringing voltage to the selected POTS port to ring the phone. A corresponding SIP **180** (ringing) message is sent back to User A RCG **44** in the reverse direction. When the phone attached to the selected POTS port is answered, the off hook condition detected by the SLIC/CODEC Interface **27** is sent through the DSP Engine **33** to the Main CPU **19** that sends the SIP **200** OK message back to User A RCG **44** to let the RCG know that the call was answered by User B RCG **56** and to turn off the audible ringing tone for User B. Once the call is established, User A RCG **44** sends and ACK F12 SIP message to User B RCG **56** indicating that User A RCG **44** understands that the call setup has been completed.

The two RCGs now exchange SIP messages that include the type of voice encoding that will be used such as G.729, G.723.1, G.711 etc to configure their RTP streams so that they can reliably transfer the user information between them. At this point the call (voice data) is sent between both RCGs and a normal telephone conversation takes place between the user A and user B.

Call teardown is accomplished by either user hanging up their telephone. The RCG of the terminating end (the end that hangs up the phone first) detects the on-hook condition and sends a SIP Bye message to the other end. The other end upon receiving the SIP Bye message responds with an OK **200** SIP message and disables the appropriate POTS port that the user was using.

The Speakerphone interface can be used for either end of a telephone conversation in exactly the same way as described above except that the corresponding POTS port that the call was intended for is disabled if the call is answered via the speakerphone.

Call Flow 2:

Calls between an RCG device and a PSTN telephone:

Refer to FIG. **3** for the following discussion.

In the previous call example, the PSTN network had nothing to do since the call was over a previously established modem connection between two RCGs. In the cases where a call originates or terminates to a standard telephone serviced by a Class 5 office, the process is a bit more complicated.

When a call originates from a user via an RCG, such as User A RCG **44**, the call handling practices are exactly the same up to the point that the SIP Proxy Server process in the Softswitch, SIP Proxy Server and Registrar **51** performs a lookup to determine how to route the call. In this case, the SIP Proxy Server process determines that the call terminates at a standard PSTN telephone attached to the Class 5 Office B **50**. Since the call originates as a native VoIP service, it must be converted to a standard switched circuit based service to be able to be delivered to User B's telephone **61**. The conversion is performed by the IXC's Media Gateway **60** device. In this example, the SIP Proxy Server process routes the call via the IXC' s Media Gateway **60** device instead of through the IXC B Modem Bank/Router **49** as before. The SIP Proxy Server process sends a SIP Invite to the IXC's Media Gateway **60** device, as well as other control information, to direct the Media Gateway **60** device to terminate the call and to apply the appropriate voice compression algorithm to the media stream to convert it between switched circuit PCM format and the selected VoIP protocol. At the same time, the Softswitch process of the Softswitch, SIP Proxy Server and Registrar **51** device sends commands to the Media Gateway **60** device to cause it to route the call's PCM data to a specific channel on the IXC B Interoffice Trunk **54**. The Softswitch process then generates an SS7 ISUP message that is sent over the PSTN SS7 signaling network to the Class 5 Office B informing it of the incoming call and on which circuit the call has been placed. It is up to the PSTN at this point to ring the User B telephone **61** and process the call between the IXC's Media Gateway and the User B Telephone **61**. The Softswitch process handles the signaling conversion between the PSTN's SS7 network and the IXC's SIP messaging, as well as any other proprietary signaling schemes utilized by the IXC to control its network. The standard SS7 call control messages, such as ringing, busy, ring back etc., all have a comparable SIP call flow control messages. The Softswitch simply maps

the SS7 messages into SIP messages and visa-versa while routing the messages to the appropriate network equipment.

As in the case of a call between two RCGs, the RTP media stream (the actual call data) is routed directly be the IXC A Modem Bank/Router **48** and the IXC's Media Gateway **60** via an IP based RTP Stream **57**.

Again, call teardown is accomplished by either user hanging up their telephone. Depending which end hangs up the phone first, the associated network will generate the appropriate messages which will eventually make it back to the Softswitch process. The Softswitch process will relay the appropriate call control messages between the PSTN and the IXC's SIP based control system.

A telephone call originating from a PSTN telephone is configured and setup in the same fashion as the above description except that the originating messaging begins within the PSTN network instead of the IXC's network.

Personal Computer based communications:

Where the RCG is connected to a Personal Computer (PC) through either its USB Port **11** or Ethernet Port **12**, the RCG operates exactly as a cable or DSL type modem device. The RCG is simply a pass through for the computer's data. The RCG receives the IP packets (of whatever type) from the computer and sends the information unchanged to the Modem/DAA **41** interface for transmission over the Internet. Received information from the Internet is processed in the reverse way.

Dynamic Bandwidth Allocation:

When a modem connection is established between the RCG and the "Network", the total available bandwidth of this connection is used in a shared/prioritized fashion. Voice services (calls) take precedence over data services. Therefore, when no calls are in progress all of the available bandwidth is used by data type services such as surfing the Internet or uploading/downloading files. However, when a call is to be passed through the RCG, the required bandwidth for the call is deallocated from the data services and prioritized for the telephone call. This necessary because the Quality Of Service (QOS) is important for effective communications over electronic networks. Since the voice data is carried over a "data centric" network topology (an IP based network), call quality can suffer greatly. Every effort must be taken to eliminate or reduce the packet delay through every network element to be able to provide the best call quality. For data applications such as surfing the Internet or downloading files packet delay is acceptable and expected, and it does not affect the "quality" of the data.

Since all voice and data is transmitted as packets, there are no "time slots" or other type of "channelization" associated with the transmission of this data over either the POTS line or the wireless interface. Channelization of the voice data does occur within the SLIC/Codec Interface—**27** but is converted into IP packets by the DSP engine—**33** and is handled as packets from that point on.

Regardless of whether the call is originating or terminating at the RCG, the bandwidth allocation process is the same. When the SIP call setup messages are processed, the type of voice compression that will be used is defined. The RCG Main CPU **19** handles the IP packet flow between the DSP Engine **33**, USB Port **12**, Ethernet Port **11**, 802.11b/g Module **36** and the Modem/DAA **41** devices giving priority to the voice packets to and from the DSP Engine **33** and the Modem/DAA **41** interfaces. Voice compression algorithms create IP packets at a specified number of packets per second. These packets are handled by a timed process in the RCG. This process is started during call setup so that the packets are handled at the correct rate based upon the compression algorithm's packet generation rate. There is no priority assigned between the voice packets of each of the three different POTS Ports **28-30**. When more than one voice call is in progress, they are handled in a round robin fashion based upon the packet rate for the compression algorithm used. If, for example, two calls are using a compression scheme that generates packets every 2 milliseconds, and the third generates packets every 4 milliseconds, then the calls utilizing the faster packet rate will be polled at twice the rate as the call using a slower packet rate but they are not given priority "over" the other call. Only when there are no voice packets ready for transmission to the Modem/DAA **41**, i.e. during the approximately 2 to 4 millisecond packetization period between packets, will any pending data packets received from the USB Port **12**, Ethernet Port **11** or the 802.11b/g Module **36** be sent to the Modem/DAA **41** for transmission over the network.

Thus, the POTS bandwidth is allocated on a per packet basis, not on a "time slot" or "channelization" or even a "frequency" basis as it the case with T-Carrier, DSL or channelized DSL systems. The same is true for the wireless interface, whether it is carrying pure data or voice.

Security is currently a big concern in today's networks, and especially with wireless 802.11 transmissions. For this reason, the RCG defaults to route voice data over the users POTS connection via Incoming POTS Port **40**. As security concerns regarding wireless communications transmissions are addressed and alleviated, voice call data can, and will, be routed over the wireless interface via the 802.11b/g Module **36**.

FAX Transmission:

Group I, 2 and 3 fax transmission is completely supported by the RCG. Fax transmission has the same priority as other voice communications. That is to say that FAX transmission is treated the same as a voice call and takes precedence over native IP data traffic.

Broadband Over POTS:

One of the primary functions of the RCG is to be able to transfer large files such as video files over the POTS lines to a residence. The ability to do this is limited by the maximum of 56 Kbps due to the design of the digital Class 5 office linecards and network transmission schemes based upon T carriers. Typical Class 5 linecard design samples the POTS lines at a rate of 8,000 samples per second. Typically, each sample is digitized into 12 to 16 bits by a codec device. The digitized sample is then companded to an 8 bit sample (1 byte) which makes up the PCM data stream that is transferred over the PSTN. Therefore, each POTS line is sampled at an effective rate of 64 Kbps. Since legacy T1 transmission equipment uses robbed-bit signaling, the maximum guaranteed transmission rate for the PSTN as a whole is 56 Kbps. Because of this limitation, standard POTS lines can only guarantee a maximum of 56 Kbps transfer rate under the best conditions. DSL equipment gets around this problem by installing DSL Access Multiplexing (DSLAM) equipment at the Class 5 office end of the POTS line. By routing around the linecard, as well as routing the data directly over the Internet or other private IP based networks, and therefore the 64 Kbps sampling rate, DSL is not bandwidth limited like PSTN traffic is. DSL, however, suffers from the very high costs associated with the purchase, installation, maintenance, floor lease costs, etc. DSL also suffers from very high deployment costs resulting from the labor intensive process to turn up each line. Each DSL "POTS" line must be inspected, conditioned and all load coils removed.

The RCG gets around the 56 Kbps POTS limitation as well as the DSL problems by using the standard POTS lines as they are, and not requiring any additional equipment to be installed

at the Class 5 end of the POTS line. This technique simplifies deployment and drastically cuts costs.

Multilink PPP Connections:

Referring to FIG. **7**, the RCG implements broadband over POTS by employing an 802.11b/g wireless interface to configure a multilink PPP bundle—**87** (per RFC 1990) comprised of the POTS lines connected to up to 32 RCGs. The limitation of 32 RCGs in a multilink PPP bundle is an arbitrary number and can be scaled up or down as required to support changes in network equipment capabilities. An 802.11b/g interface—**87** is shown as the preferred embodiment, since its 11/54 Mbps interface is considered sufficient bandwidth at this time also, its transmission distances are sufficient for implementation of this device, as opposed to other shorter ranged wireless transmission schemes. However as time goes on, some other wireless interface may be more desirable. There is nothing special or specific to the 802.11 wireless interface that makes it particularly suited to this application. Any wireless interface scheme can be used to implement this device.

The 802.11b/g interface—**88** on an individual RCG is also used to provide a peer-to-peer wireless home networking environment to other 802.11 compatible wireless component within the residence (such as a hand-held computer device) while acting as an always on dialup Internet gateway over the POTS line—**40** for the other wireless devices. An RCG that is transferring a very large file can request the services of 31 (in this embodiment) other RCGs to assist in the file transfer using their respective POTS lines. A single RCG can therefore gain the combined bandwidth of up to 32 POTS lines transferring data at as much as 56 Kbps each to transfer information. This is roughly equivalent to a transfer rate of 1.79 Mpbs in the inbound direction (towards the RCG) and approximately 1.075 Mbps in the outbound direction (towards the PSTN).

The multilink PPP connection—**87** is initiated by an RCG when it determines that the file (or streaming service) that it is to download (receive) is of sufficient size or requires a minimum amount of bandwidth to justify the use of a multilink PPP connection. This determination can be made on many different criteria such as the file size, type of data being transmitted, the type of compression if any, a Quality-of-Service requirement or any other pertinent information. (Since a certain amount of overhead is required to set up a Multilink PPP connection, it doesn't make sense to use it for small or low data rate transfers.)

Multilink PPP Bandwidth Allocation and Initialization:

Referring to FIG. **7**, an RCG—**85** that decides to initiate a multilink PPP session with a remote computer i.e. internet URL, requests a multilink PPP session with that URL resource via Link Control Protocol (LCP) session management. The initiating RCG—**85** and the remote server computer (not shown) will negotiate the pertinent multilink parameters such as compression, packet size, sync/async, link quality monitoring, bit stuffing etc. As part of a successful multilink PPP session setup, the initiating RCG—**85** receives a multilink PPP session ID, or "magic number", which is used to identify this particular multilink PPP session and is also used for adding or removing links from the multilink bundle—**87**. Once the multilink bundle is setup, the initiating RCG—**85** begins data transfer across its POTS interface-**90** with the far end computer system. The initiating RCG—**85** then looks up the addresses of up to 31 (in this embodiment) other RCGs in its router tables to use for the multilink PPP transfer. (If a Neighborhood Access Point is available the RCG could request service through it instead of setting up a Multilink PPP connection—see FIG. **8**.) The initiating RCG—**85** determines the number of remote RCGs—**86** that it wants to use to get the desired bandwidth for the transfer and sends multilink PPP service requests via the 802.11b/g wireless connections—**88** to the selected remote RCGs—**86**. The selected remote RCGs—**86** respond back to the initiating RCG with either an acceptance or denial of multilink PPP service request. This decision is made based upon the remote RCG's currently available POTS bandwidth and the current local demands for that bandwidth. The remote RCG—**86** makes a decision to participate in a multilink PPP service for an initiating RCG if its POTS line—**91** has a current average bandwidth utilization of less than some arbitrary limit such as 8 Kbps to 16 Kbps. This 8 Kbps to 16 Kbps bandwidth utilization represents about two concurrent voice conversations using standard voice compression techniques, or some small amount of data transmission occurring on the remote RCG's POTS interface—**91** or a combination thereof. Assuming that the remote RCG—**86** has a modem connection speed somewhere between 33 Kbps to 56 Kbps, this would leave approximately 17 Kbps to 40 Kbps of POTS bandwidth that the remote RCG—**86** could offer to the initiating RCG—**85** for use in its multilink PPP bundle—**87**. Of course, if there is no activity on the remote RCG—**86** POTS line, then the entire bandwidth will be used for the multilink transfer. If the remote RCG—**86** accepts the multilink PPP service request from the initiating RCG—**85** it also sends its currently available bandwidth on its POTS line—**91** that the initiating RCG—**85** will have available to it for the multilink PPP transfers. The initiating RCG then selects which of the responding remote RCGs—**86** it will use for the multilink PPP bundle—**87** and sends them a multilink initialization packet containing the URL of the destination as well as the multilink PPP session ID (magic number) and any other pertinent information required for the remote RCG to join in the existing multilink PPP bundle—**87**. Each remote RCG POTS interface—**91** participating in a multilink PPP bundle, represents a logical "link" in the initiating RCG's multilink PPP bundle—**87**. The remote RCGs—**86** then send a multilink PPP packet (over their respective POTS lines—**91**) to the destination URL with the multilink PPP session ID and request to be added to that multilink PPP bundle—**87**. The destination URL accepts the request of each of the remote RCGs—**86** and begins sending data packets to each over their respective POTS lines—**91**. When the remote RCGs—**86** receive data packets sent over their respective POTS lines—**91**, that are destined for the multilink PPP bundle—**87**, they simply relay the data packets over their 802.11b/g interface—**88** to the initiating RCG—**85**. It is the responsibility of the initiating RCG—**85** to perform all housekeeping tasks associated with the multilink transfer such as detection of lost packets and data packet reassembly, if those functions are required. Typically, lost packet detection and retransmission and reassembly are performed at higher OSI layers by the requesting software such as a browser. The remote RCGs—**86** are simply data transport nodes and do not perform any data processing on data received over a multilink PPP bundle destined for another RCG.

The initiating RCG—**85** of the multilink PPP bundle—**87** continually monitors the bandwidth of each remote RCG's—**86** multilink link which together comprise its multilink bundle—**87**. When the available bandwidth for the multilink PPP link of an individual remote RCG—**86** falls below an arbitrary minimum set by the initiating RCG—**85**, the initiating RCG—**85** instructs the offending remote RCG, via its 802.11b/g wireless interface—**88**, to remove itself from the multilink bundle. The remote RCG—**86** will then notify the remote computer (URL) to be removed as a link in the current

multilink bundle on which it is participating. Alternatively, a remote RCG—**86** can inform the initiating RCG—**85** of local demands on its POTS bandwidth, and request that the initiating RCG—**85** remove it (the remote RCG—**86**) from the participation in the initiating RCG's multilink bundle—**87**. The remote RCG—**86** will not unilaterally remove itself from participation in a multilink bundle without prior notification to the Initiating RCG—**85**. The remote RCG—**86** must get authorization from the initiating RCG—**85** to remove itself from the bundle, since the initiating RCG—**85** will have no way of knowing if the loss of data from that remote RCG is due to some sort of failure or from the remote RCG simply removing itself from participation in the multilink bundle—**87**. Also, for services that require a minimum Quality of Service (QOS) such as streaming video, the initiating RCG—**85** needs to control the multilink bundle—**87** bandwidth, and it can not do that if remote RCGs—**86** drop out of the multilink bundle—**87** at will. When a remote RCG—**86** requests to be removed from participation in a multilink bundle—**87**, the initiating RCG—**85** must immediately grant the request. If the initiating RCG—**85** were to not grant the request, then the remote RCG—**86** could, in worst case, delay or drop incoming multilink packets destined for the initiating RCG—**85**. If this were to happen, the initiating RCG—**85** will have missing packets and could over run its reassembly buffer (if reassembly is being performed by the RCG) causing catastrophic data loss and potentially have to restart the entire transmission. In the least case, the initiating RCG—**85** would have to initiate retransmission of potentially many packets which it assumes to be lost, but may simply be delayed by the remote RCG—**86**. Once a remote RCG—**86** has been removed from participating in a multilink bundle—**87**, the initiating RCG—**85** will then look up another remote RCG in its router tables that can be used to participate in the multilink PPP bundle—**87**, and request that the new remote RCG—**86** to join the existing multilink bundle—**87**. This is necessary to maintain a minimum Quality of Service. Since RCGs prioritize their bandwidth requirements based upon their own "local" service requirements, their participation in any multilink PPP service is available only to bandwidth that is not required for its own current local demands. Therefore, a remote RCG's—**86** bandwidth that is available for multilink services can change at any time. The dynamic reassignment of remote RCGs that participate in a multilink bundle is also required to prevent a remote RCG—**86** from receiving packets so slowly that the originating RCG—**85** interprets this delay as lost packets. When the initiating RCG—**85** determines that a packet has been lost, and it is performing packet reassembly, it will, itself, request that the remote computer retransmit the lost packet. The initiating RCG will not ask any remote RCG—**86** to perform retransmissions or any other kind of data computations or manipulations.

Refer to FIG. **8** for the following discussion. In areas where there are existing 802.11 network equipment such as Neighborhood Access Point—**93**, or where there is sufficient bandwidth requirements from an installed base of RCGs to warrant the deployment of a Neighborhood Access Point—**93**, the RCGs will automatically detect the presence of the compatible neighborhood access points and register with that equipment for transport services. In this case, an RCG has an alternative broadband service route in addition to the multilink option. An RCG can communicate directly with a local 802.11 Network Access Point—**93** that is connected to the PSTN or another carrier's network via some sort of high bandwidth backbone such as a T-Carrier or optical carrier connection (T1, T3, OC3, OC12 etc.). The RCGs can communicate directly with neighborhood access points at their full 11/54 Mbps data rates to provide up to that full bandwidth to the user. This functionality is, of course, subject to the Network Access Point—**93** allowing access to its resources to the RCG according to the 802.11 wireless protocol.

This architecture is important since it provides an avenue to relieve the local class 5 offices of congestion that can be caused by a wide spread deployment of RCGs within the class 5 service area. Since each RCG requires a constant 24/7 modem connection, this ties up the class 5 switch in a fashion that it was not designed for. This could lead to wholesale class 5 office expansions which would be extremely expensive, and potentially prohibitive for the Local Exchange Carriers (LECs). By deploying neighborhood access points that operate at 54 Mbps (802.11a/g), in areas where the RCG concentration starts placing too high of a demand on the local class 5 office, the bandwidth from the RCGs can be aggregated by the neighborhood access points into large capacity backbones to relieve the switch congestion. In this case, the RCG POTS interface—**40** can be used solely as a lifeline connection, or when the 802.11 wireless LAN in which the RCG resides is congested. With this implementation, voice calls will be carried over the wireless interface as opposed to the POTS interface on which they would normally be carried. Also, the RCG modem—**41** connected to the POTS interface—**40** would not need to maintain a constant always on connection, it could be a dialed on demand connection and thereby relieving the local class 5 office switch.

Bouncing or Hopping Traffic:

Refer to FIG. **9**. In areas where the density of RCGs is less than the arbitrary number of 32 RCGs within its transmission radius for multilink connections, the RCGs can bounce, or relay, the data traffic between each other to reach other RCGs located farther than the RCGs wireless transmission area. Since the POTS data rate of 56 Kbps is miniscule as compared to the 11/54 Mbps 802.11b/g transfer rate, the overhead associated with bouncing data traffic is not a concern. This will allow for the fastest possible data transfer across POTS lines for every RCG user.

RCGs can also communicate directly with an 802.11a Neighborhood Access Point—**93** device (such as that used in WI-FI networks) that is connected to a data network connection such as a DS3 or OC3 service via a Metro Access Point. Where an RCG has access to a broadband device such as an 802.11a type device, either directly or via a bounced signal across several RCGs, a direct high speed data connection can be used to transfer large files. When an RCG is communicating directly with an 802.11a device, data transfer speeds up to the full 11/54 Mbps can be achieved to speed video transfers for such applications as video on demand.

RCG Router Tables:

The RCG continually monitors its 802.11b/g wireless interface for transmissions from other RCGs or 802.11a Access Points as well as other 802.11b/g wireless devices within the residence. The RCG provides a means to identify and store the addresses of other RCGs and Neighborhood Access Points within its local area. The RCG creates routing tables, much like an IP router device, so that it knows which RCGs are local to itself, and how many hops will be needed to reach the maximum of 32 POTS lines or a Neighborhood Access Point. The RCG can then determine how to route its data transfers to gain the most efficient routing and network efficiencies.

The router tables in each RCG are continually updated by monitoring the 802.11 frames received from other RCGs or Network Access Points. The number of entries in the router tables can be limited to an arbitrary number of other RCGs but contains room for at least 32 entries. For each RCG listed in

the router tables, certain information is kept such as signal strength, if the other device is another RCG or some other 802.11 compatible device, if the other RCG is reachable directly, or if it is accessed via another RCGs by hopping. In the case there RCG hopping is used, the address of each RCG that is hopped is stored in the routing table. When an RCG is first powered up, it monitors its 802.11 interface for a period of time to identify other RCGs or Neighborhood Access Point devices, or other Wi-Fi devices within its transmission area. When first deployed, the RCG will not have any entries in its routing tables. This condition can persist for some time, until another RCG or other 802.11 device is deployed within the former RCGs transmission range. In this state, the RCG can be used for wireless networking within the residence, connecting the local computer to the RCGs always on Internet connection as well as to other wireless devices within the home. When an 802.11 frame is received by an RCG that contains the address of an RCG whose address does not exist in the receiving RCG's router table (as is the case when a new RCG is first installed), the receiving RCG polls the transmitting RCG for its router table information. The received router information is reviewed for other RCG's or other 802.11 compatible devices that are not listed in its own router tables. A decision is made to use some, all, or none of the new route information in its router tables. There is no real limitation on the number of RCGs that can be "hopped" in order to build a complete router table or to reach many more RCGs, Neighborhood Access Points or Metro Access Points.

Equipment and Services Priorities:

Just as voice has priority over data transfers within a single RCG, local RCG traffic (both voice and data) has priority over remote transfer requests by other RCGs. If an RCG is currently using all of its available POTS bandwidth for its own purposes, it will deny any remote RCG's request for access to its POTS line. Only when there is available POTS bandwidth available will an RCG allow other RCGs access to its POTS line. It will, however, bounce the traffic to other RCGs within its transmission area if requested by the originating RCG. In this case, available wireless bandwidth of any RCG (that amount of the 11/54 Mbps not currently used for its own traffic) can be used to relay traffic between other RCGs that do have available POTS bandwidth. In the same fashion, excess wireless bandwidth of any RCG can be by other RCGs to access high speed backbones via Neighborhood or Metro Access Points. RCGs can also access other 802.11 wireless networks (Wi-Fi for example) that happen to be deployed within their service areas. In this case, access agreements between the RCG service provider and the wireless network operator must be put into place. By remaining compatible with the 802.11 standards, the RCGs capabilities will benefit by the growing WI-FI network infrastructure, an the WI-FI network will benefit by the RCG network.

Voice Over POTS and Data Over Wireless:

Normally, all communications from an RCG will be transmitted over the local POTS line, or a multilink bundle made up of many remote RCG POTS lines. By default, all voice calls will be carried over the "local" POTS line—**40** to alleviate security/privacy concerns and only "data" will be transmitted via multilink bundles. Generally, since voice "data" is compressed locally by the RCG, the required bandwidth for a voice call is so small that it does not make for a good choice to route it over a multilink connection. However, it is possible to route voice calls entirely over another RCGs POTS line. It is also possible for an RCG to transmit voice data over POTS lines connected to other RCGs via multilink bundles or directly over its 802.11 wireless interface, and since the 802.11 specification does support the Wired Equivalent Privacy (WEP) specification, a secured connection can be made in this fashion.

Remote Upgradability

The RCG is designed with the capability for unassisted remote upgradability. The remote upgradability feature is not the same as the storing of operational parameters during the configuration process. This feature allows the system operator to add new features as they are developed, or to correct bugs remotely and without the users knowledge or involvement. This feature can also be used to install a complete new operating system (OS).

Key to the successful implementation of the Remote upgradability feature is that a completely fail-safe routine be implemented that can recover from any failure during the upgrade process and to re-initiate and monitor the upgrade process until it has successfully completed. This process is carried out by loading a boot loader program that is stored in non-volatile memory. The boot loader program provides the minimum capabilities to start up the RCG and connect into the system operator's diagnostics network to download fixes or a new OS. The boot loader program is technically part of the OS, but it cannot be over written by any upgrade process. It is responsible for detecting failure of the RCG and initiating a connection to the diagnostics network. Once connected with the diagnostics network, the boot loader will provide diagnostics support to help correct the RCG's operation and reconfigure the OS.

What is claimed is:

1. A communications device that is capable of providing broadband communications services, comprising:

at least one connection for connecting to a communications network;

at least one wireless interface for connecting wirelessly to at least one remote communications device; and

a processor that requests the at least one remote communications device to assist in transferring data, sends a request to the at least one remote communications device for requesting use of a portion of unused bandwidth of the at least one remote communications device, receives a response from the at least one remote communications device, the response containing information about the portion of unused bandwidth, selects the at least one remote communications device with unused bandwidth, sends control information to the at least one remote communications device for participating in a multilink connection, receives packets from the at least one remote communications device and aggregates the data from the at least one remote communications device with data transfers from the at least one connection to increase data bandwidth for the communications device.

2. The communications device of claim **1**, wherein the processor combines the data bandwidth of the at least one connection with the at least one remote communications device.

3. The communications device of claim **1**, wherein the at least one remote communications device is at least one of a residential communications gateway, a cable modem, a digital subscriber line, a wireless device, a neighborhood access point device, a Wi-Fi device and a cellular phone.

4. The communications device of claim **1**, wherein the processor allocates the at least one remote communications device into a multilink group transfer.

5. The communications device of claim **1**, wherein the processor creates and updates routing tables with the at least one remote communications device.

6. The communications device of claim 5, wherein the processor uses the routing tables to determine routing efficiencies based on at least one of quality of service, total connection speed of the at least one remote communication device, a number of data hops, available unused bandwidth of the at least one remote communication device, wireless transfer speeds and signal strength between the at least one remote communication device and the communication device.

7. The communications device of claim 1, wherein the processor determines how many remote communications devices are located in a transmission range.

8. The communications device of claim 1, wherein the communications network is at least one of a public wired network, a private wired network, a public wireless network, and a private wireless network.

9. The communications device of claim 1, wherein the communications network is at least one of a public switched telephone network, a cable network, a wireless network and a fiber network.

10. A communications device that is capable of providing broadband communications services, comprising:

at least one connection for connecting to a network;

at least one wireless interface for connecting wirelessly to remote communications devices; and

a processor that requests the remote communications devices to transfer portions of data, sends a request to the remote communications devices for requesting use of a portion of unused bandwidth of each of the remote communications devices, receives a response from each of the remote communications devices, the response containing information about the portion of unused bandwidth for each of the remote communications devices, selects a group of the remote communications devices with a larger, combined, unused bandwidth, sends control information to the selected remote communications devices for participating in a multilink transfer, and receiving packets from the selected remote communications devices and combines and sequences the portions of the data from the remote communications devices with second data transferred from the at least one connection to increase data bandwidth for the communications device.

11. The communications device of claim 10, wherein the processor creates and updates routing tables for each of the remote communications devices.

12. The communications device of claim 10, wherein the processor uses the routing tables to determine routing efficiencies based on quality of service and selects a group of the remote communications devices for optimizing the routing efficiencies.

13. The communications device of claim 10, wherein the processor uses the routing tables to determine routing efficiencies based on at least one of quality of service, total connection speed of the remote communication devices, a number of data hops, available unused bandwidth of the remote communication devices, wireless transfer speeds and signal strength between the remote communication devices and the communication device.

14. The communications device of claim 10, wherein the processor receives information whether each of the remote communications devices wants to participate in a multilink group transfer, and configures a multilink group for all the participating remote communications devices to optimize routing efficiency.

15. A communications device that is capable of providing broadband communications services, comprising:

at least one connection for connecting to a communications network;

at least one wireless interface for connecting wirelessly to at least one cellular phone; and

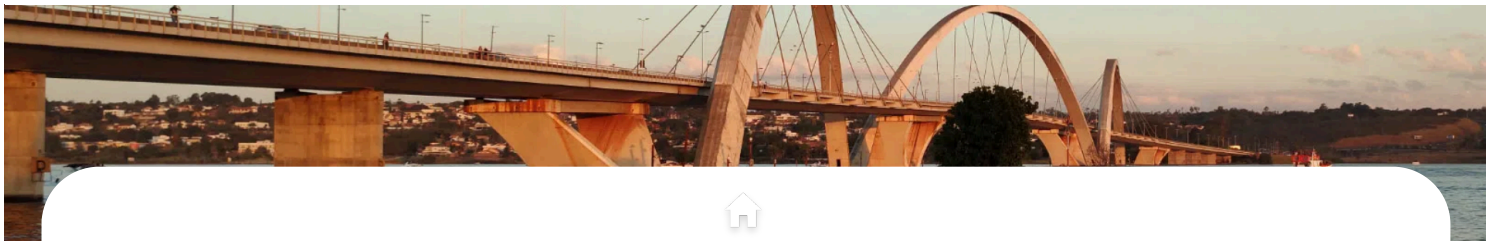
a processor that requests the at least one cellular phone to assist in transferring data, sends a request to the at least one cellular phone for requesting use of a portion of unused bandwidth of the at least one cellular phone, receives a response from the at least one cellular phone, the response containing information about the portion of unused bandwidth, selects the at least one cellular phone with unused bandwidth, sends control information to the at least one cellular phone for participating in a multilink connection, receiving packets from the at least one cellular phone and aggregates the data from the at least one cellular phone with data transfers from the at least one connection to increase data bandwidth for the communications device.

16. The communications device of claim 15, wherein the processor creates and updates routing tables with the at least one cellular phone.

17. The communications device of claim 15, wherein the processor uses the routing tables to determine routing efficiencies based on at least one of quality of service, total connection speed of the at least one cellular phone, a number of data hops, available unused bandwidth of the at least one cellular phone, wireless transfer speeds and signal strength between the at least one cellular phone and the communication device.

* * * * *

EXHIBIT F



moto g - 2025 - Specifications

Performance

Operating System	Android™ 15
Sensors	Accelerometer, Gyroscope, Proximity, Ambient light, Sensor hub, Fingerprint reader, SAR sensor, E-compass, Barometer
Internal Storage	64GB / 128GB built-in (Available user storage is less due to many factors)
Memory Card	Up to 1 TB microSD card expandable (sold separately, may not be possible to move content with DRM restrictions)
Processor	MediaTek Dimensity 6300 processor with 2.4GHz octa-core CPU and Arm Mali-G57 MC2 GPU
Memory (RAM)	4GB RAM, expandable up to 12GB with RAM Boost (Varies by market Check with your carrier or retailer for availability.)
Security	Fingerprint reader, Face unlock, ThinkShield

Battery

Battery Size	5000 mAh
Charging	30W device charging capable (requires Motorola TurboPower)
Battery Endurance cycles	≥800

Display

Display Size	6.7" display

Chat
MOLI

Screen to Body Ratio	84%
Display Technology	LCD | 120 Hz refresh rate | Corning® Gorilla® Glass 3
Aspect Ratio	20:9

Design

Dimensions	167.05 x 76.30 x 8.16mm
Body	Vegan Leather
Ports	Type-C port (USB 2.0)
Weight	193g
IP Rating	IP54 protection

Sustainability

Recycled content per EN 455557:2020:	0.00%
Recycled rate (Rcyc) per EN 45555:2019:	84.62%
Cobalt weight (grams)	above 10 g
Tantalum weight (grams)	less than 0,01 g
Neodymium weight (grams)	above 0,2 g
Gold weight (grams)	less than 0,02 g

Chat

Camera

Rear Camera Software	Night Vision | Portrait | Panorama | Pro Mode | Scan | Tilt-Shift | Shot Optimization | Auto Smile Capture | Google Lens™ integration | Auto Night Vision | Google Photos Auto Enhance | High-res Digital Zoom (Up to 8x) |

Rear Camera Video Capture	Rear main camera: FHD (30fps) Rear macro camera: HD (30fps)
Front Camera Hardware	16MP f/2.4 aperture 1.0µm pixel size | Ultra Pixel Technology for 2.0µm Front Camera Software Selfie Animation Gesture Selfie
Main Rear Camera Hardware	50MP sensor f/1.8 aperture 0.64µm pixel size | Quad Pixel Technology for 1.28µm PDAF
Camera 2	2MP f/2.4 aperture 1.75µm pixel size Macro vision
Camera 3	Ambient light sensor

Audio

Speakers	Stereo speakers with Dolby Atmos®
Headphone Jack	3.5mm headset jack
Microphones	3
FM Radio	No

Experiences

Voice Control	Google Assistant Personalize: Theme, Wallpaper, Layout, Fonts, Colors, Icon shape, Disp Size and Text, Sounds, Dark mode Display: Attentive display, Lock Screen

Chat

Moto Secure: Secure folder, Phishing detection, Auto lock, Network protection, Lock screen security, PIN pad scramble, Privacy dashboard, Security & Privacy, Permission manager, Privacy controls

Play: Media controls, Games, Dolby Atmos

Tips: Take a tour, What's new in Android 15

Connectivity

Networks + Bands	5G: NR band n2 / n5 / n7 / n12 / n14 / n25 / n26 / n28 / n29 / n30 / n41 / n48 / n66 / n70 / n71/ n77 / n78 4G: LTE band 1 / 2 / 3 / 4 / 5 / 7 / 8 / 12 / 13 / 14 / 17 /18 / 20 / 25 / 26 / 28 / 29 / 30 / 38 / 39 / 40 / 41 / 48 / 66 / 71 3G: WCDMA band 1 / 2 / 4 / 5 / 8 2G: GSM band 2 / 3 / 5 / 8
Bluetooth Technology	Bluetooth® 5.3
NFC	Yes
Wi-Fi	Wi-Fi 802.11 a/b/g/n/ac | 2.4 GHz & 5 GHz | Wi-Fi hotspot
Location Services	GPS, A-GPS, LTEPP, SUPL, GLONASS, Galileo
SIM Card	(1 physical Nano SIM + eSIM + 1 microSD)

Certain specifications may vary by market

Chat

PRODUCTS
- Sp al Offers
- Razr Family
- Motorola Edge Family
- Moto G Family
- Motorola One 5G ACE
- Moto 360

- Power & Charging
- Wearables
- Headphones
- Portable Speakers
- Auto Accessories
- Smart Nursery and Monitors
- Security and Surveillance
- Modems + Routers
- Home and Office phones
- Outdoor Products
- All Accessories
- All Smart Products
- All Electronics

SUPPORT

- P duct Support
- Forums
- Order Status
- Contact Us
- Affiliate Program
- Financing

ABOUT

- otorola
- Lenovo
- Responsibility
- Licensing
- News
- Environment
- Careers
- Privacy Policy
- Terms of sale
- Terms of use
- Product privacy
- Executive Team
- Foundation
- Get Updates
- Innovation

Chat
MOLI

more information

©2025 Motorola Mobility LLC. All Rights Reserved

MOTOROLA, the Stylized M Logo, MOTO and the MOTO family of marks are trademarks of Motorola Trademark Holdings, LLC. LENOVO is a trademark of Lenovo. All other trademarks are the property of their respective owners.

Welcome to Motorola. Shop our Android smartphones, including the new razr, edge+, moto g stylus, moto g power, and more.

All mobile phones are designed and manufactured by/for Motorola Mobility LLC, a wholly owned subsidiary of Lenovo.

Expedited shipping: Some orders with multiple products and with anticipated inventory won't be available for Expedited shipping, if you don't see the option at checkout, your order will be sent with normal ground delivery

Theoretical max speeds based on 5G mmwave chnology and eight channel carrier aggregatior 8cc). Actual speeds vary based on many factor ncluding network configuration, signal strength, etwork congestion, physical obstructions, and v ather. 5G network coverage (available in certair reas in 2020, expanding after tha

Moto Care T&Cs

* Exclusions and limitations apply. Please read tl terms and conditions for details that include ex usions, limitations, how to make a claim, cance overage, and list of coverage providers. For a c mplete list of exclusions, read the detailed terr and conditions her

† If you purchase Moto Care Accident Protectic within 30 days of receiving your device, coverag begins on the date you purchased your devic

‡ Secure deposit required for advance exchang Subject to device availability and terms. You wil eceive a certified refurbished, like-new device tl t has passed stringent software and hardware t

©2025 Motorola Mobility LLC. All Rights Reserved

Chat

EXHIBIT G

3GPP TS 37.340 V18.6.0 (2025-06)

Technical Specification

3rd Generation Partnership Project;
Technical Specification Group Radio Access Network;
Evolved Universal Terrestrial Radio Access (E-UTRA) and NR;
Multi-connectivity;
Overall Description;
Stage 2
(Release 18)

The present document has been developed within the 3rd Generation Partnership Project (3GPP™) and may be further elaborated for the purposes of 3GPP.
The present document has not been subject to any approval process by the 3GPP Organizational Partners and shall not be implemented.
This Specification is provided for future development work within 3GPP only. The Organizational Partners accept no liability for any use of this Specification.
Specifications and Reports for implementation of the 3GPP™ system should be obtained via the 3GPP Organizational Partners' Publications Offices.

3GPP

Postal address

3GPP support office address
650 Route des Lucioles - Sophia Antipolis
Valbonne - FRANCE
Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Internet
http://www.3gpp.org

Copyright Notification

No part may be reproduced except as authorized by written permission.
The copyright and the foregoing restriction extend to reproduction in all media.

© 2025, 3GPP Organizational Partners (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC).
All rights reserved.

UMTS™ is a Trade Mark of ETSI registered for the benefit of its members
3GPP™ is a Trade Mark of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners
LTE™ is a Trade Mark of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners
GSM® and the GSM logo are registered and owned by the GSM Association

Contents

Foreword....6
1 Scope....7
2 References....7
3 Definitions, symbols and abbreviations....8
3.1 Definitions....8
3.2 Abbreviations....10
4 Multi-Radio Dual Connectivity....10
4.1 General....10
4.1.1 Common MR-DC principles....10
4.1.2 MR-DC with the EPC....11
4.1.3 MR-DC with the 5GC....11
4.1.3.1 E-UTRA-NR Dual Connectivity....11
4.1.3.2 NR-E-UTRA Dual Connectivity....11
4.1.3.3 NR-NR Dual Connectivity....11
4.2 Radio Protocol Architecture....11
4.2.1 Control Plane....11
4.2.2 User Plane....12
4.3 Network interfaces....14
4.3.1 Control Plane....14
4.3.1.1 Common MR-DC principles....14
4.3.1.2 MR-DC with EPC....15
4.3.1.3 MR-DC with 5GC....15
4.3.2 User Plane....15
4.3.2.1 Common MR-DC principles....15
4.3.2.2 MR-DC with EPC....16
4.3.2.3 MR-DC with 5GC....16
5 Layer 1 related aspects....16
6 Layer 2 related aspects....17
6.1 MAC Sublayer....17
6.2 RLC Sublayer....17
6.3 PDCP Sublayer....17
6.4 SDAP Sublayer....18
6.5 BAP Sublayer....18
7 RRC related aspects....18
7.1 System information handling....18
7.2 Measurements....18
7.3 UE capability coordination....20
7.4 Handling of combined MN/SN RRC messages....21
7.5 SRB3....21
7.6 Split SRB....22
7.7 SCG/MCG failure handling....22
7.8 UE identities....23
7.9 Inter-node Resource Coordination....23
7.10 UE assistance information....24
7.11 F1-C transfer over E-UTRA....24
7.14 RLM/BFD relaxation....25
8 Bearer handling aspects....26
8.1 QoS aspects....26
8.2 Bearer type selection....27
8.3 Bearer type change....28
8.4 User data forwarding....29

9 Security related aspects 29
10 Multi-Connectivity operation related aspects 30
10.1 General 30
10.2 Secondary Node Addition 31
10.2.1 EN-DC 31
10.2.2 MR-DC with 5GC 34
10.2.3 Conditional PSCell Addition 39
10.3 Secondary Node Modification (MN/SN initiated) 39
10.3.1 EN-DC 39
10.3.2 MR-DC with 5GC 46
10.4 Secondary Node Release (MN/SN initiated) 54
10.4.1 EN-DC 54
10.4.2 MR-DC with 5GC 56
10.5 Secondary Node Change (MN/SN initiated) 59
10.5.1 EN-DC 59
10.5.2 MR-DC with 5GC 67
10.6 PSCell change 75
10.7 Inter-Master Node handover with/without Secondary Node change 76
10.7.1 EN-DC 76
10.7.2 MR-DC with 5GC 78
10.8 Master Node to eNB/gNB Change 80
10.8.1 EN-DC 80
10.8.2 MR-DC with 5GC 82
10.9 eNB/gNB to Master Node change 84
10.9.1 EN-DC 84
10.9.2 MR-DC with 5GC 85
10.10 RRC Transfer 86
10.10.1 EN-DC 86
10.10.2 MR-DC with 5GC 88
10.11 Secondary RAT data volume reporting 91
10.11.1 EN-DC 91
10.11.2 MR-DC with 5GC 92
10.12 Activity Notification 93
10.12.1 EN-DC 93
10.12.2 MR-DC with 5GC 96
10.13 Notification Control Indication 99
10.13.1 EN-DC 99
10.13.2 MR-DC with 5GC 99
10.14 PDU Session Split at UPF 99
10.14.1 PDU Session Split at UPF during PDU session resource setup 99
10.14.2 PDU Session Split at UPF during PDU session resource modify (5GC initiated) 100
10.14.3 PDU Session Split at UPF (RAN initiated QoS flows offloading from MN to SN) 100
10.15 F1-C Traffic Transfer 103
10.16 Support of inter-system handover involving EN-DC or MR-DC with 5GC 104
10.16.1 General 104
10.16.2 Inter-system handover from EPS to 5GS with the Secondary Node used as target 104
10.16.3 Inter-system handover from 5GS to EPS with the Source Node used as target Secondary Node 105
10.17 Inter-Master Node RRC Resume without Secondary Node change 106
10.17.1 MR-DC with 5GC 106
10.18 Self-optimisation for PSCell addition/change 108
10.18.1 General 108
10.18.2 PSCell change failure 108
10.18.3 Conditional PSCell addition or change failure 109
10.18.4 Successful PSCell Addition/Change Report 110
10.18.5 RA Report retrieval 110
10.19 Conditional Handover with Secondary Node 111
10.19.1 EN-DC 111
10.19.2 MR-DC with 5GC 114
10.19.3 CHO with candidate SCG(s) 117
10.20 Subsequent Conditional PSCell Addition or Change 118

11 Service related aspects 129
11.1 Roaming and Access Restrictions 129
11.2 Support of Network Sharing 129
11.3 ARPI/SPID Handling from MN 129

12 X2/Xn Interface related aspects 129

13 Other aspects 129
13.1 Interference avoidance for in-device coexistence 129
13.2 Sidelink 129
13.3 SCG UE history information 130
13.4 Application Layer Measurement Collection 130
13.4.1 Overview 130
13.4.2 SRB5 130
13.4.3 QoE Measurement Configuration 130
13.4.3.1 QoE Measurement Collection Activation and Reporting in NR-DC 130
13.4.3.2 RAN Overload Handling 132
13.4.3.3 Support for RAN visible QoE measurements and reporting in NR-DC 132
13.4.4 QoE Measurement Continuity for Mobility 132

Annex A (informative): Layer 2 handling for bearer type change 134

Annex B (informative): Supported MR-DC Handover Scenarios 136

Annex C (informative): Change history 137

Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

Y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

Z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The present document provides an overview of the multi-connectivity operation using E-UTRA and NR radio access technologies. Details of the network and radio interface protocols are specified in companion specifications of the 36 and 38 series.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document.*

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 36.300: "Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2".

[3] 3GPP TS 38.300: "NR; NR and NG-RAN Overall description; Stage 2".

[4] 3GPP TS 38.331: "NR; Radio Resource Control (RRC) protocol specification".

[5] 3GPP TS 38.423: "NG-RAN; Xn application protocol (XnAP)".

[6] 3GPP TS 38.425: "NG-RAN; NR user plane protocol".

[7] 3GPP TS 38.401: "NG-RAN; Architecture description".

[8] 3GPP TS 38.133: "NG-RAN; Requirements for support of radio resource management".

[9] 3GPP TS 36.423: "Evolved Universal Terrestrial Radio Access Network (E-UTRAN); X2 Application Protocol (X2AP)".

[10] 3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification".

[11] 3GPP TS 23.501: "System Architecture for the 5G System; Stage 2".

[12] 3GPP TS 38.101-1: "User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone".

[13] 3GPP TS 38.101-2: "User Equipment (UE) radio transmission and reception; Part 2: Range 2 Standalone".

[14] 3GPP TS 38.101-3: "User Equipment (UE) radio transmission and reception; Part 3: Range 1 and Range 2 Interworking operation with other radios".

[15] 3GPP TS 36.323: "Evolved Universal Terrestrial Radio Access (E-UTRA); Packet Data Convergence Protocol (PDCP) specification".

[16] 3GPP TS 38.323: "NR; Packet Data Convergence Protocol (PDCP) specification".

[17] 3GPP TS 38.340: "Backhaul Adaptation Protocol (BAP) specification".

[18] 3GPP TS 23.287: "Architecture enhancements for 5G System (5GS) to support Vehicle-to-Everything (V2X) services ".

[19] 3GPP TS 23.285: "Architecture enhancements for V2X services".

[20] 3GPP TS 23.502: "Procedures for the 5G System; Stage 2".

[21] 3GPP TS 38.213: "NR; Physical layer procedures".

[22] 3GPP TS 24.301: "Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS); Stage 3".

[23] 3GPP TS 38.473: "F1 application protocol (F1AP)".

[24] 3GPP TS 23.304: "Proximity based Services (ProSe) in the 5G System (5GS)".

[25] 3GPP TS 23.586: "Technical Specification Group Services and System Aspects; Architectural Enhancements to support Ranging based services and Sidelink Positioning".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1] and TS 36.300 [2].

Child node: IAB-DU's or IAB-donor-DU's next hop neighbour IAB-node.

Complete candidate configuration: one type of a candidate configuration as defined in TS 38.331 [4].

Conditional PSCell Addition: a PSCell addition procedure that is executed only when PSCell addition execution condition is met.

Conditional PSCell Change: a PSCell change procedure that is executed only when PSCell change execution condition is met.

En-gNB: node providing NR user plane and control plane protocol terminations towards the UE, and acting as Secondary Node in EN-DC.

Fast MCG link recovery: in MR-DC, an RRC procedure where the UE sends an MCG Failure Information message to the MN via the SCG upon the detection of a radio link failure on the MCG.

IAB-donor: gNB that provides network access to UEs via a network of backhaul and access links.

IAB-MT: IAB-node function that terminates the Uu interface to the parent node using the procedures and behaviours specified for UEs unless stated otherwise.

IAB-node: RAN node that supports NR access links to UEs and NR backhaul links to parent nodes and child nodes. The IAB-node does not support backhauling via E-UTRA.

Master Cell Group: in MR-DC, a group of serving cells associated with the Master Node, comprising of the SpCell (PCell) and optionally one or more SCells.

Master node: in MR-DC, the radio access node that provides the control plane connection to the core network. It may be a Master eNB (in EN-DC), a Master ng-eNB (in NGEN-DC) or a Master gNB (in NR-DC and NE-DC).

MCG bearer: in MR-DC, a radio bearer with an RLC bearer (or two RLC bearers, in case of CA packet duplication in an E-UTRAN cell group, or up to four RLC bearers in case of CA packet duplication in a NR cell group) only in the MCG.

MN terminated bearer: in MR-DC, a radio bearer for which PDCP is located in the MN.

MCG SRB: in MR-DC, a direct SRB between the MN and the UE.

Multi-Radio Dual Connectivity: Dual Connectivity between E-UTRA and NR nodes, or between two NR nodes.

Ng-eNB: as defined in TS 38.300 [3].

NR sidelink communication: AS functionality enabling at least V2X Communication as defined in TS 23.287 [18] and ProSe Communication (including ProSe UE-to-Network Relay and non-Relay communication) as defined in TS 23.304 [24], between two or more nearby UEs, using NR technology but not traversing any network node.

NR sidelink discovery: AS functionality enabling ProSe non-Relay Discovery and ProSe UE-to-Network Relay discovery for Proximity based Services as defined in TS 23.304 [24] between two or more nearby UEs, using NR technology but not traversing any network node.

Parent node: IAB-MT's next hop neighbour node; the parent node can be IAB-node or IAB-donor-DU.

PCell: SpCell of a master cell group.

PSCell: SpCell of a secondary cell group.

Ranging/Sidelink Positioning: AS functionality enabling ranging-based services and sidelink positioning as defined in TS 23.586 [25].

RLC bearer: RLC and MAC logical channel configuration of a radio bearer in one cell group.

Secondary Cell Group: in MR-DC, a group of serving cells associated with the Secondary Node, comprising of the SpCell (PSCell) and optionally one or more SCells.

Secondary node: in MR-DC, the radio access node, with no control plane connection to the core network, providing additional resources to the UE. It may be an en-gNB (in EN-DC), a Secondary ng-eNB (in NE-DC) or a Secondary gNB (in NR-DC and NGEN-DC).

SCG bearer: in MR-DC, a radio bearer with an RLC bearer (or two RLC bearers, in case of CA packet duplication in an E-UTRAN cell group, or up to four RLC bearers in case of CA packet duplication in a NR cell group) only in the SCG.

SN terminated bearer: in MR-DC, a radio bearer for which PDCP is located in the SN.

SpCell: primary cell of a master or secondary cell group.

SRB3: in EN-DC, NGEN-DC and NR-DC, a direct SRB between the SN and the UE.

SRB5: in NR-DC, a direct SRB between the SN and the UE dedicated for sending application layer measurement report information.

Split bearer: in MR-DC, a radio bearer with RLC bearers both in MCG and SCG.

Split PDU Session (or PDU Session split): a PDU Session whose QoS Flows are served by more than one SDAP entities in the NG-RAN.

Split SRB: in MR-DC, a SRB between the MN and the UE with RLC bearers both in MCG and SCG.

Subsequent Conditional PSCell Addition or Change (subsequent CPAC): a conditional PSCell addition or change procedure that is executed based on pre-configured subsequent CPAC configuration which is not implicitly released by the UE upon (conditional or non-conditional) PSCell addition, (conditional or non-conditional) PSCell change, (conditional or non-conditional) PCell change or SCG release.

User plane resource configuration: in MR-DC with 5GC, encompasses radio network resources and radio access resources related to either one or more PDU sessions, one or more QoS flows, one or more DRBs, or any combination thereof.

V2X sidelink communication: AS functionality enabling V2X Communication as defined in TS 23.285 [19], between nearby UEs, using E-UTRA technology but not traversing any network node.

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1], TS 36.300 [2] and TS 38.300 [3].

BFD	Beam Failure Detection
CHO	Conditional Handover
CLI	Cross Link Interference
CPA	Conditional PSCell Addition
CPAC	Conditional PSCell Addition or Change
CPC	Conditional PSCell Change
DAPS	Dual Active Protocol Stack
DC	Intra-E-UTRA Dual Connectivity
DCP	DCI with CRC scrambled by PS-RNTI
EN-DC	E-UTRA-NR Dual Connectivity
IAB	Integrated Access and Backhaul
IDC	In-Device Coexistence
LTM	L1/L2 Triggered Mobility
MCG	Master Cell Group
MN	Master Node
MR-DC	Multi-Radio Dual Connectivity
MUSIM	Multi-Universal Subscriber Identity Module
NE-DC	NR-E-UTRA Dual Connectivity
NGEN-DC	NG-RAN E-UTRA-NR Dual Connectivity
NR-DC	NR-NR Dual Connectivity
QMC	QoE Measurement Collection
QoE	Quality of Experience
RLM	Radio Link Monitoring
SCG	Secondary Cell Group
SMTC	SS/PBCH block Measurement Timing Configuration
SN	Secondary Node
SPR	Successful PSCell Addition/Change Report
V2X	Vehicle-to-Everything

4 Multi-Radio Dual Connectivity

4.1 General

4.1.1 Common MR-DC principles

Multi-Radio Dual Connectivity (MR-DC) is a generalization of the Intra-E-UTRA Dual Connectivity (DC) described in TS 36.300 [2], where a multiple Rx/Tx capable UE may be configured to utilise resources provided by two different nodes connected via non-ideal backhaul, one providing NR access and the other one providing either E-UTRA or NR access. One node acts as the MN and the other as the SN. The MN and SN are connected via a network interface and at least the MN is connected to the core network.

The MN and/or the SN can be operated with shared spectrum channel access.

All functions specified for a UE may be used for an IAB-MT unless otherwise stated. Similar as specified for UE, the IAB-MT can access the network using either one network node or using two different nodes with EN-DC and NR-DC architectures. In EN-DC, the backhauling traffic over the E-UTRA radio interface is not supported.

NOTE 1: MR-DC is designed based on the assumption of non-ideal backhaul between the different nodes but can also be used in case of ideal backhaul.

NOTE 2: All MR-DC normative text and procedures in this version of the specification show the aggregated node case. The details about non-aggregated node for MR-DC operation are described in TS 38.401 [7].

4.1.2 MR-DC with the EPC

E-UTRAN supports MR-DC via E-UTRA-NR Dual Connectivity (EN-DC), in which a UE is connected to one eNB that acts as a MN and one en-gNB that acts as a SN. The eNB is connected to the EPC via the S1 interface and to the en-gNB via the X2 interface. The en-gNB might also be connected to the EPC via the S1-U interface and other en-gNBs via the X2-U interface.

The EN-DC architecture is illustrated in Figure 4.1.2-1 below.

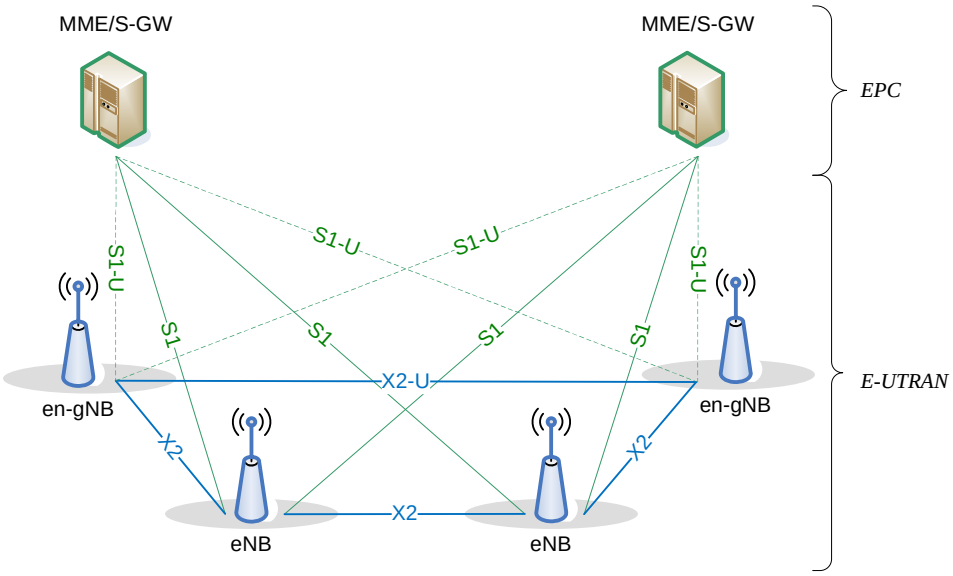


Figure 4.1.2-1: EN-DC Overall Architecture

4.1.3 MR-DC with the 5GC

4.1.3.1 E-UTRA-NR Dual Connectivity

NG-RAN supports NG-RAN E-UTRA-NR Dual Connectivity (NGEN-DC), in which a UE is connected to one ng-eNB that acts as a MN and one gNB that acts as a SN.

4.1.3.2 NR-E-UTRA Dual Connectivity

NG-RAN supports NR-E-UTRA Dual Connectivity (NE-DC), in which a UE is connected to one gNB that acts as a MN and one ng-eNB that acts as a SN.

4.1.3.3 NR-NR Dual Connectivity

NG-RAN supports NR-NR Dual Connectivity (NR-DC), in which a UE is connected to one gNB that acts as a MN and another gNB that acts as a SN. In addition, NR-DC can also be used when a UE is connected to a single gNB, acting both as a MN and as a SN, and configuring both MCG and SCG.

4.2 Radio Protocol Architecture

4.2.1 Control Plane

In MR-DC, the UE has a single RRC state, based on the MN RRC and a single C-plane connection towards the Core Network. Figure 4.2.1-1 illustrates the Control plane architecture for MR-DC. Each radio node has its own RRC entity (E-UTRA version if the node is an eNB or NR version if the node is a gNB) which can generate RRC PDUs to be sent to the UE.

RRC PDUs generated by the SN can be transported via the MN to the UE. The MN always sends the initial SN RRC configuration via MCG SRB (SRB1), but subsequent reconfigurations may be transported via MN or SN. When transporting RRC PDU from the SN, the MN does not modify the UE configuration provided by the SN.

In E-UTRA connected to EPC, at initial connection establishment SRB1 uses E-UTRA PDCP. If the UE supports EN-DC, regardless whether EN-DC is configured or not, after initial connection establishment, MCG SRBs (SRB1 and SRB2) can be configured by the network to use either E-UTRA PDCP or NR PDCP (either SRB1 and SRB2 are both configured with E-UTRA PDCP, or they are both configured with NR PDCP). Change from E-UTRA PDCP to NR PDCP (or vice-versa) is supported via a handover procedure (reconfiguration with mobility) or, for the initial change of SRB1 from E-UTRA PDCP to NR PDCP, with a reconfiguration without mobility before the initial security activation.

If the SN is a gNB (i.e. for EN-DC, NGEN-DC and NR-DC), the UE can be configured to establish a SRB with the SN (SRB3) to enable RRC PDUs for the SN to be sent directly between the UE and the SN. RRC PDUs for the SN can only be transported directly to the UE for SN RRC reconfiguration not requiring any coordination with the MN. Measurement reporting for mobility within the SN can be done directly from the UE to the SN if SRB3 is configured.

In NR-DC, the UE can be configured to establish a SRB with the SN (SRB5) to enable RRC messages which include application layer measurement report information to be sent directly between the UE and the SN. The application measurement report can be sent directly from the UE to the SN if SRB5 is configured and indicated by the network for the application measurement reporting.

Split SRB is supported for all MR-DC options, allowing duplication of RRC PDUs generated by the MN, via the direct path and via the SN. Split SRB uses NR PDCP. This version of the specification does not support the duplication of RRC PDUs generated by the SN via the MN and SN paths.

In EN-DC, the SCG configuration is kept in the UE during suspension. During connection resumption, if the UE supports resuming with EN-DC, the UE can be configured to release, restore, or reconfigure the SCG configuration. Otherwise, the UE releases the SCG configuration (but not the radio bearer configuration) during resumption initiation.

In MR-DC with 5GC, the UE stores the PDCP/SDAP configuration and the SCG configuration when moving to RRC Inactive. During connection resumption, if the UE supports resuming with MR-DC, the UE can be configured to release, restore, or reconfigure the SCG configuration. Otherwise, it releases the SCG configuration.

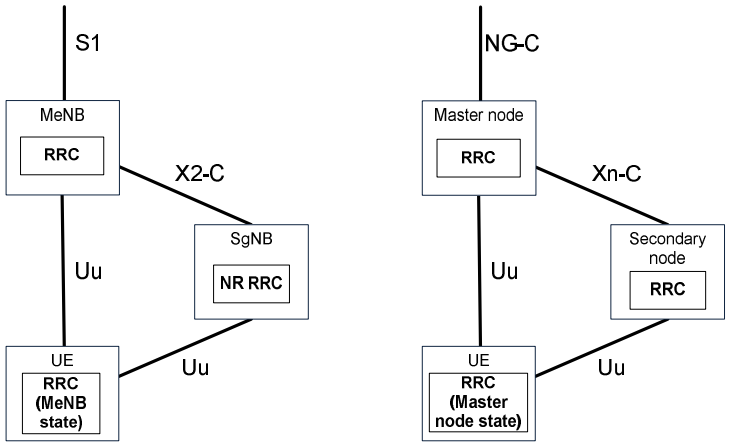


Figure 4.2.1-1: Control plane architecture for EN-DC (left) and MR-DC with 5GC (right).

4.2.2 User Plane

In MR-DC, from a UE perspective, three bearer types exist: MCG bearer, SCG bearer and split bearer. These three bearer types are depicted in Figure 4.2.2-1 for MR-DC with EPC (EN-DC) and in Figure 4.2.2-2 for MR-DC with 5GC (NGEN-DC, NE-DC and NR-DC).

In E-UTRA connected to EPC, if the UE supports EN-DC, regardless whether EN-DC is configured or not, the network can configure either E-UTRA PDCP or NR PDCP for MN terminated MCG bearers while NR PDCP is always used for all other bearers. Change from E-UTRA to NR PDCP or vice-versa can be performed via a reconfiguration procedure (with or without handover), either using release and add of the DRBs or using the full configuration option.

In MR-DC with 5GC, NR PDCP is always used for all bearer types. In NGEN-DC, E-UTRA RLC/MAC is used in the MN while NR RLC/MAC is used in the SN. In NE-DC, NR RLC/MAC is used in the MN while E-UTRA RLC/MAC is used in the SN. In NR-DC, NR RLC/MAC is used in both MN and SN.

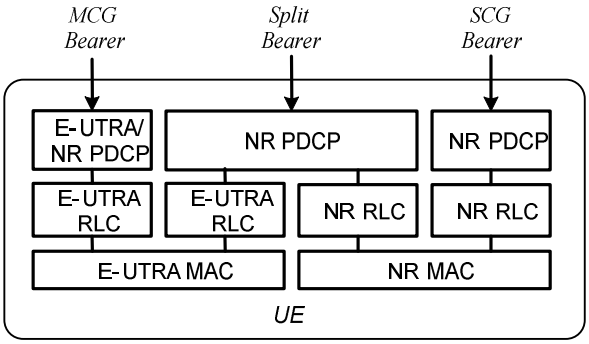


Figure 4.2.2-1: Radio Protocol Architecture for MCG, SCG and split bearers from a UE perspective in MR-DC with EPC (EN-DC)

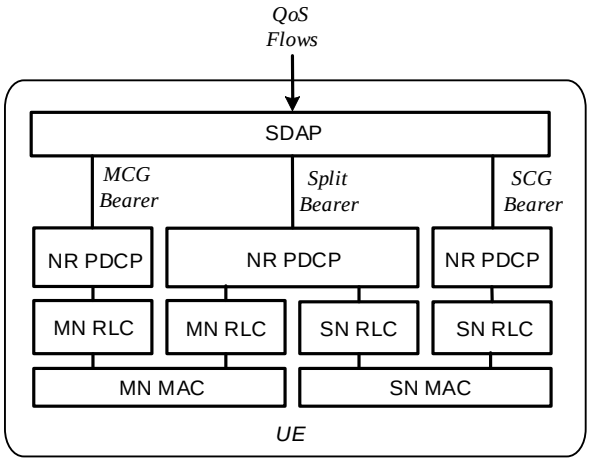


Figure 4.2.2-2: Radio Protocol Architecture for MCG, SCG and split bearers from a UE perspective in MR-DC with 5GC (NGEN-DC, NE-DC and NR-DC).

From a network perspective, each bearer (MCG, SCG and split bearer) can be terminated either in MN or in SN. Network side protocol termination options are shown in Figure 4.2.2-3 for MR-DC with EPC (EN-DC) and in Figure 4.2.2-4 for MR-DC with 5GC (NGEN-DC, NE-DC and NR-DC).

NOTE 1: Even if only SCG bearers are configured for a UE, for SRB1 and SRB2 the logical channels are always configured at least in the MCG, i.e. this is still an MR-DC configuration and a PCell always exists.

NOTE 2: If only MCG bearers are configured for a UE, i.e. there is no SCG, this is still considered an MR-DC configuration, as long as at least one of the bearers is terminated in the SN.

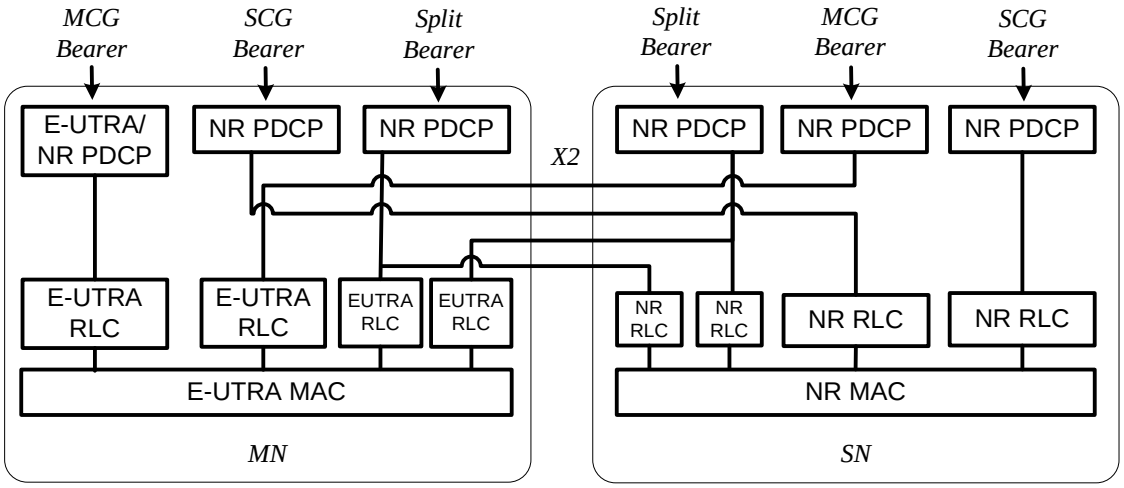


Figure 4.2.2-3: Network side protocol termination options for MCG, SCG and split bearers in MR-DC with EPC (EN-DC).

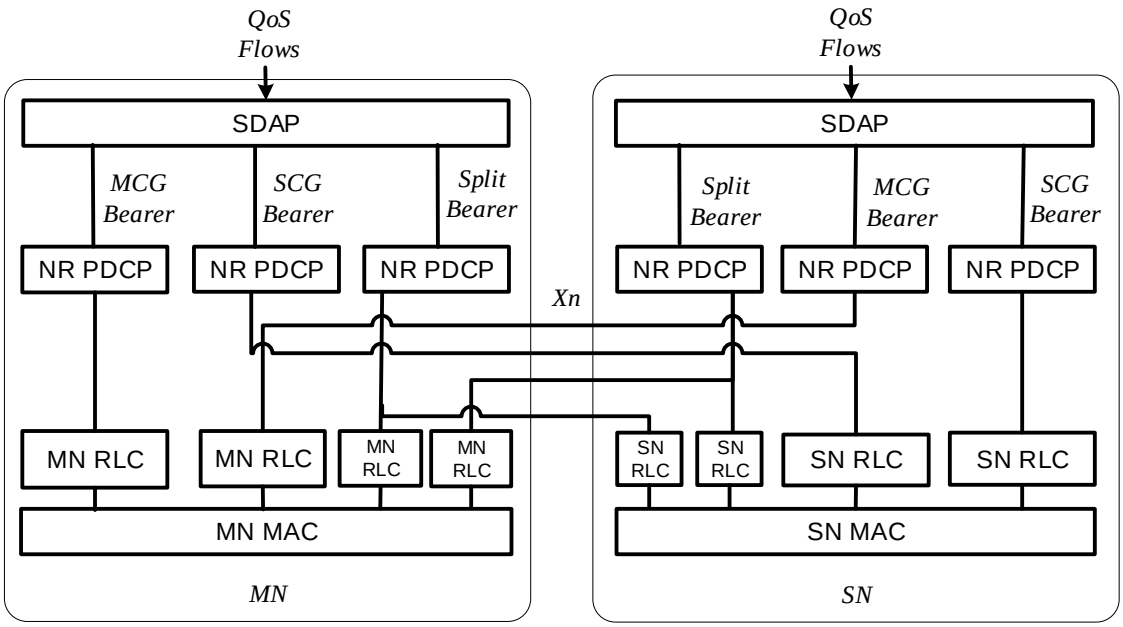


Figure 4.2.2-4: Network side protocol termination options for MCG, SCG and split bearers in MR-DC with 5GC (NGEN-DC, NE-DC and NR-DC).

4.3 Network interfaces

4.3.1 Control Plane

4.3.1.1 Common MR-DC principles

In MR-DC, there is an interface between the MN and the SN for control plane signalling and coordination. For each MR-DC UE, there is also one control plane connection between the MN and a corresponding CN entity. The MN and

the SN involved in MR-DC for a certain UE control their radio resources and are primarily responsible for allocating radio resources of their cells.

Figure 4.3.1.1-1 shows C-plane connectivity of MN and SN involved in MR-DC for a certain UE.

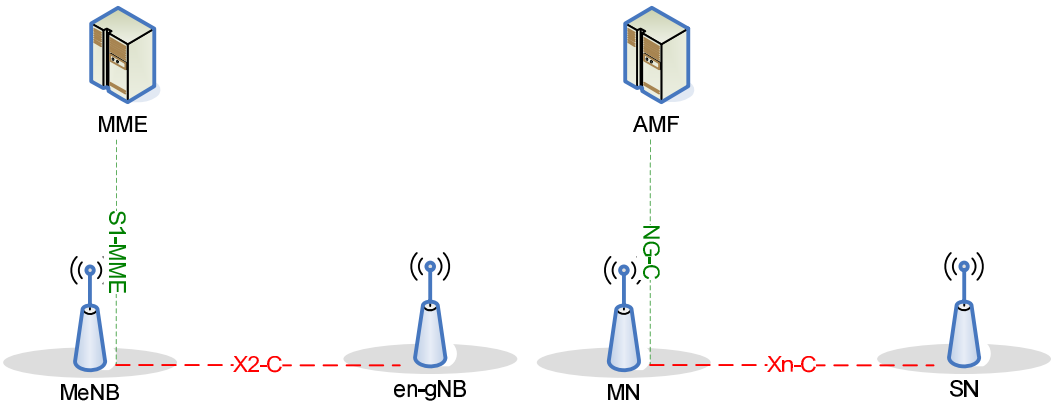


Figure 4.3.1.1-1: C-Plane connectivity for EN-DC (left) and MR-DC with 5GC (right).

4.3.1.2 MR-DC with EPC

In MR-DC with EPC (EN-DC), the involved core network entity is the MME. S1-MME is terminated in MN and the MN and the SN are interconnected via X2-C.

4.3.1.3 MR-DC with 5GC

In MR-DC with 5GC (NGEN-DC, NE-DC and NR-DC), the involved core network entity is the AMF. NG-C is terminated in the MN and the MN and the SN are interconnected via Xn-C.

4.3.2 User Plane

4.3.2.1 Common MR-DC principles

There are different U-plane connectivity options of the MN and SN involved in MR-DC for a certain UE, as shown in Figure 4.3.2.1-1. The U-plane connectivity depends on the bearer option configured:

- For *MN terminated bearers*, the user plane connection to the CN entity is terminated in the MN;
- For *SN terminated bearers*, the user plane connection to the CN entity is terminated in the SN;
- The transport of user plane data over the Uu either involves MCG or SCG radio resources or both:
  - For *MCG bearers*, only MCG radio resources are involved;
  - For *SCG bearers*, only SCG radio resources are involved;
  - For *split bearers*, both MCG and SCG radio resources are involved.
- For split bearers, *MN terminated SCG bearers* and *SN terminated MCG bearers*, PDCP data is transferred between the MN and the SN via the MN-SN user plane interface.

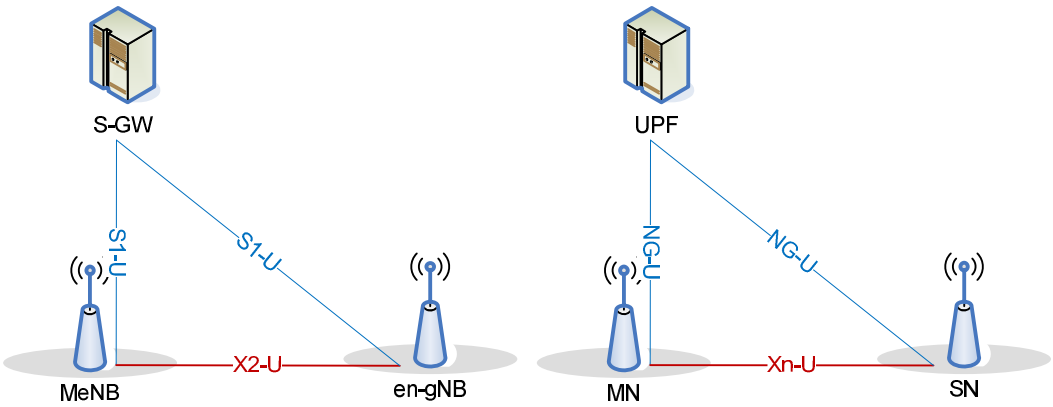


Figure 4.3.2.1-1: U-Plane connectivity for EN-DC (left) and MR-DC with 5GC (right).

4.3.2.2 MR-DC with EPC

For MR-DC with EPC (EN-DC), X2-U interface is the user plane interface between MN and SN, and S1-U is the user plane interface between the MN, the SN or both and the S-GW.

4.3.2.3 MR-DC with 5GC

For MR-DC with 5GC (NGEN-DC, NE-DC and inter-gNB NR-DC), Xn-U interface is the user plane interface between MN and SN, and NG-U is the user plane interface between the MN, the SN or both and the UPF.

5 Layer 1 related aspects

In MR-DC, two or more Component Carriers (CCs) may be aggregated over two cell groups. A UE may simultaneously receive or transmit on multiple CCs depending on its capabilities. The maximum number of configured CCs for a UE is 32 for DL and UL. Depending on UE's capabilities, up to 31 CCs can be configured for an E-UTRA cell group when the NR cell group is configured. For the NR cell group, the maximum number of configured CCs for a UE is 16 for DL and 16 for UL.

A gNB may configure the same Physical Cell ID (PCI) to more than one NR cell it serves. To avoid PCI confusion for MR-DC, NR PCIs should be allocated in a way that an NR cell is uniquely identifiable by a PCell identifier. This PCell is in the coverage area of an NR cell included in the MR-DC operation. In addition, NR PCIs should only be re-used in NR cells on the same SSB frequency sufficiently distant from each other. X2-C/Xn-C signalling supports disambiguation of NR PCIs by including the CGI of the PCell in respective X2AP/XnAP messages (e.g. SGNB ADDITION REQUEST/S-NODE ADDITION REQUEST) and by providing neighbour cell relationship via non-UE associated signaling (e.g. via the Xn Setup procedure or the NG-RAN node Configuration Update procedure).

NR-DC supports the case of no synchronization between PCell and PSCell. However, some UEs may support NR-DC only if slot-level synchronization between PCell and PSCell is ensured.

In MR-DC, power sharing can be performed within a frequency range with either semi-static or dynamic power sharing. With semi-static power sharing, the maximum UE transmission power is semi-statically split between MCG and SCG by RRC configuration. With dynamic power sharing:

- when determining the UL transmission power of an SCG transmission in (NG)EN-DC or in NR-DC, the UE takes into account transmission(s) on MCG overlapping with any part of the SCG transmission;
- when determining the UL transmission power of an MCG transmission in NE-DC, the UE takes into account transmission(s) on SCG overlapping with any part of the MCG transmission.

Details are specified in TS38.213[21].

In EN-DC, a UE configured with uplink Tx switching can have Tx dynamically switched between E-UTRA uplink carrier and NR uplink carrier for enabling 2Tx UL transmission on NR carrier.

6 Layer 2 related aspects

6.1 MAC Sublayer

In MR-DC, the UE is configured with two MAC entities: one MAC entity for the MCG and one MAC entity for the SCG. The serving cells other than the PCell can be activated/deactivated by RRC or MAC Control Element. For activation/deactivation by MAC Control Element, the serving cells of the MCG other than the PCell can only be activated/deactivated by the MAC Control Element received on MCG, and the serving cells of the SCG other than PSCell can only be activated/ deactivated by the MAC Control Element received on SCG. The MAC entity applies the bitmap for the associated cells of either MCG or SCG. When the SCG is not deactivated, the PSCell is always activated like the PCell (i.e. deactivation timer is not applied to PSCell). With the exception of PUCCH SCell, one deactivation timer is configured per SCell by RRC.

In MR-DC, semi-persistent scheduling (SPS) resources and configured grant (CG) resources can be configured on serving cells in both MCG and SCG.

In MR-DC, for 4-step RA type, contention based random access (CBRA) procedure is supported on both PCell and PSCell while contention free random access (CFRA) procedure is supported on all serving cells in both MCG and SCG. For 2-step RA type, CBRA can be supported on the PCell, if the MN is a gNB (i.e. for NE-DC and NR-DC) and on the PSCell, if the SN is a gNB (i.e, for EN-DC, NGEN-DC and NR-DC) while CFRA is only supported on the PCell, if the MN is a gNB (i.e. for NE-DC and NR-DC).

In (NG)EN-DC and NR-DC, when SCG is deactivated as described in clause 7.13, the TA timer associated with SCG continues running, the UE considers the TA is valid as long as TA timer is running. In case of SCG activation, the UE can be instructed by the network to perform random access towards PSCell even if the TA timer associated with PSCell is running and RLF and beam failure are not declared. Besides, the UE can be instructed by the network to perform SCG activation without performing random access, if the TA timer associated with PSCell is running and RLM and beam failure detection are configured but RLF or beam failure is not declared. In case of network-initiated SCG activation, both CBRA and CFRA on PSCell are supported. For CFRA, the dedicated RACH resources can be provided in the RRC message used to activate SCG.

In MR-DC, the BSR configuration, triggering and reporting are independently performed per cell group. For split bearers, the PDCP data is considered in BSR in the cell group(s) configured by RRC.

In MR-DC, separate DRX configurations are provided for MCG and SCG. A secondary DRX group can be configured in MR-DC for a cell group that includes cells in different Frequency Ranges as specified in TS 38.331 [4].

In MR-DC, PHR is independently configured per cell group. Events in one cell group can trigger power headroom reporting in both MCG and SCG. Power headroom information for one cell group is also included in a PHR transmitted in the other cell group. While the SCG is deactivated, PHR for SCG is not reported.

In MR-DC, consistent LBT failure recovery procedure as described in clause 5.6.1 in TS 38.300 [3] can be configured for both MAC entities of MCG and/or SCG when operating with shared spectrum channel access.

In MR-DC, for power saving purpose, the UE can be configured with DCP to be monitored on the PCell, if the MN is a gNB (i.e. for NE-DC and NR-DC) and/or with DCP to be monitored on the PSCell, if the SN is a gNB (i.e. for EN-DC, NGEN-DC and NR-DC).

In MR-DC, the UE may be configured with enhanced intra-UE overlapping resources prioritization on MN, if the MN is a gNB (i.e. for NE-DC and NR-DC) and on SN, if the SN is a gNB (i.e. for EN-DC, NGEN-DC and NR-DC).

6.2 RLC Sublayer

Both RLC AM and UM can be configured for MR-DC, for all bearer types (MCG, SCG and split bearers).

6.3 PDCP Sublayer

In EN-DC, CA duplication (see [3]) can be applied in the MN and in the SN, but MCG bearer CA duplication can be configured only in combination with E-UTRAN PDCP and MCG bearer CA duplication can be configured only if DC duplication is not configured for any split bearer.

In NGEN-DC, CA duplication can only be configured for SCG bearer. In NE-DC, CA duplication can only be configured for MCG bearer. In NR-DC, CA duplication can be configured for both MCG and SCG bearers, and can be configured together with DC duplication.

In MR-DC, RoHC and EHC (as described in TS 36.323 [15] and TS 38.323 [16]) can be configured for all the bearer types. In MR-DC with 5GC, UDC (as described in TS 38.323 [16]) can be configured for all the bearer types.

6.4 SDAP Sublayer

In MR-DC with 5GC, the network may host up to two SDAP protocol entities for each individual PDU session, one for MN and another one for SN (see clause 8.1). The UE is configured with one SDAP protocol entity per PDU session.

6.5 BAP Sublayer

In EN-DC and NR-DC, IAB-node and IAB-donor-DU can be configured with BAP sublayer for backhaul traffic (as described in TS 38.300 [3] and TS 38.340 [17]). In EN-DC, the BAP sublayer routes the backhaul traffic via only the NR interface. In NR-DC, the BAP sublayer can route the backhaul traffic via the two NR interfaces to the same IAB-donor.

7 RRC related aspects

7.1 System information handling

In MR-DC, the SN is not required to broadcast system information other than for radio frame timing and SFN. System information for initial configuration is provided to the UE by dedicated RRC signalling via the MN. The UE acquires, at least, radio frame timing and SFN of SCG from the PSS/SSS and MIB (if the SN is an eNB) / NR-PSS/SSS and PBCH (if the SN is a gNB) of the PSCell. In EN-DC, SN may broadcast system information to allow only IAB-MT to access the SN.

NOTE: The option that the SN does not broadcast system information other than radio frame timing and SFN relies on proper OAM configuration.

Additionally, upon change of the relevant system information of a configured SCell, the network releases and subsequently adds the concerned SCell (with updated system information), via one or more *RRC reconfiguration* messages sent on SRB1 or SRB3, if configured.

7.2 Measurements

If the measurement is configured to the UE in preparation for the Secondary Node Addition procedure described in clause 10.2, the Master node should configure the measurement to the UE.

In case of the intra-secondary node mobility described in clause 10.3, the SN should configure the measurement to the UE in coordination with the MN, if required.

The Secondary Node Change procedure described in clause 10.5 can be triggered by both the MN (only for inter-frequency secondary node change) and the SN. For secondary node changes triggered by the SN, the RRM measurement configuration is maintained by the SN which also processes the measurement reporting, without providing the measurement results to the MN.

Measurements can be configured independently by the MN and by the SN (intra-RAT measurements on serving and non-serving frequencies). The MN indicates the maximum number of frequency layers and measurement identities of intra-frequency and inter-frequency measurement that can be used in the SN to ensure that UE capabilities are not exceeded. In MR-DC, to assist MN to identify the measurement type, the SN indicates to the MN the list of SCG serving frequencies. In NR-DC, to assist SN to identify the measurement type, the MN indicates also to SN the list of MCG serving frequencies. The SN can also request the MN for new maximum values of the number of measurement identities that it can configure, and it is up to the MN whether to accommodate the SN request, based on the capability coordination principles as described in 7.3. If the SN receives from the MN a new value for the maximum number of

measurement identities, is SN responsibility to ensure that its configured measurement identities to comply with the new limit.

If MN and SN both configure measurements on the same carrier frequency then the configurations need to be consistent (if the network wants to ensure these are considered as a single measurement layer). Each node (MN and SN) can configure independently a threshold for the SpCell quality. In (NG)EN-DC scenario, when the PCell quality is above the threshold configured by the MN, the UE is still required to perform inter-RAT measurements configured by the MN on the SN RAT (while it's not required to perform intra-RAT measurements); when the PSCell quality is above the threshold configured by the SN, the UE is not required to perform measurements configured by the SN. In NR-DC or NE-DC scenario, when the PCell quality is above the threshold configured by the MN, the UE is not required to perform measurements configured by the MN; when the PSCell quality is above the threshold configured by the SN, the UE is not required to perform measurements configured by the SN.

NOTE: The SN cannot renegotiate the number of frequency layers allocated by the MN in this version of the protocol.

In MR-DC, both the MN and the SN can configure CGI reporting. The MN can configure CGI reporting for intra-RAT and inter-RAT cells but the SN can only configure CGI reporting of intra-RAT cells. At any point in time, the UE can be configured with at most one CGI reporting configuration. For CGI reporting coordination, the SN sends the CGI measurement request and the embedded CGI reporting configuration to the MN. Optionally, the SN sends the unknown cell information to the MN. If there is no ongoing CGI reporting measurement on UE side, the MN forwards the SN CGI measurement configuration to UE. Otherwise the MN rejects the request by sending X2/Xn reject message. In case the SN indicates the unknown cell information, and the CGI information of the requested cell is already available in the MN, the MN can also reject the request, and sends the CGI information of the requested cell to the SN. The SN cannot configure the CGI measurement using the SRB3.

Both MN-configured and SN-configured RRM measurements are supported while the SCG is deactivated. The PSCell measurement cycle when in deactivated SCG state is configured by RRC.

When SRB3 is not configured or the SCG is deactivated, reports for measurements configured by the SN are sent on SRB1. When SRB3 is configured and SCG transmission of radio bearers is not suspended and the SCG is not deactivated, reports for measurements configured by the SN are sent on SRB3.

Measurement results related to the target SN can be provided by MN to target SN at MN initiated SN change procedure. Measurement results of target SN can be forwarded from source SN to target SN via MN at SN initiated SN change procedure. Measurement results related to the target SN can be provided by source MN to target MN at Inter-MN handover with/without SN change procedure.

Measurement results according to measurement configuration from the MN are encoded according to SN RRC when they are provided by MN to SN in *SgNB Addition Request* message / *SN Addition Request* message. During SN initiated SN change procedure, measurement results according to measurement configuration from SN are encoded according to SN RRC when they are provided by MN to SN in *SgNB Addition Request* message / *SN Addition Request* message.

Per-UE or per-FR measurement gaps can be configured, depending on UE capability to support independent FR measurement and network preference. Per-UE gap applies to both FR1 (E-UTRA, UTRA-FDD and NR) and FR2 (NR) frequencies. For per-FR gap, two independent gap patterns (i.e. FR1 gap and FR2 gap) are configured for FR1 and FR2 respectively. The UE may also be configured with a per-UE gap sharing configuration (applying to per-UE gap) or with two separate gap sharing configurations (applying to FR1 and FR2 measurement gaps respectively) [8].

A measurement gap configuration is always provided:

- In EN-DC, NGEN-DC and NE-DC, for UEs configured with E-UTRA inter-frequency measurements as described in table 9.1.2-2 in TS 38.133 [8];
- In EN-DC and NGEN-DC, for UEs configured with UTRAN and GERAN measurements as described in table 9.1.2-2 in TS 38.133 [8];
- In NR-DC, for UEs configured with E-UTRAN measurements as described in table 9.1.2-3 in TS 38.133 [8];
- In NR-DC, NE-DC, for UEs configured with UTRAN measurements as described in table 9.4.6.3-1 and 9.4.6.3-2 in TS 38.133 [8];
- In MR-DC, for UEs that support either per-UE or per-FR gaps, when the conditions to measure SSB based inter-frequency measurement or SSB based intra-frequency measurement as described in clause 9.2.4 in TS 38.300 [3] are met;

If per-UE gap is used, the MN decides the gap pattern and the related gap sharing configuration. If per-FR gap is used, in EN-DC and NGEN-DC, the MN decides the FR1 gap pattern and the related gap sharing configuration for FR1, while the SN decides the FR2 gap pattern and the related gap sharing configuration for FR2; in NE-DC and NR-DC, the MN decides both the FR1 and FR2 gap patterns and the related gap sharing configurations.

In EN-DC and NGEN-DC, the measurement gap configuration from the MN to the UE indicates if the configuration from the MN is a per-UE gap or an FR1 gap configuration. The MN also indicates the configured per-UE or FR1 measurement gap pattern and the gap purpose (per-UE or per-FR1) to the SN. Measurement gap configuration assistance information can be exchanged between the MN and the SN. For the case of per-UE gap, the SN indicates to the MN the list of SN configured frequencies in FR1 and FR2 measured by the UE. For the per-FR gap case, the SN indicates to the MN the list of SN configured frequencies in FR1 measured by the UE and the MN indicates to the SN the list of MN configured frequencies in FR2 measured by the UE.

In NE-DC, the MN indicates the configured per-UE or FR1 measurement gap pattern to the SN. The SN can provide a gap request to the MN, without indicating any list of frequencies.

In NR-DC, the MN indicates the configured per-UE, FR1 or FR2 measurement gap pattern and the gap purpose to the SN. The SN can indicate to the MN the list of SN configured frequencies in FR1 and FR2 measured by the UE.

In (NG)EN-DC and NR-DC, SMTC can be used for PSCell addition/PSCell change to assist the UE in finding the SSB in the target PSCell. In case the SMTC of the target PSCell is provided by both MN and SN it is up to UE implementation which one to use.

CLI measurements can be configured for NR cells in all MR-DC options. In EN-DC and NGEN-DC, only the SN can configure CLI measurements. In NE-DC, only the MN can configure CLI measurements. In NR-DC, both the MN and the SN can configure CLI measurements, and the MN informs the SN about the maximum number of CLI measurement resources that can be configured by the SN to ensure that the total number of CLI measurement resources does not exceed the UE capabilities.

For MUSIM operation, when the UE is configured to operate in NR-DC in Network A (as described in TS 38.300 [3]), the MN indicates the per-UE MUSIM gap configuration to the SN.

7.3 UE capability coordination

In (NG)EN-DC and NE-DC, the capabilities of a UE supporting MR-DC are carried by different capability containers. Some MR-DC related capabilities are in the MR-DC container e.g. MR-DC band combinations, while other MR-DC related capabilities are contained in the E-UTRA and NR capability containers e.g. feature sets as described in TS 38.300 [3]. The MR-DC capabilities in the MR-DC container need to be visible to both MN and SN, while the capabilities in the E-UTRA and NR containers only need to be visible to the node of the concerned RAT.

In NR-DC, all NR-DC related capabilities are in the NR capability container and are visible to both MN and SN.

When retrieving MR-DC related capabilities, the MN shall provide an MR-DC filter that affects the MR-DC related capabilities in MR-DC, E-UTRA and NR capability containers. When using different *UE capability enquiry* messages to retrieve the different containers, the MN shall employ the same MR-DC filter in all enquiry messages. In the E-UTRA RRC UE capability enquiry, the MR-DC filter is also used for retrieval of NR capabilities i.e. there is in fact one MR-DC/NR filter (while there is a separate filter for E-UTRA capabilities). Furthermore, the MN stores the retrieved capabilities and the corresponding filter, used to retrieve those capabilities, in the core network for later use.

For the UE capabilities requiring coordination between E-UTRA and NR (i.e. band combinations, feature sets and the maximum power for FR1 the UE can use in SCG) or between NR MN and NR SN (i.e. band combinations, feature sets and the maximum power for FR1 and FR2), it is up to the MN to decide on how to resolve the dependency between MN and SN configurations. The MN then provides the resulting UE capabilities usable for SCG configuration to the SN, including the list of allowed MR-DC band combinations and feature sets, and the SN indicates the selected band combination and feature set to the MN. When subsequently reconfiguring the SCG, the SN should inform the MN whenever the band combination and/or feature set it selected for the SCG changes (i.e. even if the selection concerns a band combination and feature set that is allowed). As part of an SN initiated SN modification, the SN may also indicate the desired UE capabilities usable for SCG configuration (e.g. a band combination and a feature set) outside those allowed by the MN (i.e. it may re-negotiate the UE capabilities for SCG configuration), and it is up to the MN to make the final decision whether to accept or reject the request. If the MN accepts the request, the MN may provide the resulting UE capabilities e.g. by indicating the allowed band combinations and feature sets. If MN accepts but does not provide resulting UE capabilities, SN assumes the UE capabilities usable for SCG configuration are updated in accordance with the modification it requested. Otherwise, the MN rejects the request by sending X2/Xn refuse message.

In EN-DC and MR-DC with 5GC, the MN may provide the UE radio capability ID to the SN. For EN-DC, the SN may retrieve the UE Radio Capability information associated to a UE radio capability ID from the MN. For MR-DC with 5GC, the SN may retrieve the UE radio capability information associated to a UE radio capability ID from the 5GC.

For MUSIM operation, when the UE is configured to operate in NR-DC in Network A (as described in TS 38.300 [3]), the MN may indicate the temporary capability restriction to the SN based on the temporary capability restrictions indicated by the UE.

For LTM operation, the MN indicates the maximum number of LTM candidate configurations the SN is allowed to configure for SCG LTM, to ensure that UE capabilities are not exceeded. The SN can also request the MN for a new value of the maximum number of allowed LTM candidate configurations to configure for SCG LTM, and it is up to the MN whether to accommodate the SN request. If the SN receives from the MN a new value for the maximum number of LTM candidate configurations, it is SN responsibility to ensure that its configured LTM candidate configurations to comply with the new limit.

For the LTM related UE capabilities about L1 measurements requiring coordination between the MN and the SN, it is up to the MN to decide on how to resolve the dependency between MN and SN configurations and ensure that the UE capabilities are not exceeded. The MN then provides the resulting UE capabilities about L1 measurements usable for SCG configuration to the SN. The SN can also request a new value for such UE capabilities for L1 measurements, and it is up to the MN whether to accommodate the SN request. If the SN receives from the MN a new value for such UE capabilities for L1 measurements, it is SN responsibility to ensure that its configured L1 measurement configurations to comply with the new limit.

7.4 Handling of combined MN/SN RRC messages

When both MCG and SCG reconfiguration is required due to the need for coordination with the MN, the *SN RRC reconfiguration* message is encapsulated in an MN RRC message that also carries the corresponding MCG reconfiguration that ensures that the combined configuration can be jointly processed by the UE. If the MN terminates a bearer using NR PDCP, the NR PDCP configuration is generated by the MN itself. If the SN terminates the bearer, the SN generates the NR PDCP configuration and sends it to the MN as a separate container.

The UE uses a joint success/failure procedure for messages in an encapsulating MN RRC message. A failure of the MN RRC messages, including one encapsulated SN RRC message with or without any MCG reconfiguration fields, triggers a re-establishment procedure. Each *SN RRC reconfiguration* message should have its own RRC response message even when the SN RRC message is encapsulated in an MN RRC message. The SN RRC response message is forwarded over X2/Xn to the SN. If a *SN RRC reconfiguration* message is contained in a MN RRC message, the UE sends a MN RRC response message that encapsulates the SN RRC response message.

NOTE: If the MN RRC message does not encapsulate an *SN RRC reconfiguration* message (i.e. an SCG configuration) but only information elements generated by the SN (e.g. the PDCP configuration for an SN terminated bearer), the UE will not send an SN RRC response message.

7.5 SRB3

SRB3 is supported in EN-DC, NGEN-DC and NR-DC, but not in NE-DC.

The decision to establish SRB3 is taken by the SN, which provides the SRB3 configuration using an SN RRC message. SRB3 establishment and release can be done at Secondary Node Addition and Secondary Node Change. SRB3 reconfiguration can be done at Secondary Node Modification procedure.

SRB3 may be used to send *SN RRC Reconfiguration*, *SN RRC Reconfiguration Complete*, *SN Measurement Report*, *SN Failure Information* (i.e., in case of failure for an SCG RLC bearer), *SN UE Assistance Information* message and *SN IABOtherInformation*, only in procedures where the MN is not involved. *SN RRC Reconfiguration Complete* messages are mapped to the same SRB as the message initiating the procedure. *SN Measurement Report* messages are mapped to SRB3, if configured, regardless of whether the configuration is received directly from the SN or via the MN. No MN RRC messages are mapped to SRB3.

If split SRB1 is not configured, SRB3 may be used by the UE to transmit to the MN an encapsulated *MCG Failure Information* message in the *ULInformationTransferMRDC* message and receive in response an encapsulated *RRC reconfiguration* message, *MobilityFromNRCommand* message, *MobilityFromEUTRACommand* message or *RRC release* message in the *DLInformationTransferMRDC* message.

SRB3 is modelled as one of the SRBs defined in TS 38.331 [4] and uses the NR-DCCH logical channel type. RRC PDUs on SRB3 are ciphered and integrity protected using NR PDCP, with security keys derived from S-K_{gNB}. The SN selects ciphering and integrity protection algorithms for the SRB3 and provides them to the MN within the SCG Configuration for transmission to the UE.

NOTE: A NR SCG RRC message sent via E-UTRA MCG SRB is protected by E-UTRA MCG SRB security (NR security is not used in this case).

SRB3 is of higher scheduling priority than all DRBs. The default scheduling priorities of split SRB1 and SRB3 are the same.

There is no requirement on the UE to perform any reordering of RRC messages between SRB1 and SRB3.

When SCG is released, SRB3 is released.

7.6 Split SRB

Split SRB is supported for both SRB1 and SRB2 (split SRB is not supported for SRB0, SRB3, SRB4 and SRB5) in all MR-DC cases. RRC PDUs on split SRB are ciphered and integrity protected using NR PDCP.

Split SRB can be configured by the MN in Secondary Node Addition and/or Modification procedure, with SN configuration part provided by the SN. A UE can be configured with both split SRB and SRB3 simultaneously. SRB3 and the SCG leg of split SRB can be independently configured.

For the split SRB, the selection of transmission path in downlink depends on network implementation. For uplink, the UE is configured via MN RRC signalling whether to use MCG path or duplicate the transmission on both MCG and SCG.

7.7 SCG/MCG failure handling

RLF is declared separately for the MCG and for the SCG.

If radio link failure is detected for MCG, fast MCG link recovery is configured and the SCG is not deactivated, the UE triggers fast MCG link recovery. Otherwise, the UE initiates the RRC connection re-establishment procedure. During the execution of PSCell addition or PSCell change, if radio link failure is detected for MCG, the UE initiates the RRC connection re-establishment procedure.

During fast MCG link recovery, the UE suspends MCG transmissions for all radio bearers, except SRB0, and, if any, BH RLC channels and reports the failure with *MCGFailureInformation* message to the MN via the SCG, using the SCG leg of split SRB1 or SRB3.

The UE includes in the *MCGFailureInformation* message the measurement results available according to current measurement configuration of both the MN and the SN. Once the fast MCG link recovery is triggered, the UE maintains the current measurement configurations from both the MN and the SN, and continues measurements based on configuration from the MN and the SN, if possible. The UE initiates the RRC connection re-establishment procedure if it does not receive an *RRCConnectionReconfiguration* message, *RRCReconfiguration* message, *MobilityFromNRCommand* message, *MobilityFromEUTRACommand* message, *RRCConnectionRelease* message or *RRCRelease* message within a certain time after fast MCG link recovery was initiated.

Upon reception of the *MCGFailureInformation* message, the MN can send *RRCConnectionReconfiguration* message, *RRCReconfiguration* message, *MobilityFromNRCommand* message, *MobilityFromEUTRACommand* message, *RRCConnectionRelease* message or *RRCRelease* message to the UE, using the SCG leg of split SRB1 or SRB3. Upon receiving an *RRCConnectionReconfiguration* message, *RRCReconfiguration* message, *MobilityFromNRCommand* message or *MobilityFromEUTRACommand* message, the UE resumes MCG transmissions for all radio bearers. Upon receiving an *RRCConnectionRelease* message or *RRCRelease* message, the UE releases all the radio bearers and configurations.

NOTE 1: It is up to network implementation to guarantee that the RRC-related messages are delivered to the UE by the SN before the release of its control plane resources.

The following SCG failure cases are supported:

- SCG RLF;

- SCG beam failure while the SCG is deactivated;
- SN addition/change failure;
- For EN-DC, NGEN-DC and NR-DC, SCG configuration failure or CPC configuration failure (only for messages on SRB3);
- For EN-DC, NGEN-DC and NR-DC, SCG RRC integrity check failure (on SRB3);
- For EN-DC, NGEN-DC and NR-DC, consistent UL LBT failure on PSCell;
- For IAB-MT, reception of a BH RLF indication from SCG;
- CPA/CPC or subsequent CPAC execution failure;
- SCG LTM cell switch failure.

Upon SCG failure, if MCG transmissions of radio bearers are not suspended, the UE suspends SCG transmissions for all radio bearers and, if any, BH RLC channels, if the SCG failure is not triggered by SCG beam failure, and reports the *SCGFailureInformation* to the MN, instead of triggering re-establishment. If SCG failure is detected while MCG transmissions for all radio bearers are suspended, the UE initiates the RRC connection re-establishment procedure.

SCG/MCG failure handling by UE also applies to IAB MT.

In all SCG failure cases, the UE maintains the current measurement configurations from both the MN and the SN and the UE continues measurements based on configuration from the MN and the SN if possible. The SN measurements configured to be routed via the MN will continue to be reported after the SCG failure.

NOTE 2: UE may not continue measurements based on configuration from the SN after SCG failure in certain cases (e.g. UE cannot maintain the timing of PSCell).

The UE includes in the *SCGFailureInformation* message the measurement results available according to current measurement configuration of both the MN and the SN. The MN handles the *SCGFailureInformation* message and may decide to keep, change, or release the SN/SCG. In all the cases, the measurement results according to the SN configuration and the SCG failure type may be forwarded to the old SN and/or to the new SN.

In case of CPA/CPC, upon transmission of the *SCGFailureInformation* message to the MN, the UE stops evaluating the CPA/CPC execution condition. In case of subsequent CPAC, upon transmission of the *SCGFailureInformation* message to the MN or upon transmission of the *MCGFailureInformation* message to the SN, the UE stops evaluating the subsequent CPAC execution condition. In case of CPA/CPC/subsequent CPAC/CHO with candidate SCG(s), the UE is not required to continue measurements for candidate PSCell(s) for execution condition upon transmission of the *SCGFailureInformation* message to the MN.

7.8 UE identities

In MR-DC, two C-RNTIs are independently allocated to the UE: one for MCG, and one for SCG.

7.9 Inter-node Resource Coordination

For MR-DC operations, MN and SN may coordinate their UL and DL radio resources in semi-static manner via UE associated signalling. The MN may coordinate its sidelink radio resources with the SN using the same UE associated signalling.

In EN-DC, CSI-RS based SgNB change between neighbour en-gNBs is supported by enabling that neighbour en-gNBs can exchange their own CSI-RS configurations and on/off status via the MeNB.

In NGEN-DC and NR-DC, CSI-RS based SN change between neighbour gNBs is supported
by enabling that neighbour gNBs can exchange their own CSI-RS configurations and on/off status via the MN.

7.10 UE assistance information

In MR-DC, the UE can be configured to report MCG specific UE assistance information if the MN is a gNB and/or SCG specific UE assistance information if the SN is a gNB, if it prefers an adjustment on the connected mode DRX parameters, the maximum aggregated bandwidth, the maximum number of secondary component carriers, the maximum number of MIMO layers, whether the UE prefers the SCG to be deactivated, the minimum scheduling offset for cross-slot scheduling cycle length, whether the UE is applying RLM/BFD measurements relaxation for power saving, and/or whether the UE is experiencing IDC problems as described in TS 36.300 [2] and TS 38.300 [3]. In these cases, it is up to the network whether to accommodate the preference or how to use the relaxation status indications or how to solve the IDC problems. SCG specific UE assistance information for power saving or IDC can be configured by the network via SRB1 or SRB3. SCG specific UE assistance information for power saving or IDC is directly transmitted to the SN via SRB3, if SRB3 is configured and the SCG is activated, otherwise UE transmits SCG specific UE assistance information for power saving or IDC in a transparent container to the MN. When network simultaneously configures the UE to perform radio link monitoring on the SCG and beam failure detection on the SCG while the SCG is deactivated, UE assistance information for the relaxation state report of RLM/BFD measurements for SCG is reported over MCG. UE can implicitly indicate a preference for NR SCG release by indicating zero number of carriers and zero aggregated maximum bandwidth in both FR1 and FR2.

7.11 F1-C transfer over E-UTRA

In EN-DC, the F1-AP message encapsulated in SCTP/IP or F1-C related (SCTP/)IP packet can be transferred between IAB-donor and IAB-node via E-UTRA, if configured by IAB-donor, as specified in TS 38.331 [4]. When both E-UTRA and NR are configured to transfer the F1-AP message encapsulated in SCTP/IP or F1-C related (SCTP/)IP packet, it is up to the IAB implementation when to select the E-UTRA. SRB2 is used for transporting the F1-AP message encapsulated in SCTP/IP or F1-C related (SCTP/)IP packet between IAB-MT and MN [10], and the F1-AP message encapsulated in SCTP/IP or F1-C related (SCTP/)IP packet is transferred as a container via X2-AP between MN and SN, see TS 36.423 [9].

7.12 F1-C Traffic Transfer in NR-DC

In NR-DC, an F1-AP message encapsulated in SCTP/IP or an F1-C related (SCTP/)IP packet can be transferred via BAP sublayer or via SRB between the IAB-node and the IAB-donor (as specified in TS 38.401 [7]), as specified in TS 38.331 [4]. When both MCG and SCG are configured to transfer the F1-AP message encapsulated in SCTP/IP or the F1-C related (SCTP/)IP packet, it is up to the IAB-node implementation for path selection. Two scenarios are supported, as shown in Figure 7.12-1.

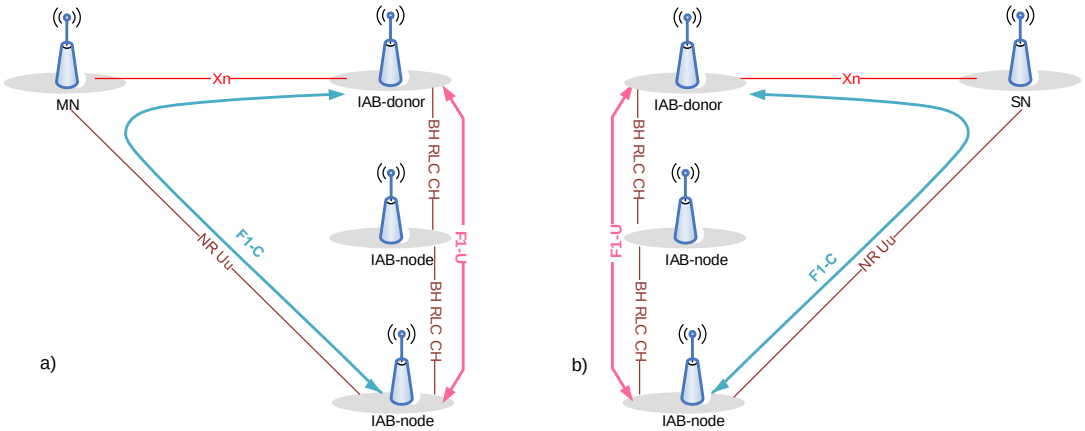


Figure 7.12-1: F1-C transfer in NR-DC; a) Scenario 1; b) Scenario 2

Scenario 1: IAB-node exchanges an F1-AP message encapsulated in SCTP/IP or an F1-C related (SCTP/)IP packet with the SN (IAB-donor) using NR access link via MN, and exchanges F1-U traffic using backhaul link(s) with SN. SRB2 is used for transporting the F1-AP message encapsulated in SCTP/IP or the F1-C related (SCTP/)IP packet between IAB-MT and MN (see TS 38.331 [4]), and the F1-AP message encapsulated in SCTP/IP or the F1-C related (SCTP/)IP packet is transferred in a container via XnAP between MN and SN, see TS 38.423 [5].

Scenario 2: IAB-node exchanges an F1-AP message encapsulated in SCTP/IP or an F1-C related (SCTP/)IP packet with the MN (IAB-donor) using NR access link via SN, and exchanges F1-U traffic using backhaul link(s) with MN. Split SRB2 is used for transporting the F1-AP message encapsulated in SCTP/IP or the F1-C related (SCTP/)IP packet between IAB-MT and SN (see TS 38.331 [4]), and the F1-AP message encapsulated in SCTP/IP or the F1-C related (SCTP/)IP packet is transferred in a container via XnAP between SN and MN, see TS 38.423 [5].

The F1-AP message encapsulated in SCTP/IP or the F1-C related (SCTP/)IP packet can be transferred either over BAP sublayer or over SRB, but the two mechanisms cannot be supported simultaneously on the same parent link. The F1-AP message encapsulated in SCTP/IP or the F1-C related (SCTP/)IP packet is transferred over BAP sublayer, if the BH RLC channel used for transferring the F1-C traffic is configured on the cell group indicated for F1-C traffic transfer according to TS 38.331 [4].

7.13 Activation and Deactivation of SCG

To enable reasonable UE battery consumption while having fast usage of SCG when (NG)EN-DC or NR-DC is configured, an activation/deactivation mechanism of SCG is supported. While the SCG is deactivated, there is no transmission via SCG RLC bearers. Only the NR SCG can be deactivated, and all SCG SCell(s) are in deactivated state while the SCG is deactivated.

Upon SCG deactivation and while the SCG is deactivated, the network ensures that there is no uplink control PDU transmission to the deactivated SCG (e.g. the network releases statusReportRequired from PDCP entities of SCG bearers if configured, the network does not perform QoS flow remapping from a DRB associated to the deactivated SCG to another DRB). The network ensures the SCG is activated while PDCP duplication is activated for SCG RLC entities associated with a PDCP entity.

NOTE: Upon SCG (de)activation, it is up to the network to ensure there is no pending SDUs or PDUs in SCG RLC entity (e.g. instructs the UE to perform PDCP data recovery and RLC re-establishment/release, if needed).

While the SCG is deactivated, the UE will not transmit PUSCH, SRS and CSI report on SCG, and the UE is not required to monitor PDCCH or receive DL-SCH on SCG. If configured by the network, the UE performs radio link monitoring on the SCG and beam failure detection on the SCG while SCG is deactivated. In case of SCG activation without performing random access, the network can indicate TCI states to UE for PDCCH/PDSCH reception on PSCell, if not provided, the UE uses the previously activated TCI states.

The MN can configure the SCG as activated or deactivated upon e.g. PSCell addition, PSCell change, RRC Resume or handover. In case the SCG is configured as deactivated, the UE does not perform random access towards the PSCell. The network can trigger SCG RRC reconfiguration (e.g. PSCell change, configuration update) when deactivating the SCG and while the SCG is in deactivated state.

SCG activation can be requested by the MN, by the SN and by the UE. SCG deactivation can be requested by the MN and by the SN. For UL data arrival on SCG bearer(s) while the SCG is deactivated, the UE indicates to the MN that it has UL data to transmit over SCG bearer. During handover procedure, the target MN can indicate the SCG state in the RRC reconfiguration message sent to the UE by the source MN.

Network can configure whether the UE is allowed to indicate a preference for SCG deactivation to the MN.

7.14 RLM/BFD relaxation

For RLM and BFD relaxation, network may configure low mobility criterion in the NR PCell for the case of NE-DC/NR-DC, and in the NR PSCell for the case of EN-DC and NGEN-DC. MN informs SN when low mobility criterion has been configured in the NR PCell for NR-DC.

For RLM relaxation, network may configure good serving cell criterion in the NR PCell for the case of NE-DC/NR-DC, and in the NR PSCell for the case of EN-DC, NGEN-DC and NR-DC.

For BFD relaxation, network may configure good serving cell criterion in the NR PCell and/or SCell(s) for the case of NE-DC/NR-DC, and in the NR PSCell and/or SCell(s) for the case of EN-DC, NGEN-DC and NR-DC.

For RLM/BFD relaxation, network may simultaneously configure the UE to perform radio link monitoring on the SCG and beam failure detection on the SCG while SCG is deactivated. In such case, UE initiates UE assistance information for the relaxation state report of RLM/BFD measurements for SCG.

For RLM/BFD relaxation, network may simultaneously configure the UE not to perform radio link monitoring on the SCG and beam failure detection on the SCG while SCG is deactivated. In such case, UE assistance information for the relaxation state report of RLM/BFD measurements for SCG will not be initiated.

8 Bearer handling aspects

8.1 QoS aspects

In EN-DC, the E-UTRAN QoS framework defined in TS 36.300 [2] applies:

- An S1-U bearer is established between the EPC and the SN for SN terminated bearers;
- An X2-U bearer is established between the MN and the SN for split bearers, MN terminated SCG bearers and SN terminated MCG bearers;
- MN terminated and SN terminated bearers may have either MCG or SCG radio resources or both, MCG and SCG radio resources, established;

In MR-DC with 5GC:

- The NG-RAN QoS framework defined in TS 38.300 [3] applies;
- QoS flows belonging to the same PDU session may be mapped to different bearer types (see clause 4.2.2) and as a result there may be two different SDAP entities for the same PDU session: one at the MN and another one at the SN, in which case the MN decides which QoS flows are assigned to the SDAP entity in the SN. If the SN decides that its SDAP entity cannot host a given QoS flow any longer, the SN informs the MN and the MN cannot reject the request. If the MN decides that its SDAP entity can host a given QoS flow which has already been relocated to SN, the MN informs the SN;
- The MN or SN node that hosts the SDAP entity for a given QoS flow decides how to map the QoS flow to DRBs;
- If the SDAP entity for a given QoS flow is hosted by the MN and the MN decides that SCG resources are to be configured it provides to the SN
  - DRB QoS flow level QoS parameters, which the SN may reject, and
  - QoS flow to DRB mapping information and the respective per QoS flow information;
- If the SDAP entity for a given QoS flow is hosted by the SN and the SN configures MCG resources, based on offered MCG resource information from the MN, the SN provides to the MN
  - DRB QoS flow level QoS parameters, which the MN may reject, and
  - QoS flow to DRB mapping information and the respective per QoS flow information.
- If the SDAP entity for a given QoS flow is hosted by the SN, the MN provides sufficient QoS related information to enable the SN to configure appropriate SCG resources and to request the configuration of appropriate MCG resources. The MN may offer MCG resources to the SN and may indicate for GBR QoS flows the amount offered to the SN on a per QoS flow level. Otherwise, the SN can only use SCG resources for the concerned QoS flow. The SN may request the MN to release QoS flows from the SDAP entity hosted by the SN that the MN cannot reject. The MN may also offer MCG resources per PDU Session for all DRBs to which non-GBR QoS flows contained in the PDU Session are mapped.
- MN decides the DL PDU session AMBR and UL PDU session AMBR limits to be assigned to the SN, and indicates these to the SN:
  - The PDCP entity at the SN applies the received DL PDU session AMBR limi t to the set of all bearers for which the SN hosts PDCP for the UE;
  - The MAC entity at the SN applies the received UL PDU session AMBR limit to the scheduled uplink radio traffic at the SN for the UE.

- The MN can decide to reallocate one or more QoS flows from the MN to the SN. In such case, the SN decides which DRBs the offloaded QoS flows are mapped to. It is possible to avoid/ minimise loss and ensure in-order delivery when reallocating all QoS flows mapped to a given DRB in the MN by keeping the QoS flows mapped to the same DRB in the SN. To achieve this, the SN should behave similar to what is specified for the target NG-RAN node upon handover, see TS 38.300 clause 9.2.3.2.2 [3]. The corresponding behaviour applies when QoS flows are re-allocated from the SN to the MN.

- The MN decides the DL UE Slice MBR and UL UE Slice MBR limits to be assigned to the SN, and indicates these to the SN:

  - The PDCP entity at the SN applies the received DL UE Slice MBR limit to the set of all bearers for which the SN hosts PDCP for the concerned Slice, as defined in TS 23.501 [11];

  - The MAC entity at the SN applies the received UL UE Slice MBR limit to the scheduled uplink radio traffic at the SN for the concerned Slice, as defined in TS 23.501 [11].

In all MR-DC cases:

- The MN decides the DL UE AMBR and UL UE AMBR limits to be assigned to the SN, and indicates these to the SN:

  - The PDCP entity at the SN applies the received DL UE AMBR limit to the set of all bearers for which the SN hosts PDCP for the UE;

  - The MAC entity at the SN applies the received UL UE AMBR limit to the scheduled uplink radio traffic at the SN for the UE.

To support PDU sessions mapped to different bearer types, MR-DC with 5GC provides the possibility for the MN to request the 5GC:

- For some PDU sessions of a UE: Direct the User Plane traffic of the whole PDU session either to the MN or to the SN. In that case, there is a single NG-U tunnel termination at the NG-RAN for such PDU session.

  - The MN may request to change this assignment during the life time of the PDU session.

- For some other PDU sessions of a UE: Direct the User Plane traffic of a subset of the QoS flows of the PDU session to the SN (respectively MN) while the rest of the QoS flows of the PDU session is directed to the MN (respectively SN). In that case, there are two NG-U tunnel terminations at the NG-RAN for such PDU session.

  - The MN may request to change this assignment during the life time of the PDU session.

To support notification control indication for GBR QoS flows along the QoS framework specified in 38.300 [3] for MR-DC with 5GC, SN and MN may mutually indicate whenever QoS requirements for GBR QoS flows cannot be fulfilled anymore or can be fulfilled again. When indicating that GBR QoS flows cannot be fulfilled anymore, SN or MN may additionally indicate the reference to the QoS Parameter Set which it can currently fulfil.

8.2 Bearer type selection

In EN-DC, for each radio bearer the MN decides the location of the PDCP entity and in which cell group(s) radio resources are to be configured. Once an SN terminated split bearer is established, e.g. by means of the Secondary Node Addition procedure or MN initiated Secondary Node Modification procedure, the SN may remove SCG resources for the respective E-RAB, as long as the QoS for the respective E-RAB is guaranteed. In case an SN terminated bearer is released or reconfigured to an MN terminated bearer, only the MN generates the corresponding configuration and the SN does not generate the release configuration.

In MR-DC with 5GC, the following principles apply:

- The MN decides per PDU session the location of the SDAP entity, i.e. whether it shall be hosted by the MN or the SN or by both (split PDU session);

- If the MN decides to host an SDAP entity it may decide some of the related QoS flows to be realized as MCG bearer, some as SCG bearer, and others to be realized as split bearer;

- If the MN decides that an SDAP entity shall be hosted in the SN, some of the related QoS flows may be realized as SCG bearer, some as MCG bearer, while others may be realized as split bearer. In this case, the SN decides how to realise the QoS flow, but if the MN does not offer MCG resources, the SN can only realize the QoS flow as SCG bearer. The SN may remove or add SCG resources for the respective QoS flows, as long as the QoS for the respective QoS flow is guaranteed

- If the MN decides that an SDAP entity shall be hosted in the SN, coordination of DRB IDs between the MN and the SN is needed to ensure unique allocation of DRBs for a UE. The SN is responsible to assign the DRB IDs for the DRBs it terminates, based on the DRB IDs indicated by the MN.

- For each PDU session, including split PDU sessions, at most one default DRB may be configured (see [3]). The MN decides whether the SN is allowed to setup the default DRB or not;

- In case an SN terminated bearer is released or reconfigured to an MN terminated bearer, the MN generates the corresponding configuration and the SN does not generate the release configuration. The only exceptional case where SN generates the release configuration is for the DRB release due to QoS flow to DRB remapping within SN.

8.3 Bearer type change

In MR-DC, all the possible bearer type change options are supported:

- MCG bearer to/from split bearer;

- MCG bearer to/from SCG bearer;

- SCG bearer to/from split bearer.

Bearer termination point change is supported for all bearer types, and can be performed with or without bearer type change:

- MN terminated bearer to/from SN terminated bearer.

For MR-DC:

- when the security key is changed for a bearer due to a termination point change, the associated PDCP and RLC entities are re-established, while MAC behavior might depend on the solution selected by the network, e.g. MAC reset, change of LCID, etc. (see Annex A);

- for MCG bearer, split bearer and SCG bearer, during MN security key change the MCG/SCG PDCP and RLC are re-established and MCG/SCG MAC is reset;

- if a bearer type change happens together with MN security key change then for MCG bearer, split bearer and SCG bearer, the MCG/SCG PDCP and RLC are re-established and MCG/SCG MAC is reset;

- if a bearer type change happens through SN change procedure, then SN terminated PDCP and SCG RLC are re-established and SCG MAC is reset. MCG RLC/MAC behavior depends on the solution selected by the network, see Annex A;

- one step (direct) bearer type change between MN terminated bearer types without using the handover procedure is supported;

- one step (direct) bearer type change between SN terminated bearer types without using the handover or SN change procedure is supported;

- one step (direct) bearer type change from/to MN terminated bearer to/from SN terminated bearer without using the handover procedure is supported;

- PDCP SN length change for an AM DRB or RLC mode change for DRB is performed using a release and add of the DRBs (in a single message) or full configuration;

- One step (direct) bearer type change with PDCP version change (only applicable for EN-DC) is supported.

For MR-DC with 5GC:

- in a bearer termination point change of a DRB from a source NG-RAN node to a target NG-RAN node, for each DRB for which the source NG-RAN node provides QoS flow to DRB mapping information to the target NG-RAN node, the source NG-RAN node also offers the indicated DRB ID for usage at the target NG-RAN node. The target NG-RAN node informs the source NG-RAN node if it accepts the DRB offloading and takes the DRB ID into use.

NOTE 1: In this clause the term "handover" refers to an E-UTRA handover or to an NR synchronous reconfiguration not necessarily implying a P(S)Cell change with or without security key change.

NOTE 2: L2 handling for bearer type change in MR-DC is also summarized in Annex A (the table does not consider the cases that PDCP SN length is changed and avoiding reuse of COUNT).

8.4 User data forwarding

Upon EN-DC specific activities, user data forwarding may be performed for E-RABs for which the bearer type change from/to MN terminated bearer to/from SN terminated bearer is performed. The behaviour of the node from which data is forwarded is the same as specified for the "source eNB" for handover, the behaviour of the node to which data is forwarded is the same as specified for the "target eNB" for handover.

For MR-DC with 5GC, user data forwarding may be performed between NG-RAN nodes whenever the logical node hosting the PDCP entity changes. The behaviour of the node from which data is forwarded is the same as specified for the "source NG-RAN node" for handover, the behaviour of the node to which data is forwarded is the same as specified for the "target NG-RAN node" for handover.

For SN change involving full configuration, the source SN behaviour is the same as the description as specified in intra-system data forwarding in TS 36.300 [2] for the source eNB or TS 38.300 [3] for the source NG-RAN node, respectively. In case that a DRB DL forwarding tunnel was established, the target SN may identify the PDCP SDUs for which delivery was attempted by the source SN, by the presence of the PDCP SN in the forwarded GTP-U packet and may discard them.

For mobility scenarios which involve more than two RAN nodes, either direct or indirect data forwarding may be applied. Two transport layer addresses of different versions may be provided to enable that the source RAN node can select either IPv4 or IPv6.

Direct data forwarding from source SN to target NG-RAN node and from source NG-RAN node to target SN for mobility scenario is supported. Direct data forwarding from source SN to target SN for SN change scenario is also supported.

In case of NR-DC to NR-DC handover, direct data forwarding from source SN to target MN, from source SN to target SN and from source MN to target SN is supported.

Direct data forwarding for inter-system handover is specified in TS 38.300 [3]. If a gNB and an en-gNB are involved in direct data forwarding and realised within the same network entity, inter-system handover to and from EN-DC allows direct data forwarding being performed in a node-internal way, in which case the source RAN node provides a UE context reference to the target side as described in clause 10.16. If the gNB and en-gNB are not realised within the same network entity, direct data forwarding for inter-system handover to and from en-gNB/gNB could be supported if there is direct connectivity between the two nodes.

For MR-DC with 5GC, offloading of QoS flows within one PDU session may be performed between NG-RAN nodes. The handling of End Marker packets in case of NG-RAN initiated PDU session split is described in clause 10.14.3 and 10.14.4.

9 Security related aspects

MR-DC can only be configured after security activation in the MN.

In EN-DC and NGEN-DC, for bearers terminated in the MN the network configures the UE with K_{eNB}; for bearers terminated in the SN the network configures the UE with S-K_{gNB}. In NE-DC, for bearers terminated in the MN the network configures the UE with K_{gNB}; for bearers terminated in the SN the network configures the UE with S-K_{eNB}. In NR-DC, for bearers terminated in the MN the network configures the UE with K_{gNB}; for bearers terminated in the SN the network configures the UE with S-K_{gNB}.

In NE-DC and NR-DC, a PCell change without K_{gNB} change does not require a S-K_{eNB} change (NE-DC case) or a S-K_{gNB} change (NR-DC case).

In EN-DC, NGEN-DC and NR-DC, for a PSCell change that does not require a K_{eNB} change (i.e. no simultaneous PCell handover in EN-DC and NGEN-DC) or a K_{gNB} change (in NR-DC), S-K_{gNB} key refresh is not required if the PDCP termination point of the SN is not changed. In NE-DC, a PSCell change always requires a S-K_{eNB} change.

In EN-DC, the UE supports the NR security algorithms corresponding to the E-UTRA security algorithms signalled at NAS level and the UE NR AS Security capability is not signalled to the MN over RRC. Mapping from E-UTRA security algorithms to the corresponding NR security algorithms, where necessary, is performed at the MN. The MN sends the complete UE security capabilities including all security capability bits previously received (after mapping, where necessary) to the SN.

An EN-DC capable UE supporting user plane integrity protection when connected to E-UTRA/EPC (see TS 24.301 [22]) shall support integrity protection for all DRBs (MN and SN terminated) at any data rate, up to and including the highest data rate supported by the UE for both UL and DL. MN and/or SN terminated DRBs can have UP integrity protection activation either on or off, on a per radio bearer basis.

For MR-DC with 5GC, UP integrity protection can be configured on a per radio bearer basis. All DRBs which belong to the same PDU session always have the same UP integrity protection activation, i.e., either on or off:

- For NR-DC: MN and/or SN terminated DRBs of a PDU session can have UP integrity protection activation either on or off. A UE configured to operate in NR-DC shall support integrity protection for all DRBs (MN and SN terminated) at any data rate, up to and including the highest data rate supported by the UE for both UL and DL (see TS 38.300 [3]).

- For NE-DC: MN terminated DRBs of a PDU session can have UP integrity protection activation on; however, in this case, the MN will not at any point offload any DRB of such PDU session to the SN. A UE configured to operate in NE-DC shall support integrity protection for all MN terminated DRBs at any data rate, up to and including the highest data rate supported by the UE's radio access capabilities for both UL and DL (see TS 38.300 [3]). SN terminated DRBs of a PDU session always have UP integrity protection activation off.

- For NGEN-DC: Both MN terminated and SN terminated DRBs of a PDU session always have UP integrity protection activation off.

In MR-DC with 5GC, the MN sends the complete UE security capabilities to the SN including all NR and E-UTRA security capability bits previously received by the MN from the Core Network or from another NG-RAN node as specified in TS 38.300 [3].

In (NG)EN-DC and NR-DC, if the SCG is deactivated as described in clause 7.13, whether to perform security key update upon SCG activation is up to network implementation.

10 Multi-Connectivity operation related aspects

10.1 General

Similar procedures as defined under clause 10.1.2.8 (Dual Connectivity operation) in TS 36.300 [2] apply for MR-DC.

Similar CHO principles as defined in TS 36.300 [2] and TS 38.300 [3] apply for the Conditional PSCell Change and Conditional PSCell Addition in MR-DC.

Similar LTM principles as defined in TS 38.300 [3] apply for MCG LTM and SCG LTM in NR-DC. MCG LTM with SCG release and MCG LTM without SCG change are supported. LTM for simultaneous PCell and PSCell change is not supported.

Conditional PSCell Change and conditional PSCell addition are not supported for the MR-DC options NE-DC and NGEN-DC.

Subsequent CPAC is only supported for NR-DC. Coexistence of CPAC and subsequent CPAC for the same candidate SN is not supported.

Configuration of a deactivated SCG in a conditional configuration, configuration of CPC (or subsequent CPAC) while the SCG is deactivated and SCG deactivation while CPC (or subsequent CPAC) is configured are not supported.

In MR-DC, CHO is supported in Master Node to eNB/gNB Change procedure and Conditional Handover with Secondary Node procedure.

10.2 Secondary Node Addition

10.2.1 EN-DC

The Secondary Node Addition procedure is initiated by the MN and is used to establish a UE context at the SN to provide resources from the SN to the UE. For bearers requiring SCG radio resources, this procedure is used to add at least the first cell of the SCG. This procedure can also be used to configure an SN terminated MCG bearer (where no SCG configuration is needed). In case of CPA, the Conditional Secondary Node Addition procedure can be used for CPA configuration and CPA execution.

Secondary Node Addition

Figure 10.2.1-1 shows the Secondary Node Addition procedure.

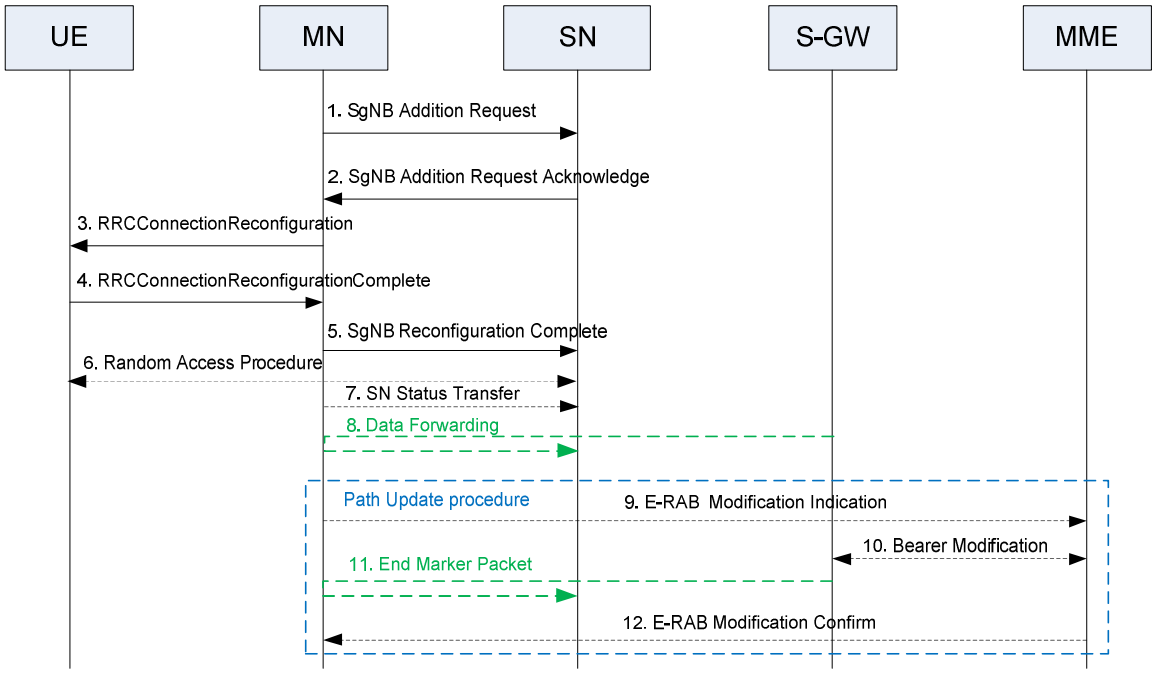


Figure 10.2.1-1: Secondary Node Addition procedure

1. The MN decides to request the SN to allocate resources for a specific E-RAB, indicating E-RAB characteristics (E-RAB parameters, TNL address information corresponding to bearer type). In addition, for bearers requiring SCG radio resources, MN indicates the requested SCG configuration information, including the entire UE capabilities and the UE capability coordination result. In this case, the MN also provides the latest measurement results for SN to choose and configure the SCG cell(s). The MN may request the SN to allocate radio resources for split SRB operation. The MN always provides all the needed security information to the SN (even if no SN terminated bearers are setup) to enable SRB3 to be setup based on SN decision. In case of bearer options that require X2-U resources between the MN and the SN, the MN provides X2-U TNL address information for the respective E-RAB, X2-U DL TNL address information for SN terminated bearers, X2-U UL TNL address information for MN terminated bearers. In case of SN terminated split bearers the MN provides the maximum QoS level that it can support. The MN may request the SCG to be activated or deactivated. The SN may reject the addition request.

NOTE 1: For split bearers, MCG and SCG resources may be requested of such an amount, that the QoS for the respective E-RAB is guaranteed by the exact sum of resources provided by the MCG and the SCG together, or even more. For MN terminated split bearers, the MNs decision is reflected in step 1 by the E-RAB parameters signalled to the SN, which may differ from E-RAB parameters received over S1.

NOTE 2: For a specific E-RAB, the MN may request the direct establishment of an SCG or a split bearer, i.e., without first having to establish an MCG bearer. It is also allowed that all E-RABs can be configured as SN terminated bearers, i.e. there is no E-RAB established as an MN terminated bearer.

2. If the RRM entity in the SN is able to admit the resource request, it allocates respective radio resources and, dependent on the bearer option, respective transport network resources. For bearers requiring SCG radio resources, the SN triggers Random Access so that synchronisation of the SN radio resource configuration can be performed. The SN decides the PSCell and other SCG SCells and provides the new SCG radio resource configuration to the MN in a *NR RRC configuration* message contained in the *SgNB Addition Request Acknowledge* message. In case of bearer options that require X2-U resources between the MN and the SN, the SN provides X2-U TNL address information for the respective E-RAB, X2-U UL TNL address information for SN terminated bearers, X2-U DL TNL address information for MN terminated bearers. For SN terminated bearers, the SN provides the S1-U DL TNL address information for the respective E-RAB and security algorithm. If SCG radio resources have been requested, the SCG radio resource configuration is provided. If the MN requested the SCG to be deactivated, the SN may keep the SCG activated. If the MN requests the SCG to be activated, the SN shall keep the SCG activated.

NOTE 3: For the SN terminated split bearer option, the SN may either decide to request resources from the MN of such an amount, that the QoS for the respective E-RAB is guaranteed by the exact sum of resources provided by the MN and the SN together, or even more. The SNs decision is reflected in step 2 by the E-RAB parameters signalled to the MN, which may differ from E-RAB parameters received in step 1. The QoS level requested from the MN shall not exceed the level that the MN offered when setting up the split bearer in step 1.

NOTE 4: In case of MN terminated bearers, transmission of user plane data may take place after step 2.

NOTE 5: In case of SN terminated bearers, data forwarding and the SN Status Transfer may take place after step 2.

3. The MN sends to the UE the *RRCConnectionReconfiguration* message including the NR RRC configuration message, without modifying it. Within the MN *RRCConnectionReconfiguration* message, the MN can indicate the SCG is deactivated.

4. The UE applies the new configuration and replies to MN with *RRCConnectionReconfigurationComplete* message, including a NR RRC response message, if needed. In case the UE is unable to comply with (part of) the configuration included in the *RRCConnectionReconfiguration* message, it performs the reconfiguration failure procedure.

5. The MN informs the SN that the UE has completed the reconfiguration procedure successfully via *SgNB ReconfigurationComplete* message, including the encoded NR RRC response message, if received from the UE.

6. If configured with bearers requiring SCG radio resources and the SCG is not deactivated, the UE performs synchronisation towards the PSCell of the SN. The order the UE sends the *RRCConnectionReconfigurationComplete* message and performs the Random Access procedure towards the SCG is not defined. The successful RA procedure towards the SCG is not required for a successful completion of the RRC Connection Reconfiguration procedure.

7. If PDCP termination point is changed to the SN for bearers using RLC AM, and when RRC full configuration is not used, the MN sends the *SN Status Transfer* message.

8. For SN terminated bearers moved from the MN, dependent on the bearer characteristics of the respective E-RAB, the MN may take actions to minimise service interruption due to activation of EN-DC (Data forwarding).

9-12. If applicable, the update of the UP path towards the EPC is performed.

Conditional Secondary Node Addition

Figure 10.2.1-2 shows the Conditional Secondary Node Addition procedure.

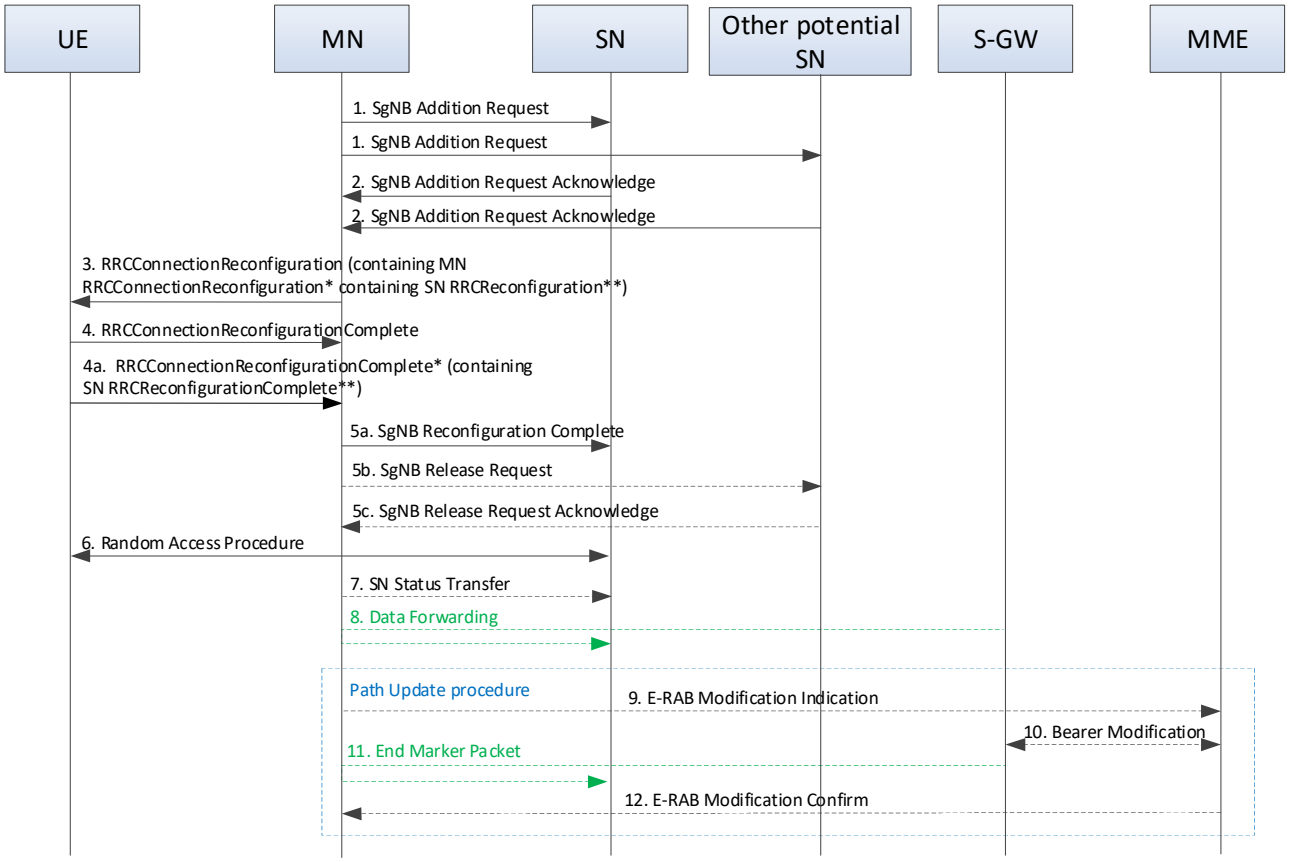


Figure 10.2.1-2: Conditional Secondary Node Addition procedure

1. The MN decides to configure CPA for the UE and requests the candidate SN(s) to allocate resources for a specific E-RAB, indicating E-RAB characteristics (E-RAB parameters, TNL address information corresponding to bearer type), indicating that the request is for CPAC and providing the upper limit for the number of PSCells that can be prepared by the candidate SN. In addition, for the bearers requiring SCG radio resources, the MN indicates the requested SCG configuration information, including the entire UE capabilities and the UE capability coordination result. In this case, the MN also provides the candidate cells recommended by MN via the latest measurement results for the candidate SN to choose from and configure the SCG cell(s). The MN may request the candidate SN to allocate radio resources for split SRB operation. The MN always provides all the needed security information to the candidate SN (even if no SN terminated bearers are setup) to enable SRB3 to be setup based on SN decision. In case of bearer options that require X2-U resources between the MN and the candidate SN, the MN provides X2-U TNL address information for the respective E-RAB, X2-U DL TNL address information for SN terminated bearers, X2-U UL TNL address information for MN terminated bearers. In case of SN terminated split bearers the MN provides the maximum QoS level that it can support. The candidate SN may reject the addition request.

NOTE 6: For split bearers, MCG and SCG resources may be requested of such an amount, that the QoS for the respective E-RAB is guaranteed by the exact sum of resources provided by the MCG and the SCG together, or even more. For MN terminated split bearers, the MN decision is reflected in step 1 by the E-RAB parameters signalled to the candidate SN, which may differ from E-RAB parameters received over S1.

NOTE 7: For a specific E-RAB, the MN may request the direct establishment of an SCG or a split bearer, i.e., without first having to establish an MCG bearer. It is also allowed that all E-RABs can be configured as SN terminated bearers, i.e. there is no E-RAB established as an MN terminated bearer.

2. If the RRM entity in the candidate SN is able to admit the resource request, it allocates respective radio resources and, dependent on the bearer option, respective transport network resources, and provides the prepared PSCell ID(s) to the MN. For bearers requiring SCG radio resources, the candidate SN configures Random Access so that synchronisation of the SN radio resource configuration can be performed at the CPA execution. From the list of cells indicated within the measurement results provided by the MN, the candidate SN decides the list of PSCell(s) to prepare (considering the maximum number indicated by the MN) and, for each prepared PSCell, the candidate SN decides SCG SCells and provides the corresponding SCG radio resource configuration to the MN

in an NR *RRCReconfiguration*** message contained in the *SgNB Addition Request Acknowledge* message. The candidate SN can either accept or reject each of the candidate cells listed within the measurement results indicated by the MN, i.e. it cannot configure any alternative candidates. In case of bearer options that require X2-U resources between the MN and the candidate SN, the candidate SN provides X2-U TNL address information for the respective E-RAB, X2-U UL TNL address information for SN terminated bearers, X2-U DL TNL address information for MN terminated bearers. For SN terminated bearers, the candidate SN provides the S1-U DL TNL address information for the respective E-RAB and security algorithm. If SCG radio resources have been requested, the SCG radio resource configuration is provided.

NOTE 8: For the SN terminated split bearer option, the candidate SN may either decide to request resources from the MN of such an amount, that the QoS for the respective E-RAB is guaranteed by the exact sum of resources provided by the MN and the candidate SN together, or even more. The candidate SN decision is reflected in step 2 by the E-RAB parameters signalled to the MN, which may differ from E-RAB parameters received in step 1. The QoS level requested from the MN shall not exceed the level that the MN offered when setting up the split bearer in step 1.

NOTE 9: In case of SN terminated bearers, early data forwarding may take place after step 2. For the early data forwarding of SN terminated bearers, the MN forwards the PDCP SDU to the candidate SN and also sends the *Early Status Transfer* message. For the early transmission of MN terminated split/SCG bearers, the MN forwards the PDCP PDU to the candidate SN.

3. The MN sends to the UE an *RRCConnectionReconfiguration* message including the CPA configuration, i.e. a list of *RRCConnectionReconfiguration** messages and associated execution conditions. Each *RRCConnectionReconfiguration** message contains the SCG configuration in the *RRCReconfiguration*** message received from the candidate SN in step 2 and possibly an MCG configuration. Besides, the *RRCConnectionReconfiguration* message can also include an updated MCG configuration, e.g., to configure the required conditional measurements.

4. The UE applies the *RRCConnectionReconfiguration* message received in step 3, stores the CPA configuration and replies to the MN with an *RRCConnectionReconfigurationComplete* message. In case the UE is unable to comply with (part of) the configuration included in the *RRCConnectionReconfiguration* message, it performs the reconfiguration failure procedure.

4a. The UE starts evaluating the execution conditions. If the execution condition of one candidate PSCell is satisfied, the UE applies *RRCConnectionReconfiguration** message corresponding to the selected candidate PSCell, and sends an *RRCConnectionReconfigurationComplete** message, including an NR *RRCReconfigurationComplete*** message for the selected candidate PSCell, and information enabling the MN to identify the SN of the selected candidate PSCell.

5a-5c. The MN informs the SN of the selected candidate PSCell that the UE has completed the reconfiguration procedure successfully via *SgNB Reconfiguration Complete* message, including the *RRCReconfigurationComplete*** message. The MN sends the *SgNB Release Request* message(s) to cancel CPA in the other candidate SN(s), if configured. The other candidate SN(s) acknowledges the release request.

6. The UE performs synchronisation towards the PSCell indicated in the *RRCConnectionReconfiguration** message applied in step 4a. The order the UE sends the *RRCConnectionReconfigurationComplete** message and performs the Random Access procedure towards the SCG is not defined. The successful RA procedure towards the SCG is not required for a successful completion of the RRC Connection Reconfiguration procedure.

7. If PDCP termination point is changed to the SN for bearers using RLC AM, and when RRC full configuration is not used, the MN sends the *SN Status Transfer* message.

8. For SN terminated bearers moved from the MN, dependent on the bearer characteristics of the respective E-RAB, the MN may take actions to minimise service interruption due to activation of EN-DC (Data forwarding).

9-12. If applicable, the update of the UP path towards the EPC is performed.

10.2.2 MR-DC with 5GC

The Secondary Node (SN) Addition procedure is initiated by the MN and is used to establish a UE context at the SN in order to provide resources from the SN to the UE. For bearers requiring SCG radio resources, this procedure is used to add at least the initial SCG serving cell of the SCG. This procedure can also be used to configure an SN terminated MCG bearer (where no SCG configuration is needed). In case of CPA, the Conditional Secondary Node Addition

procedure can be used for CPA configuration and CPA execution. This procedure can also be used to support coordination between the MN and the SN for managing the configuration and reporting of QoE measurements and/or RAN visible QoE measurements in NR-DC.

Secondary Node Addition

Figure 10.2.2-1 shows the SN Addition procedure.

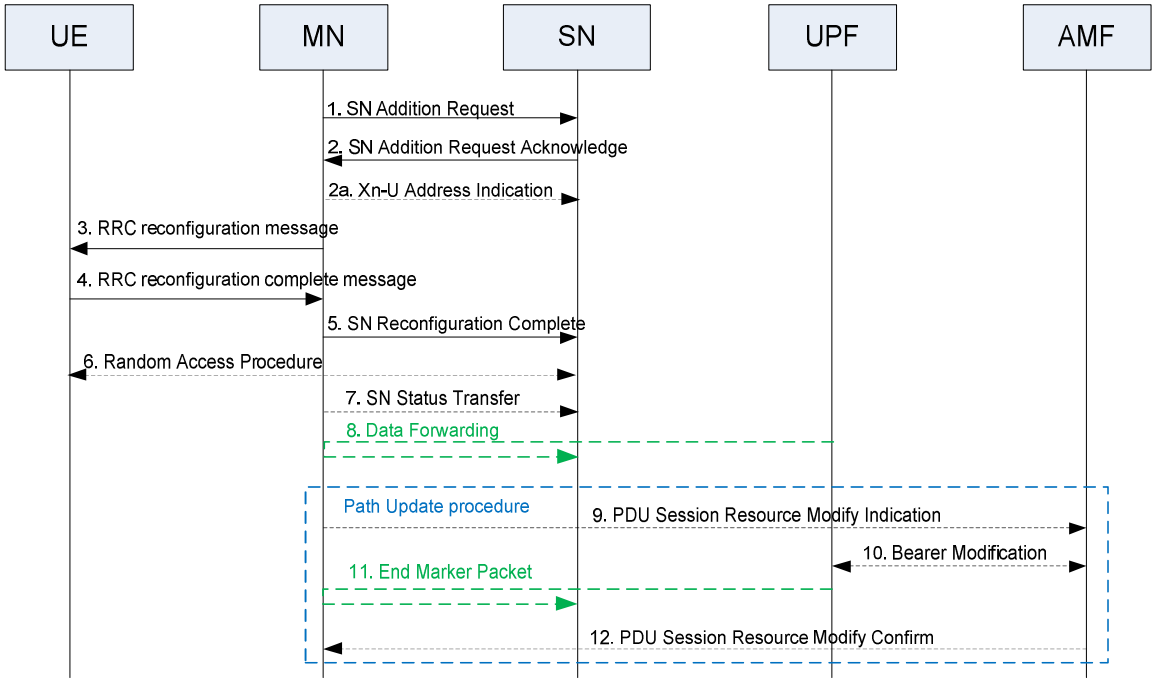


Figure 10.2.2-1: SN Addition procedure

1. The MN decides to request the target SN to allocate resources for one or more specific PDU Sessions/QoS Flows, indicating QoS Flows characteristics (QoS Flow Level QoS parameters, PDU session level TNL address information, and PDU session level Network Slice info). In addition, for bearers requiring SCG radio resources, MN indicates the requested SCG configuration information, including the entire UE capabilities and the UE capability coordination result. In this case, the MN also provides the latest measurement results for SN to choose and configure the SCG cell(s). The MN may request the SN to allocate radio resources for split SRB operation. In NGEN-DC and NR-DC, the MN always provides all the needed security information to the SN (even if no SN terminated bearers are setup) to enable SRB3 to be setup based on SN decision. The MN may request the SCG to be activated or deactivated.

   For MN terminated bearer options that require Xn-U resources between the MN and the SN, the MN provides Xn-U UL TNL address information. For SN terminated bearers, the MN provides a list of available DRB IDs. The S-NG-RAN node shall store this information and use it when establishing SN terminated bearers. The SN may reject the request.

   For SN terminated bearer options that require Xn-U resources between the MN and the SN, the MN provides in step 1 a list of QoS flows per PDU Sessions for which SCG resources are requested to be setup upon which the SN decides how to map QoS flows to DRB.

   In case of coordination between the MN and the SN on QoE and/or RAN visible QoE measurement configuration and reporting, the *SN Addition Request* message may contain the *QMC Coordination Request* IE.

NOTE 1: For split bearers, MCG and SCG resources may be requested of such an amount, that the QoS for the respective QoS Flow is guaranteed by the exact sum of resources provided by the MCG and the SCG together, or even more. For MN terminated split bearers, the MN decision is reflected in step 1 by the QoS Flow parameters signalled to the SN, which may differ from QoS Flow parameters received over NG.

NOTE 2: For a specific QoS flow, the MN may request the direct establishment of SCG and/or split bearers, i.e. without first having to establish MCG bearers. It is also allowed that all QoS flows can be mapped to SN terminated bearers, i.e. there is no QoS flow mapped to an MN terminated bearer.

2. If the RRM entity in the SN is able to admit the resource request, it allocates respective radio resources and, dependent on the bearer type options, respective transport network resources. For bearers requiring SCG radio resources the SN triggers UE Random Access so that synchronisation of the SN radio resource configuration can be performed. The SN decides for the PSCell and other SCG SCells and provides the new SCG radio resource configuration to the MN within an SN RRC configuration message contained in the *SN Addition Request Acknowledge* message. If the MN requested the SCG to be deactivated, the SN may keep the SCG activated. If the MN requests the SCG to be activated, the SN shall keep the SCG activated. In case of bearer options that require Xn-U resources between the MN and the SN, the SN provides Xn-U TNL address information for the respective DRB, Xn-U UL TNL address information for SN terminated bearers, Xn-U DL TNL address information for MN terminated bearers. For SN terminated bearers, the SN provides the NG-U DL TNL address information for the respective PDU Session and security algorithm. If SCG radio resources have been requested, the SCG radio resource configuration is provided.

   In case of coordination between the MN and the SN on QoE and/or RAN visible QoE measurement configuration and reporting, the *SN Addition Request Acknowledge* message may contain the *QMC Coordination Response* IE.

NOTE 3: In case of MN terminated bearers, transmission of user plane data may take place after step 2.

NOTE 4: In case of SN terminated bearers, data forwarding and the SN Status Transfer may take place after step 2.

NOTE 5: For MN terminated bearers for which PDCP duplication with CA is configured in NR SCG side, the MN allocates up to 4 separate Xn-U bearers and the SN provides a logical channel ID for primary or split secondary path to the MN.

   For SN terminated bearers for which PDCP duplication with CA is configured in NR MCG side, the SN allocates up to 4 separate Xn-U bearers and the MN provides a logical channel ID for primary or split secondary path to the SN via an additional MN-initiated SN modification procedure.

2a. For SN terminated bearers using MCG resources, the MN provides Xn-U DL TNL address information in the *Xn-U Address Indication* message.

3. The MN sends the MN RRC reconfiguration message to the UE including the SN RRC configuration message, without modifying it. Within the MN RRC reconfiguration message, the MN can indicate the SCG is deactivated.

4. The UE applies the new configuration and replies to MN with MN RRC reconfiguration complete message, including an SN RRC response message for SN, if needed. In case the UE is unable to comply with (part of) the configuration included in the MN RRC reconfiguration message, it performs the reconfiguration failure procedure.

5. The MN informs the SN that the UE has completed the reconfiguration procedure successfully via *SN Reconfiguration Complete* message, including the SN RRC response message, if received from the UE.

6. If configured with bearers requiring SCG radio resources and the SCG is not deactivated, the UE performs synchronisation towards the PSCell configured by the SN. The order the UE sends the MN RRC reconfiguration complete message and performs the Random Access procedure towards the SCG is not defined. The successful RA procedure towards the SCG is not required for a successful completion of the RRC Connection Reconfiguration procedure.

7. If PDCP termination point is changed to the SN for bearers using RLC AM, and when RRC full configuration is not used, the MN sends the *SN Status Transfer* message.

8. For SN terminated bearers or QoS flows moved from the MN, dependent on the characteristics of the respective bearer or QoS flow, the MN may take actions to minimise service interruption due to activation of MR-DC (Data forwarding).

9-12. If applicable, the update of the UP path towards the 5GC is performed via a PDU Session Path Update procedure.

Conditional Secondary Node Addition

Figure 10.2.2-2 shows the Conditional SN Addition procedure.

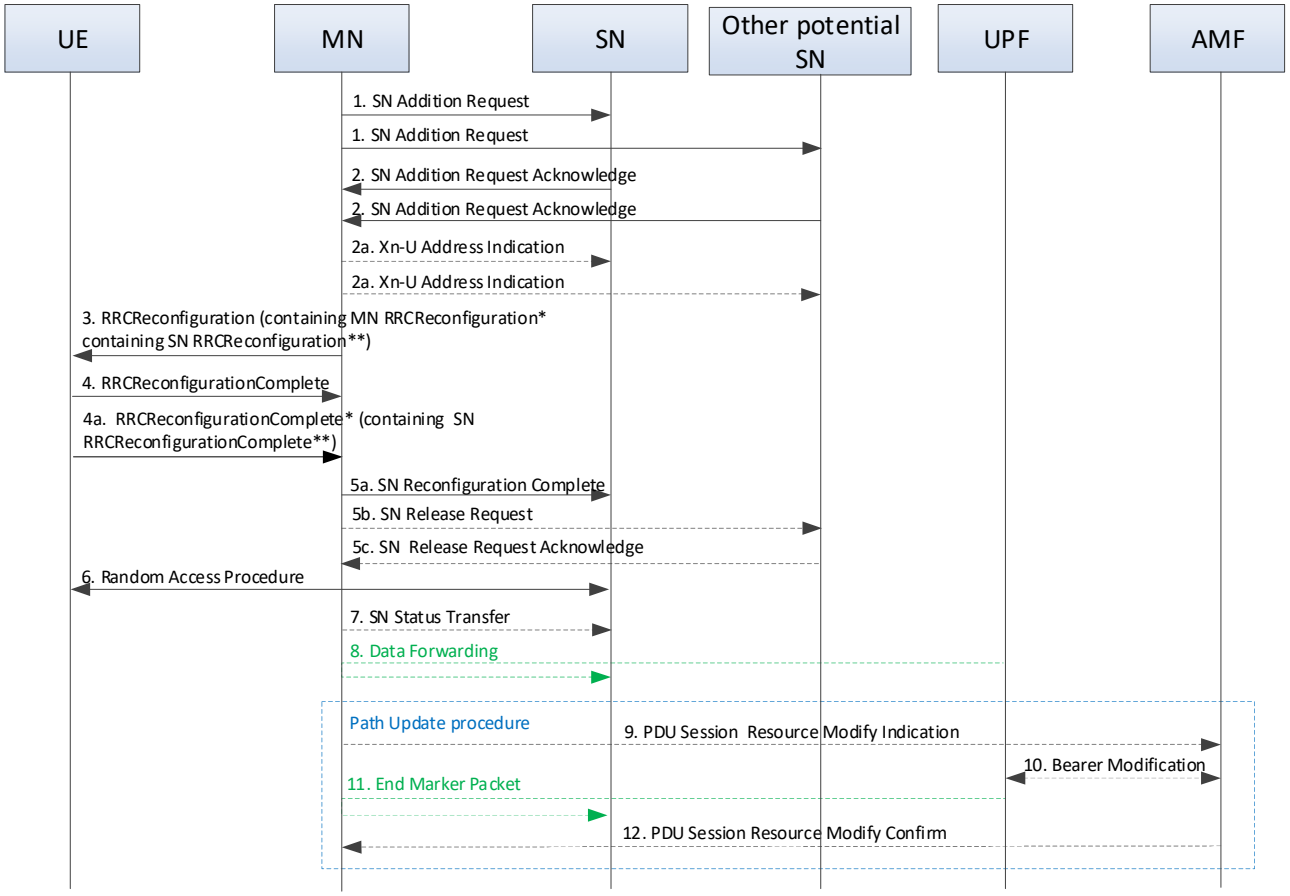


Figure 10.2.2-2: Conditional Secondary Node Addition procedure

1. The MN decides to configure CPA for the UE. The MN requests the candidate SN(s) to allocate resources for one or more specific PDU Sessions/QoS Flows, indicating QoS Flows characteristics (QoS Flow Level QoS parameters, PDU session level TNL address information, and PDU session level Network Slice info), indicating that the request is for CPA and providing the upper limit for the number of PSCells that can be prepared by the candidate SN. In addition, for bearers requiring SCG radio resources, the MN indicates the requested SCG configuration information, including the entire UE capabilities and the UE capability coordination result. In this case, the MN also provides the candidate cells recommended by MN via the latest measurement results for the candidate SN to choose and configure the SCG cell(s). The MN may request the candidate SN to allocate radio resources for split SRB operation. In NR-DC, the MN always provides all the needed security information to the candidate SN (even if no SN terminated bearers are setup) to enable SRB3 to be setup based on SN decision.

   For MN terminated bearer options that require Xn-U resources between the MN and the candidate SN, the MN provides Xn-U UL TNL address information. For SN terminated bearers, the MN provides a list of available DRB IDs. The candidate SN shall store this information and use it when establishing SN terminated bearers. The candidate SN may reject the addition request.

   For SN terminated bearer options that require Xn-U resources between the MN and the candidate SN, the MN provides in step 1 a list of QoS flows per PDU Sessions for which SCG resources are requested to be setup upon which the candidate SN decides how to map QoS flows to DRB.

NOTE 6: For split bearers, MCG and SCG resources may be requested of such an amount, that the QoS for the respective QoS Flow is guaranteed by the exact sum of resources provided by the MCG and the SCG together, or even more. For MN terminated split bearers, the MN decision is reflected in step 1 by the QoS Flow parameters signalled to the candidate SN, which may differ from QoS Flow parameters received over NG.

NOTE 7: For a specific QoS flow, the MN may request the direct establishment of SCG and/or split bearers, i.e. without first having to establish MCG bearers. It is also allowed that all QoS flows can be mapped to SN terminated bearers, i.e. there is no QoS flow mapped to an MN terminated bearer.

2. If the RRM entity in the candidate SN is able to admit the resource request, it allocates respective radio resources and, dependent on the bearer type options, respective transport network resources, and provides the prepared PSCell ID(s) to the MN. For bearers requiring SCG radio resources the candidate SN configures Random Access so that synchronisation of the SN radio resource configuration can be performed at the CPA execution. Fromthe list of cells indicated within the measurement results provided by the MN, the candidate SN decides the list of PSCell(s) to prepare (considering the maximum number indicated by the MN) and, for each prepared PSCell, the candidate SN decides other SCG SCells and provides the new corresponding SCG radio resource configuration to the MN in an NR *RRCReconfiguration*** message, contained in the *SN Addition Request Acknowledge* message. The candidate SN can either accept or reject each of the candidate cells listed within the measurement results indicated by the MN, i.e. it cannot configure any alternative candidates. In case of bearer options that require Xn-U resources between the MN and the candidate SN, the candidate SN provides Xn-U TNL address information for the respective DRB, Xn-U UL TNL address information for SN terminated bearers, Xn-U DL TNL address information for MN terminated bearers. For SN terminated bearers, the candidate SN provides the NG-U DL TNL address information for the respective PDU Session and security algorithm. If SCG radio resources have been requested, the SCG radio resource configuration is provided.

NOTE 8: For MN terminated bearers for which PDCP duplication with CA is configured in NR SCG side, the MN allocates up to 4 separate Xn-U bearers and the candidate SN provides a logical channel ID for primary or split secondary path to the MN.

For SN terminated bearers for which PDCP duplication with CA is configured in NR MCG side, the candidate SN allocates up to 4 separate Xn-U bearers and the MN provides a logical channel ID for primary or split secondary path to the candidate SN via an additional MN-initiated SN modification procedure.

NOTE 9: In case of SN terminated bearers, early data forwarding may take place after step 2. For the early data forwarding of SN terminated bearers, the MN forwards the PDCP SDU to the candidate SN. For the early transmission of MN terminated split/SCG bearers, the MN forwards the PDCP PDU to the candidate SN.

2a. For SN terminated bearers using MCG resources, the MN provides Xn-U DL TNL address information in the *Xn-U Address Indication* message. In case of early data forwarding in CPA, the MN sends the *Early Status Transfer* message to the candidate SN.

3. The MN sends to the UE an *RRCReconfiguration* message including the CPA configuration, i.e. a list of *RRCReconfiguration** messages and associated execution conditions. Each *RRCReconfiguration** message contains the SCG configuration in the *RRCReconfiguration*** received from the candidate SN in step 2 and possibly an MCG configuration. Besides, the *RRCReconfiguration* message can also include an updated MCG configuration. e.g. to configure the required conditional measurements.

4. The UE applies the *RRCReconfiguration* message received in step 3, stores the CPA configuration and replies to the MN with an *RRCReconfigurationComplete* message. In case the UE is unable to comply with (part of) the configuration included in the *RRCReconfiguration* message, it performs the reconfiguration failure procedure.

4a. The UE starts evaluating the execution conditions. If the execution condition of one candidate PSCell is satisfied, the UE applies *RRCReconfiguration** message corresponding to the selected candidate PSCell, and sends an MN *RRCReconfigurationComplete** message, including an *RRCReconfigurationComplete*** message for the selected candidate PSCell, and information enabling the MN to identify the SN of the selected candidate PSCell.

5a-5c. The MN informs the SN of the selected candidate PSCell that the UE has completed the reconfiguration procedure successfully via *SN Reconfiguration Complete* message, including the *RRCReconfigurationComplete*** message. The MN sends the *SN Release Request* message(s) to cancel CPA in the other candidate SN(s), if configured. The other candidate SN(s) acknowledges the release request.

6. The UE performs synchronisation towards the PSCell indicated in the *RRCReconfiguration** message applied in step 4a. The order the UE sends the MN *RRCReconfigurationComplete** message and performs the Random Access procedure towards the SCG is not defined. The successful RA procedure towards the SCG is not required for a successful completion of the RRC Connection Reconfiguration procedure.

7. If PDCP termination point is changed to the SN for bearers using RLC AM, and when RRC full configuration is not used, the MN sends the *SN Status Transfer* message.

8. For SN terminated bearers or QoS flows moved from the MN, dependent on the characteristics of the respective bearer or QoS flow, the MN may take actions to minimise service interruption due to activation of MR-DC (Data forwarding).

9-12. If applicable, the update of the UP path towards the 5GC is performed via a PDU Session Path Update procedure.

10.2.3 Conditional PSCell Addition

A Conditional PSCell Addition (CPA) is defined as a PSCell addition that is executed by the UE when execution condition(s) is met. The UE starts evaluating the execution condition(s) upon receiving the CPA configuration, and stops evaluating the execution condition(s) once PSCell addition or PCell change is triggered.

The following principles apply to CPA:

- The CPA configuration contains the configuration of CPA candidate PSCell(s), execution condition(s) and may contain the MCG configuration, to be applied when CPA execution is triggered.

- An execution condition may consist of one or two trigger condition(s) (see *CondEvent*, as defined in TS 38.331 [4] or TS 36.331 [10]). Only a single RS type and at most two different trigger quantities (e.g. RSRP and RSRQ, RSRP and SINR, etc.) can be used for the evaluation of CPA execution condition of a single candidate PSCell.

- Before any CPA execution condition is satisfied, upon reception of PSCell addition command or PCell change command, the UE executes the PSCell addition procedure as described in clause 10.2.1 or 10.2.2, or the PCell change procedure as described in clause 9.2.3.2 in TS 38.300[3] or clause 10.1.2.1 in TS 36.300 [2], regardless of any previously received CPA configuration. Upon the successful completion of PSCell addition procedure or PCell change procedure, the UE releases the stored CPA configuration.

- While executing CPA, the UE is not required to continue evaluating the execution condition of other candidate PSCell(s) or PCell(s).

- Once the CPA procedure is executed successfully, the UE releases all stored conditional reconfigurations (i.e. for CPA and for CHO, as specified in TS 38.300 [3] or TS 36.300 [2]) except for subsequent CPAC.

CPA configuration in HO command, in PSCell addition command, or within any conditional reconfiguration (i.e., CPA, CPC or CHO configuration) is not supported.

10.3 Secondary Node Modification (MN/SN initiated)

10.3.1 EN-DC

The Secondary Node Modification procedure may be initiated either by the MN or by the SN and be used to modify, establish or release bearer contexts, to transfer bearer contexts to and from the SN or to modify other properties of the UE context within the same SN. It may also be used to transfer an NR RRC message from the SN to the UE via the MN and the response from the UE via MN to the SN (e.g. when SRB3 is not used). In case of CPA or inter-SN CPC, this procedure is used to modify CPA or inter-SN CPC configuration within the same candidate SN. In case of CPA or inter-SN CPC, this procedure may also be triggered by the candidate SN to add some prepared PSCells from the suggested list or cancel part of the prepared PSCells. In case of intra-SN CPC, this procedure is used to configure, modify or release intra-SN CPC configuration. This procedure may be initiated by the MN or SN to request the SN or MN to deactivate or activate the SCG.

The Secondary Node modification procedure does not necessarily need to involve signalling towards the UE.

MN initiated SN Modification

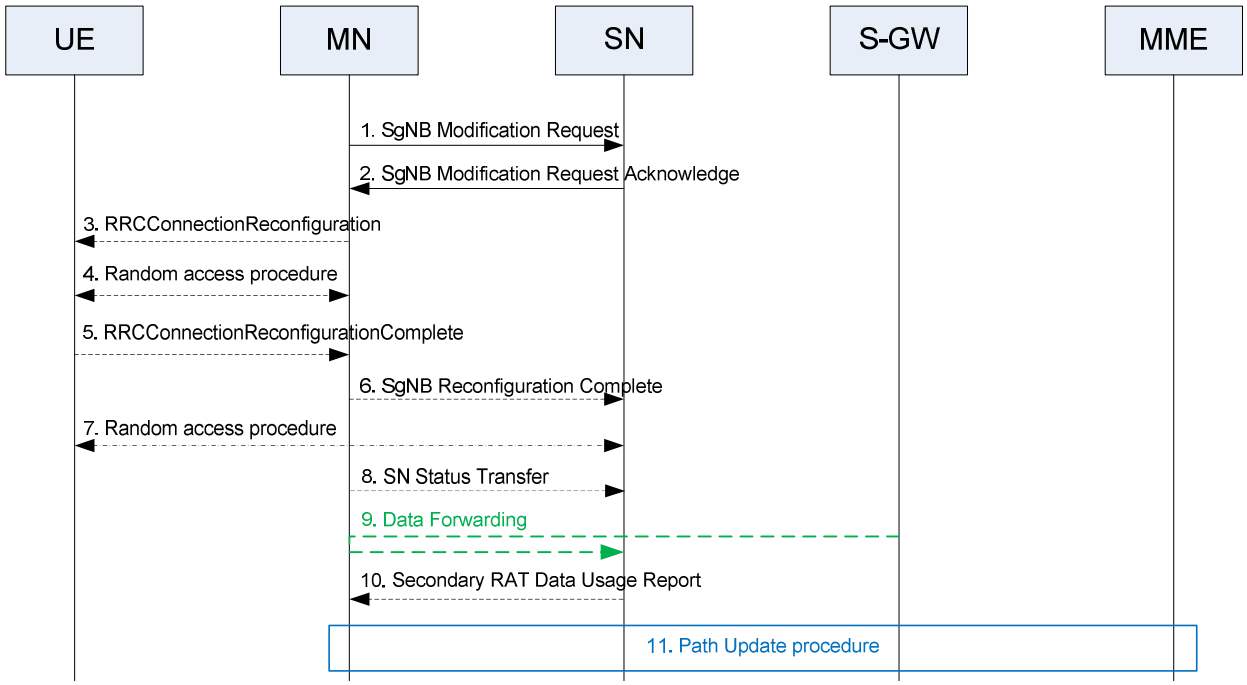


Figure 10.3.1-1: SN Modification procedure - MN initiated

The MN uses the procedure to initiate configuration changes of the SCG within the same SN, e.g. the addition, modification or release of SCG bearer(s) and the SCG RLC bearer of split bearer(s), as well as configuration changes for SN terminated MCG bearers. Bearer termination point change is realized by adding the new bearer configuration and releasing the old bearer configuration within a single MN initiated SN Modification procedure for the respective E-RAB. The MN uses this procedure to perform handover within the same MN while keeping the SN. The MN also uses the procedure to query the current SCG configuration, e.g. when delta configuration is applied in an MN initiated SN change. The MN also uses the procedure to provide the S-RLF related information to the SN. The MN also uses this procedure to activate or deactivate the SCG. The MN may not use the procedure to initiate the addition, modification or release of SCG SCells. The SN may reject the request, except if it concerns the release of SN terminated bearer(s) or the SCG RLC bearer of MN terminated bearer(s), or if it is used to perform handover within the same MN while keeping the SN. Figure 10.3.1-1 shows an example signalling flow for an MN initiated SN Modification procedure.

1. The MN sends the *SgNB Modification Request* message, which may contain bearer context related or other UE context related information, data forwarding address information (if applicable) and the requested SCG configuration information, including the UE capability coordination result to be used as basis for the reconfiguration by the SN. The MN may request the SCG to be activated or deactivated. In case a security key update in the SN is required, a new *SgNB Security Key* is included. In case of SCG RLC re-establishment for E-RABs configured with an MN terminated bearer with an SCG RLC bearer for which no bearer type change is performed, the MN provides a new UL GTP tunnel endpoint to the SN. The SN shall continue sending UL PDCP PDUs to the MN with the previous UL GTP tunnel endpoint until it re-establishes the RLC and use the new UL GTP tunnel endpoint after re-establishment. In case of PDCP re-establishment for E-RABs configured with an SN terminated bearer with an MCG RLC bearer for which no bearer type change is performed, the MN provides a new DL GTP tunnel endpoint to the SN. The SN shall continue sending DL PDCP PDUs to the MN with the previous DL GTP tunnel endpoint until it performs PDCP re-establishment and use the new DL GTP tunnel endpoint starting with the PDCP re-establishment.

2. The SN responds with the *SgNB Modification Request Acknowledge* message, which may contain SCG radio resource configuration information within a NR RRC configuration message and data forwarding address information (if applicable). If the MN requested the SCG to be activated or deactivated, the SN indicates whether the SCG is activated or deactivated. In case of a security key update (with or without PSCell change), for E-RABs configured with the MN terminated bearer option that require X2-U resources between the MN and the SN, for which no bearer type change is performed, the SN provides a new DL GTP tunnel endpoint to the MN. The MN shall continue sending DL PDCP PDUs to the SN with the previous DL GTP tunnel endpoint until it performs PDCP re-establishment or PDCP data recovery, and use the new DL GTP tunnel endpoint starting with the PDCP re-establishment or data recovery. In case of a security key update (with or without PSCell change), for E-RABs configured with the SN terminated bearer option that require X2-U resources between the MN and the SN, for which no bearer type change is performed, the SN provides a new UL GTP tunnel endpoint to the

MN. The MN shall continue sending UL PDCP PDUs to the SN with the previous UL GTP tunnel endpoint until it re-establishes the RLC and use the new UL GTP tunnel endpoint after re-establishment.

NOTE 00: In case SN includes the indication of full RRC configuration in *SgNB Modification Request Acknowledge* message to MN e.g. comprehension failure upon intra-CU inter-DU change, MN performs release and add of the NR SCG part of the configuration but does not release SN terminated radio bearers towards the UE.

3-5. The MN initiates the RRC connection reconfiguration procedure, including the NR RRC configuration message. The UE applies the new configuration, synchronizes to the MN (if instructed, in case of intra-MN handover) and replies with *RRCConnectionReconfigurationComplete*, including a NR RRC response message, if needed. In case the UE is unable to comply with (part of) the configuration included in the *RRCConnectionReconfiguration* message, it performs the reconfiguration failure procedure.

6. Upon successful completion of the reconfiguration, the success of the procedure is indicated in the *SgNB Reconfiguration Complete* message.

7. If instructed, the UE performs synchronisation towards the PSCell of the SN as described in SgNB addition procedure. Otherwise, the UE may perform UL transmission after having applied the new configuration.

8. If PDCP termination point is changed for bearers using RLC AM, and when RRC full configuration is not used, the SN Status Transfer takes place between the MN and the SN (Figure 10.3.1-1 depicts the case where a bearer context is transferred from the MN to the SN).

NOTE 0: The SN may not be aware that a SN terminated bearer requested to be released is reconfigured to a MN terminated bearer. The SN Status for the released SN terminated bearers with RLC AM may also be transferred to the MN.

9. If applicable, data forwarding between MN and the SN takes place (Figure 10.3.1-1 depicts the case where a bearer context is transferred from the MN to the SN).

10. The SN sends the *Secondary RAT Data Usage Report* message to the MN and includes the data volumes delivered to and received from the UE over the NR radio for the E-RABs to be released and for the E-RABs for which the S1 UL GTP Tunnel endpoint was requested to be modified.

NOTE 1: The order the SN sends the *Secondary RAT Data Usage Report* message and performs data forwarding with MN is not defined. The SN may send the report when the transmission of the related bearer is stopped.

11. If applicable, a path update is performed.

SN initiated SN Modification with MN involvement

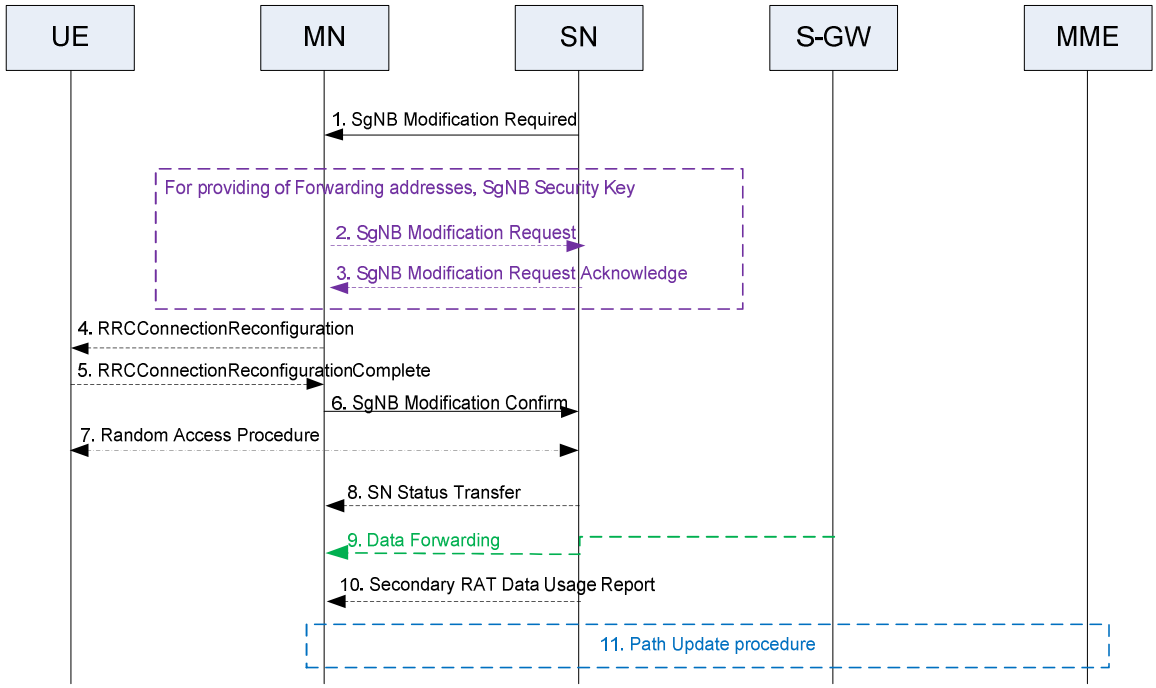


Figure 10.3.1-2: SN Modification procedure - SN initiated with MN involvement

The SN uses the procedure to perform configuration changes of the SCG within the same SN, e.g. to trigger the release of SCG bearer(s) and the SCG RLC bearer of split bearer(s) (upon which the MN may release the bearer or maintain current bearer type or reconfigure it to an MCG bearer, either MN terminated or SN terminated), to trigger the release of SCG resources (e.g., release SCG lower layer resources but keep SN), and to trigger PSCell change (e.g. when a new security key is required or when the MN needs to perform PDCP data recovery). The MN cannot reject the release request of SCG bearer and the SCG RLC bearer of a split bearer and the release request of SCG resources. The SN also uses this procedure to activate or deactivate the SCG. The MN shall either accept modification of all of the requested SCG bearer(s) and the SCG RLC bearer of split bearer(s) and the request of activation or deactivation of the SCG, or fail the procedure. Figure 10.3.1-2 shows an example signalling flow for an SN initiated SgNB Modification procedure, with MN involvement.

1. The SN sends the *SgNB Modification Required* message including a NR RRC configuration message, which may contain bearer context related, other UE context related information and the new SCG radio resource configuration. The SN may request the SCG to be activated or deactivated. For bearer release or modification, a corresponding E-RAB list is included in the *SgNB Modification Required* message. In case of change of security key, the *PDCP Change Indication* indicates that a S-K_{gNB} update is required. In case the MN needs to perform PDCP data recovery, the *PDCP Change Indication* indicates that PDCP data recovery is required. In case SN decides to trigger SCG release, the E-RABs to be modified list includes all the E-RABs of the UE with SCG resource indicated as not present for each E-RAB.

   The SN can decide whether the change of security key is required.

NOTE 1a: In case SN includes the indication of full RRC configuration in *SgNB Modification Required* message to MN e.g. comprehension failure upon intra-CU inter-DU change, MN performs release and add of the NR SCG part of the configuration but does not release SN terminated radio bearers towards the UE.

NOTE 1b: In case that a MN initiated conditional reconfiguration (e.g. CHO or MN initiated inter-SN CPC) is prepared, and if any execution of a prepared SN initiated intra-SN CPC procedure or reconfiguration of the SCG, the SN notifies to the MN via the *SgNB Modification Required* message. In this case, the steps 2 and 3 are skipped.

NOTE 1c: In case of SN initiated inter-SN CPC and in case that a candidate SN triggered the SN Initiated SN Modification procedure to include some more prepared PSCells (within the candidate cells suggested by the source SN in SN initiated inter-SN CPC) or to remove some prepared PSCells, the MN may decide to trigger the step 2 towards the source SN.

2/3. The MN initiated SN Modification procedure may be triggered by the *SN Modification Required* message (e.g. to provide information such as data forwarding addresses, new SN security key, measurement gap, etc...)

NOTE 2: If only SN security key is provided in step 2, the MN does not need to wait for the reception of step 3 to initiate the RRC connection reconfiguration procedure.

4. The MN sends the *RRCConnectionReconfiguration* message including a NR RRC configuration message to the UE including the new SCG radio resource configuration.

5. The UE applies the new configuration and sends the *RRCConnectionReconfigurationComplete* message, including an encoded NR RRC response message, if needed. In case the UE is unable to comply with (part of) the configuration included in the *RRCConnectionReconfiguration* message, it performs the reconfiguration failure procedure.

6. Upon successful completion of the reconfiguration, the success of the procedure is indicated in the *SgNB Modification Confirm* message containing the encoded NR RRC response message, if received from the UE.

7. If instructed, the UE performs synchronisation towards the PSCell of the SN as described in SN addition procedure. Otherwise, the UE may perform UL transmission after having applied the new configuration.

8. If PDCP termination point is changed for bearers using RLC AM, and when RRC full configuration is not used, the SN Status Transfer takes place between the MN and the SN (Figure 10.3.1-2 depicts the case where a bearer context is transferred from the SN to the MN).

NOTE 2a: The SN may not be aware that a SN terminated bearer requesting to release is reconfigured to a MN terminated bearer. The SN Status for the released SN terminated bearers with RLC AM may also be transferred to the MN.

9. If applicable, data forwarding between MN and the SN takes place (Figure 10.3.1-2 depicts the case where a bearer context is transferred from the SN to the MN).

10. The SN sends the *Secondary RAT Data Usage Report* message to the MN and includes the data volumes delivered to and received from the UE over the NR radio for the E-RABs to be released.

NOTE 3: The order the SN sends the *Secondary RAT Data Usage Report* message and performs data forwarding with MN is not defined. The SN may send the report when the transmission of the related bearer is stopped.

11. If applicable, a path update is performed.

SN initiated SN Modification without MN involvement

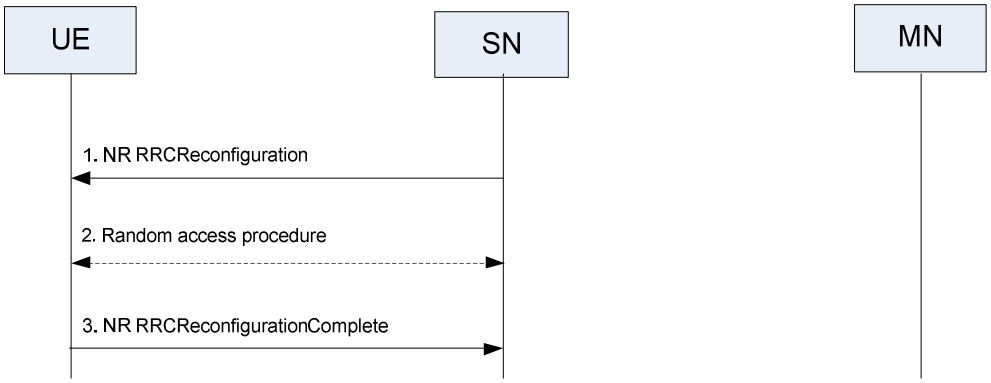


Figure 10.3.1-3: SN modification - SN initiated without MN involvement

The SN initiated modification without MN involved procedure is used to modify the configuration within SN in case no coordination with MN is required, including the addition/modification/release of SCG SCell and PSCell change (e.g.

when the security key does not need to be changed and the MN does not need to be involved in PDCP recovery). The SN may initiate the procedure to configure, modify or release intra-SN CPC configuration within the same SN. Figure 10.3.1-3 shows an example signalling flow for SN initiated SN modification procedure, without MN involvement. The SN can decide whether the Random Access procedure is required.

1. The SN sends the *RRCReconfiguration* message to the UE through SRB3. The UE applies the new configuration. In case the UE is unable to comply with (part of) the configuration included in the *RRCReconfiguration* message, it performs the reconfiguration failure procedure.
2. If instructed, the UE performs synchronisation towards the PSCell of the SN.
3. The UE replies with the *RRCReconfigurationComplete* message.

SN initiated Conditional SN Modification without MN involvement (SRB3 is used)

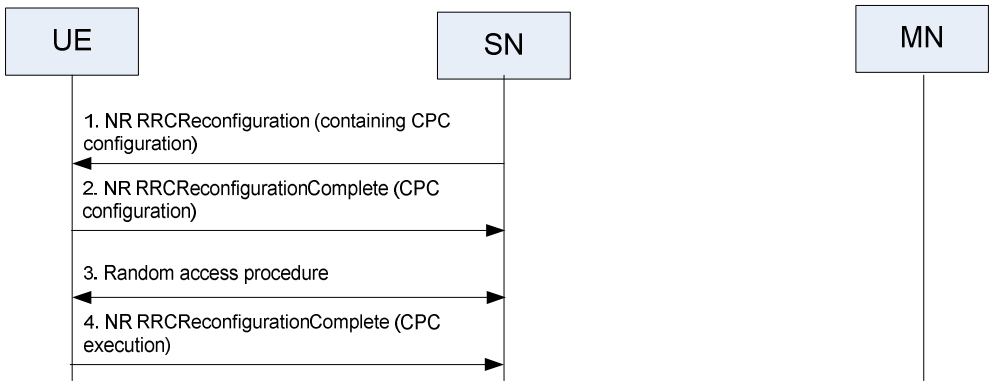


Figure 10.3.1-3a: SN Modification - SN-initiated without MN involvement and SRB3 is used to configure intra-SN CPC.

The SN initiates the procedure when it needs to transfer an NR RRC message to the UE and SRB3 is used to configure intra-SN CPC.

1. The SN sends the *RRCReconfiguration* message including CPC configuration to the UE through SRB3.
2. The UE applies the new configuration. In case the UE is unable to comply with (part of) the configuration included in the *RRCReconfiguration* message, it performs the reconfiguration failure procedure. The UE starts evaluating the CPC execution conditions for the candidate PSCell(s). The UE maintains connection with the source PSCell and replies with the *RRCReconfigurationComplete* message to the SN via SRB3.
3. If at least one CPC candidate PSCell satisfies the corresponding CPC execution condition, the UE detaches from the source PSCell, applies the stored configuration corresponding to the selected candidate PSCell and synchronises to the candidate PSCell.
4. The UE completes the CPC execution procedure by sending an *RRCReconfigurationComplete* message to the new PSCell.

Transfer of an NR RRC message to/from the UE (when SRB3 is not used)

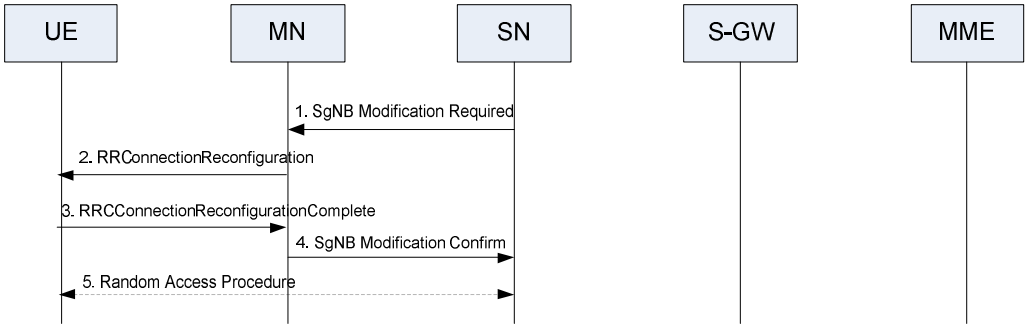


Figure 10.3.1-4: Transfer of an NR RRC message to/from the UE

The SN initiates the procedure when it needs to transfer an NR RRC message to the UE and SRB3 is not used.

1. The SN initiates the procedure by sending the *SgNB Modification Required* to the MN.
2. The MN forwards the NR RRC message to the UE in the *RRCConnectionReconfiguration* message.
3. The UE applies the new configuration and replies with the *RRCConnectionReconfigurationComplete* message. In case the UE is unable to comply with (part of) the configuration included in the NR RRC message, it performs the reconfiguration failure procedure.
4. The MN forwards the NR RRC response message, if received from the UE, to the SN in the *SgNB Modification Confirm* message.
5. If instructed, the UE performs synchronisation towards the PSCell of the SN as described in SgNB Addition procedure. Otherwise the UE may perform UL transmission after having applied the new configuration.

SN initiated Conditional SN Modification without MN involvement (SRB3 is not used)

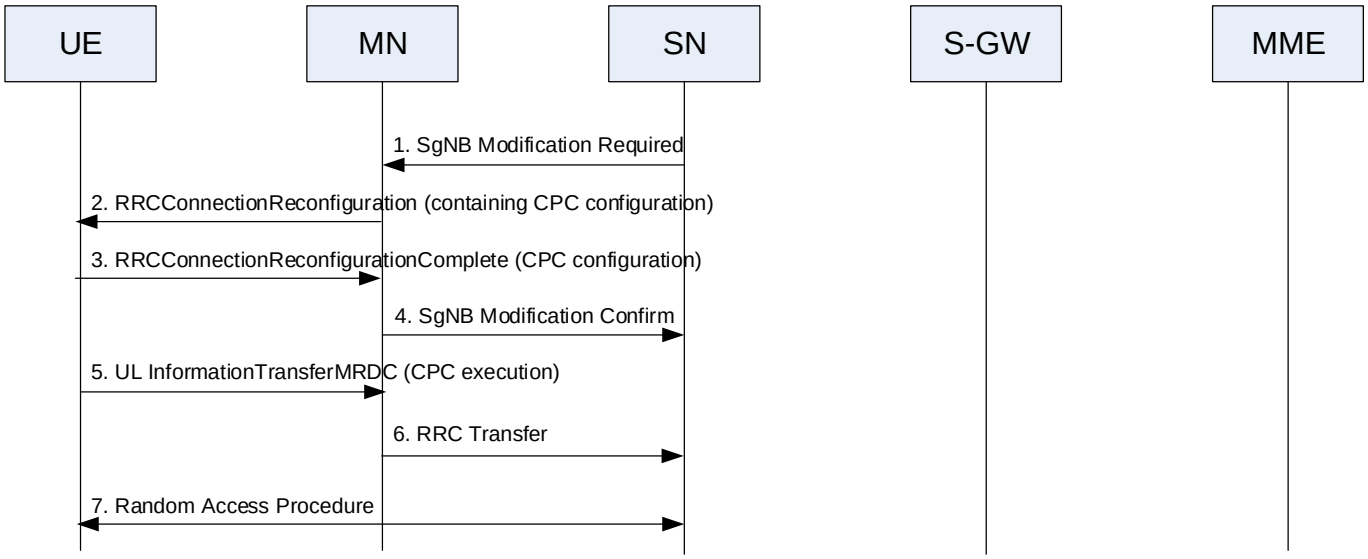


Figure 10.3.1-5: SN Modification - SN-initiated without MN involvement and SRB3 is not used to configure intra-SN CPC

The SN initiates the procedure when it needs to transfer an NR RRC message to the UE and SRB3 is not used to configure intra-SN CPC.

1. The SN initiates the procedure by sending the *SgNB Modification Required* to the MN including the SN RRC reconfiguration message with CPC configuration.
2. The MN forwards the SN RRC reconfiguration message to the UE including it in the *RRCConnectionReconfiguration* message.
3. The UE replies with the *RRCConnectionReconfigurationComplete* message by including the SN RRC reconfiguration complete message. In case the UE is unable to comply with (part of) the configuration included in the SN RRC reconfiguration message, it performs the reconfiguration failure procedure. The UE maintains connection with source PSCell after receiving CPC configuration, and starts evaluating the CPC execution conditions for the candidate PSCell(s).
4. The MN forwards the SN RRC response message, if received from the UE, to the SN by including it in the *SgNB Modification Confirm* message.
5. If at least one CPC candidate PSCell satisfies the corresponding CPC execution condition, the UE completes the CPC execution procedure by an *ULInformationTransferMRDC* message to the MN which includes an embedded *RRCReconfigurationComplete* message to the selected target PSCell.
6. The *RRCReconfigurationComplete* message is forwarded to the SN embedded in *RRC Transfer* message.

7. The UE detaches from the source PSCell, applies the stored corresponding configuration and synchronises to the selected candidate PSCell.

10.3.2 MR-DC with 5GC

The SN Modification procedure may be initiated either by the MN or by the SN and be used to modify the current user plane resource configuration (e.g. related to PDU session, QoS flow or DRB) or to modify other properties of the UE context within the same SN. It may also be used to transfer an RRC message from the SN to the UE via the MN and the response from the UE via MN to the SN (e.g. when SRB3 is not used). In NGEN-DC and NR-DC, the RRC message is an NR message (i.e., *RRCReconfiguration*) whereas in NE-DC it is an E-UTRA message (i.e., *RRCConnectionReconfiguration*). In case of CPA, inter-SN CPC or subsequent CPAC, this procedure is used to modify CPA, inter-SN CPC or subsequent CPAC configuration within the same candidate SN. In case of CPA, inter-SN CPC or subsequent CPAC, this procedure may also be triggered by the candidate SN to add some prepared PSCells from the suggested list or cancel part of the prepared PSCells. In case of intra-SN CPC or subsequent CPAC, this procedure is used to configure, modify or release intra-SN CPC or subsequent CPAC configuration. In case of intra-SN SCG LTM, this procedure is used to configure, modify or release intra-SN SCG LTM configuration. This procedure may be initiated by the MN or SN to request the SN or MN to activate or deactivate the SCG. This procedure can also be used to support coordination between the MN and the SN for managing the configuration and reporting of QoE measurements and/or RAN visible QoE measurements in NR-DC.

The SN modification procedure does not necessarily need to involve signalling towards the UE.

MN initiated SN Modification

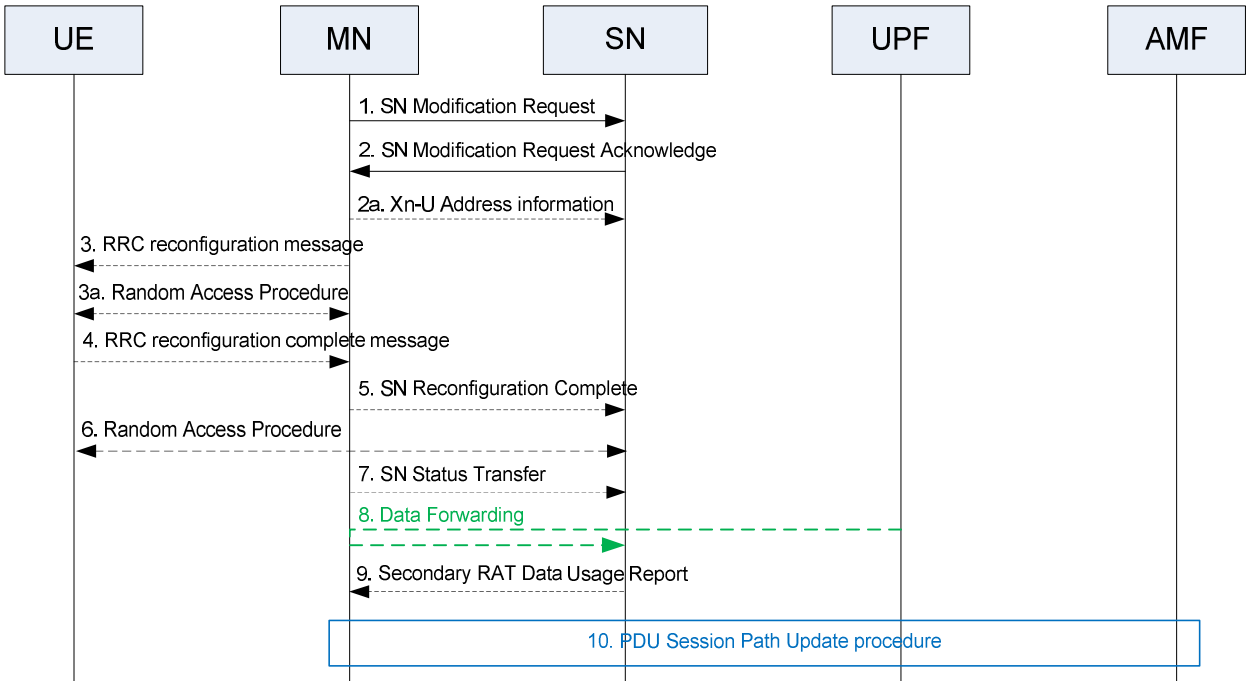


Figure 10.3.2-1: SN Modification procedure - MN initiated

The MN uses the procedure to initiate configuration changes of the SCG within the same SN, including addition, modification or release of the user plane resource configuration. The MN uses this procedure to perform handover within the same MN while keeping the SN, when the SN needs to be involved (i.e. in NGEN-DC). The MN also uses the procedure to query the current SCG configuration, e.g. when delta configuration is applied in an MN initiated SN change. The MN also uses the procedure to provide the S-RLF related information to the SN or to provide additional available DRB IDs to be used for SN terminated bearers. The MN also uses this procedure to activate or deactivate the SCG. The MN may not use the procedure to initiate the addition, modification or release of SCG SCells. The SN may reject the request, except if it concerns the release of the user plane resource configuration, or if it is used to perform handover within the same MN while keeping the SN. Figure 10.3.2-1 shows an example signalling flow for an MN initiated SN Modification procedure.

1. The MN sends the *SN Modification Request* message, which may contain user plane resource configuration related or other UE context related information, PDU session level Network Slice info and the requested SCG

configuration information, including the UE capabilities coordination result to be used as basis for the reconfiguration by the SN. In case a security key update in the SN is required, a new *SN Security Key* is included. In case the PDCP data recovery in the SN is required, the *PDCP Change Indication* is included which indicates that PDCP data recovery is required in SN. In case of coordination between the MN and the SN on QoE and/or RAN visible QoE measurement configuration and reporting, the *SN Modification Request* message may contain the *QMC Coordination Request* IE.

2. The SN responds with the *SN Modification Request Acknowledge* message, which may contain new SCG radio configuration information within an SN RRC reconfiguration message, and data forwarding address information (if applicable). If the MN requested the SCG to be activated or deactivated, the SN indicates whether the SCG is activated or deactivated. In case of coordination between the MN and the SN on QoE and/or RAN visible QoE measurement configuration and reporting, the *SN Modification Request Acknowledge* message may contain the *QMC Coordination Response* IE.

NOTE 1: For MN terminated bearers to be setup for which PDCP duplication with CA is configured in NR SCG side, the MN allocates up to 4 separate Xn-U bearers and the SN provides a logical channel ID for primary or split secondary path to the MN.

For SN terminated bearers to be setup for which PDCP duplication with CA is configured in NR MCG side, the SN allocates up to 4 separate Xn-U bearers and the MN provides a logical channel ID for primary or split secondary path to the SN via an additional MN-initiated SN modification procedure.

2a. When applicable, the MN provides data forwarding address information to the SN. For SN terminated bearers using MCG resources, the MN provides Xn-U DL TNL address information in the *Xn-U Address Indication* message.

3/4. The MN initiates the RRC reconfiguration procedure, including an SN RRC reconfiguration message. The UE applies the new configuration, synchronizes to the MN (if instructed, in case of intra-MN handover) and replies with MN RRC reconfiguration complete message, including an SN RRC response message, if needed. In case the UE is unable to comply with (part of) the configuration included in the MN RRC reconfiguration message, it performs the reconfiguration failure procedure.

5. Upon successful completion of the reconfiguration, the success of the procedure is indicated in the *SN Reconfiguration Complete* message.

6. If instructed, the UE performs synchronisation towards the PSCell of the SN as described in SN addition procedure. Otherwise, the UE may perform UL transmission after having applied the new configuration.

7. If PDCP termination point is changed for bearers using RLC AM, and when RRC full configuration is not used, the SN Status Transfer takes place between the MN and the SN (Figure 10.3.2-1 depicts the case where a bearer context is transferred from the MN to the SN).

8. If applicable, data forwarding between MN and the SN takes place (Figure 10.3.2-1 depicts the case where a user plane resource configuration related context is transferred from the MN to the SN).

9. The SN sends the *Secondary RAT Data Usage Report* message to the MN and includes the data volumes delivered to and received from the UE as described in clause 10.11.2.

NOTE 2: The order the SN sends the *Secondary RAT Data Usage Report* message and performs data forwarding with MN is not defined. The SN may send the report when the transmission of the related QoS flow is stopped.

10. If applicable, a PDU Session path update procedure is performed.

SN initiated SN Modification with MN involvement

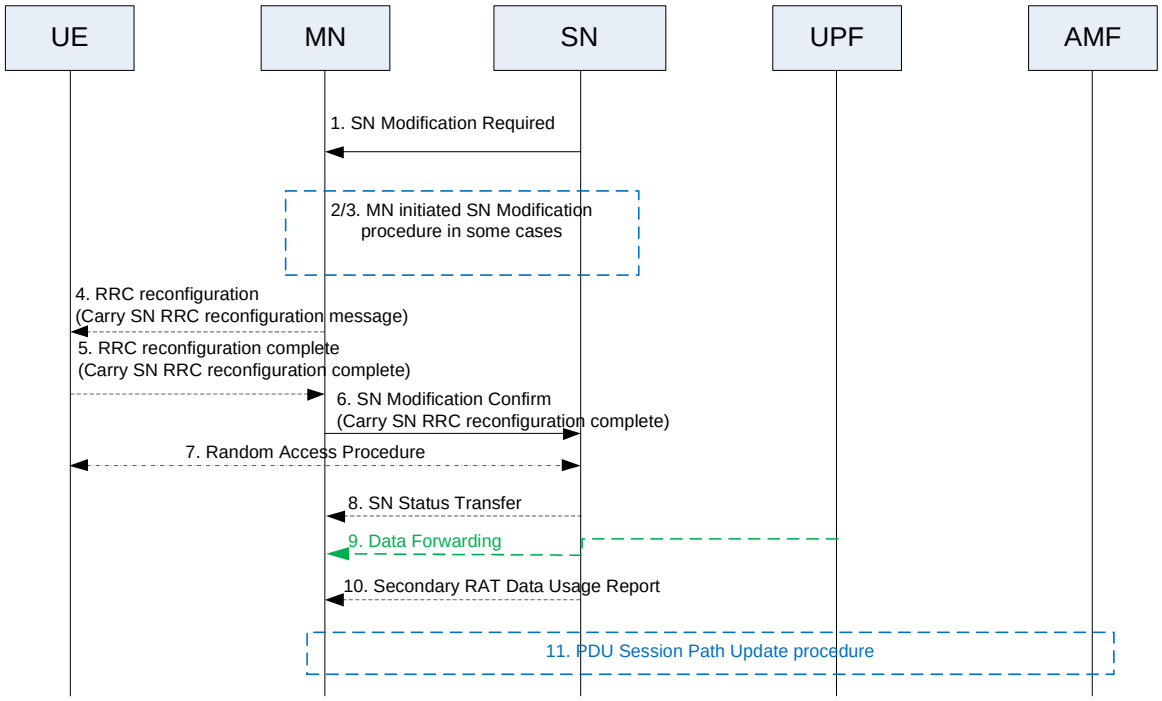


Figure 10.3.2-2: SN Modification procedure - SN initiated with MN involvement

The SN uses the procedure to perform configuration changes of the SCG within the same SN, e.g. to trigger the modification/release of the user plane resource configuration, to trigger the release of SCG resources (e.g., release SCG lower layer resources but keep SN), and to trigger PSCell changes (e.g. when a new security key is required or when the MN needs to perform PDCP data recovery). The MN cannot reject the release request of PDU session/QoS flows and the release request of SCG resources. The SN also uses the procedure to request the MN to provide more DRB IDs to be used for SN terminated bearers or to return DRB IDs used for SN terminated bearers that are not needed any longer. The SN also uses this procedure to activate or deactivate the SCG. Figure 10.3.2-2 shows an example signalling flow for SN initiated SN Modification procedure.

1. The SN sends the *SN Modification Required* message including an SN RRC reconfiguration message, which may contain user plane resource configuration related context, other UE context related information and the new radio resource configuration of SCG. The SN may request the SCG to be activated or deactivated. In case of change of security key, the *PDCP Change Indication* indicates that an SN security key update is required. In case the MN needs to perform PDCP data recovery, the *PDCP Change Indication* indicates that PDCP data recovery is required. In case of coordination between the MN and the SN on QoE and/or RAN visible QoE measurement configuration and reporting, the *SN Modification Required* message may contain the *QMC Coordination Request* IE.

   The SN can decide whether the change of security key is required.

NOTE 3a: In case that a MN initiated conditional reconfiguration (e.g. CHO, MN initiated inter-SN CPC or MN initiated subsequent CPAC) is prepared, and if any execution of a prepared SN initiated intra-SN CPC or SN initiated intra-SN subsequent CPAC without MN involvement procedure or reconfiguration of the SCG, the SN notifies the MN via the *SN Modification Required* message. In this case, the steps 2 and 3 are skipped.

NOTE 3b: In case of SN initiated inter-SN CPC or SN initiated subsequent CPAC and in case that a candidate SN triggered the SN Initiated SN Modification procedure to include some prepared PSCells (within the candidate cells suggested by the source SN in SN initiated inter-SN CPC or SN initiated subsequent CPAC) or to remove some prepared PSCells, the MN may decide to trigger the step 2 towards the source SN.

2/3. The MN initiated SN Modification procedure may be triggered by *SN Modification Required* message, e.g. when an SN security key change needs to be applied, or as described in clause 10.20.

NOTE 3: For SN terminated bearers to be setup for which PDCP duplication with CA is configured in NR MCG side, the SN allocates up to 4 separate Xn-U bearers and the MN provides a logical channel ID for primary or split secondary path to the SN via the nested MN-initiated SN modification procedure.

4. The MN sends the MN RRC reconfiguration message to the UE including the SN RRC reconfiguration message with the new SCG radio resource configuration.

5. The UE applies the new configuration and sends the MN RRC reconfiguration complete message, including an SN RRC response message, if needed. In case the UE is unable to comply with (part of) the configuration included in the MN RRC reconfiguration message, it performs the reconfiguration failure procedure.

6. Upon successful completion of the reconfiguration, the success of the procedure is indicated in the *SN Modification Confirm* message including the SN RRC response message, if received from the UE. In case of coordination between the MN and the SN on QoE and/or RAN visible QoE measurement configuration and reporting, the *SN Modification Confirm* message may contain the *QMC Coordination Response* IE.

7. If instructed, the UE performs synchronisation towards the PSCell configured by the SN as described in SN Addition procedure. Otherwise, the UE may perform UL transmission directly after having applied the new configuration.

8. If PDCP termination point is changed for bearers using RLC AM, and when RRC full configuration is not used, the SN Status Transfer takes place between the MN and the SN (Figure 10.3.2-2 depicts the case where a bearer context is transferred from the SN to the MN).

9. If applicable, data forwarding between MN and the SN takes place (Figure 10.3.2-2 depicts the case where a user plane resource configuration related context is transferred from the SN to the MN).

10. The SN sends the *Secondary RAT Data Usage Report* message to the MN and includes the data volumes delivered to and received from the UE as described in clause 10.11.2.

NOTE 4: The order the SN sends the *Secondary RAT Data Usage Report* message and performs data forwarding with MN is not defined. The SN may send the report when the transmission of the related QoS flow is stopped.

11. If applicable, a PDU Session path update procedure is performed.

SN initiated SN Modification without MN involvement

This procedure is not supported for NE-DC.

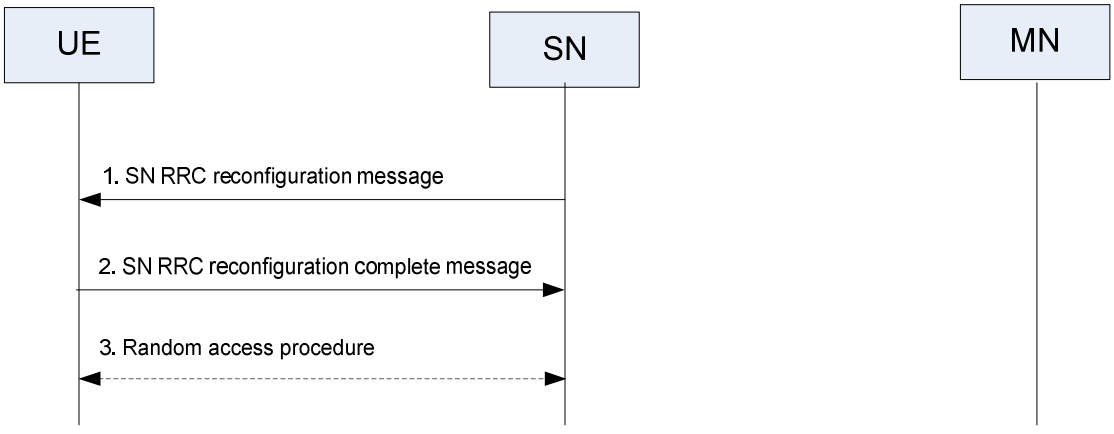


Figure 10.3.2-3: SN Modification – SN initiated without MN involvement

The SN initiated SN modification procedure without MN involvement is used to modify the configuration within SN in case no coordination with MN is required, including the addition/modification/release of SCG SCell and PSCell change (e.g. when the security key does not need to be changed and the MN does not need to be involved in PDCP recovery). The SN may initiate the procedure to configure, modify or release intra-SN CPC or intra-SN subsequent CPAC configuration within the same SN. The SN may initiate the procedure to configure, modify or release intra-SN SCG LTM configuration within the same SN. Figure 10.3.2-3 shows an example signalling flow for SN initiated SN

modification procedure without MN involvement. The SN can decide whether the Random Access procedure is required.

1. The SN sends the SN RRC reconfiguration message to the UE through SRB3.
2. The UE applies the new configuration and replies with the SN RRC reconfiguration complete message. In case the UE is unable to comply with (part of) the configuration included in the SN RRC reconfiguration message, it performs the reconfiguration failure procedure.
3. If instructed, the UE performs synchronisation towards the PSCell of the SN as described in SN Addition procedure. Otherwise the UE may perform UL transmission after having applied the new configuration.

SN initiated Conditional SN Modification without MN involvement (SRB3 is used)

This procedure is not supported for NE-DC and NGEN-DC.

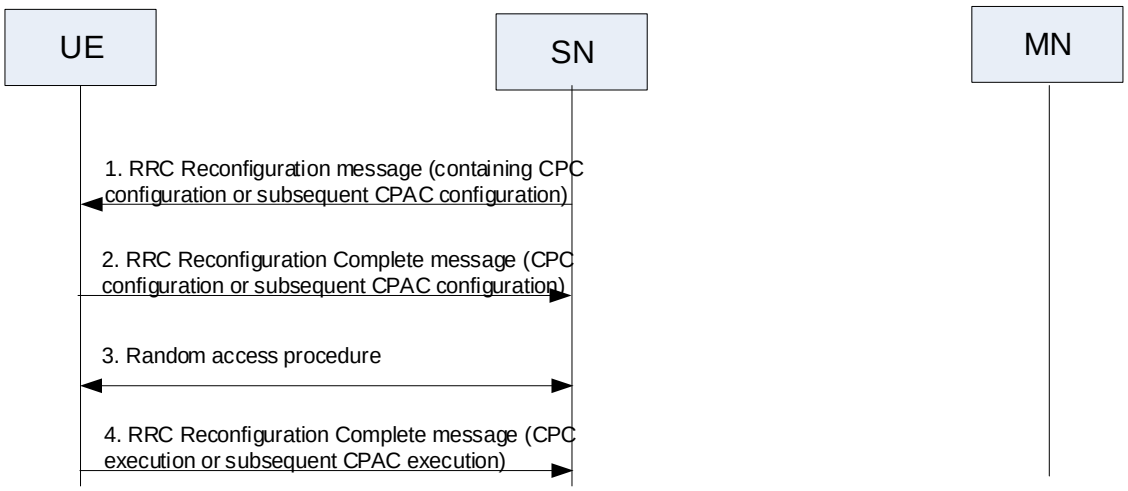


Figure 10.3.2-3a: SN Modification – SN-initiated without MN involvement and SRB3 is used to configure intra-SN CPC or intra-SN subsequent CPAC.

The SN initiates the procedure when it needs to transfer an NR RRC message to the UE and SRB3 is used to configure intra-SN CPC or intra-SN subsequent CPAC.

1. The SN sends the SN RRC reconfiguration including CPC configuration or subsequent CPAC configuration to the UE through SRB3.
2. The UE applies the new configuration. In case the UE is unable to comply with (part of) the configuration included in the SN RRC reconfiguration message, it performs the reconfiguration failure procedure. The UE starts evaluating the execution conditions for the candidate PSCell(s). The UE maintains connection with the source PSCell and replies with the *RRCReconfigurationComplete* message to the SN via SRB3.
3. If at least one candidate PSCell satisfies the corresponding execution condition, the UE detaches from the source PSCell, applies the stored configuration corresponding to the selected candidate PSCell and synchronises to the candidate PSCell. In subsequent CPAC, the UE keeps the configured subsequent CPAC configuration and evaluates the execution conditions of other candidate PSCells for the following execution of subsequent CPAC after completion of the subsequent CPAC execution.
4. The UE completes the CPC or subsequent CPAC execution procedure by sending an *RRCReconfigurationComplete* message to the new PSCell.

NOTE 5: For a subsequent CPAC configuration, after a PSCell change, if the execution condition of one candidate PSCell is satisfied, the UE executes steps 3-4, e.g. based on the configuration provided in step 1.

SN initiated SCG LTM without MN involvement (SRB3 is used)

This procedure is not supported for NE-DC and NGEN-DC.

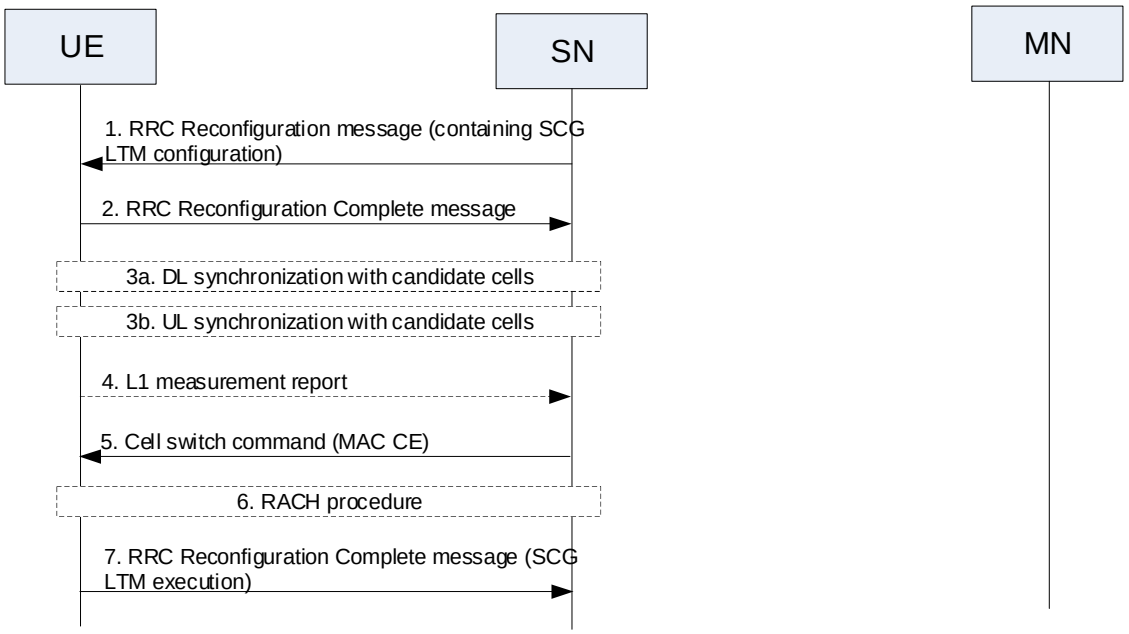


Figure 10.3.2-3b: SN Modification – SN-initiated without MN involvement and SRB3 is used to configure intra-SN SCG LTM

The SN initiates the procedure when it needs to transfer an NR RRC message to the UE and SRB3 is used to configure intra-SN SCG LTM.

1. The SN sends the SN *RRCReconfiguration* including SCG LTM candidate configurations to the UE through SRB3.

2. The UE stores the SCG LTM candidate configurations and transmits an *RRCReconfigurationComplete* message to the SN.

3a. The UE performs DL synchronization with LTM candidate cell(s) before receiving the cell switch command, as specified in clause 9.2.3.5.2 in TS 38.300 [3].

3b. The UE may perform UL synchronization with LTM candidate cell(s) before receiving the cell switch command, as specified in clause 9.2.3.5.2 in TS 38.300 [3].

4. The UE performs L1 measurements on the configured LTM candidate cell(s) and transmits L1 measurement reports to the SN, if the L1 measurement configuration in *RRCReconfiguration* is received in step 1. The UE starts to perform L1 measurements once the L1 measurement configuration is applicable.

5. The SN decides to execute cell switch to a target cell and transmits an LTM cell switch command MAC CE triggering cell switch by including a target configuration ID and other related information for the target cell, as specified in clause 9.2.3.5.2 in TS 38.300 [3]. The UE switches to the target cell and applies the candidate configuration indicated by the target configuration ID.

6. The UE performs the random access procedure towards the target cell, if the UE does not have valid TA of the target cell.

7. The UE completes the SCG LTM cell switch procedure by sending *RRCReconfigurationComplete* message to target cell. If the UE has performed a RA procedure in step 6 the UE considers that LTM execution is successfully completed when the random access procedure is successfully completed. For RACH-less LTM, the UE considers that LTM cell switch execution is successfully completed when the UE determines that the target cell has successfully received its first UL data, as specified in clause 9.2.3.5.2 in TS 38.300 [3].

NOTE 6: The steps 3-7 can be performed multiple times for subsequent SCG LTM cell switch execution using the SCG LTM candidate configuration(s) provided in step 1.

Transfer of an NR RRC message to/from the UE (when SRB3 is not used)

This procedure is supported for all the MR-DC options.

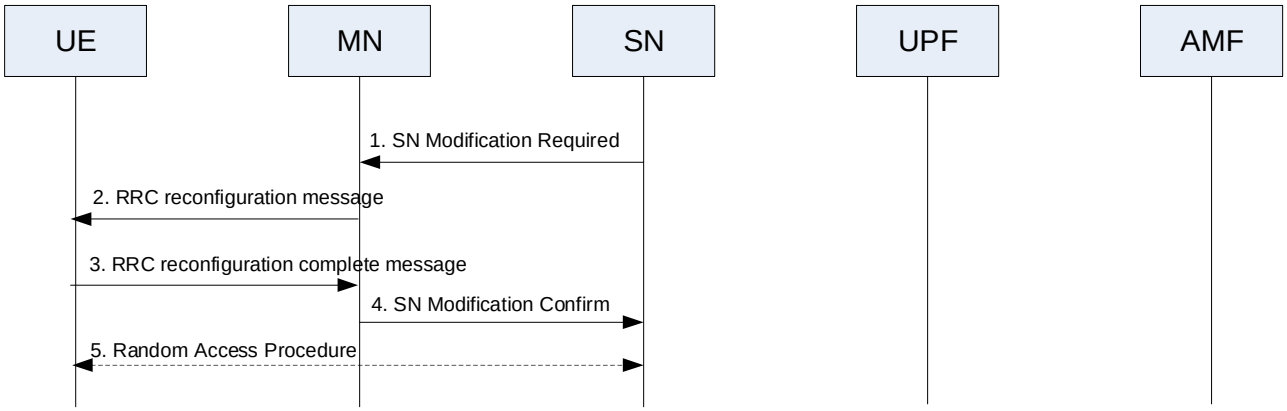


Figure 10.3.2-4: Transfer of an NR RRC message to/from the UE

The SN initiates the procedure when it needs to transfer an NR RRC message to the UE and SRB3 is not used.

1. The SN initiates the procedure by sending the *SN Modification Required* to the MN including the SN RRC reconfiguration message.
2. The MN forwards the SN RRC reconfiguration message to the UE including it in the RRC reconfiguration message.
3. The UE applies the new configuration and replies with the RRC reconfiguration complete message by including the SN RRC reconfiguration complete message. In case the UE is unable to comply with (part of) the configuration included in the SN RRC reconfiguration message, it performs the reconfiguration failure procedure.
4. The MN forwards the SN RRC response message, if received from the UE, to the SN by including it in the *SN Modification Confirm* message.
5. If instructed, the UE performs synchronisation towards the PSCell of the SN as described in SN Addition procedure. Otherwise the UE may perform UL transmission after having applied the new configuration.

SN initiated Conditional SN Modification without MN involvement (SRB3 is not used)

This procedure is not supported for NE-DC and NGEN-DC.

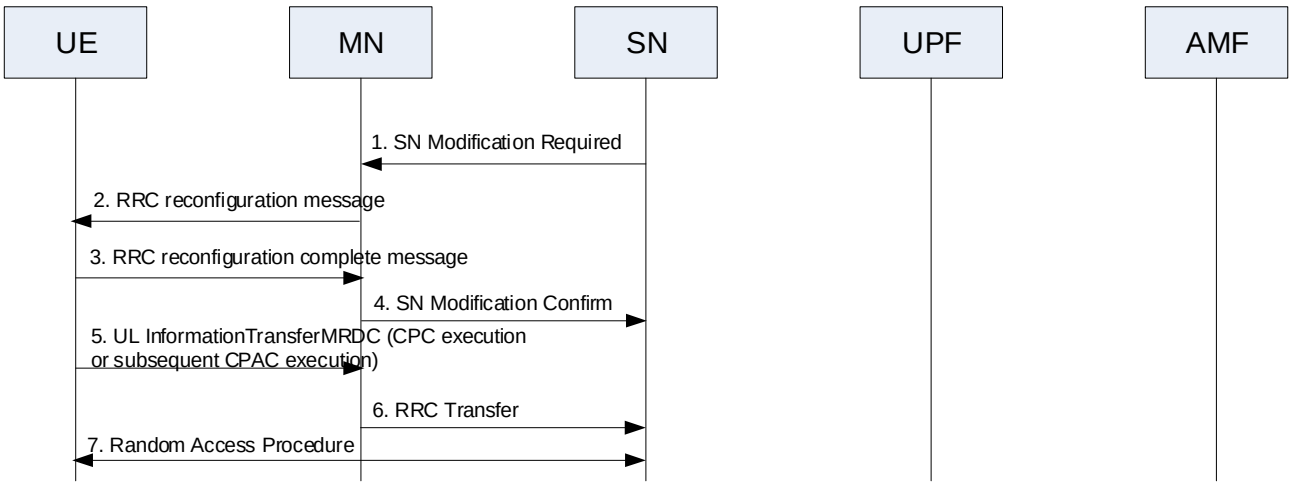


Figure 10.3.2-5: SN Modification – SN-initiated without MN involvement and SRB3 is not used to configure intra-SN CPC or intra-SN subsequent CPAC

The SN initiates the procedure when it needs to transfer an NR RRC message to the UE and SRB3 is not used to configure intra-SN CPC or intra-SN subsequent CPAC.

1. The SN initiates the procedure by sending the *SN Modification Required* to the MN including the SN RRC reconfiguration message with CPC configuration or subsequent CPAC configuration.

2. The MN forwards the SN RRC reconfiguration message to the UE including it in the *RRCReconfiguration* message.

3. The UE replies with the *RRCReconfigurationComplete* message by including the SN RRC reconfiguration complete message. In case the UE is unable to comply with (part of) the configuration included in the SN RRC reconfiguration message, it performs the reconfiguration failure procedure. The UE maintains connection with source PSCell after receiving CPC configuration or subsequent CPAC configuration, and starts evaluating the execution conditions for the candidate PSCell(s).

4. The MN forwards the SN RRC response message, if received from the UE, to the SN by including it in the *SN Modification Confirm* message.

5. If at least one candidate PSCell satisfies the corresponding execution condition, the UE completes the CPC or subsequent CPAC execution procedure by an *ULInformationTransferMRDC* message to the MN which includes an embedded *RRCReconfigurationComplete* message to the selected target PSCell. In subsequent CPAC, the UE keeps the configured subsequent CPAC configuration and evaluates the execution conditions of other candidate PSCells for the following execution of subsequent CPAC after completion of the subsequent CPAC execution.

6. The *RRCReconfigurationComplete* message is forwarded to the SN embedded in *RRC Transfer* message.

7. The UE detaches from the source PSCell, applies the stored corresponding configuration and synchronises to the selected candidate PSCell.

NOTE 7: For a subsequent CPAC configuration, after a PSCell change, if the execution condition of one candidate PSCell is satisfied, the UE executes steps 5-7, e.g. based on the configuration provided in step 2.

SN initiated SCG LTM without MN involvement (SRB3 is not used)

This procedure is not supported for NE-DC and NGEN-DC.

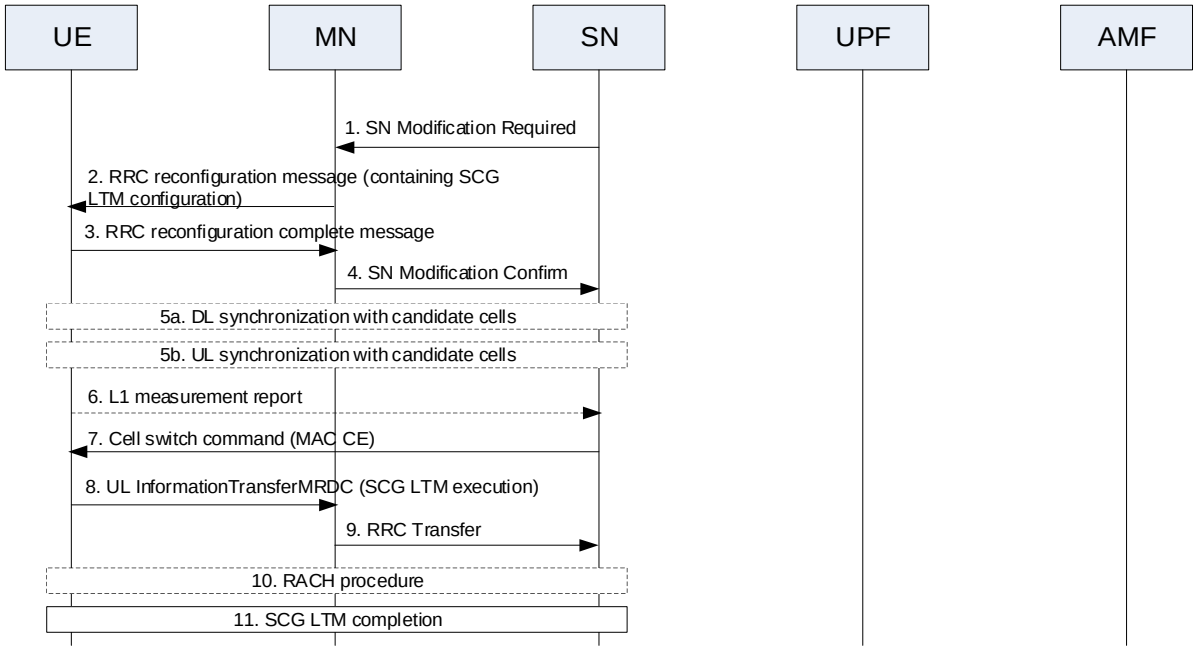


Figure 10.3.2-6: SN Modification – SN-initiated without MN involvement and SRB3 is not used to configure intra-SN SCG LTM

The SN initiates the procedure when it needs to transfer an NR RRC message to the UE and SRB3 is not used to configure intra-SN SCG LTM.

1. The SN initiates the procedure by sending the *SN Modification Required* to the MN including the SN *RRCReconfiguration* message with SCG LTM candidate configurations.

2. The MN forwards the SN *RRCReconfiguration* message to the UE including it in the *RRCReconfiguration* message.

3. The UE stores the SCG LTM candidate configurations and replies with the *RRCReconfigurationComplete* message by including the SN *RRCReconfigurationComplete* message.

4. The MN forwards the SN RRC response message, if received from the UE, to the SN by including it in the *SN Modification Confirm* message.

5a. The UE performs DL synchronization with LTM candidate cell(s) before receiving the cell switch command, as specified in clause 9.2.3.5.2 in TS 38.300 [3].

5b. The UE may perform UL synchronization with LTM candidate cell(s) before receiving the cell switch command, as specified in clause 9.2.3.5.2 in TS 38.300 [3].

6. The UE performs L1 measurements on the configured LTM candidate cell(s) and transmits L1 measurement reports to the SN, if the L1 measurement configuration in *RRCReconfiguration* is received in step 2. The UE starts to perform L1 measurements once the L1 measurement configuration is applicable.

7. The SN decides to execute cell switch to a target cell and transmits an LTM cell switch command MAC CE triggering cell switch by including a target configuration ID and other related information for the target cell, as specified in clause 9.2.3.5.2 in TS 38.300 [3]. The UE switches to the target cell and applies the candidate configuration indicated by the target configuration ID.

8. The UE sends an *ULInformationTransferMRDC* message to the MN which includes an embedded *RRCReconfigurationComplete* message to the target cell.

9. The *RRCReconfigurationComplete* message is forwarded to the SN embedded in *RRC Transfer* message.

10. The UE performs the random access procedure towards the target cell, if the UE does not have valid TA of the target cell.

11. The UE completes the SCG LTM cell switch procedure by sending an UL transmission to target cell. If the UE has performed a RA procedure in step 10 the UE considers that LTM execution is successfully completed when the random access procedure is successfully completed. For RACH-less LTM, the UE considers that LTM execution is successfully completed when the UE determines that the SN has successfully received its first UL transmission, as specified in clause in 9.2.3.5.2 in TS 38.300 [3].

NOTE 8: The steps 5-11 can be performed multiple times for subsequent SCG LTM cell switch execution using the SCG LTM candidate configuration(s) provided in step 2.

10.4 Secondary Node Release (MN/SN initiated)

10.4.1 EN-DC

The Secondary Node Release procedure may be initiated either by the MN or by the SN and is used to initiate the release of the UE context at the SN. The recipient node of this request can reject it, e.g., if a SN change procedure is triggered by the SN.

In case of CPA or inter-SN CPC, this procedure may be initiated either by the MN or the candidate SN, and it is used to cancel all the prepared PSCells at the candidate SN and initiate the release of related UE context at the candidate SN.

It does not necessarily need to involve signalling towards the UE, e.g., in case of the RRC connection re-establishment due to Radio Link Failure in MN.

MN initiated SN Release

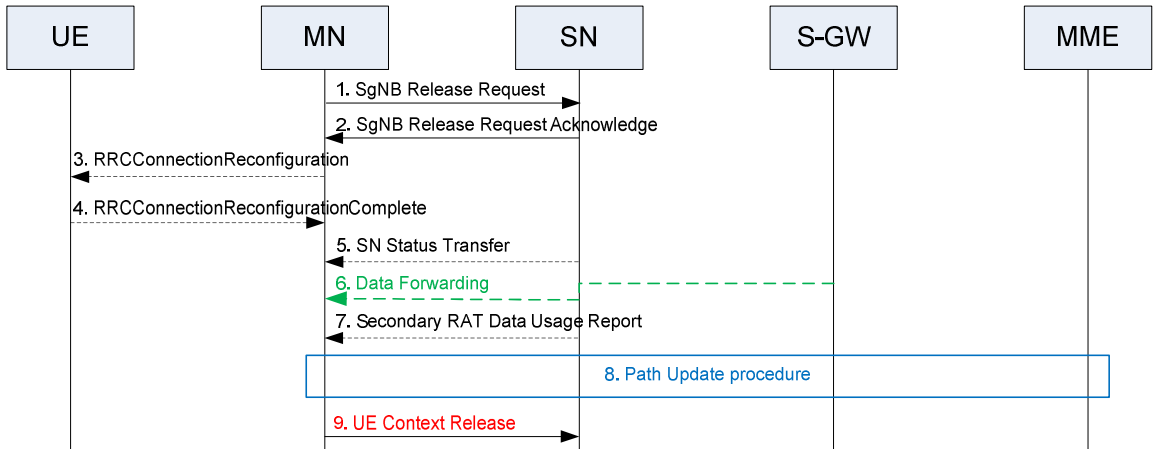


Figure 10.4.1-1: SN Release procedure – MN initiated

Figure 10.4.1-1 shows an example signalling flow for the MN initiated Secondary Node Release procedure when SN Release is confirmed by SN.

1. The MN initiates the procedure by sending the *SgNB Release Request* message. If applicable, the MN provides data forwarding addresses to the SN.

2. The SN confirms SN Release by sending the *SgNB Release Request Acknowledge* message. If appropriate, the SN may reject SN Release, e.g. if the SN change procedure is triggered by the SN.

NOTE 0: If inter-SN CPC is configured, upon reception of the *SgNB Release Request Acknowledge* message from the source SN, the MN cancels all CPC with the target candidate SN(s).

NOTE 0a: If CPA or inter-SN CPC is configured, upon reception of the *SgNB Release Request Acknowledge* message from a candidate SN, the MN cancels all CPAC configurations in the candidate SN. In case of SN initiated inter-SN CPC, the MN triggers the Conditional PSCell Change Cancel procedure towards the source SN to inform it of the cancellation of CPAC in the candidate SN.

3/4. If required, the MN indicates in the *RRCConnectionReconfiguration* message towards the UE that the UE shall release the entire SCG configuration. In case the UE is unable to comply with (part of) the configuration included in the *RRCConnectionReconfiguration* message, it performs the reconfiguration failure procedure.

NOTE 1: If data forwarding is applied, timely coordination between steps 1 and 2 may minimize gaps in service provision, this is however regarded to be an implementation matter.

5. For bearers using RLC AM, the SN sends the *SN Status Transfer* message.

6. Data forwarding from the SN to the MN may start.

7. The SN sends the *Secondary RAT Data Usage Report* message to the MN and includes the data volumes delivered to and received from the UE over the NR radio for the related E-RABs.

NOTE 2: If data forwarding is applied, the order the SN sends the *Secondary RAT Data Usage Report* message and starts data forwarding with MN is not defined i.e., step 7 can take place before step 6. The SN does not need to wait for the end of data forwarding to send the *Secondary RAT Data Usage Report* message.

8. If applicable, the path update procedure is initiated.

9. Upon reception of the *UE Context Release* message, the SN releases radio and C-plane related resources associated to the UE context. Any ongoing data forwarding may continue.

SN initiated SN Release

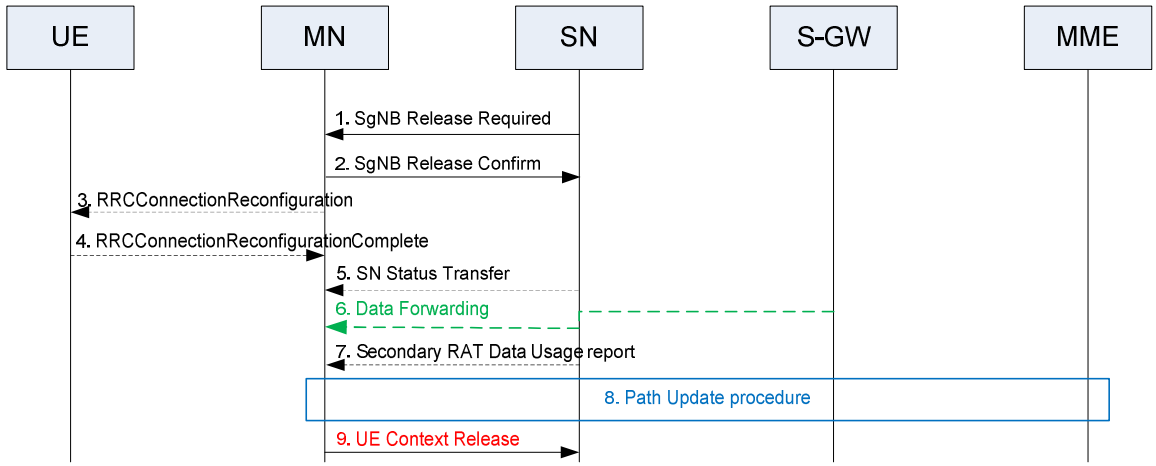


Figure 10.4.1-2: SN Release procedure – SN initiated

Figure 10.4.1-2 shows an example signalling flow for the SN initiated Secondary Node Release procedure.

1. The SN initiates the procedure by sending the *SgNB Release Required* message which may contain inter-node message to support delta configuration.

2. If applicable, the MN provides data forwarding addresses to the SN in the *SgNB Release Confirm* message. The SN may start data forwarding and stop providing user data to the UE as early as it receives the *SgNB Release Confirm* message.

NOTE 2a: If inter-SN CPC is configured, upon reception of the *SgNB Release Required* message from the source SN, the MN cancels all CPC with the target candidate SN(s).

NOTE 2b: If CPA or inter-SN CPC is configured, upon reception of the *SgNB Release Required* message from a candidate SN, the MN cancels all CPAC configurations in the candidate SN. In case of SN initiated inter-SN CPC, the MN triggers the Conditional PSCell Change Cancel procedure towards the source SN to inform it of the cancellation of CPAC in the candidate SN.

3/4. If required, the MN indicates in the *RRCConnectionReconfiguration* message towards the UE that the UE shall release the entire SCG configuration. In case the UE is unable to comply with (part of) the configuration included in the *RRCConnectionReconfiguration* message, it performs the reconfiguration failure procedure.

NOTE 3: If data forwarding is applied, timely coordination between steps 2 and 3 may minimize gaps in service provision. This is however regarded to be an implementation matter.

5. For bearers using RLC AM, the SN sends the *SN Status Transfer* message.

6. Data forwarding from the SN to the MN may start.

7. The SN sends the *Secondary RAT Data Usage Report* message to the MN and includes the data volumes delivered to and received from the UE over the NR radio for the related E-RABs.

NOTE 4: If data forwarding is applied, the order the SN sends the *Secondary RAT Data Usage Report* message and starts data forwarding with MN is not defined i.e., step 7 can take place before step 6. The SN does not need to wait for the end of data forwarding to send the *Secondary RAT Data Usage Report* message.

8. If applicable, the path update procedure is initiated.

9. Upon reception of the *UE Context Release* message, the SN releases radio and C-plane related resources associated to the UE context. Any ongoing data forwarding may continue.

10.4.2 MR-DC with 5GC

The SN Release procedure may be initiated either by the MN or by the SN and is used to initiate the release of the UE context and relevant resources at the SN. The recipient node of this request can reject it, e.g., if an SN change procedure is triggered by the SN.

In case of CPA, inter-SN CPC or subsequent CPAC, this procedure may be initiated either by the MN or the candidate SN, and it is used to cancel all the prepared PSCells at the candidate SN and initiate the release of related UE context at the candidate SN.

MN initiated SN Release

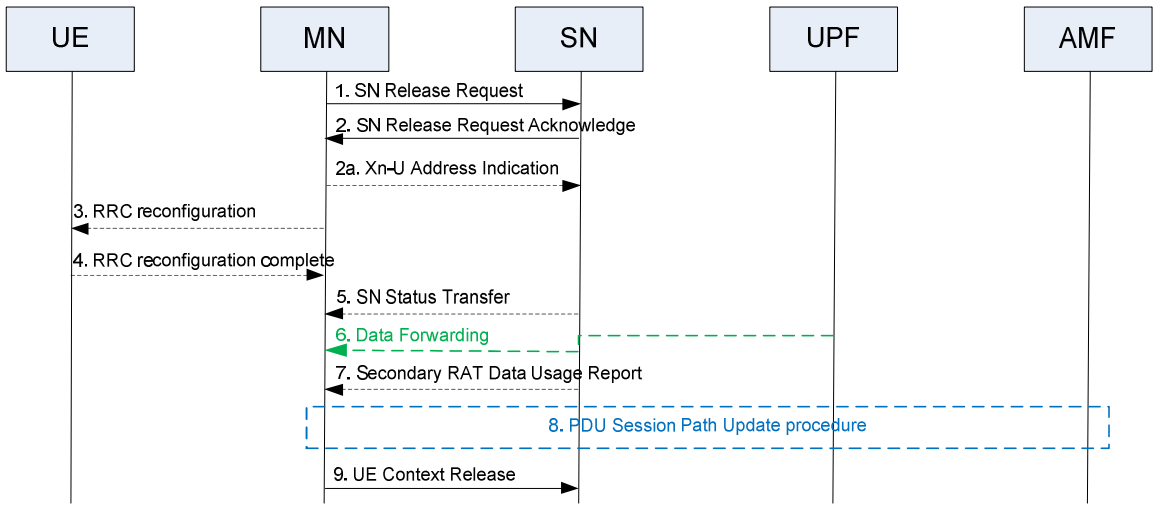


Figure 10.4.2-1: SN release procedure - MN initiated

Figure 10.4.2-1 shows an example signalling flow for the MN initiated SN Release procedure.

1. The MN initiates the procedure by sending the *SN Release Request* message.

2. The SN confirms SN Release by sending the *SN Release Request Acknowledge* message. If appropriate, the SN may reject SN Release, e.g., if the SN change procedure is triggered by the SN.

NOTE 00: If inter-SN CPC is configured, upon reception of the *SN Release Request Acknowledge* message from the source SN, the MN cancels all CPC with the target candidate SN(s).

NOTE 00A: If CPA or inter-SN CPC is configured, upon reception of the *SN Release Request Acknowledge* message from a candidate SN, the MN cancels all CPAC configurations in the candidate SN. In case of SN initiated inter-SN CPC, the MN triggers the Conditional PSCell Change Cancel procedure towards the source SN to inform it of the cancellation of CPAC in the candidate SN.

NOTE 00a: If subsequent CPAC is configured, upon reception of the *SN Release Request Acknowledge* message from the source SN, the MN may retain the subsequent CPAC configuration or cancel the subsequent CPAC configuration. If the MN maintains the subsequent CPAC configuration, it should provide suitable execution conditions for the evaluation of the subsequent CPAC.

NOTE 00b: If subsequent CPAC is configured, upon reception of the *SN Release Request Acknowledge* message from a candidate SN, the MN cancels all subsequent CPAC with the candidate SN. If applicable, the MN triggers the Conditional PSCell Change Cancel procedure towards the source SN, and triggers the MN initiated SN Modification procedure towards the other candidate SN(s), to inform them of the cancellation of the candidate SN.

2a. When applicable, the MN provides forwarding address information to the SN.

NOTE 0: The MN may send the *Xn-U Address Indication* message to provide forwarding address information before step 2.

3/4. If required, the MN indicates in the MN RRC reconfiguration message towards the UE that the UE shall release the entire SCG configuration. In case the UE is unable to comply with (part of) the configuration included in the MN RRC reconfiguration message, it performs the reconfiguration failure procedure.

NOTE 1: If data forwarding is applied, timely coordination between steps 1 and 2 may minimize gaps in service provision, this is however regarded to be an implementation matter.

5. If PDCP termination point is changed to the MN for bearers using RLC AM, the SN sends the *SN Status Transfer* message.

6. Data forwarding from the SN to the MN may start.

7. The SN sends the *Secondary RAT Data Usage Report* message to the MN and includes the data volumes delivered to and received from the UE as described in clause 10.11.2.

NOTE 1a: If data forwarding is applied, the order the SN sends the *Secondary RAT Data Usage Report* message and starts data forwarding with MN is not defined i.e., step 7 can take place before step 6. The SN does not need to wait for the end of data forwarding to send the *Secondary RAT Data Usage Report* message.

8. If applicable, the PDU Session path update procedure is initiated.

9. Upon reception of the *UE Context Release* message, the SN releases radio and C-plane related resources associated to the UE context. Any ongoing data forwarding may continue.

SN initiated SN Release

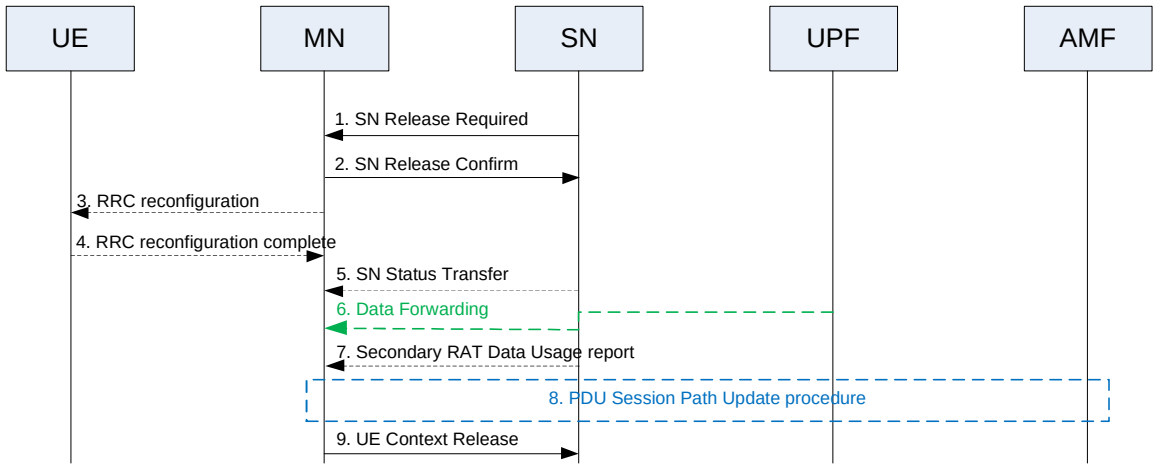


Figure 10.4.2-2: SN release procedure - SN initiated

Figure 10.4.2-2 shows an example signalling flow for the SN initiated SN Release procedure.

1. The SN initiates the procedure by sending the *SN Release Required* message which may contain inter-node message to support delta configuration.

2. If data forwarding is requested, the MN provides data forwarding addresses to the SN in the *SN Release Confirm* message. The SN may start data forwarding and stop providing user data to the UE as early as it receives the *SN Release Confirm* message.

NOTE 1b: If inter-SN CPC is configured, upon reception of the *SN Release Required* message from the source SN, the MN cancels all CPC with the target candidate SN(s).

NOTE 1b1: If CPA or inter-SN CPC is configured, upon reception of the *SN Release Required* message from a candidate SN, the MN cancels all CPAC configurations in the candidate SN. In case of SN initiated inter-SN CPC, the MN triggers the Conditional PSCell Change Cancel procedure towards the source SN to inform it of the cancellation of CPAC in the candidate SN.

NOTE 1c: If subsequent CPAC is configured, upon reception of the *SN Release Required* message from the source SN, the MN may retain the subsequent CPAC configuration or cancel the subsequent CPAC configuration. If the MN maintains the subsequent CPAC configuration, it should provide suitable execution conditions for the evaluation of the subsequent CPAC.

NOTE 1d: If subsequent CPAC is configured, upon reception of the *SN Release Required* message from a candidate SN, the MN cancels all subsequent CPAC with the candidate SN. If applicable, the MN triggers the Conditional PSCell Change Cancel procedure towards the source SN, and triggers the MN initiated SN Modification procedure towards the other candidate SN(s), to inform them of the cancellation of the candidate SN.

3/4. If required, the MN indicates in the MN RRC reconfiguration message towards the UE that the UE shall release the entire SCG configuration. In case the UE is unable to comply with (part of) the configuration included in the MN RRC reconfiguration message, it performs the reconfiguration failure procedure.

NOTE 2: If data forwarding is applied, timely coordination between steps 2 and 3 may minimize gaps in service provision. This is however regarded to be an implementation matter.

5. If PDCP termination point is changed to the MN for bearers using RLC AM, the SN sends the *SN Status Transfer* message.

6. Data forwarding from the SN to the MN may start.

7. The SN sends the *Secondary RAT Data Usage Report* message to the MN and includes the data volumes delivered to and received from the UE as described in clause 10.11.2.

NOTE 3: If data forwarding is applied, the order the SN sends the *Secondary RAT Data Usage Report* message and starts data forwarding with MN is not defined i.e., step 7 can take place before step 6. The SN does not need to wait for the end of data forwarding to send the *Secondary RAT Data Usage Report* message.

8. If applicable, the PDU Session path update procedure is initiated.

9. Upon reception of the *UE Context Release* message, the SN releases radio and C-plane related resources associated to the UE context. Any ongoing data forwarding may continue.

10.5 Secondary Node Change (MN/SN initiated)

10.5.1 EN-DC

The Secondary Node Change procedure is initiated either by MN or SN and used to transfer a UE context from a source SN to a target SN and to change the SCG configuration in UE from one SN to another. In case of inter-SN CPC, the Conditional Secondary Node Change procedure initiated either by the MN or SN is also used for inter-SN CPC configuration and inter-SN CPC execution.

NOTE 1: Inter-RAT SN change procedure with single RRC reconfiguration is not supported in this version of the protocol (i.e. no transition from EN-DC to DC).

The Secondary Node Change procedure always involves signalling over MCG SRB towards the UE.

MN initiated SN Change

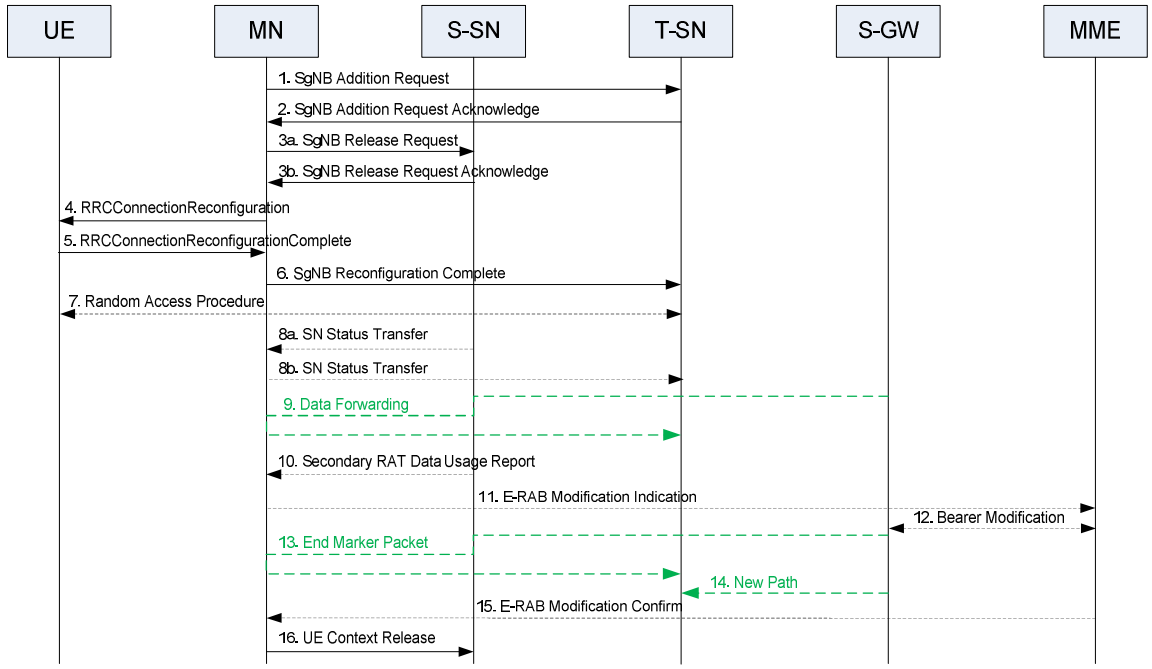


Figure 10.5.1-1: SN Change – MN initiated

Figure 10.5.1-1 shows an example signalling flow for the MN initiated Secondary Node Change:

1/2. The MN initiates the SN change by requesting the target SN to allocate resources for the UE by means of the SgNB Addition procedure. The MN may include measurement results related to the target SN. If forwarding is needed, the target SN provides forwarding addresses to the MN. The target SN includes the indication of the full or delta RRC configuration.

NOTE 2: The MN may trigger the MN-initiated SN Modification procedure (to the source SN) to retrieve the current SCG configuration before step 1.

NOTE 2a: In case the target SN includes the indication of the full RRC configuration, the MN performs release of the SN terminated radio bearer configuration and release and add of the NR SCG configuration part towards the UE.

3. If the allocation of target SN resources was successful, the MN initiates the release of the source SN resources including a Cause indicating SCG mobility. The Source SN may reject the release. If data forwarding is needed the MN provides data forwarding addresses to the source SN. If direct data forwarding is used for SN terminated bearers, the MN provides data forwarding addresses as received from the target SN to source SN. Reception of the *SgNB Release Request* message triggers the source SN to stop providing user data to the UE and, if applicable, to start data forwarding.

4/5. The MN triggers the UE to apply the new configuration. The MN indicates to the UE the new configuration in the *RRCConnectionReconfiguration* message including the NR RRC configuration message generated by the target SN. The UE applies the new configuration and sends the *RRCConnectionReconfigurationComplete* message, including the encoded NR RRC response message for the target SN, if needed. In case the UE is unable to comply with (part of) the configuration included in the *RRCConnectionReconfiguration* message, it performs the reconfiguration failure procedure.

6. If the RRC connection reconfiguration procedure was successful, the MN informs the target SN via *SgNBReconfigurationComplete* message with the encoded NR RRC response message for the target SN, if received from the UE.

7. If configured with bearers requiring SCG radio resources, the UE synchronizes to the target SN.

8. For SN terminated bearers using RLC AM, the source SN sends the *SN Status Transfer* message, which the MN sends then to the target SN, if needed.

9. If applicable, data forwarding from the source SN takes place. It may be initiated as early as the source SN receives the *SgNB Release Request* message from the MN.

10. The source SN sends the *Secondary RAT Data Usage Report* message to the MN and includes the data volumes delivered to and received from the UE over the NR radio for the related E-RABs.

NOTE 3: The order the SN sends the *Secondary RAT Data Usage Report* message and performs data forwarding with MN is not defined. The SN may send the report when the transmission of the related bearer is stopped.

11-15. If applicable, a path update is triggered by the MN.

16. Upon reception of the *UE Context Release* message, the source SN releases radio and C-plane related resources associated to the UE context. Any ongoing data forwarding may continue.

SN initiated SN Change

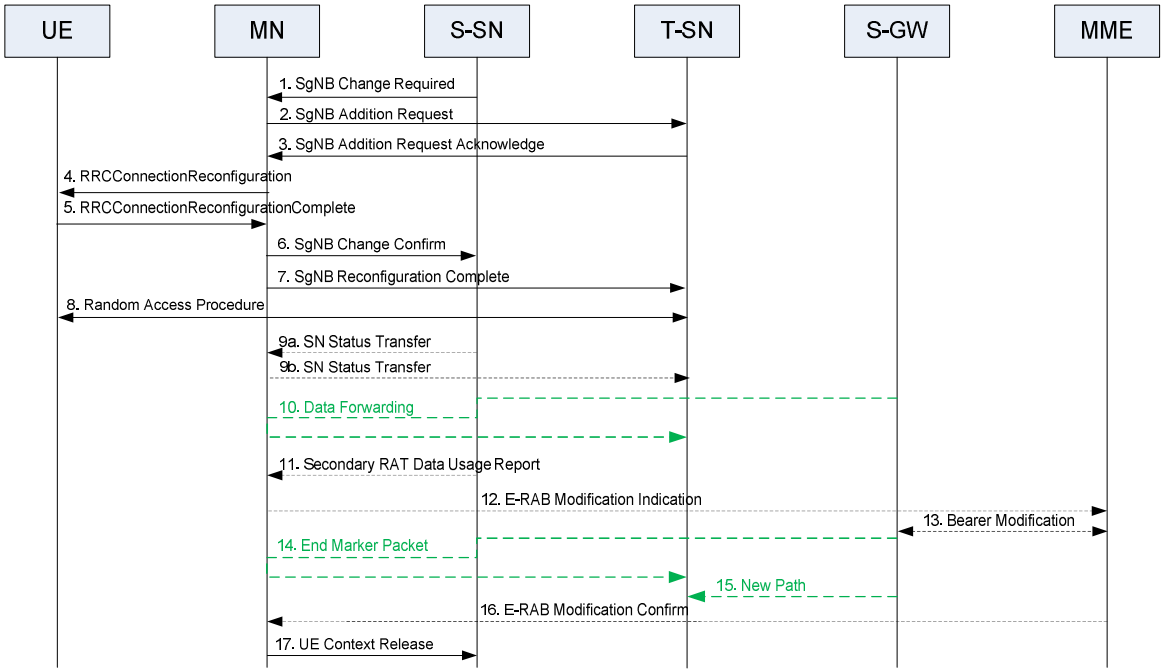


Figure 10.5.1-2: SN Change – SN initiated

Figure 10.5.1-2 shows an example signalling flow for the Secondary Node Change initiated by the SN:

1. The source SN initiates the SN change procedure by sending *SgNB Change Required* message which contains target SN ID information and may include the SCG configuration (to support delta configuration) and measurement results related to the target SN.

2/3. The MN requests the target SN to allocate resources for the UE by means of the SgNB Addition procedure, including the measurement results related to the target SN received from the source SN. If forwarding is needed, the target SN provides forwarding addresses to the MN. The target SN includes the indication of the full or delta RRC configuration.

NOTE 3a: In case the target SN includes the indication of the full RRC configuration, the MN performs release of the SN terminated radio bearer configuration and release and add of the NR SCG configuration part towards the UE.

4/5. The MN triggers the UE to apply the new configuration. The MN indicates the new configuration to the UE in the *RRCConnectionReconfiguration* message including the NR RRC configuration message generated by the target SN. The UE applies the new configuration and sends the *RRCConnectionReconfigurationComplete* message, including the encoded NR RRC response message for the target SN, if needed. In case the UE is unable to comply with (part of) the configuration included in the *RRCConnectionReconfiguration* message, it performs the reconfiguration failure procedure.

6. If the allocation of target SN resources was successful, the MN confirms the release of the source SN resources. If data forwarding is needed the MN provides data forwarding addresses to the source SN. If direct data forwarding is used for SN terminated bearers, the MN provides data forwarding addresses as received from the

target SN to source SN. Reception of the *SgNB Change Confirm* message triggers the source SN to stop providing user data to the UE and, if applicable, to start data forwarding.

7. If the RRC connection reconfiguration procedure was successful, the MN informs the target SN via *SgNB Reconfiguration Complete* message with the encoded NR RRC response message for the target SN, if received from the UE.

8. The UE synchronizes to the target SN.

9. For SN terminated bearers using RLC AM, the source SN sends the *SN Status Transfer* message, which the MN sends then to the target SN, if needed.

10. If applicable, data forwarding from the source SN takes place. It may be initiated as early as the source SN receives the *SgNB Change Confirm* message from the MN.

11. The source SN sends the *Secondary RAT Data Usage Report* message to the MN and includes the data volumes delivered to and received from the UE over the NR radio for the related E-RABs.

NOTE 4: The order the source SN sends the *Secondary RAT Data Usage Report* message and performs data forwarding with MN/target SN is not defined. The SgNB may send the report when the transmission of the related bearer is stopped.

12-16. If applicable, a path update is triggered by the MN.

17. Upon reception of the *UE Context Release* message, the source SN releases radio and C-plane related resources associated to the UE context. Any ongoing data forwarding may continue.

MN initiated conditional SN Change

The MN initiated conditional inter-SN change procedure is used for inter-SN CPC configuration and inter-SN CPC execution.

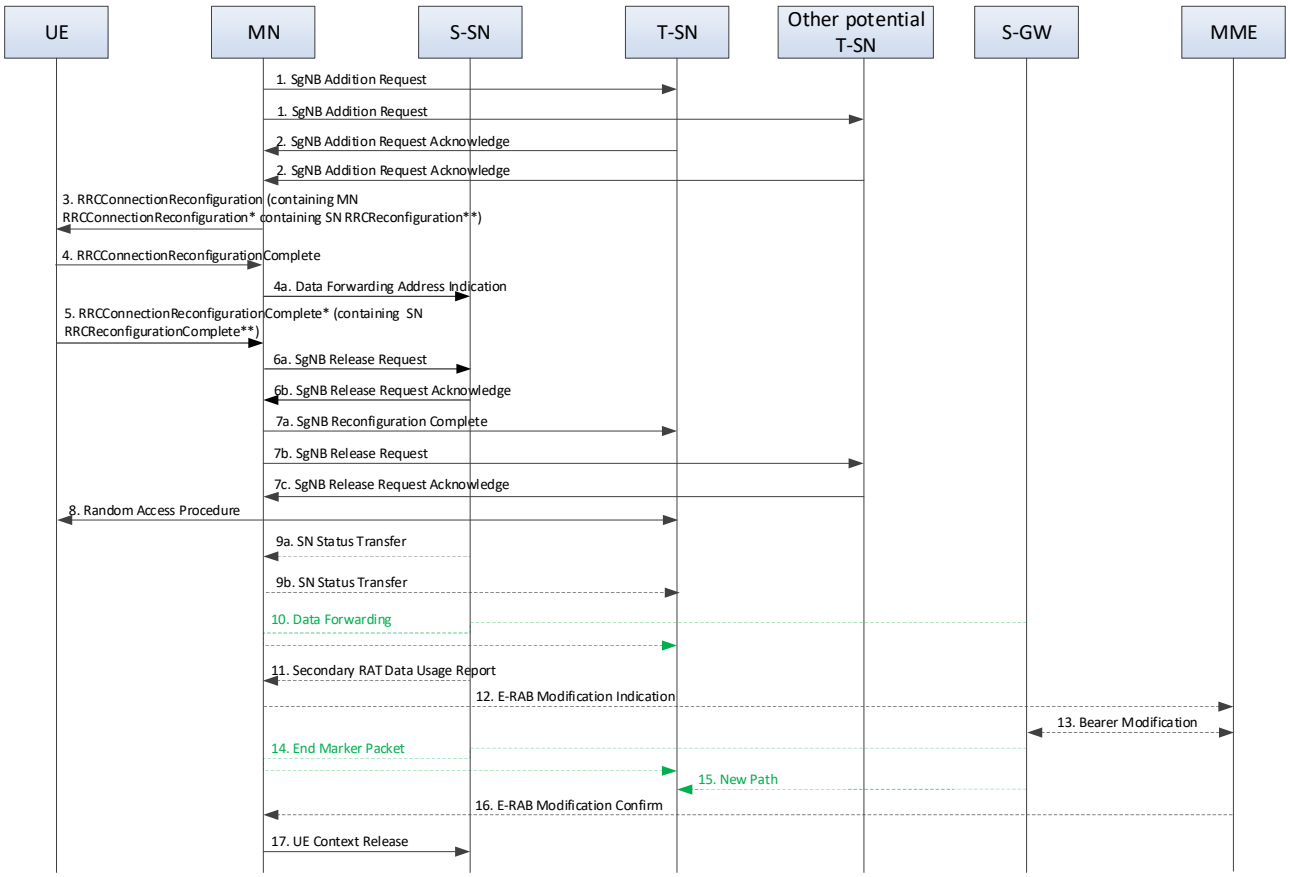


Figure 10.5.1-3: Conditional SN Change – MN initiated

Figure 10.5.1-3 shows an example signalling flow for the MN initiated Conditional Secondary Node Change:

1/2. The MN initiates the conditional SN change by requesting the candidate SN(s) to allocate resources for the UE by means of the SgNB Addition procedure, indicating that the request is for CPAC. The MN also provides the candidate cells recommended by MN via the latest measurement results for the candidate SN(s) to choose and configure the SCG cell(s), and provides the upper limit for the number of PSCells that can be prepared by the candidate SN. From the measurement results indicated by the MN, the candidate SN decides the list of PSCell(s) to prepare (considering the maximum number indicated by the MN) and, for each prepared PSCell, the candidate SN decides other SCG SCells and provides the new corresponding SCG radio resource configuration to the MN in an NR *RRCReconfiguration*** message contained in the *SgNB Addition Request Acknowledge* message with the prepared PSCell ID(s). If forwarding is needed, the candidate SN provides forwarding addresses to the MN. The candidate SN includes the indication of the full or delta RRC configuration. The candidate SN can either accept or reject each of the candidate cells listed within the measurement results indicated by the MN, i.e. it cannot configure any alternative candidates.

NOTE 5: The MN may trigger the MN-initiated SN Modification procedure (to the source SN) to retrieve the current SCG configuration before step 1.

NOTE 5a: In case the candidate SN includes the indication of the full RRC configuration, the MN performs release of the SN terminated radio bearer configuration and release and add of the NR SCG configuration part towards the UE in the conditional configuration.

3. The MN sends to the UE an *RRCConnectionReconfiguration* message including the CPC configuration, i.e. a list of *RRCConnectionReconfiguration** messages and associated execution conditions, in which each *RRCConnectionReconfiguration** message contains the SCG configuration in the *RRCReconfiguration*** message received from the candidate SN in step 2 and possibly an MCG configuration. Besides, the *RRCConnectionReconfiguration* message can also include an updated MCG configuration, e.g., to configure the required conditional measurements.

4. The UE applies the *RRCConnectionReconfiguration* message received in step 3, stores the CPC configuration and replies to the MN with an *RRCConnectionReconfigurationComplete* message. In case the UE is unable to comply with (part of) the configuration included in the *RRCConnectionReconfiguration* message, it performs the reconfiguration failure procedure.

4a. Upon receiving the *RRCConnectionReconfigurationComplete* message from the UE, the MN triggers the Data Forwarding Address Indication procedure to the source SN to inform that the CPC has been configured, the source SN, if applicable, together with the Early Status Transfer procedure, starts early data forwarding. The PDCP SDU forwarding may take place during early data forwarding.

NOTE 5b: Separate Data Forwarding Address Indication procedures may be invoked to provide different forwarding addresses of the prepared candidate target SNs. In this case, it is up to the MN and the source SN implementations to make sure that the EARLY STATUS TRANSFER message(s) from the source SN, if any, is forwarded to the right target destination. The Data Forwarding Address Indication procedure may further be invoked to indicate to the source SN to stop already initiated early data forwarding for some SN-terminated bearers if they are no longer subject to data forwarding due to the modification or cancellation of the prepared conditional SN change procedures.

NOTE 5c: For the early transmission of MN terminated split/SCG bearers, the MN forwards the PDCP PDU to the candidate SN(s).

5. The UE starts evaluating the execution conditions. If the execution condition of one candidate PSCell is satisfied, the UE applies *RRCConnectionReconfiguration** message corresponding to the selected candidate PSCell, and sends an *RRCConnectionReconfigurationComplete** message, including an NR *RRCReconfigurationComplete*** message for the selected candidate PSCell, and information enabling the MN to identify the SN of the selected candidate PSCell.

6a-6b. The MN triggers the MeNB initiated SgNB Release procedure to inform the source SN to stop providing user data to the UE, and, if applicable, the address of the SN of the selected candidate PSCell to start data forwarding.

7a-7c. If the RRC connection reconfiguration procedure was successful, the MN informs the SN of the selected candidate PSCell via *SgNB Reconfiguration Complete* message, including the SN *RRCReconfigurationComplete*** message. The MN sends the *SgNB Release Request* message(s) to cancel CPC in the other candidate SN(s), if configured. The other candidate SN(s) acknowledges the release request.

8. The UE synchronizes to the PSCell indicated in the *RRCConnectionReconfiguration** message applied in step 5.

9a-9b. For SN terminated bearers using RLC AM, the source SN sends the *SN Status Transfer* message, which the MN sends to the SN of the selected candidate PSCell, if needed.

10. If applicable, data forwarding from the source SN takes place. It may be initiated as early as the source SN receives the early data forwarding address in step 4a.

11. The source SN sends the *Secondary RAT Data Usage Report* message to the MN and includes the data volumes delivered to and received from the UE over the NR radio for the related E-RABs.

NOTE 6: The order the SN sends the *Secondary RAT Data Usage Report* message and performs data forwarding with MN is not defined. The SN may send the report when the transmission of the related bearer is stopped.

12-16. If applicable, a path update is triggered by the MN.

17. Upon reception of the *UE Context Release* message, the source SN releases radio and C-plane related resources associated to the UE context. Any ongoing data forwarding may continue.

SN initiated conditional SN Change

The SN initiated conditional SN change procedure is used for inter-SN CPC configuration and inter-SN CPC execution.

The SN initiated conditional SN change procedure may also be initiated by the source SN, to modify the existing SN initiated inter-SN CPC configuration, or to trigger the release of the candidate SN by cancellation of all the prepared PSCells at the candidate SN and releasing the CPC related UE context at the candidate SN.

NOTE 6a0: To modify or release an existing intra-SN CPC configuration, the source SN triggers an SN initiated Conditional SN Modification (with or without SRB3) without MN involvement, as specified in 10.3.

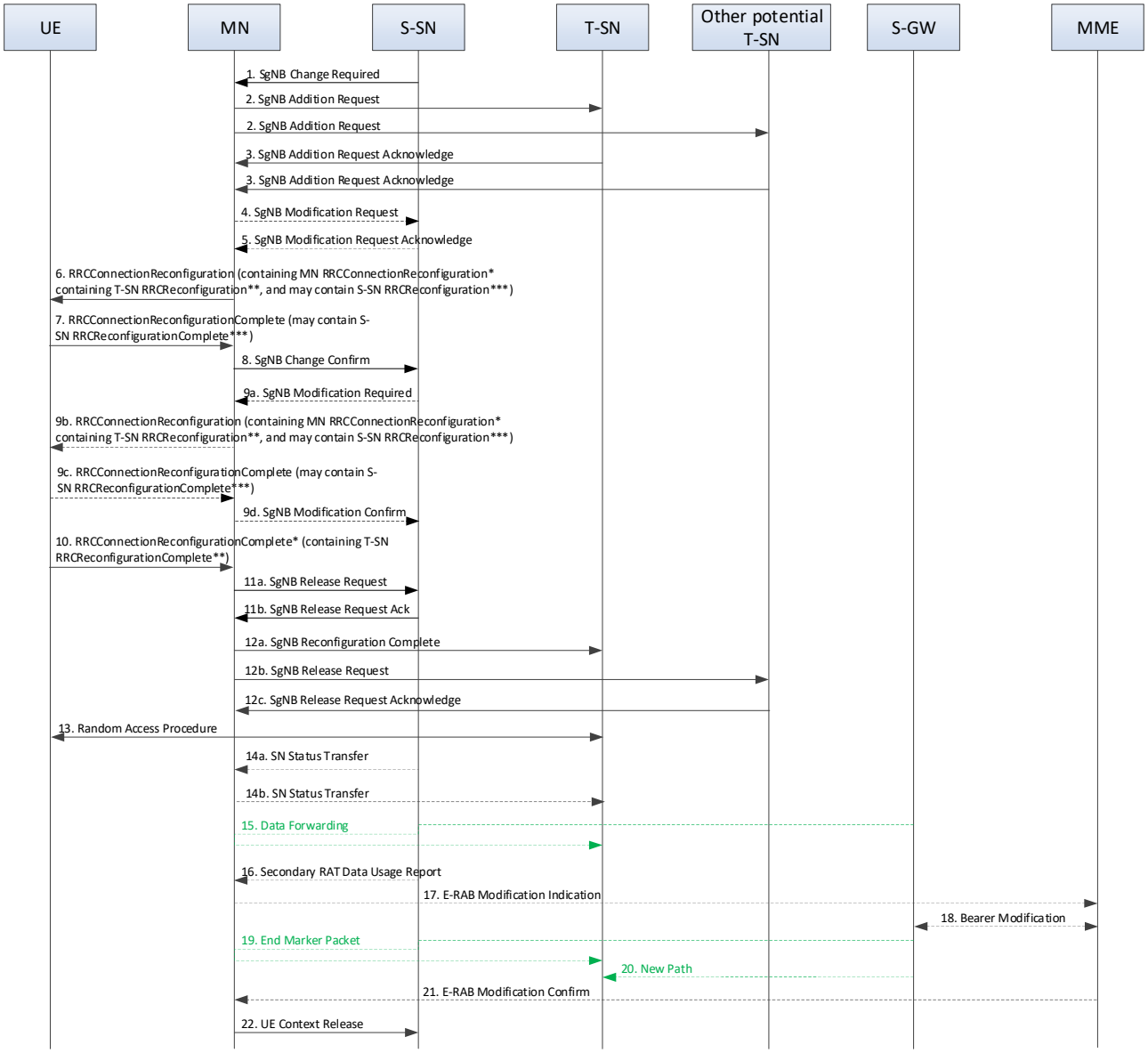


Figure 10.5.1-4: Conditional SN Change – SN initiated

Figure 10.5.1-4 shows an example signalling flow for the Conditional Secondary Node Change initiated by the SN:

1. The source SN initiates the conditional SN change procedure by sending *SgNB Change Required* message which contains a CPC initiation indication. The message also contains candidate SN ID(s) information and may include the SCG configuration (to support delta configuration), and contains the measurement results related to the candidate SN(s). The message also includes a list of proposed PSCell candidates recommended by the source SN, including execution conditions, the upper limit for the number of PSCells that can be prepared by each candidate SN, and may also include the SCG measurement configurations for CPC (e.g. measurement ID(s) to be used for CPC).

2/3. The MN requests each candidate SN to allocate resources for the UE by means of the SgNB Addition procedure(s) , indicating the request is for CPAC, and the measurements results related to the candidate SN and indicating a list of proposed PSCell candidates received from the source SN, but not including execution conditions. Within the list of PSCells suggested by the source SN, the candidate SN decides the list of PSCell(s) to prepare (considering the maximum number indicated by the MN) and, for each prepared PSCell, the candidate SN decides SCG SCells and provides the new corresponding SCG radio resource configuration to the MN in an NR *RRCReconfiguration*** message contained in the *SgNB Addition Request Acknowledge* message. If data forwarding is needed, the candidate SN provides data forwarding addresses to the MN. The candidate SN includes the indication of full or delta RRC configuration, and the list of prepared PSCell IDs to the MN. The candidate SN can either accept or reject each of the candidate cells suggested by the source SN, i.e. it cannot configure any alternative candidates.

NOTE 6a: In case the candidate SN includes the indication of the full RRC configuration, the MN performs release of the SN terminated radio bearer configuration and release and add of the NR SCG configuration part towards the UE in the conditional configuration.

4/5. The MN may indicate the candidate PSCells accepted by each candidate SN to the source SN via *SgNB Modification Request* message before it configures the UE e.g., when not all candidate PSCells were accepted by the candidate SN(s). If the MN does not send such indication, step 4 and 5 are skipped. If requested,the source SN sends an *SgNB Modification Request Acknowledge* message and if needed, provides an updated measurement configurations and/or the execution conditions for CPC to the MN.

6. The MN sends to the UE an *RRCConnectionReconfiguration* message including the CPC configuration, i.e. a list of *RRCConnectionReconfiguration** messages and associated execution conditions, in which each *RRCConnectionReconfiguration** message contains the SCG configuration in the *RRCReconfiguration*** message received from the candidate SN in step 3 and possibly an MCG configuration. Besides, the *RRCConnectionReconfiguration* message can also include an updated MCG configuration, as well as the NR *RRCReconfiguration**** message generated by the source SN, e.g., to configure the required conditional measurements.

7. The UE applies the *RRCConnectionReconfiguration* message received in step 6, stores the CPC configuration and replies to the MN with an *RRCConnectionReconfigurationComplete* message, which can include an NR *RRCReconfigurationComplete**** message. In case the UE is unable to comply with (part of) the configuration included in the *RRCConnectionReconfiguration* message, it performs the reconfiguration failure procedure.

8. If an NR RRC response message is included, the MN informs the source SN with the NR *RRCReconfigurationComplete**** message via *SgNB Change Confirm* message. If step 4 and 5 are skipped, the MN will indicate the candidate PSCells accepted by each candidate SN to the source SN in the *SgNB Change Confirm* message.

   The MN sends the *SgNB Change Confirm* message towards the source SN to indicate that CPC is prepared, and in such case the source SN continues providing user data to the UE. If early data forwarding is applied, the MN informs the source SN the data forwarding address(es), the source SN, if applicable, together with the Early Status Transfer procedure, starts early data forwarding. The PDCP SDU forwarding may take place during early data forwarding. In case multiple candidate SNs are prepared, the MN includes a list of Target SgNB ID and list of data forwarding addresses to the source SN.

NOTE 6b: The Data Forwarding Address Indication procedure may further be invoked to indicate to the source SN to stop already initiated early data forwarding for some PDCP SDUs if they are no longer subject to data forwarding due to the modification or cancellation of the prepared conditional PSCell change.

NOTE 6c: For the early transmission of MN terminated split/SCG bearers, the MN forwards the PDCP PDU to the candidate SN(s).

9a-9d. The source SN may send the *SgNB Modification Required* message to trigger an update of CPC execution condition and/or corresponding SCG measurement configuration for CPC. In such case in step 9b, the MN reconfigures the UE and in step 9c the UE responds with *RRCConnectionReconfigurationComplete*, similarly as in steps 6 and 7.

10. The UE starts evaluating the execution conditions. If the execution condition of one candidate PSCell is satisfied, the UE applies the *RRCConnectionReconfiguration** message corresponding to the selected candidate PSCell, and sends an *RRCConnectionReconfigurationComplete** message, including the NR *RRCReconfigurationComplete*** message for the selected candidate PSCell, and information enabling the MN to identify the SN of the selected candidate PSCell.

11a-11b. The MN triggers the MeNB initiated SgNB Release procedure to inform source SN to stop providing user data to the UE, and if applicable, provides the address of the SN of the selected candidate PSCell to start late data forwarding.

12a-12c. If the RRC connection reconfiguration procedure was successful, the MN informs the SN of the selected candidate PSCell via *SgNB Reconfiguration Complete* message, including the SN *RRCReconfigurationComplete*** message. The MN sends the *SgNB Release Request* message(s) to cancel CPC in the other candidate SN(s), if configured. The other candidate SN(s) acknowledges the release request.

13. The UE synchronizes to the PSCell indicated in the *RRCConnectionReconfiguration** message applied in step 10.

14a-14b. For SN terminated bearers using RLC AM, the source SN sends the *SN Status Transfer* message, which the MN sends then to the SN of the selected candidate PSCell, if needed.

15. If applicable, data forwarding from the source SN takes place. It may be initiated as early as the source SN receives the early data forwarding message from the MN.

16. The source SN sends the *Secondary RAT Data Usage Report* message to the MN and includes the data volumes delivered to and received from the UE over the NR radio for the related E-RABs.

NOTE 7: The order the source SN sends the *Secondary RAT Data Usage Report* message and performs data forwarding with MN/target SN is not defined. The SgNB may send the report when the transmission of the related bearer is stopped.

17-21. If applicable, a path update is triggered by the MN.

22. Upon reception of the *UE Context Release* message, the source SN releases radio and C-plane related resources associated to the UE context. Any ongoing data forwarding may continue.

10.5.2 MR-DC with 5GC

MN initiated SN Change

The MN initiated SN change procedure is used to transfer a UE context from the source SN to a target SN and to change the SCG configuration in UE from one SN to another.

The Secondary Node Change procedure always involves signalling over MCG SRB towards the UE.

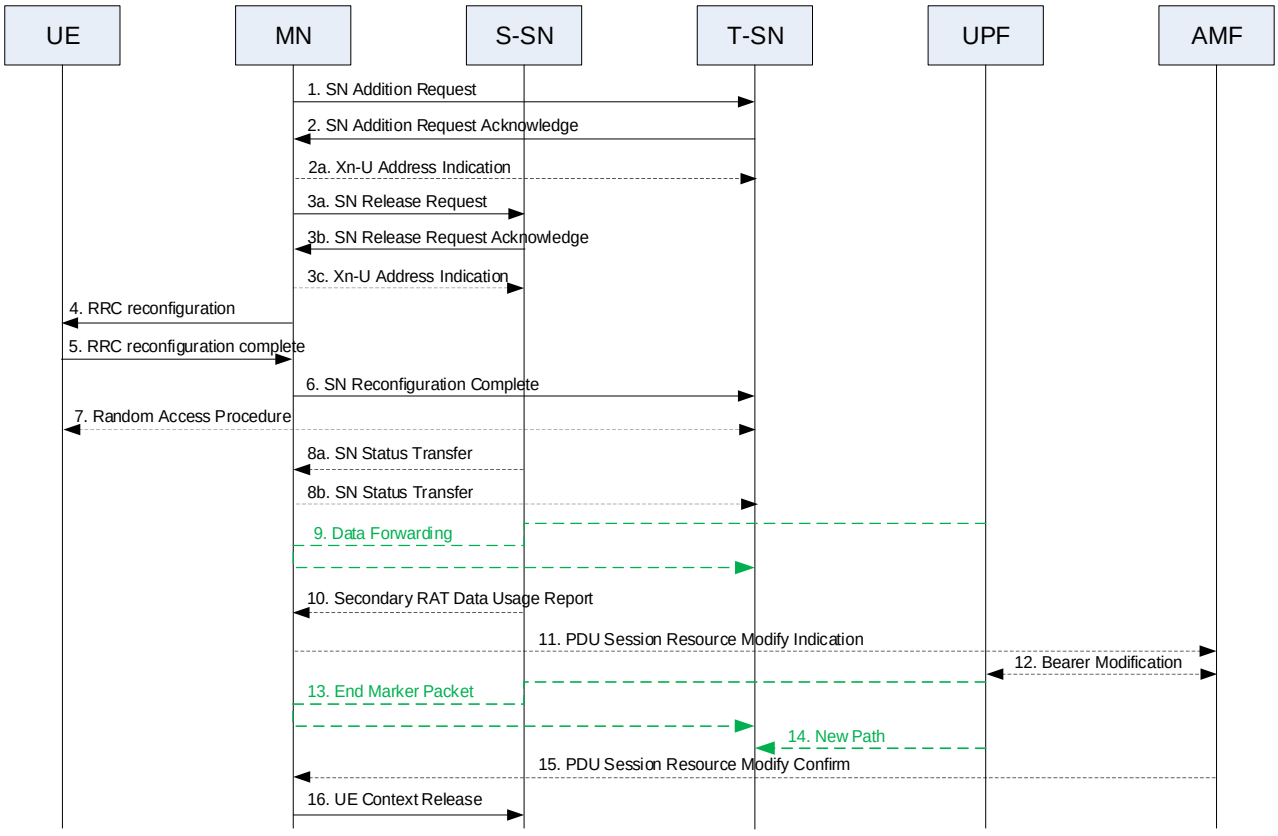


Figure 10.5.2-1: SN change procedure - MN initiated

Figure 10.5.2-1 shows an example signalling flow for the SN Change initiated by the MN:

1/2. The MN initiates the SN change by requesting the target SN to allocate resources for the UE by means of the SN Addition procedure. The MN may include measurement results related to the target SN. If data forwarding is needed, the target SN provides data forwarding addresses to the MN. The target SN includes the indication of the full or delta RRC configuration.

NOTE 1: The MN may trigger the MN-initiated SN Modification procedure (to the source SN) to retrieve the current SCG configuration and the QMC configuration information managed by the SN, and to allow provision of data forwarding related information before step 1.

2a. For SN terminated bearers using MCG resources, the MN provides Xn-U DL TNL address information in the *Xn-U Address Indication* message.

3. If the allocation of target SN resources was successful, the MN initiates the release of the source SN resources including a Cause indicating SCG mobility. The Source SN may reject the release. If data forwarding is needed the MN provides data forwarding addresses to the source SN. If direct data forwarding is used for SN terminated bearers, the MN provides data forwarding addresses as received from the target SN to source SN. Reception of the *SN Release Request* message triggers the source SN to stop providing user data to the UE.

4/5. The MN triggers the UE to apply the new configuration. The MN indicates the new configuration to the UE in the MN RRC reconfiguration message including the target SN RRC reconfiguration message. The UE applies the new configuration and sends the MN RRC reconfiguration complete message, including the SN RRC response message for the target SN, if needed. In case the UE is unable to comply with (part of) the configuration included in the MN RRC reconfiguration message, it performs the reconfiguration failure procedure.

6. If the RRC connection reconfiguration procedure was successful, the MN informs the target SN via *SN Reconfiguration Complete* message with the included SN RRC response message for the target SN, if received from the UE.

7. If configured with bearers requiring SCG radio resources the UE synchronizes to the target SN.

8. If PDCP termination point is changed for bearers using RLC AM, the source SN sends the *SN Status Transfer* message, which the MN sends then to the target SN, if needed.

9. If applicable, data forwarding from the source SN takes place. It may be initiated as early as the source SN receives the *SN Release Request* message from the MN.

10. The source SN sends the *Secondary RAT Data Usage Report* message to the MN and includes the data volumes delivered to and received from the UE as described in clause 10.11.2.

NOTE 2: The order the SN sends the *Secondary RAT Data Usage Report* message and performs data forwarding with MN is not defined. The SN may send the report when the transmission of the related QoS flow is stopped.

11-15. If applicable, a PDU Session path update procedure is triggered by the MN.

16. Upon reception of the *UE Context Release* message, the source SN releases radio and C-plane related resources associated to the UE context. Any ongoing data forwarding may continue

SN initiated SN Change

The SN initiated SN change procedure is used to transfer a UE context from the source SN to a target SN and to change the SCG configuration in UE from one SN to another.

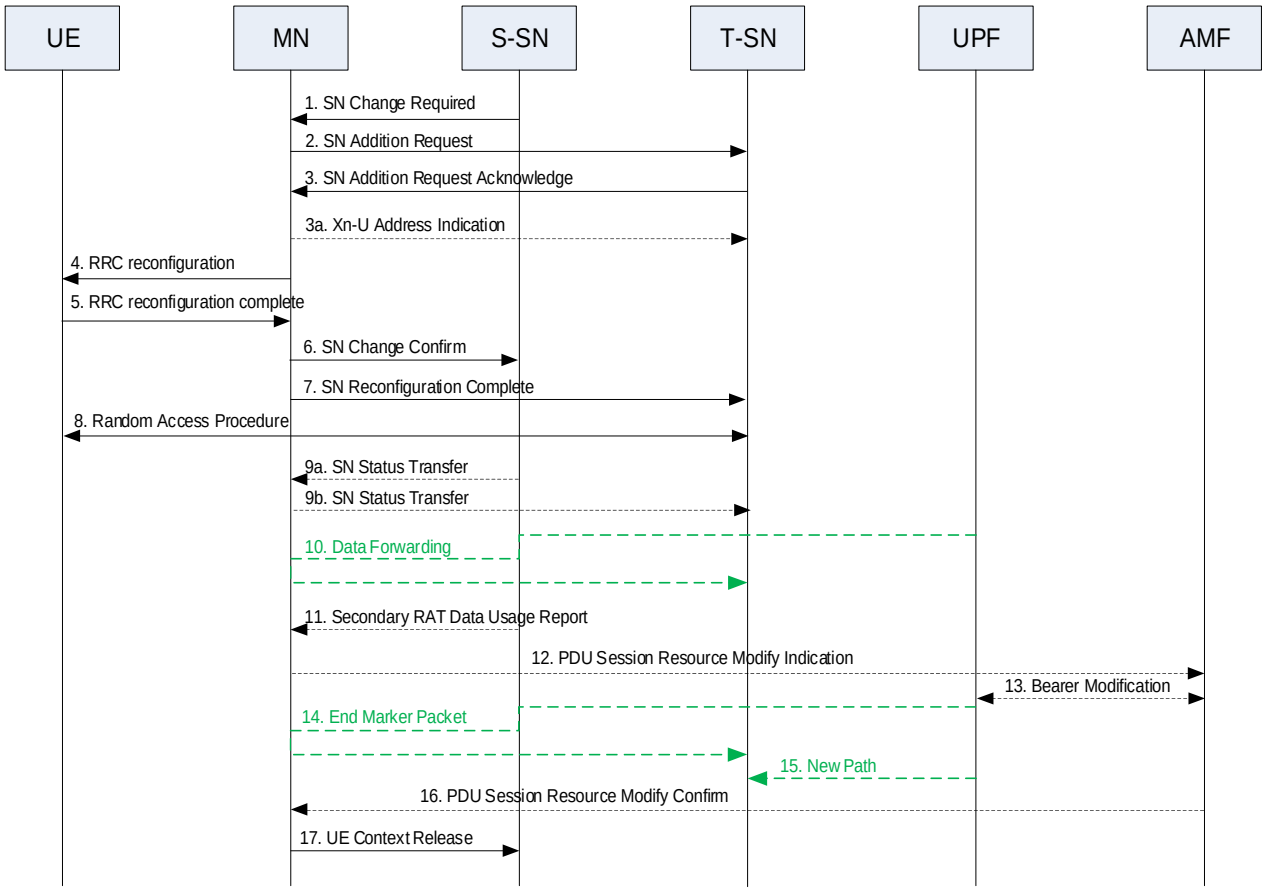


Figure 10.5.2-2: SN change procedure - SN initiated

Figure 10.5.2-2 shows an example signalling flow for the SN Change initiated by the SN:

1. The source SN initiates the SN change procedure by sending the *SN Change Required* message, which contains a candidate target node ID and may include the SCG configuration (to support delta configuration) and measurement results related to the target SN. For supporting QMC continuity during mobility, the *SN Change Required* message may contain the information about the QMC configurations at the source SN.

2/3. The MN requests the target SN to allocate resources for the UE by means of the SN Addition procedure, including the measurement results related to the target SN received from the source SN. If data forwarding is needed, the target SN provides data forwarding addresses to the MN. The target SN includes the indication of the full or delta RRC configuration.

3a. For SN terminated bearers using MCG resources, the MN provides Xn-U DL TNL address information in the *Xn-U Address Indication* message.

4/5. The MN triggers the UE to apply the new configuration. The MN indicates the new configuration to the UE in the MN RRC reconfiguration message including the SN RRC reconfiguration message generated by the target SN. The UE applies the new configuration and sends the MN RRC reconfiguration complete message, including the SN RRC response message for the target SN, if needed. In case the UE is unable to comply with (part of) the configuration included in the MN RRC reconfiguration message, it performs the reconfiguration failure procedure.

6. If the allocation of target SN resources was successful, the MN confirms the change of the source SN. If data forwarding is needed the MN provides data forwarding addresses to the source SN. If direct data forwarding is used for SN terminated bearers, the MN provides data forwarding addresses as received from the target SN to source SN. Reception of the *SN Change Confirm* message triggers the source SN to stop providing user data to the UE and, if applicable, to start data forwarding.

7. If the RRC connection reconfiguration procedure was successful, the MN informs the target SN via *SN Reconfiguration Complete* message with the included SN RRC response message for the target SN, if received from the UE.

8. The UE synchronizes to the target SN.

9. If PDCP termination point is changed for bearers using RLC AM, the source SN sends the *SN Status Transfer* message, which the MN sends then to the target SN, if needed.

10. If applicable, data forwarding from the source SN takes place. It may be initiated as early as the source SN receives the *SN Change Confirm* message from the MN.

11. The source SN sends the *Secondary RAT Data Usage Report* message to the MN and includes the data volumes delivered to and received from the UE as described in clause 10.11.2.

NOTE 3: The order the SN sends the *Secondary RAT Data Usage Report* message and performs data forwarding with MN/target SN is not defined. The SN may send the report when the transmission of the related QoS flow is stopped.

12-16. If applicable, a PDU Session path update procedure is triggered by the MN.

17. Upon reception of the *UE Context Release* message, the source SN releases radio and C-plane related resources associated to the UE context. Any ongoing data forwarding may continue.

MN initiated conditional SN Change

The Conditional Secondary Node Change procedure is initiated by the MN for inter-SN CPC configuration and inter-SN CPC execution.

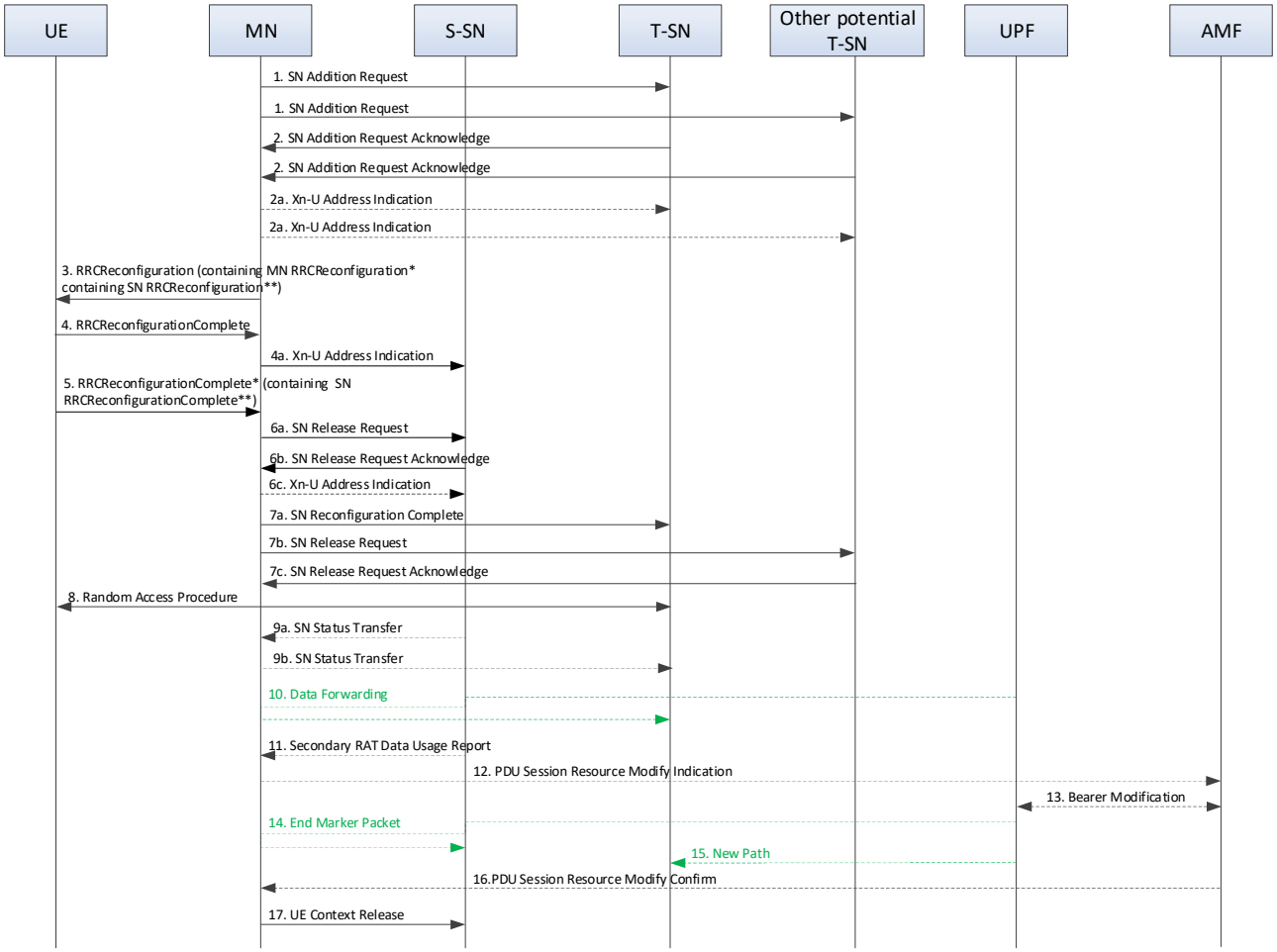


Figure 10.5.2-3: Conditional SN change procedure - MN initiated

Figure 10.5.2-3 shows an example signalling flow for the conditional SN Change initiated by the MN:

1/2. The MN initiates the conditional SN change by requesting the candidate SN(s) to allocate resources for the UE by means of the SN Addition procedure, indicating that the request is for CPAC. The MN also provides the candidate cells recommended by MN via the latest measurement results for the candidate SN(s) to choose and

configure the SCG cell(s), provides the upper limit for the number of PSCells that can be prepared by the candidate SN. Within the list of cells as indicated within the measurement results indicated by the MN, the candidate SN decides the list of PSCell(s) to prepare (considering the maximum number indicated by the MN) and, for each prepared PSCell, the candidate SN decides other SCG SCells and provides the new corresponding SCG radio resource configuration to the MN in an NR *RRCReconfiguration*** message contained in the *SN Addition Request Acknowledge* message with the prepared PSCell ID(s). If data forwarding is needed, the candidate SN provides data forwarding addresses to the MN. The candidate SN includes the indication of the full or delta RRC configuration. The candidate SN can either accept or reject each of the candidate cells listed within the measurement results indicated by the MN, i.e. it cannot configure any alternative candidates.

NOTE 4: The MN may trigger the MN-initiated SN Modification procedure (to the source SN) to retrieve the current SCG configuration and to allow provision of data forwarding related information before step 1.

2a. For SN terminated bearers using MCG resources, the MN provides Xn-U DL TNL address information in the *Xn-U Address Indication* message to the candidate SN(s).

3. The MN sends to the UE an *RRCReconfiguration* message including the CPC configuration, i.e. a list of *RRCReconfiguration** messages and associated execution conditions, in which each *RRCReconfiguration** message contains the SCG configuration in the *RRCReconfiguration*** message received from the candidate SN in step 2 and possibly an MCG configuration. Besides, the *RRCReconfiguration* message can also include an updated MCG configuration, e.g., to configure the required conditional measurements.

4. The UE applies the *RRCReconfiguration* message received in step 3, stores the CPC configuration and replies to the MN with an *RRCReconfigurationComplete* message. In case the UE is unable to comply with (part of) the configuration included in the *RRCReconfiguration* message, it performs the reconfiguration failure procedure.

4a. Upon receiving the MN *RRCReconfigurationComplete* message from the UE, the MN informs the source SN that the CPC has been configured via Xn-U Address Indication procedure, the source SN, if applicable, together with the Early Status Transfer procedure, starts early data forwarding. The PDCP SDU forwarding may take place during early data forwarding.

NOTE 4a: Separate Xn-U Address Indication procedures may be invoked to provide different forwarding addresses of the prepared candidate target SNs. In this case, it is up to the MN and the source SN implementations to make sure that the EARLY STATUS TRANSFER message(s) from the source SN, if any, is forwarded to the right target destination. The Xn-U Address Indication procedure may further be invoked to indicate to the source SN to stop already initiated early data forwarding for some SN-terminated bearers if they are no longer subject to data forwarding due to the modification or cancellation of the prepared conditional SN change procedures.

NOTE 4b: For the early transmission of MN terminated split/SCG bearers, the MN forwads the PDCP PDU to the candidate SN(s).

5. The UE starts evaluating the execution conditions. If the execution condition of one candidate PSCell is satisfied, the UE applies *RRCReconfiguration** message corresponding to the selected candidate PSCell, and sends an MN *RRCReconfigurationComplete** message, including an NR *RRCReconfigurationComplete*** message for the selected candidate PSCell, and information enabling the MN to identify the SN of the selected candidate PSCell.

6a-6c. The MN triggers the MN initiated SN Release procedure to inform the source SN to stop providing user data to the UE, and if applicable, triggers the Xn-U Address Indication procedure to inform the source SN the address of the SN of the selected candidate PSCell, to start late data forwarding.

7a-7c. If the RRC connection reconfiguration procedure was successful, the MN informs the SN of the selected candidate PSCell via *SN Reconfiguration Complete* message, including the SN *RRCReconfigurationComplete*** message. The MN sends the *SN Release Request* message(s) to cancel CPC in the other candidate SN(s), if configured. The other candidate SN(s) acknowledges the release request.

8. The UE synchronizes to the PSCell indicated in the *RRCReconfiguration** message applied in step 5.

9a-9b. If PDCP termination point is changed for bearers using RLC AM, the source SN sends the message, which the MN sends then to the SN of the selected candidate PSCell, if needed.

10. If applicable, data forwarding from the source SN takes place. It may be initiated as early as the source SN receives the early data forwarding address in step 4a.

11. The source SN sends the *Secondary RAT Data Usage Report* message to the MN and includes the data volumes delivered to and received from the UE as described in clause 10.11.2.

NOTE 5: The order the SN sends the *Secondary RAT Data Usage Report* message and performs data forwarding with MN is not defined. The SN may send the report when the transmission of the related QoS flow is stopped.

12-16. If applicable, a PDU Session path update procedure is triggered by the MN.

17. Upon reception of the *UE Context Release* message, the source SN releases radio and C-plane related resources associated to the UE context. Any ongoing data forwarding may continue.

SN initiated conditional SN Change

The SN initiated conditional SN change procedure is used for inter-SN CPC configuration and inter-SN CPC execution.

The SN initiated conditional SN change procedure may also be initiated by the source SN, to modify the existing SN initiated inter-SN CPC configuration, or to trigger the release of the candidate SN by cancellation of all the prepared PSCells at the candidate SN and releasing the CPC related UE context at the candidate SN.

NOTE 5a0: To modify or release an existing intra-SN CPC configuration, the source SN triggers an SN initiated Conditional SN Modification (with or without SRB3) without MN involvement, as specified in 10.3.

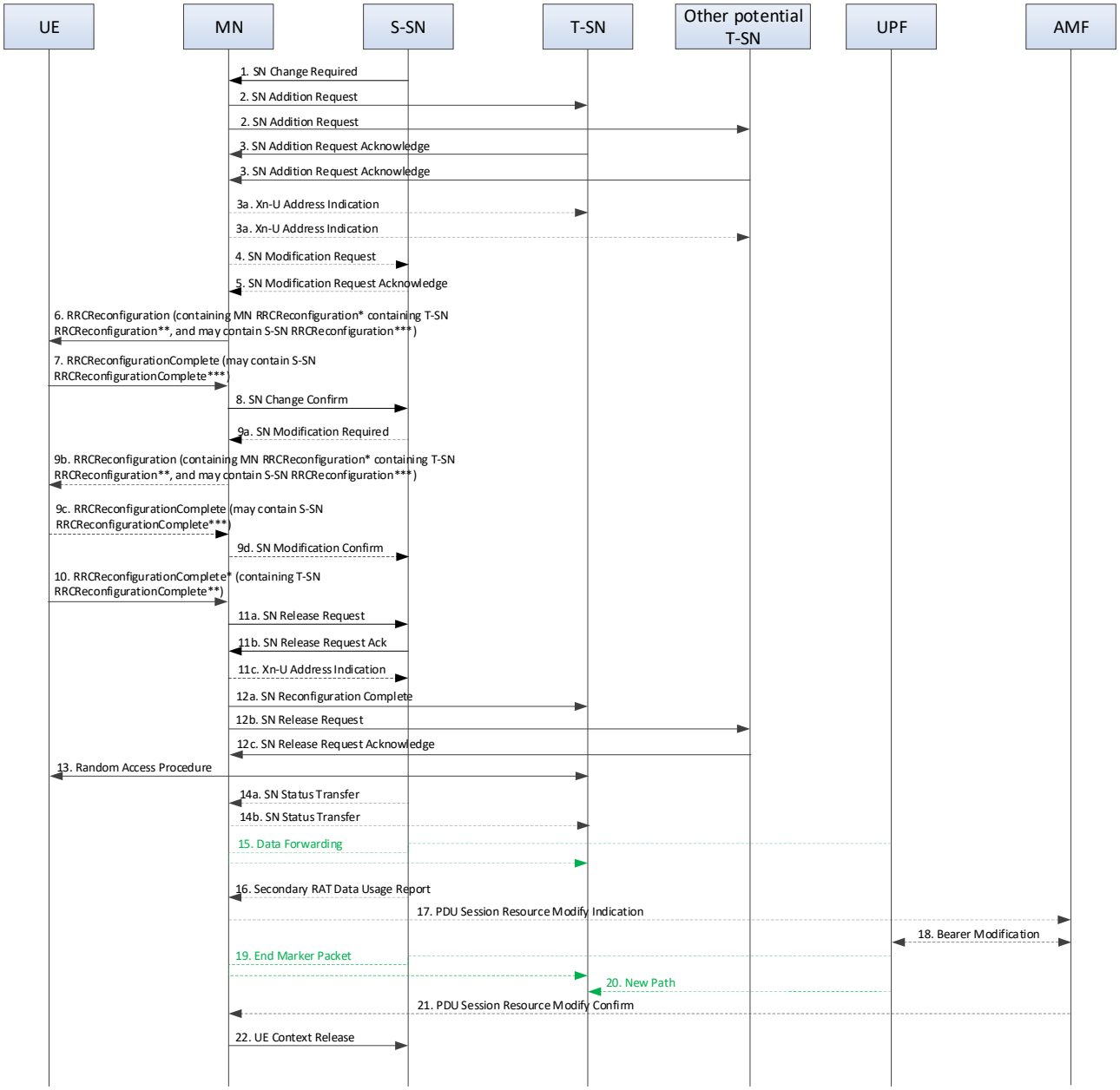


Figure 10.5.2-4: Conditional SN change procedure - SN initiated

Figure 10.5.2-4 shows an example signalling flow for the conditional SN Change initiated by the SN:

1. The source SN initiates the conditional SN change procedure by sending the *SN Change Required* message, which contains a CPC initiation indication. The message also contains candidate node ID(s) and may include the SCG configuration (to support delta configuration), and contains the measurements results which may include cells that are not CPC candidates. The message also includes a list of proposed PSCell candidates recommended by the source SN, including execution conditions, the upper limit for the number of PSCells that can be prepared by each candidate SN, and may also include the SCG measurement configurations for CPC (e.g. measurement ID(s) to be used for CPC).

2/3. The MN requests each candidate SN(s) to allocate resources for the UE by means of the SN Addition procedure(s), indicating the request is for CPAC, and the measurements results which may include cells that are not CPC candidates received from the source SN to the candidate SN, and indicating a list of proposed PSCell candidates received from the source SN, but not including execution conditions. Within the list of PSCells suggested by the source SN, the candidate SN decides the list of PSCell(s) to prepare (considering the maximum number indicated by the MN) and, for each prepared PSCell, the candidate SN decides SCG SCells and provides the new corresponding SCG radio resource configuration to the MN in an NR *RRCReconfiguration*** message contained in the *SgNB Addition Request Acknowledge* message. If data forwarding is needed, the candidate SN

provides data forwarding addresses to the MN. The candidate SN includes the indication of full or delta RRC configuration, and the list of prepared PSCell IDs to the MN. The candidate SN can either accept or reject each of the candidate cells suggested by the source SN, i.e., it cannot configure any alternative candidates.

3a. For SN terminated bearers using MCG resources, the MN provides Xn-U DL TNL address information in the *Xn-U Address Indication* message to the candidate SN(s).

4/5. The MN may indicate the candidate PSCells accepted by each candidate SN to the source SN via *SN Modification Request* message before it configures the UE, e.g., when not all candidate PSCells were accepted by the candidate SN(s). If the MN does not send such indication, step 4 and 5 are skipped. If requested, the source SN sends an *SN Modification Request Acknowledge* message and if needed, provides an updated measurement configurations and/or the execution conditions to the MN.

6. The MN sends to the UE an *RRCReconfiguration* message including the CPC configuration, i.e. a list of *RRCReconfiguration** messages and associated execution conditions, in which each *RRCReconfiguration** message contains the SCG configuration in the *RRCReconfiguration*** message received from the candidate SN in step 3 and possibly an MCG configuration. Besides, the *RRCReconfiguration* message can also include an updated MCG configuration, as well as the NR *RRCReconfiguration**** message generated by the source SN, e.g., to configure the required conditional measurements.

7. The UE applies the *RRCReconfiguration* message received in step 6, stores the CPC configuration and replies to the MN with an *RRCReconfigurationComplete* message, which can include an NR *RRCReconfigurationComplete**** message. In case the UE is unable to comply with (part of) the configuration included in the *RRCReconfiguration* message, it performs the reconfiguration failure procedure.

8. If an SN RRC response message is included, the MN informs the source SN with the SN *RRCReconfigurationComplete**** message via *SN Change Confirm* message. If step 4 and 5 are skipped, the MN will indicate the candidate PSCells accepted by each candidate SN to the source SN in the *SN Change Confirm* message.

   The MN sends the *SN Change Confirm* message towards the source SN to indicate that CPC is prepared, and in such case the source SN continues providing user data to the UE. If early data forwarding is applied, the MN informs the source SN the data forwarding address(es), the source SN, if applicable, together with the Early Status Transfer procedure, starts early data forwarding. The PDCP SDU forwarding may take place during early data forwarding. In case multiple candidate SNs are prepared, the MN includes a list of Target SN ID and list of data forwarding addresses to the source SN.

NOTE 5a: The Xn-U Address Indication procedure may further be invoked to indicate to the source SN to stop already initiated early data forwarding for some PDCP SDUs if they are no longer subject to data forwarding due to the modification or cancellation of the prepared conditional PSCell change.

NOTE 5b: For the early transmission of MN terminated split/SCG bearers, the MN forwads the PDCP PDU to the candidate SN(s).

9a-9d. The source SN may send the *SN Modification Required* message to trigger an update of CPC execution condition and/or corresponding SCG measurement configuration for CPC. In such case in step 9b, the MN reconfigures the UE and in step 9c the UE responds with *RRCReconfigurationComplete*, similarly as in steps 6 and 7.

10. The UE starts evaluating the execution conditions. If the execution condition of one candidate PSCell is satisfied, the UE applies *RRCReconfiguration** message corresponding to the selected candidate PSCell, and sends an *RRCReconfigurationComplete** message, including an *RRCReconfigurationComplete*** message for the selected candidate PSCell, and information enabling the MN to identify the SN of the selected candidate PSCell.

11a-11c. The MN triggers the MN initiated SN Release procedure to inform the source SN to stop providing user data to the UE, and if applicable, triggers the Xn-U Address Indication procedure to inform the source SN the address of the SN of the selected candidate PSCell to start late data forwarding.

12a-12c. If the RRC connection reconfiguration procedure was successful, the MN informs the SN of the selected candidate PSCell via *SN Reconfiguration Complete* message, including the SN *RRCReconfigurationComplete*** message. The MN sends the *SN Release Request* message(s) to cancel CPC in the other candidate SN(s), if configured. The other candidate SN(s) acknowledges the release request.

13. The UE synchronizes to the PSCell indicated in the *RRCReconfiguration** message applied in step 10.

14. If PDCP termination point is changed for bearers using RLC AM, the source SN sends the *SN Status Transfer* message, which the MN sends then to the SN of the selected candidate PSCell, if needed.

15. If applicable, data forwarding from the source SN takes place. It may be initiated as early as the source SN receives the data forwarding address related information from the MN.

16. The source SN sends the *Secondary RAT Data Usage Report* message to the MN and includes the data volumes delivered to and received from the UE as described in clause 10.11.2.

NOTE 6: The order the SN sends the *Secondary RAT Data Usage Report* message and performs data forwarding with MN/target SN is not defined. The SN may send the report when the transmission of the related QoS flow is stopped.

17-21. If applicable, a PDU Session path update procedure is triggered by the MN.

22. Upon reception of the *UE Context Release* message, the source SN releases radio and C-plane related resources associated to the UE context. Any ongoing data forwarding may continue.

10.6 PSCell change

In MR-DC, a PSCell change does not always require a security key change.

If a security key change is required, this is performed through a synchronous SCG reconfiguration procedure towards the UE involving random access on PSCell and a security key change, during which the MAC entity configured for SCG is reset and RLC configured for SCG is re-established regardless of the bearer type(s) established on SCG. For SN terminated bearers, PDCP is re-established. In all MR-DC options, to perform this procedure within the same SN, the SN Modification procedure as described in clause 10.3 is used, setting the *PDCP Change Indication* to indicate that a S-K_{gNB} (for EN-DC, NGEN-DC and NR-DC) or S-K_{eNB} (for NE-DC) update is required when the procedure is initiated by the SN or including the *SgNB Security Key* / *SN Security Key* when the procedure is initiated by the MN. In all MR-DC options, to perform a PSCell change between different SN nodes, the SN Change procedure as described in clause 10.5 is used.

If a security key change is not required (only possible in EN-DC, NGEN-DC and NR-DC), this is performed through a synchronous SCG reconfiguration procedure without security key change towards the UE involving random access on PSCell, during which the MAC entity configured for SCG is reset and RLC configured for SCG is re-established regardless of the bearer type(s) established on SCG. For DRBs using RLC AM mode PDCP data recovery applies, and for DRBs using RLC UM no action is performed in PDCP. For SRB3 PDCP may discard all stored SDUs and PDUs. Unless MN terminated SCG or split bearers are configured, this does not require MN involvement. In this case, if location information was requested for the UE, the SN informs the MN about the PSCell change (as part of location information) using the SN initiated SN modification procedure independently from the reconfiguration of the UE. In case of MN terminated SCG or split bearers, the SN initiated SN Modification procedure as described in clause 10.3 is used, setting the *PDCP Change Indication* to indicate that a PDCP data recovery is required. If the MN subscribes to PSCell changes to retrieve the SCG UE history information, the SN informs the MN about the SCG UE history information using the SN initiated SN modification procedure when the SCG UE history information changes.

A Conditional PSCell Change (CPC) is defined as a PSCell change that is executed by the UE when execution condition(s) is met. The UE starts evaluating the execution condition(s) upon receiving the CPC configuration, and stops evaluating the execution condition(s) once PSCell change or PCell change is triggered. Intra-SN CPC without MN involvement, inter-SN CPC initiated either by MN or SN are supported.

The following principles apply to CPC:

- The CPC configuration contains the configuration of CPC candidate PSCell(s) and execution condition(s) and may contain the MCG configuration for inter-SN CPC, to be applied when CPC execution is triggered.

- An execution condition may consist of one or two trigger condition(s) (see *CondEvent*, as defined in TS 38.331 [4] or TS 36.331 [10]). Only single RS type and at most two different trigger quantities (e.g. RSRP and RSRQ, RSRP and SINR, etc.) can be used for the evaluation of CPC execution condition of a single candidate PSCell.

- Before any CPC execution condition is satisfied, upon reception of PSCell change command or PCell change command, the UE executes the PSCell change procedure as described in clause 10.3 and 10.5 or the PCell change procedure as described in clause 9.2.3.2 in TS 38.300[3] or clause 10.1.2.1 in TS 36.300 [2], regardless

of any previously received CPC configuration. Upon the successful completion of PSCell change procedure or PCell change procedure, the UE releases all stored CPC configurations.

- While executing CPC, the UE is not required to continue evaluating the execution condition of other candidate PSCell(s) or PCell(s).
- Once the CPC procedure is executed successfully, the UE releases all stored conditional reconfigurations (i.e. for CPC and for CHO, as specified in TS 38.300 [3] or TS 36.300 [2]) except for subsequent CPAC.
- Upon the release of SCG, the UE releases the stored CPC configurations.
- MN can inform SN of the maximum number of conditional reconfigurations the SN is allowed to configure for SN initiated CPC including both intra-SN and inter-SN CPC.

CPC configuration in HO command, in PSCell addition/change command or within any conditional reconfiguration (i.e. CPA, CPC or CHO configuration) is not supported.

An SCG LTM is defined as a PSCell cell switch procedure that the network triggers via MAC CE. Only intra-SN SCG LTM without MN involvement is supported.

10.7 Inter-Master Node handover with/without Secondary Node change

10.7.1 EN-DC

Inter-Master Node handover with/without MN initiated Secondary Node change is used to transfer context data from a source MN to a target MN while the context at the SN is kept or moved to another SN. During an Inter-Master Node handover, the target MN decides whether to keep or change the SN (or release the SN, as described in clause 10.8).

NOTE 1: Void.

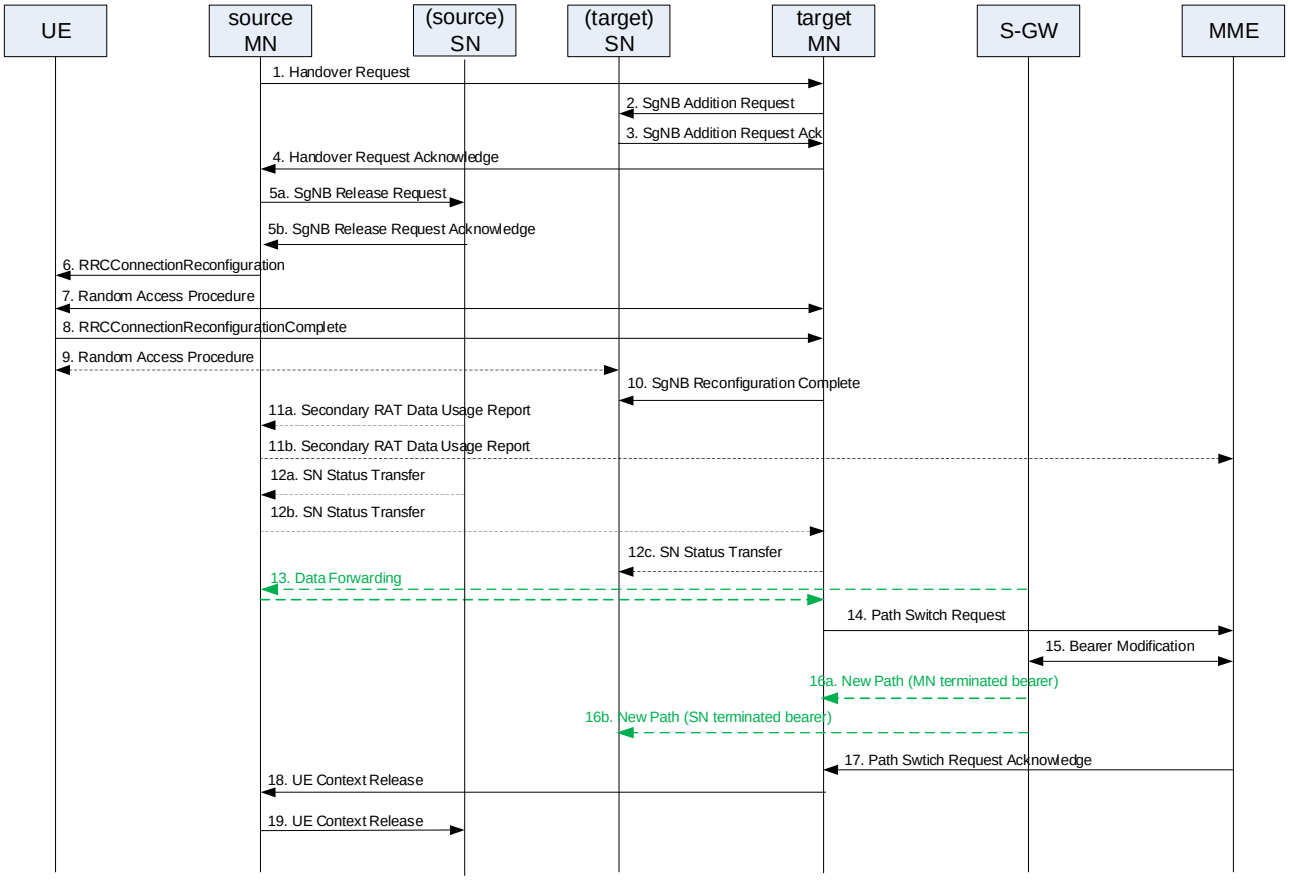


Figure 10.7.1-1: Inter-MN handover with/without MN initiated SN change

Figure 10.7.1-1 shows an example signaling flow for inter-Master Node handover with or without MN initiated Secondary Node change:

NOTE 2: For an inter-Master Node handover without Secondary Node change, the source SN and the target SN shown in Figure 10.7.1-1 are the same node.

1. The source MN starts the handover procedure by initiating the X2 Handover Preparation procedure including both MCG and SCG configuration. The source MN includes the (source) SN UE X2AP ID, SN ID and the UE context in the (source) SN in the *Handover Request* message.

NOTE 3: The source MN may trigger the MN-initiated SN Modification procedure (to the source SN) to retrieve the current SCG configuration before step 1.

2. If the target MN decides to keep the UE context in SN, the target MN sends *SgNB Addition Request* to the SN including the SN UE X2AP ID as a reference to the UE context in the SN that was established by the source MN. If the target MN decides to change the SN allowing delta configuration, the target MN sends the *SgNB Addition Request* to the target SN including the UE context in the source SN that was established by the source MN. Otherwise, the target MN may send the *SgNB Addition Request* to the target SN including neither the SN UE X2AP ID nor the UE context in the source SN that was established by the source MN.

3. The (target) SN replies with *SgNB Addition Request Acknowledge*. The (target) SN may include the indication of the full or delta RRC configuration.

NOTE 3a: In case the target SN includes the indication of the full RRC configuration, the MN performs release of the SN terminated radio bearer configuration and release and add of the NR SCG configuration part towards the UE.

NOTE 3b: Void.

4. The target MN includes within the *Handover Request Acknowledge* message a transparent container to be sent to the UE as an RRC message to perform the handover, and may also provide forwarding addresses to the source

MN. The target MN indicates to the source MN that the UE context in the SN is kept if the target MN and the SN decided to keep the UE context in the SN in step 2 and step 3.

5. The source MN sends *SgNB Release Request* to the (source) SN including a Cause indicating MCG mobility. The (source) SN acknowledges the release request. The source MN indicates to the (source) SN that the UE context in SN is kept, if it receives the indication from the target MN. If the indication as the UE context kept in SN is included, the SN keeps the UE context.

6. The source MN triggers the UE to apply the new configuration.

7/8. The UE synchronizes to the target MN and replies with *RRCConnectionReconfigurationComplete* message.

9. If configured with bearers requiring SCG radio resources, the UE synchronizes to the (target) SN.

NOTE 3b1: The order the UE performs Random Access towards the MN (step 7) and performs the Random Access procedure towards the SN (step 9) is not defined.

10. If the RRC connection reconfiguration procedure was successful, the target MN informs the (target) SN via *SgNB Reconfiguration Complete* message.

11a. The SN sends the *Secondary RAT Data Usage Report* message to the source MN and includes the data volumes delivered to and received from the UE over the NR radio for the related E-RABs.

NOTE 4: The order the source SN sends the *Secondary RAT Data Usage Report* message and performs data forwarding with MN/target SN is not defined. The SgNB may send the report when the transmission of the related bearer is stopped.

11b. The source MN sends the *Secondary RAT Report* message to MME to provide information on the used NR resource.

12. For bearers using RLC AM, the source MN sends the *SN Status Transfer* message, including, if needed, SN Status received from the source SN to the target MN. The target forwards the SN Status to the target SN, if needed.

13. If applicable, data forwarding takes place from the source side. If the SN is kept, data forwarding may be omitted for SN-terminated bearers kept in the SN.

14-17. The target MN initiates the S1 Path Switch procedure.

NOTE 5: If new UL TEIDs of the S-GW are included, the target MN performs the MN initiated SN Modification procedure to provide them to the SN.

18. The target MN initiates the UE Context Release procedure towards the source MN.

19. Upon reception of the *UE Context Release* message, the (source) SN releases C-plane related resources associated to the UE context towards the source MN. Any ongoing data forwarding may continue. The SN shall not release the UE context associated with the target MN if the UE context kept indication was included in the *SgNB Release Request* message in step 5.

10.7.2 MR-DC with 5GC

Inter-MN handover with/without MN initiated SN change is used to transfer UE context data from a source MN to a target MN while the UE context at the SN is kept or moved to another SN. During an Inter-Master Node handover, the target MN decides whether to keep or change the SN (or release the SN, as described in clause 10.8). Only intra-RAT Inter-Master node handover with/without SN change is supported (e.g. no transition from NGEN-DC to NR-DC).

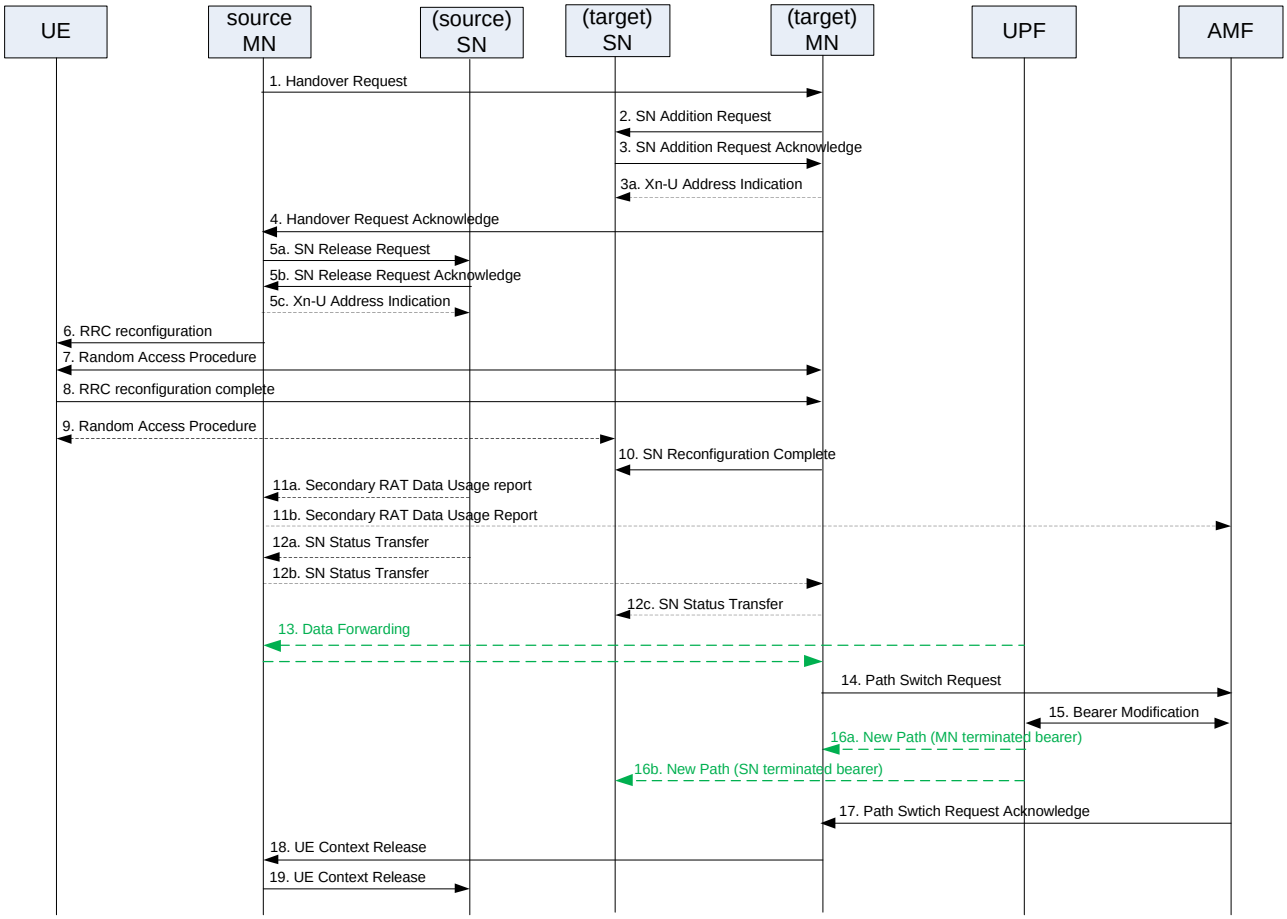


Figure 10.7.2-1: Inter-MN handover with/without MN initiated SN change procedure

Figure 10.7.2-1 shows an example signalling flow for inter-MN handover with or without MN initiated SN change:

NOTE 1: For an Inter-Master Node handover without Secondary Node change, the source SN and the target SN shown in Figure 10.7.2-1 are the same node.

1. The source MN starts the handover procedure by initiating the Xn Handover Preparation procedure including both MCG and SCG configuration. The source MN includes the source SN UE XnAP ID, SN ID and the UE context in the source SN in the *Handover Request* message.

NOTE 2: The source MN may trigger the MN-initiated SN Modification procedure (to the source SN) to retrieve the current SCG configuration and the QMC configuration information managed by the SN and to allow provision of data forwarding related information before step 1.

2. If the target MN decides to keep the UE context in source SN, the target MN sends *SN Addition Request* to the SN including the SN UE XnAP ID as a reference to the UE context in the SN that was established by the source MN. If the target MN decides to change the SN allowing delta configuration, the target MN sends the *SN Addition Request* to the target SN including the UE context in the source SN that was established by the source MN. Otherwise, the target MN may send the *SN Addition Request* to the target SN including neither the SN UE XnAP ID nor the UE context in the source SN that was established by the source MN.

3. The (target) SN replies with *SN Addition Request Acknowledge*. The (target) SN may include the indication of the full or delta RRC configuration.

NOTE 2a0: Void.

3a. For SN terminated bearers using MCG resources, the target MN provides Xn-U DL TNL address information in the *Xn-U Address Indication* message.

4. The target MN includes within the *Handover Request Acknowledge* message the MN RRC reconfiguration message to be sent to the UE in order to perform the handover, and may also provide forwarding addresses to the

source MN. If PDU session split is performed in the target side during handover procedure, more than one data forwarding addresses corresponding to each node are included in the *Handover Request Acknowledge* message. The target MN indicates to the source MN that the UE context in the SN is kept if the target MN and the SN decided to keep the UE context in the SN in step 2 and step 3.

5a/5b. The source MN sends *SN Release Request* message to the (source) SN including a Cause indicating MCG mobility. The (source) SN acknowledges the release request. The source MN indicates to the (source) SN that the UE context in SN is kept, if it receives the indication from the target MN. If the indication as the UE context kept in SN is included, the SN keeps the UE context.

5c. The source MN sends XN-U Address Indication message to the (source) SN to transfer data forwarding information. More than one data forwarding addresses may be provided if the PDU session is split in the target side.

6. The source MN triggers the UE to perform handover and apply the new configuration.

7/8. The UE synchronizes to the target MN and replies with MN RRC reconfiguration *complete* message.

9. If configured with bearers requiring SCG radio resources, the UE synchronizes to the (target) SN.

NOTE 2a1: The order the UE performs Random Access towards the MN (step 7) and performs the Random Access procedure towards the SN (step 9) is not defined.

10. If the RRC connection reconfiguration procedure was successful, the target MN informs the (target) SN via *SN Reconfiguration Complete* message.

11a. The source SN sends the *Secondary RAT Data Usage Report* message to the source MN and includes the data volumes delivered to and received from the UE over the NR/E-UTRA radio as described in clause 10.11.2.

NOTE 2a2: The order the source SN sends the *Secondary RAT Data Usage Report* message and performs data forwarding with MN/target SN is not defined. The SN may send the report when the transmission of the related QoS is stopped.

11b. The source MN sends the *Secondary RAT Report* message to AMF to provide information on the used NR/E-UTRA resource.

12. For bearers using RLC AM, the source MN sends the *SN Status Transfer* message to the target MN, including, if needed, SN Status received from the source SN. The target forwards the SN Status to the target SN, if needed.

13. If applicable, data forwarding takes place from the source side. If the SN is kept, data forwarding may be omitted for SN terminated bearers or QoS flows kept in the SN.

14-17. The target MN initiates the Path Switch procedure. If the target MN includes multiple DL TEIDs for one PDU session in the *Path Switch Request* message, multiple UL TEID of the UPF for the PDU session should be included in the *Path Switch Ack* message in case there is TEID update in UPF.

NOTE 3: If new UL TEIDs of the UPF for SN are included, the target MN performs MN initiated SN Modification procedure to provide them to the SN.

18. The target MN initiates the UE Context Release procedure towards the source MN.

19. Upon reception of the *UE Context Release* message from source MN, the (source) SN releases C-plane related resources associated to the UE context towards the source MN. Any ongoing data forwarding may continue. The SN shall not release the UE context associated with the target MN if the UE contest kept indication was included in the *SN Release Request* message in step 5.

10.8 Master Node to eNB/gNB Change

10.8.1 EN-DC

The Master Node to eNB Change procedure is used to transfer context data from a source MN/SN to a target eNB.

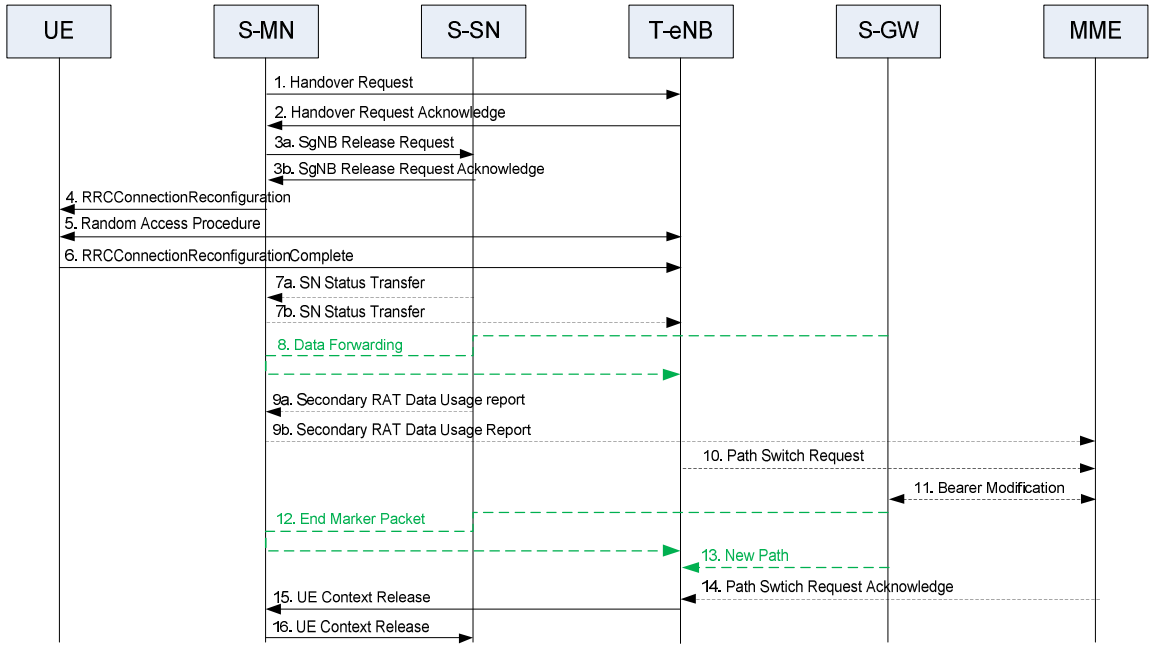


Figure 10.8.1-1: Master Node to eNB Change procedure

Figure 10.8.1-1 shows an example signalling flow for the Master Node to eNB Change procedure:

1. The source MN starts the MN to eNB Change procedure by initiating the X2 Handover Preparation procedure, including both MCG and SCG configuration.

NOTE 1: The source MN may trigger the MN-initiated SN Modification procedure (to the source SN) to retrieve the current SCG configuration before step 1.

2. The target eNB includes the field in HO command which releases SCG configuration, and may also provide forwarding addresses to the source MN.

3. If the allocation of target eNB resources was successful, the MN initiates the release of the source SN resources towards the source SN including a Cause indicating MCG mobility. The SN acknowledges the release request. If data forwarding is needed, the MN provides data forwarding addresses to the source SN. Reception of the *SgNB Release Request* message triggers the source SN to stop providing user data to the UE and, if applicable, to start data forwarding.

NOTE 1a: In case the handover is a conditional handover, step 3a and step 3b are performed after the source MN receives an indication that the UE has successfully accessed one of the potential target eNB(s) as described in step 11a in Figure 10.1.2.1a-1in TS 36.300 [2], i.e,. after step 6 in Figure 10.8.1-1.

NOTE 1b: In case the handover is a conditional handover, the Data Forwarding Address Indication procedure is executed right after step 2. This Data Forwarding Address Indication procedure notifies conditional handover to the source SN, for which it may decide to perform, if applicable, early data forwarding for SN-terminated bearers, together with the sending of an *EARLY STATUS TRANSFER* message to the source MN. Separate Data Forwarding Address Indication procedures may be invoked to provide different forwarding addresses of the prepared conditional handovers. In this case, it is up to the source MN and SN implementations to make sure that the EARLY STATUS TRANSFER message(s) from the source SN, if any, is forwarded to the right target destination. The Data Forwarding Address Indication procedure may further be invoked to indicate to the source SN to stop already initiated early data forwarding for some SN-terminated bearers if they are no longer subject to data forwarding due to the modification or cancellation of the prepared conditional handovers. If applicable, the normal data forwarding and *SN STATUS TRANSFER* message would follow from the source SN once it receives the *SgNB Release Request* message of the step 3a that is performed after step 6.

4. The MN triggers the UE to apply the new configuration. Upon receiving the new configuration, the UE releases the entire SCG configuration.

5/6. The UE synchronizes to the target eNB.

7. For SN terminated bearers using RLC AM, the SN sends the *SN Status Transfer* message, which the source MN sends then to the target eNB.

8. If applicable, data forwarding takes place from the source side.

9a. The source SN sends the *Secondary RAT Data Usagee Report* message to the source MN and includes the data volumes delivered to and received from the UE over the NR radio for the related E-RABs.

NOTE 2: The order the SN sends the *Secondary RAT Data Usage Report* message and performs data forwarding with MN is not defined. The SN may send the report when the transmission of the related bearer is stopped.

9b. The source MN sends the *Secondary RAT Report* message to MME to provide information on the used NR resource.

10-14. The target eNB initiates the S1 Path Switch procedure.

15. The target eNB initiates the UE Context Release procedure towards the source MN.

16. Upon reception of the *UE Context Release* message, the SN releases radio and C-plane related resources associated to the UE context. Any ongoing data forwarding may continue.

NOTE 3: Inter-system HO from E-UTRA with EN-DC configuration to NR or to E-UTRA connected to 5GC is also supported.

10.8.2 MR-DC with 5GC

The MN to ng-eNB/gNB Change procedure is used to transfer UE context data from a source MN/SN to a target ng-eNB/gNB. Both the cases where the source MN and the target node belong to the same RAT (i.e. they are both ng-eNBs or both gNBs) and the cases where the source MN and the target node belong to different RATs are supported.

NOTE 0: Inter-system HO from ng-eNB/gNB MN to eNB is also supported.

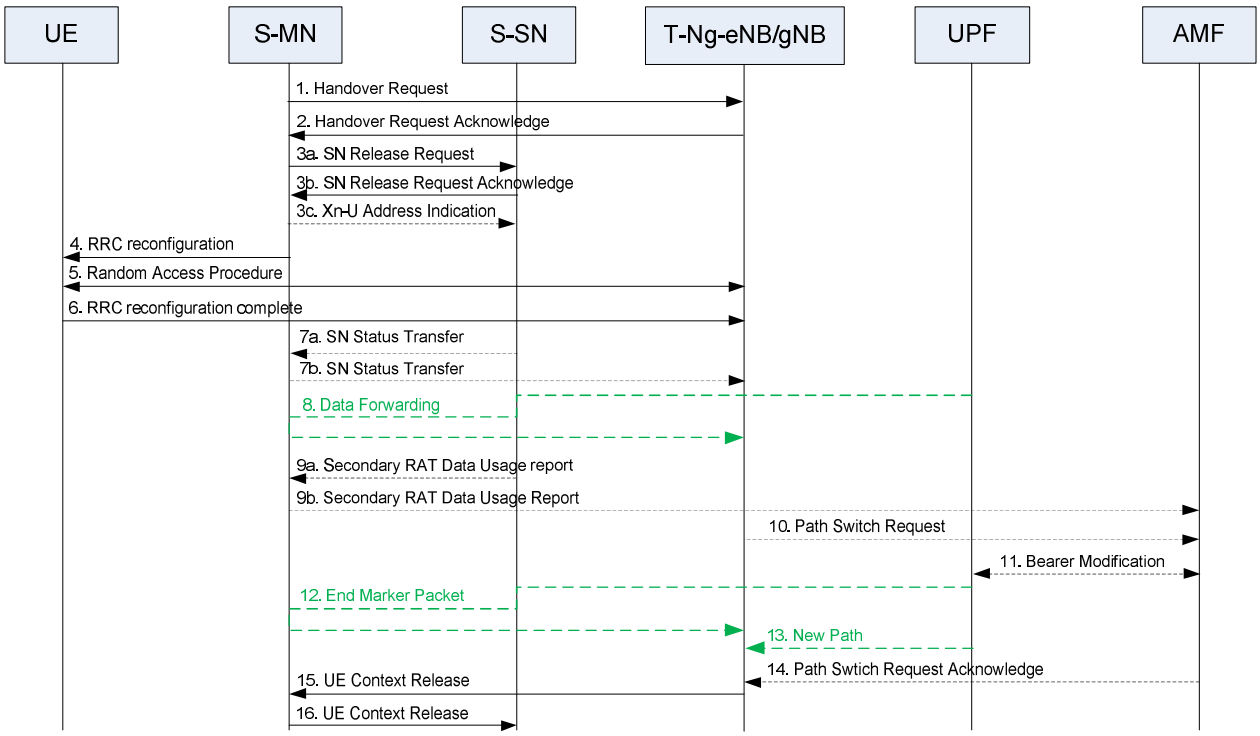


Figure 10.8.2-1: MN to ng-eNB/gNB Change procedure

Figure 10.8.2-1 shows an example signalling flow for the MN to ng-eNB/gNB Change procedure:

1. The source MN starts the MN to ng-eNB/gNB Change procedure by initiating the Xn Handover Preparation procedure, including both MCG and SCG configuration.

NOTE 1: The source MN may trigger the MN-initiated SN Modification procedure (to the source SN) to retrieve the current SCG configuration and to allow provision of data forwarding related information before step 1.

2. The target ng-eNB/gNB includes the field in HO command which releases the SCG configuration, and may also provide forwarding addresses to the source MN.

3. If the resource allocation of target ng-eNB/gNB was successful, the MN initiates the release of the source SN resources towards the source SN including a Cause indicating MCG mobility. The SN acknowledges the release request. If data forwarding is needed, the MN provides data forwarding addresses to the source SN. Reception of the *SN Release Request* message triggers the source SN to stop providing user data to the UE and, if applicable, to start data forwarding.

NOTE 1a: In case the handover is a conditional handover, step 3a and step 3b are performed after the source MN receives an indication that the UE has successfully accessed one of the potential target gNB(s) as described in step 8a in Figure 9.2.3.4.2-1 in TS 38.300 [3], i.e., after step 6 in Figure 10.8.2-1.

NOTE 1b: In case the handover is a conditional handover, the step 3c is executed right after step 2. The *Xn-U Address Indication* message notifies conditional handover to the source SN, for which it may decide to perform, if applicable, early data forwarding for SN-terminated bearers, together with the sending of an *EARLY STATUS TRANSFER* message to the source MN. Separate Xn-U Address Indication procedures may be invoked to provide different forwarding addresses of the prepared conditional handovers. In this case, it is up to the source MN and SN implementations to make sure that the EARLY STATUS TRANSFER message(s) from the source SN, if any, is forwarded to the right target destination. The Xn-U Address Indication procedure may further be invoked to indicate to the source SN to stop already initiated early data forwarding for some SN-terminated bearers if they are no longer subject to data forwarding due to the modification or cancellation of the prepared conditional handovers. If applicable, the normal data forwarding and *SN STATUS TRANSFER* message would follow from the source SN once it receives the *SN Release Request* message of the step 3a that is performed after step 6. In case the step 3c Xn-U Address Indication procedure corresponding to the conditional handover that the UE successfully accessed was rejected by the source SN, the source MN re-sends it after the step 3b that is performed after step 6.

4. The MN triggers the UE to perform HO and apply the new configuration. Upon receiving the new configuration, the UE releases the entire SCG configuration.

5/6. The UE synchronizes to the target ng-eNB/gNB.

7. If PDCP termination point is changed for bearers using RLC AM, the SN sends the *SN Status Transfer* message, which the source MN sends then to the target ng-eNB/gNB.

8. If applicable, data forwarding takes place from the source side.

9a. The source SN sends the *Secondary RAT Data Usage Report* message to the source MN and includes the data volumes delivered to and received from the UE as described in clause 10.11.2.

NOTE 2: The order the SN sends the *Secondary RAT Data Usage Report* message and performs data forwarding with MN is not defined. The SN may send the report when the transmission of the related QoS flow is stopped.

9b. The source MN sends the *Secondary RAT Report* message to AMF to provide information on the used NR/E-UTRA resource.

10-14. The target ng-eNB/gNB initiates the Path Switch procedure.

15. The target ng-eNB/gNB initiates the UE Context Release procedure towards the source MN.

16. Upon reception of the *UE Context Release* message from the MN, the source SN releases radio and C-plane related resources associated to the UE context. Any ongoing data forwarding may continue.

10.9 eNB/gNB to Master Node change

10.9.1 EN-DC

The eNB to Master Node change procedure is used to transfer context data from a source eNB to a target MN that adds an SN during the handover.

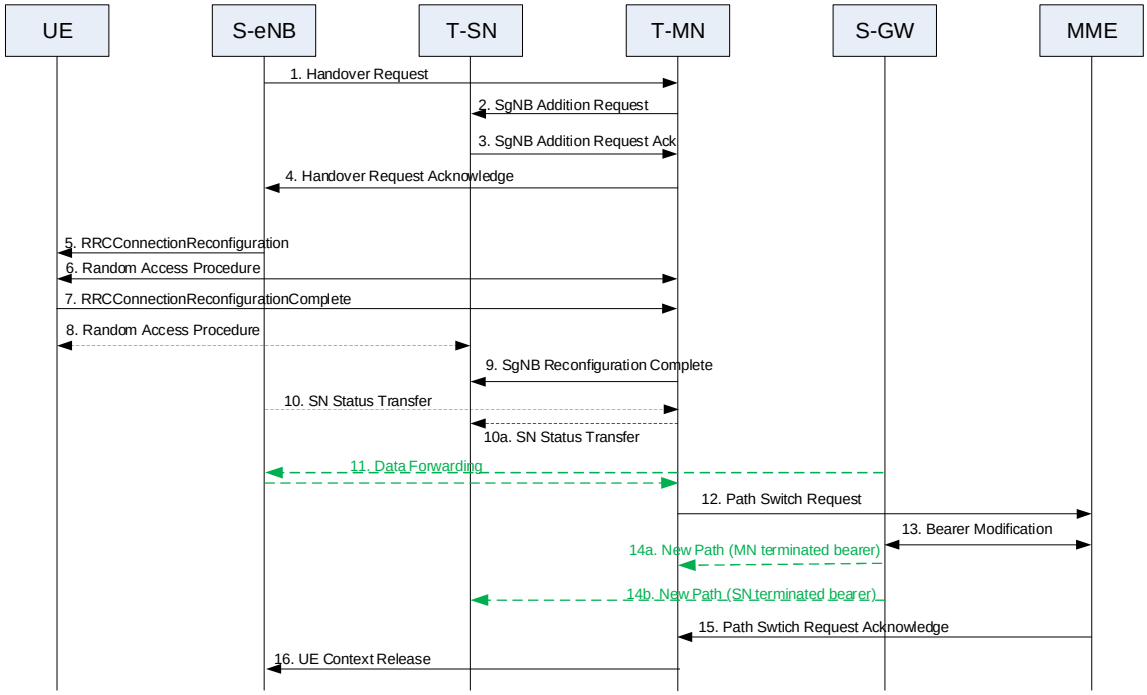


Figure 10.9.1-1: eNB to Master Node change

Figure 10.9.1-1 shows an example signaling flow for eNB to Master Node change:

1. The source eNB starts the handover procedure by initiating the X2 Handover Preparation procedure.
2. The target MN sends *SgNB Addition Request* to the target SN.
3. The target SN replies with *SgNB Addition Request Acknowledge*. If data forwarding is needed, the target SN provides forwarding addresses to the target MN.

NOTE 0: Void.

4. The target MN includes within the *Handover Request Acknowledge* message a transparent container to be sent to the UE as an E-UTRA RRC message, including a NR RRC configuration message which also includes the SCG configuration, to perform the handover, and may also provide forwarding addresses to the source eNB.
5. The source eNB triggers the UE to apply the new configuration.

6/7. The UE synchronizes to the target MN and replies with *RRCConnectionReconfigurationComplete* message.

8. If configured with bearers requiring SCG radio resources, the UE synchronizes to the target SN.

NOTE 0: The order the UE performs Random Access towards the target MN (step 6) and performs the Random Access procedure towards the target SN (step 8) is not defined.

9. If the RRC connection reconfiguration procedure was successful, the target MN informs the target SN.
10. For bearers using RLC AM, the source eNB sends the *SN Status Transfer* message, which the target MN forwards then to the target SN, if needed.
11. Data forwarding from the source eNB takes place.

12-15. The target MN initiates the S1 Path Switch procedure.

NOTE 1: If new UL TEIDs of the S-GW are included, the target MN performs MN initiated SN Modification procedure to provide them to the target SN.

16. The target MN initiates the *UE Context Release* procedure towards the source eNB.

NOTE 2: Void.

NOTE 3: Void.

10.9.2 MR-DC with 5GC

The ng-eNB/gNB to MN change procedure is used to transfer UE context data from a source ng-eNB/gNB to a target MN that adds an SN during the handover. Only the cases where the source node and the target MN belong to the same RAT (i.e. they are both ng-eNBs or both gNBs) are supported.

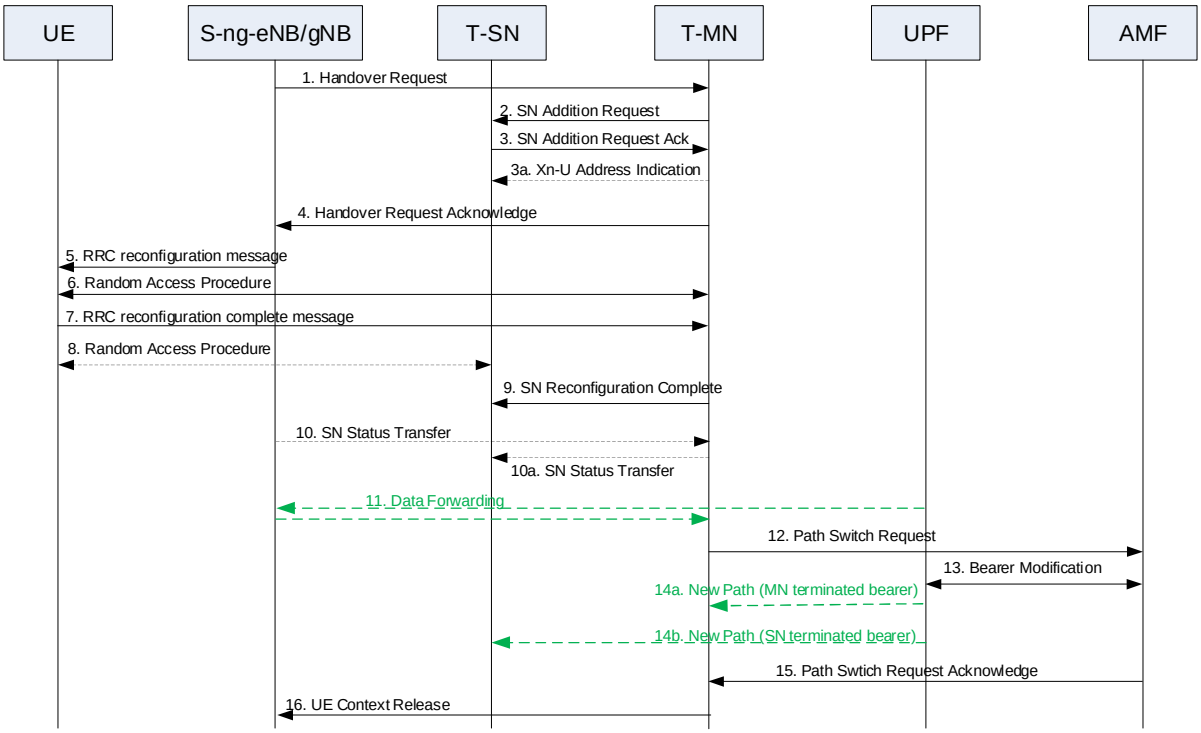


Figure 10.9.2-1: ng-eNB/gNB to MN change procedure

Figure 10.9.2-1 shows an example signalling flow for ng-eNB/gNB to MN change:

1. The source ng-eNB/gNB starts the handover procedure by initiating the Xn Handover Preparation procedure.
2. The target MN sends *SN Addition Request* to the target SN.
3. The target SN replies with *SN Addition Request Acknowledge*. If data forwarding is needed, the target SN provides forwarding addresses to the target MN.

NOTE 0: Void.

3a. For SN terminated bearers using MCG resources, the target MN provides Xn-U DL TNL address information in the *Xn-U Address Indication* message.

4. The target MN includes within the *Handover Request Acknowledge* message the SN RRC reconfiguration message to be sent to the UE that includes the SCG configuration to perform the handover, and may also provide forwarding addresses to the source ng-eNB/gNB.
5. The source ng-eNB/gNB triggers the UE to perform handover and apply the new configuration.

6/7. The UE synchronizes to the target MN and replies with MN RRC reconfiguration complete message including the SN RRC reconfiguration complete message.

8. If configured with bearers requiring SCG radio resources, the UE synchronizes to the target SN.

NOTE 1: The order the UE performs Random Access towards the target MN (step 6) and performs the Random Access procedure towards the target SN (step 8) is not defined.

9. If the RRC connection reconfiguration procedure was successful, the target MN informs the target SN via *SN Reconfiguration Complete* message.

10. For bearers using RLC AM, the source ng-eNB/gNB sends the *SN Status Transfer* message, which the target MN forwards then to the target SN, if needed.

11. Data forwarding from the source ng-eNB/gNB takes place.

12-15. The target MN initiates the PDU Session Path Switch procedure.

NOTE 2: If new UL TEIDs of the UPF are included, the target MN performs MN initiated SN Modification procedure to provide them to the target SN.

16. The target MN initiates the *UE Context Release* procedure towards the source ng-eNb/gNB.

10.10 RRC Transfer

10.10.1 EN-DC

The RRC Transfer procedure is used to deliver an RRC message, encapsulated in a PDCP PDU between the MN and the SN (and vice versa) so that it may be forwarded to/from the UE using split SRB. The RRC transfer procedure is also used for:

- providing an NR measurement report, NR failure information, NR UE assistance information or intra-SN CPC execution completion from the UE to the SN via the MN. If UE is IAB-MT, providing NR IAB other information from the IAB-MT to the SN via the MN;
- providing MCG failure information from the UE to the MN via the SN and an RRC reconfiguration, or release, or an inter-RAT handover command from the MN to the UE via the SN.

Additional details of the RRC transfer procedure are defined in TS 36.423 [9].

Split SRB:

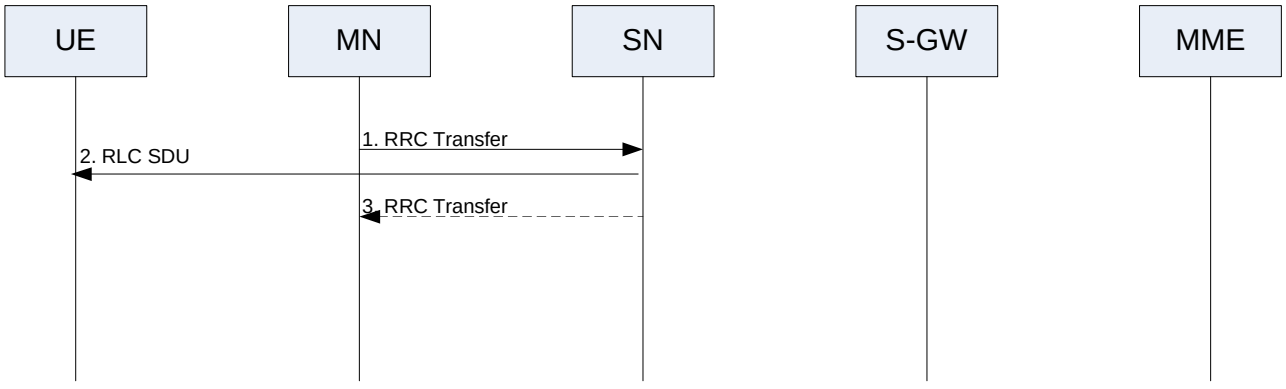


Figure 10.10.1-1: RRC Transfer procedure for the split SRB (DL operation)

Figure 10.10.1-1 shows an example signaling flow for the DL RRC Transfer in case of the split SRB:

1. The MN, when it decides to use the split SRBs, starts the procedure by initiating the RRC Transfer procedure. The MN encapsulates the RRC message in a PDCP-C PDU and ciphers with own keys.

NOTE: The usage of the split SRBs shall be indicated in the Secondary Node Addition procedure or Modification procedure.

2. The SN forwards the RRC message to the UE.
3. The SN may send PDCP delivery acknowledgement of the RRC message forwarded in step 2.

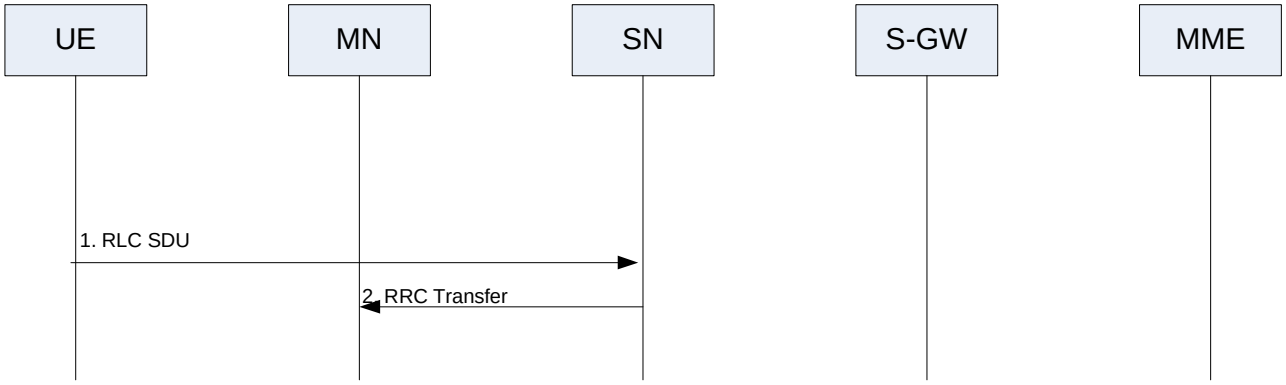


Figure 10.10.1-2: RRC Transfer procedure for the split SRB (UL operation)

Figure 10.10.1-2 shows an example signaling flow for the UL RRC Transfer in case of the split SRB:

1. When the UE provides response to the RRC message, it sends it to the SN.
2. The SN initiates the RRC Transfer procedure, in which it transfers the received PDCP-C PDU with encapsulated RRC message.

NR measurement report, NR failure information, NR UE assistance information, NR IAB other information or intra-SN CPC execution completion:

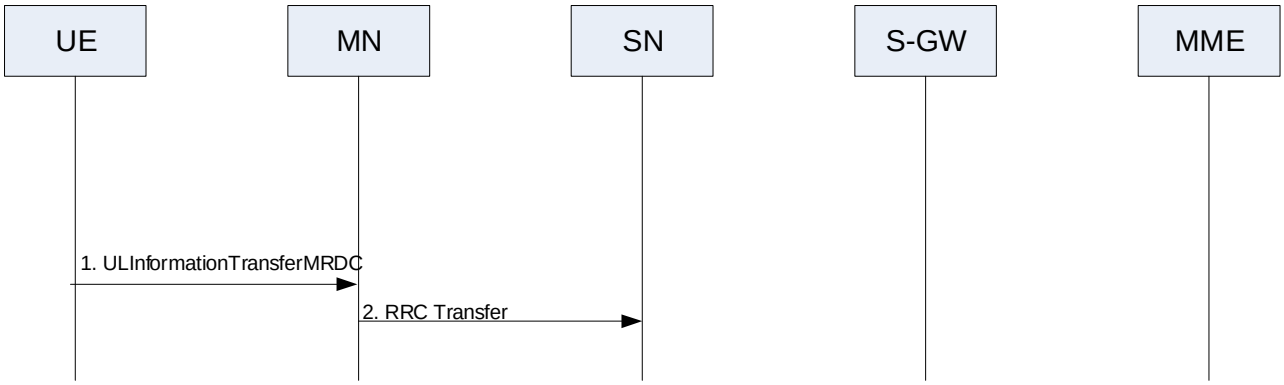


Figure 10.10.1-3: RRC Transfer procedure for NR measurement report, NR failure information, NR UE assistance information, NR IAB other information or intra-SN CPC execution completion

Figure 10.10.1-3 shows an example signaling flow for RRC Transfer in case of the forwarding of the NR measurement report, NR failure information, NR IAB other information from the UE, NR UE assistance information or intra-SN CPC execution completion:

1. When the UE sends a measurement report, NR failure information, NR UE assistance information, NR IAB other information or intra-SN CPC execution completion, it sends it to the MN in a container within *ULInformationTransferMRDC* message as specified in TS 36.331 [10].
2. The MN initiates the RRC Transfer procedure, in which it transfers the received NR measurement report, NR failure information, NR UE assistance information, NR IAB other information or intra-SN CPC execution completion as an octet string.

MCG failure information and RRC Reconfiguration / RRC Release / inter-RAT handover command over SRB3:

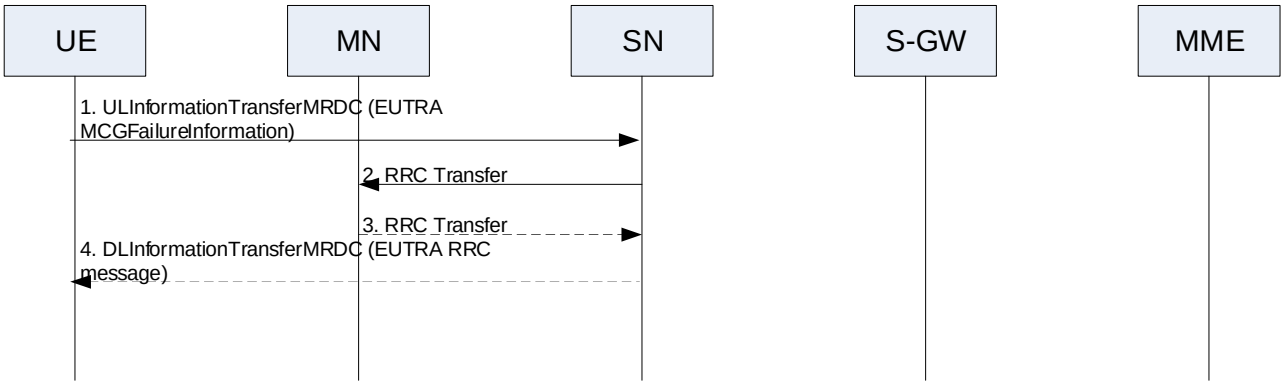


Figure 10.10.1-4: RRC Transfer procedure for MCG failure information

Figure 10.10.1-4 shows an example signaling flow for RRC Transfer in case of the forwarding of the MCG failure information from the UE:

1. When the UE sends EUTRA *MCGFailureInformation* message over SRB3, it sends it to the SN in a container within *ULInformationTransferMRDC* message as specified in TS 38.331 [4].
2. The SN initiates the RRC Transfer procedure, in which it transfers the received EUTRA *MCGFailureInformation* message as an octet string.
3. The MN initiates the RRC Transfer procedure, in which it transfers the EUTRA *RRCConnectionReconfiguration* message, or EUTRA *RRCConnectionRelease* message, or *MobilityFromEUTRACommand* message as an octet string.
4. The SN sends the received EUTRA RRC message to the UE over SRB3 in a container within *DLInformationTransferMRDC*, message as specified in TS 38.331 [4].

10.10.2 MR-DC with 5GC

The RRC Transfer procedure is used to deliver an RRC message, encapsulated in a PDCP PDU between the MN and the SN (and vice versa) so that it may be forwarded to/from the UE using split SRB. The RRC transfer procedure is also used for:

- providing a SN measurement report, failure information report, SN UE assistance information, intra-SN CPC execution completion or intra-SN subsequent CPAC without MN involvement execution completion from the UE to the SN. If UE is IAB-MT, providing NR IAB other information from the IAB-MT to the SN when the IAB-donor is the SN;
- providing MCG failure information from the UE to the MN via the SN and an RRC reconfiguration, or release, or an inter-RAT handover command from the MN to the UE via the SN;
- providing F1-C traffic from an IAB-node to the MN via the SN, or F1-C traffic from the MN to an IAB-node via the SN.

Additional details of the RRC transfer procedure are defined in TS 38.423 [5].

Split SRB:

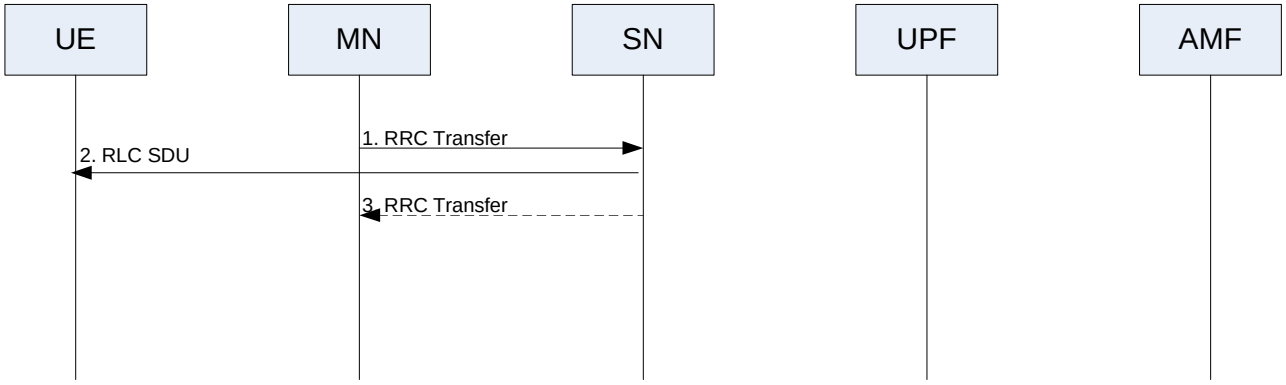


Figure 10.10.2-1: RRC Transfer procedure for split SRB (DL operation)

Figure 10.10.2-1 shows an example signaling flow for DL RRC Transfer in case of the split SRB:

1. The MN, when it decides to use the split SRBs, starts the procedure by initiating the RRC Transfer procedure. The MN encapsulates the RRC message in a PDCP PDU and ciphers with own keys.

NOTE: The usage of the split SRBs shall be indicated in the Secondary Node Addition procedure or Modification procedure.

2. The SN forwards the RRC message to the UE.
3. The SN may send PDCP delivery acknowledgement of the RRC message forwarded in step 2.

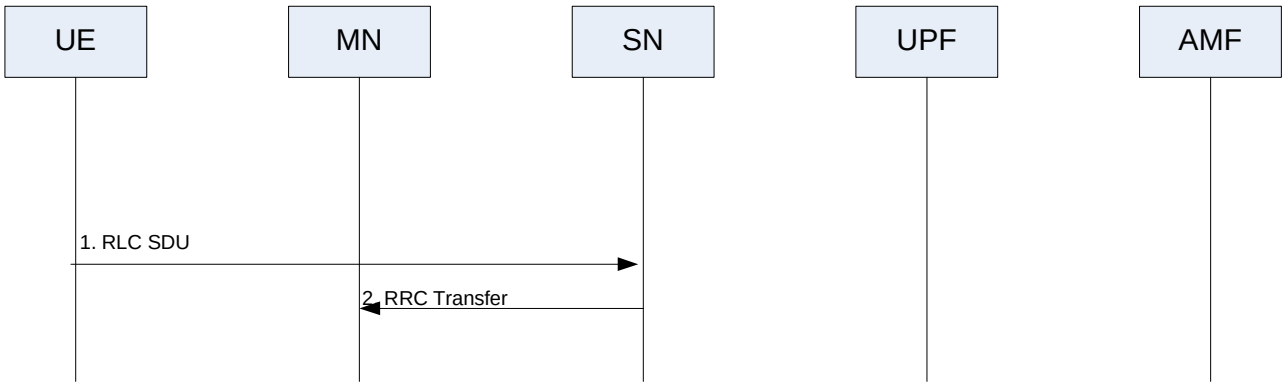


Figure 10.10.2-2: RRC Transfer procedure for split SRB (UL operation)

Figure 10.10.2-2 shows an example signaling flow for UL RRC Transfer in case of the split SRB:

1. When the UE provides response to the RRC message, it sends it to the SN.
2. The SN initiates the RRC Transfer procedure, in which it transfers the received PDCP PDU with encapsulated RRC message.

SN measurement report, failure information report, SN UE assistance information, intra-SN CPC execution completion, intra-SN subsequent CPAC without MN involvement execution completion or IAB other information:

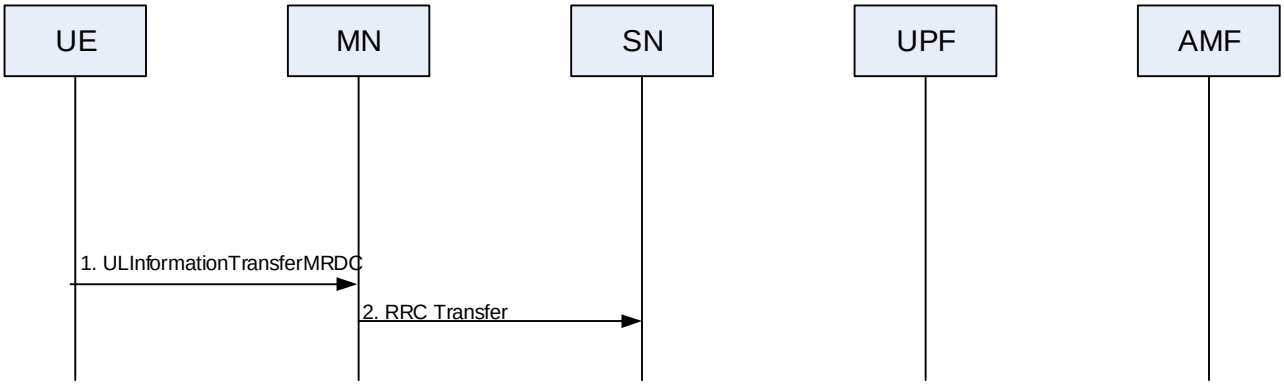


Figure 10.10.2-3: RRC Transfer procedure for SN measurement report, failure information report, SN UE assistance information, intra-SN CPC execution completion, intra-SN subsequent CPAC without MN involvement execution completion or IAB other information

Figure 10.10.2-3 shows an example signaling flow for RRC Transfer in case of the forwarding of the SN measurement report, failure information report, SN UE assistance information, intra-SN CPC execution completion, intra-SN subsequent CPAC without MN involvement execution completion or IAB other information from the UE:

1. When the UE sends an SN measurement report, failure information report, SN UE assistance information, intra-SN CPC execution completion, intra-SN subsequent CPAC without MN involvement execution completion or IAB other information it sends it to the MN in a container called *ULInformationTransferMRDC* message as specified in TS 38.331 [4].

2. The MN initiates the RRC Transfer procedure, in which it transfers the received SN measurement report, failure information, SN UE assistance information, intra-SN CPC execution completion, intra-SN subsequent CPAC without MN involvement execution completion or IAB other information as an octet string.

MCG failure information and RRC Reconfiguration / RRC Release / inter-RAT handover command over SRB3:

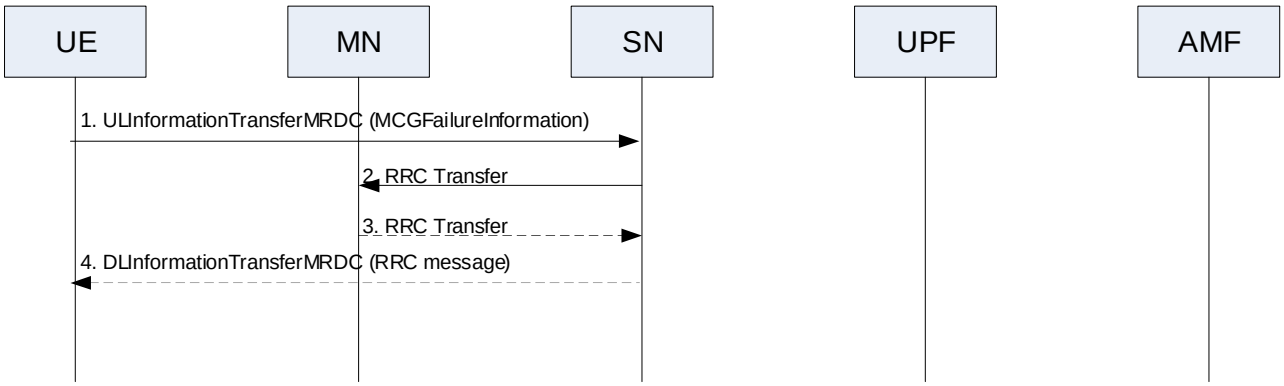


Figure 10.10.2-4: RRC Transfer procedure for MCG failure information

Figure 10.10.2-4 shows an example signaling flow for RRC Transfer in case of the forwarding of the MCG failure information from the UE:

1. When the UE sends *MCGFailureInformation* message over SRB3, it sends it to the SN in a container called *ULInformationTransferMRDC* message as specified in TS 38.331 [4].

2. The SN initiates the RRC Transfer procedure, in which it transfers the received *MCGFailureInformation* message as an octet string.

3. The MN initiates the RRC Transfer procedure, in which it transfers the *RRCConnectionReconfiguration* message, or *RRCReconfiguration* message, or *RRCConnectionRelease* message, or *RRCRelease* message, or *MobilityFromNRCommand* message, or *MobilityFromEUTRACommand* message as an octet string.

4. The SN sends the received RRC message to the UE in a container called *DLInformationTransferMRDC* message, as specified in TS 38.331 [4].

F1-C traffic transfer:

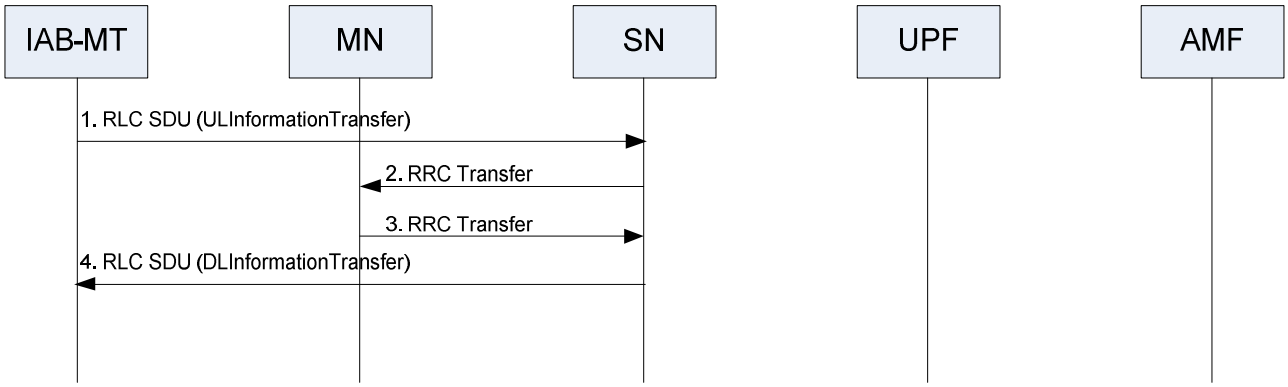


Figure 10.10.2-5: RRC Transfer procedure for supporting scenario 2 of F1-C traffic transfer in NR-DC

1. The IAB-MT receives from its co-located IAB-DU an F1-AP message encapsulated in SCTP/IP or an F1-C related (SCTP/)IP packet and forwards it to the SN via split SRB2 in a container within *ULInformationTransfer* message encapsulated in a PDCP PDU as specified in TS 38.331 [4].

2. The SN initiates the RRC Transfer procedure, in which it transfers the received PDCP PDU (*ULInformationTransfer* message) including the F1-AP message or the F1-C related (SCTP/)IP packet.

3. When the MN (IAB-donor) sends a F1-AP message encapsulated in SCTP/IP or the F1-C related (SCTP/)IP packet, it starts the procedure by initiating the RRC Transfer procedure, if split SRB2 is determined to be used and usage of SCG path is determined. The MN sends the F1-AP message or the F1-C related (SCTP/)IP packet to the SN in a container within *DLInformationTransfer* message encapsulated in a PDCP PDU specified in TS 38.331 [4].

4. The SN forwards the encapsulated *DLInformationTransfer* message in a PDCP PDU as specified in TS 38.331 [4] to IAB-MT.

10.11 Secondary RAT data volume reporting

10.11.1 EN-DC

The secondary RAT data volume reporting function is used to report the data volume of secondary RAT to CN. In EN-DC, if configured, the MN reports the uplink and downlink data volumes of used NR resources to the EPC on a per EPS bearer basis as specified in TS 36.300 [2]. Periodic reporting is performed by periodically sending the *Secondary RAT Data Usage Report* messages to the MME.

The data volume is counted by the node hosting PDCP. Downlink data volume is counted in bytes of PDCP SDUs successfully delivered to the UE over NR (for RLC AM) or transmitted to the UE over NR (for RLC UM). Uplink data volume is counted in bytes of PDCP SDUs received by the node hosting PDCP over NR. Forwarded packets shall not be counted when PDCP entity is relocated. When PDCP duplication is activated, packets shall be counted only once.

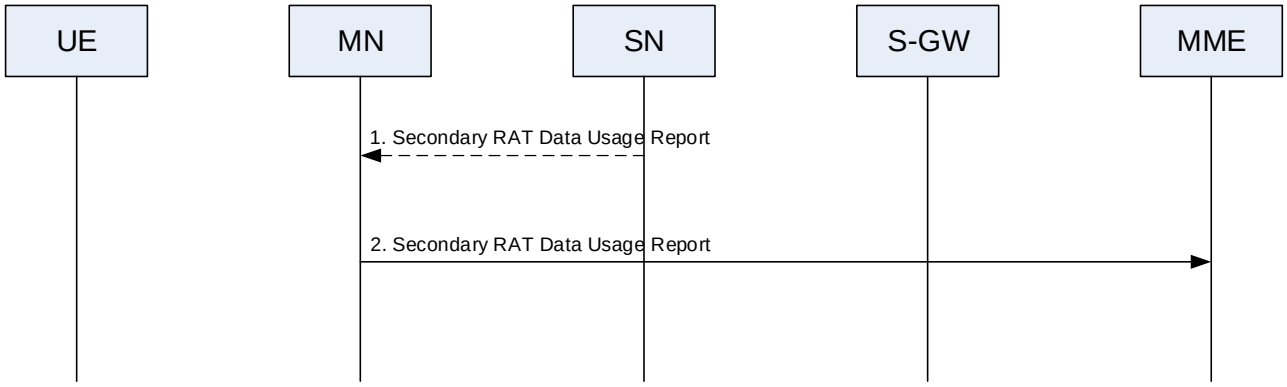


Figure 10.11.1-1: Secondary RAT data volume periodic reporting - EN-DC

Figure 10.11.1-1 shows an example signalling flow for secondary RAT data volume periodic reporting:

1. If the periodic reporting is configured, then the SN periodically sends the *Secondary RAT Data Usage Report* message to the MN and includes the data volumes of used NR radio resources for the related SN-terminated E-RABs.

2. The MN sends the *Secondary RAT Data Usage Report* message to MME to provide information on the used NR resource.

NOTE: The *Secondary RAT Data Usage Report* message sent by the MN may also include secondary RAT report information of MN-terminated bearers.

10.11.2 MR-DC with 5GC

The secondary RAT data volume reporting function is used to report the data volume of secondary RAT to the 5GC. In MR-DC with 5GC, if configured, the MN reports the uplink and downlink data volumes of used secondary RAT resources to the 5GC as specified in TS 23.501 [11]. Configuration for reporting of secondary RAT data volume may happen separately for NR and E-UTRA. Secondary RAT data volume reporting indicates the secondary RAT type. For each PDU session, it contains data volumes consumed for the whole PDU Session, or for selected QoS flow, or both. Periodic reporting is performed by periodically sending the *Secondary RAT Data Usage Report* messages to the 5GC.

The data volume is counted by the node hosting PDCP. Downlink data volume is counted in bytes of SDAP SDUs successfully delivered to the UE (for RLC AM) or transmitted to the UE (for RLC UM). Uplink data volume is counted in bytes of SDAP SDUs received by the node hosting PDCP. Forwarded packets shall not be counted when PDCP entity is relocated. When PDCP duplication is activated, packets shall be counted only once.

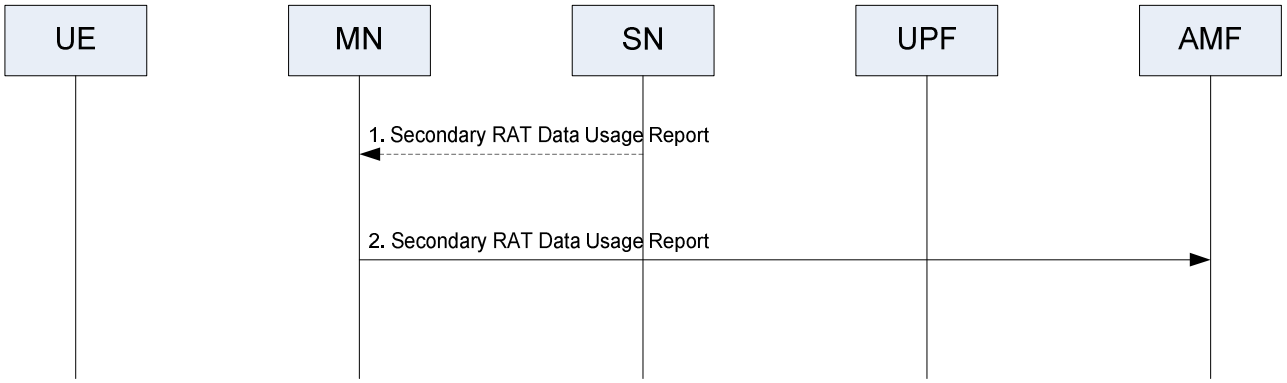


Figure 10.11.2-1: Secondary RAT data volume periodic reporting - MR-DC with 5GC

Figure 10.11.2-1 shows an example signalling flow for secondary RAT data volume periodic reporting:

1. For SN terminated bearers, the SN sends the *Secondary RAT Data Usage Report* message to the MN and includes the data volumes of used secondary RAT resources for PDU Sessions or selected QoS flows or both

mapped to SN-terminated bearers. If periodic reporting is configured, then the SN periodically sends the *Secondary RAT Data Usage Report* message to the MN and includes the data volumes of used radio resources.

2. The MN sends the *Secondary RAT Data Usage Report* message to the 5GC to provide information on the used radio resources.

NOTE: The *Secondary RAT Data Usage Report* message sent by the MN may also include secondary RAT data volumes of used secondary RAT resources for MN terminated bearers.

10.12 Activity Notification

10.12.1 EN-DC

The Activity Notification function is used to report user plane activity within SN resources. It can either report inactivity or resumption of activity after inactivity was reported. In EN-DC the Activity Reporting is provided from the SN only. The MN may take further actions.

EN-DC Activity Notification

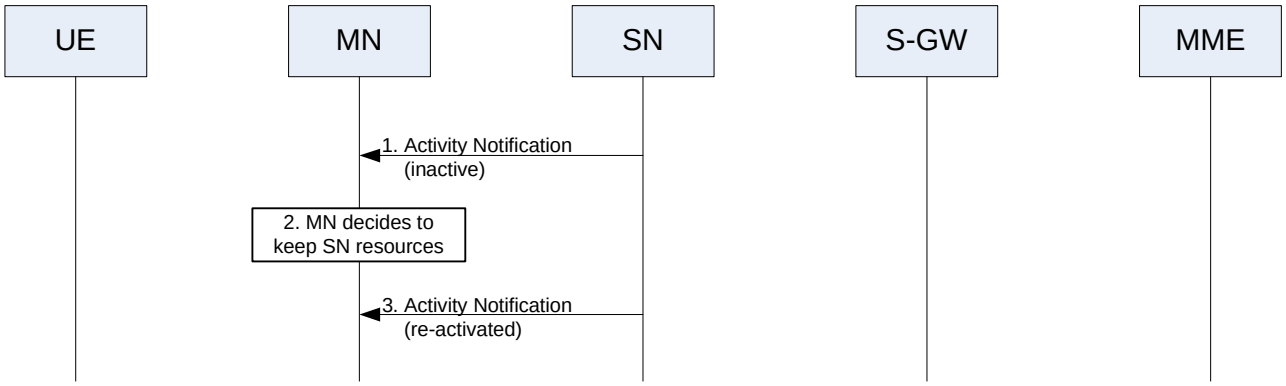


Figure 10.12.1-1: Support of Activity Notification in EN-DC

Support of Activity Notification in EN-DC is used to keep the MN informed about user traffic activity in resources owned by the SN. The MN may take appropriate action upon receiving such notification.

1. The SN informs the MN about user data inactivity of resources owned by the SN.
2. The MN decides to keep SN resources.
3. After a while the SN reports resumption of user plane activity.

EN-DC with suspended RRC connection – SCG configuration released in SN

The Activity Notification function may be used to enable EN-DC with suspended RRC connected operation. The MN node may decide, after inactivity is reported from the SN and also MN resources show no activity, to send the UE to suspended RRC connection. Resumption to RRC_CONNECTED may take place after activity is reported from the SN for SN terminated bearers.

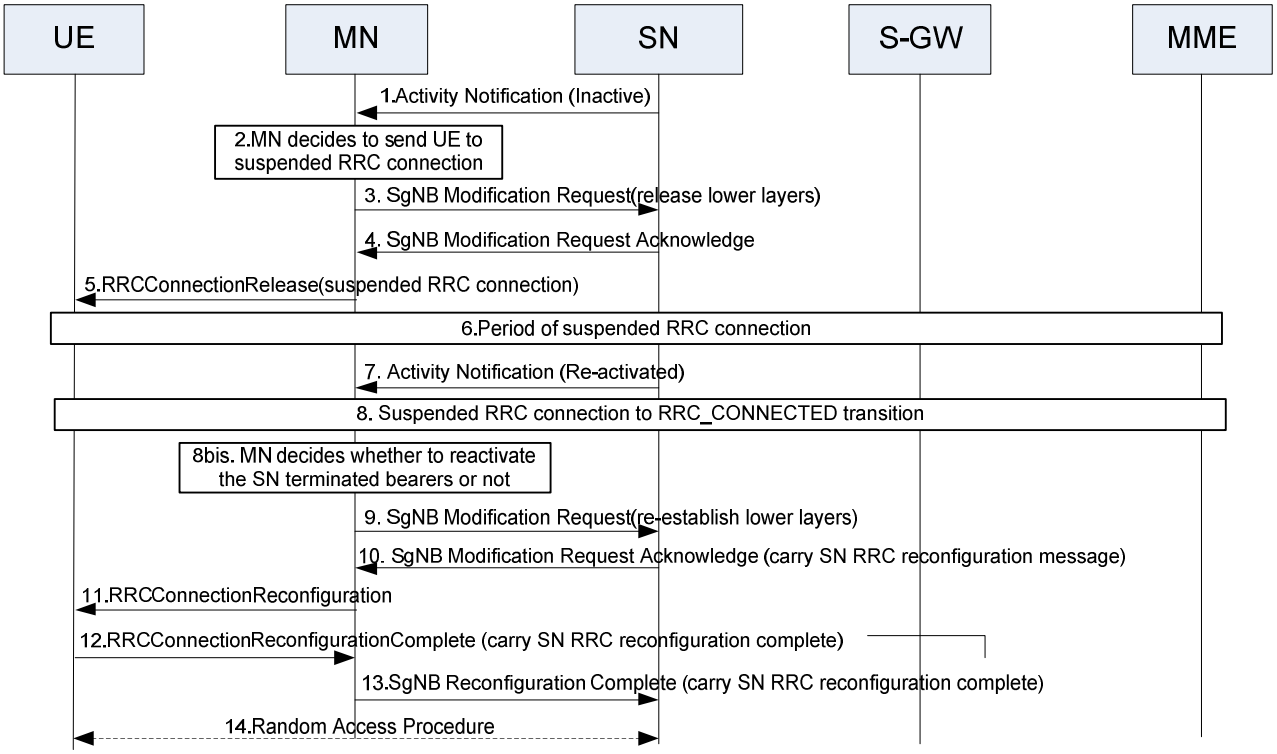


Figure 10.12.1-2: Support of Activity Notification in EN-DC with suspended RRC connection – SCG configuration released in SN

Figure 10.12.1-2 shows how Activity Notification function interacts with E-UTRAN functions for suspended RRC connection and SgNB Modification procedures in order to keep the higher layer EN-DC E-UTRAN resources established for UEs in suspended RRC connection, including S1 and X2 interface C-plane, U-plane and bearer contexts established while lower layer MCG and SCG resources are released. E-UTRAN memorises the cell group configuration for MCG in order to apply delta signalling at resume, as specified in TS 36.331 [4]. After the UE has transited successfully back to RRC_CONNECTED, lower layer SCG resources are established afterwards by means of RRC Connection Reconfiguration.

1. The SN notifies the MN about user data inactivity for SN terminated bearers.

2. The MN decides to send the UE to suspended RRC connection.

3/4. The MN triggers the MN initiated SgNB Modification procedure, requesting the SN to release lower layers.

5. The UE is sent to suspended RRC connection.

6-8. After a period of suspended RRC connection, upon activity notification from the SN, the UE returns to RRC_CONNECTED.

8bis. MN decides whether to reactivate the SN terminated bearers. If (e.g. due to UE mobility), MN decides not to reactivate the SN terminated bearers, it initiates the MN initiated SN release procedure and the procedure ends.

9/10. The MN triggers the MN initiated SgNB Modification procedure to re-establish lower layers. The SN provides configuration data within an SN RRC configuration message.

11-14. The RRC Connection Reconfiguration procedure commences.

EN-DC with suspended RRC connection - SCG configuration suspended in SN

The Activity Notification function may be used to enable EN-DC with suspended RRC connection operation. The MN node may decide, after inactivity is reported from the SN and also MN resources show no activity, to send the UE to suspended RRC connection, while keeping the SCG configuration. Resumption to RRC_CONNECTED may take place after activity is reported from the SN for SN terminated bearers.

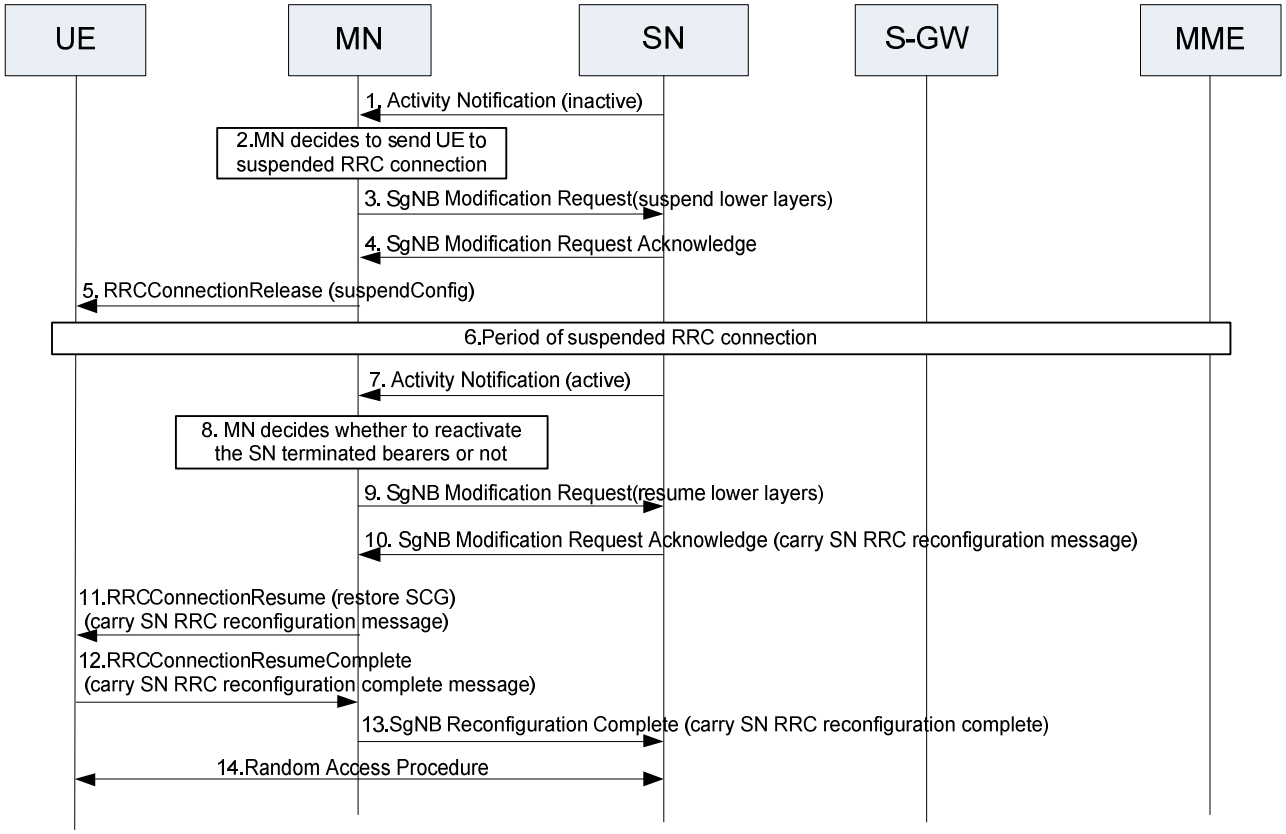


Figure 10.12.1-3: Support of Activity Notification in EN-DC with suspended RRC connection - SCG configuration suspended in SN

Figure 10.12.1-3 shows how Activity Notification function interacts with functions for suspended RRC connection and SgNB Modification procedures in order to keep the full EN-DC resources established for UEs in suspended RRC connection. When the UE transits successfully back to RRC_CONNECTED, lower layer MCG and SCG configurations are restored or reconfigured by means of RRC Connection Resume.

1. The SN notifies the MN about user data inactivity for SN terminated bearers.

2. The MN decides to send the UE to suspended RRC connection.

3/4. The MN triggers the MN initiated SN Modification procedure, requesting the SN to suspend lower layers.

5. The UE is sent to suspended RRC connection.

6-7. After a period of suspended RRC connection, the MN receives activity notification from the SN.

8. The MN decides whether to reactivate the SN terminated bearers. If (e.g. due to UE mobility), the MN decides not to reactivate the SN terminated bearers, it initiates the MN initiated SN release procedure, rather than the MN initiated SN modification procedure in steps 9/10. If the MN decides to return the UE to RRC_CONNECTED, the network triggered state transition from suspended RRC connection to RRC_CONNECTED commences.

9/10. The MN triggers the MN initiated SN Modification procedure to resume the SCG lower layers. If the SCG configuration needs to be updated, the SN provides the configuration data within an SN RRC configuration message.

11/12. The UE is instructed to resume both the MCG and the SCG. If the SCG configuration is to be updated, the new configuration is provided in the *RRCConnectionResume* message.

13. The MN informs the SN that the UE has completed the reconfiguration procedure successfully, via the *SgNB Reconfiguration Complete* message, including the SN RRC response message, if received from the UE.

14. The UE performs synchronisation towards the PSCell of the SN.

10.12.2 MR-DC with 5GC

The Activity Notification function is used to report user plane activity within SN resources or to report a RAN Paging Failure event to the SN. It can either report inactivity or resumption of activity after inactivity was reported. In MR-DC with 5GC the Activity Reporting is provided from the SN only. The MN may take further actions. RAN Paging Failure Reporting is provided from the MN only.

MR-DC with 5GC Activity Notification

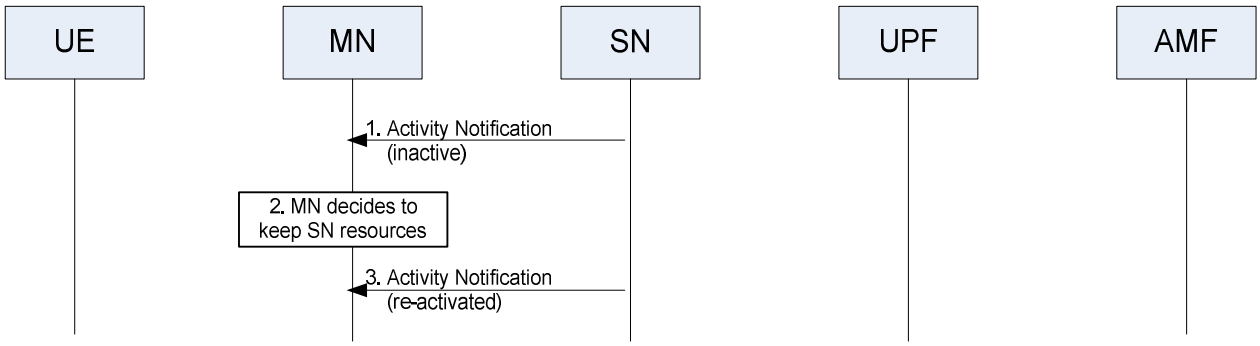


Figure 10.12.2-1: Support of Activity Notification in MR-DC with 5GC

1. The SN notifies the MN about user data inactivity.
2. The MN decides further actions that impact SN resources (e.g. send UE to RRC_INACTIVE, bearer reconfiguration). In the case shown, MN takes no action.
3. The SN notifies the MN that the (UE or PDU Session or QoS flow) is no longer inactive.

MR-DC with 5GC with RRC_INACTIVE – SCG configuration released in SN

The Activity Notification function may be used to enable MR-DC with 5GC with RRC_INACTIVE operation. The MN node may decide, after inactivity is reported from the SN and also MN resources show no activity, to send the UE to RRC_INACTIVE. Resumption to RRC_CONNECTED may take place after activity is reported from the SN for SN terminated bearers.

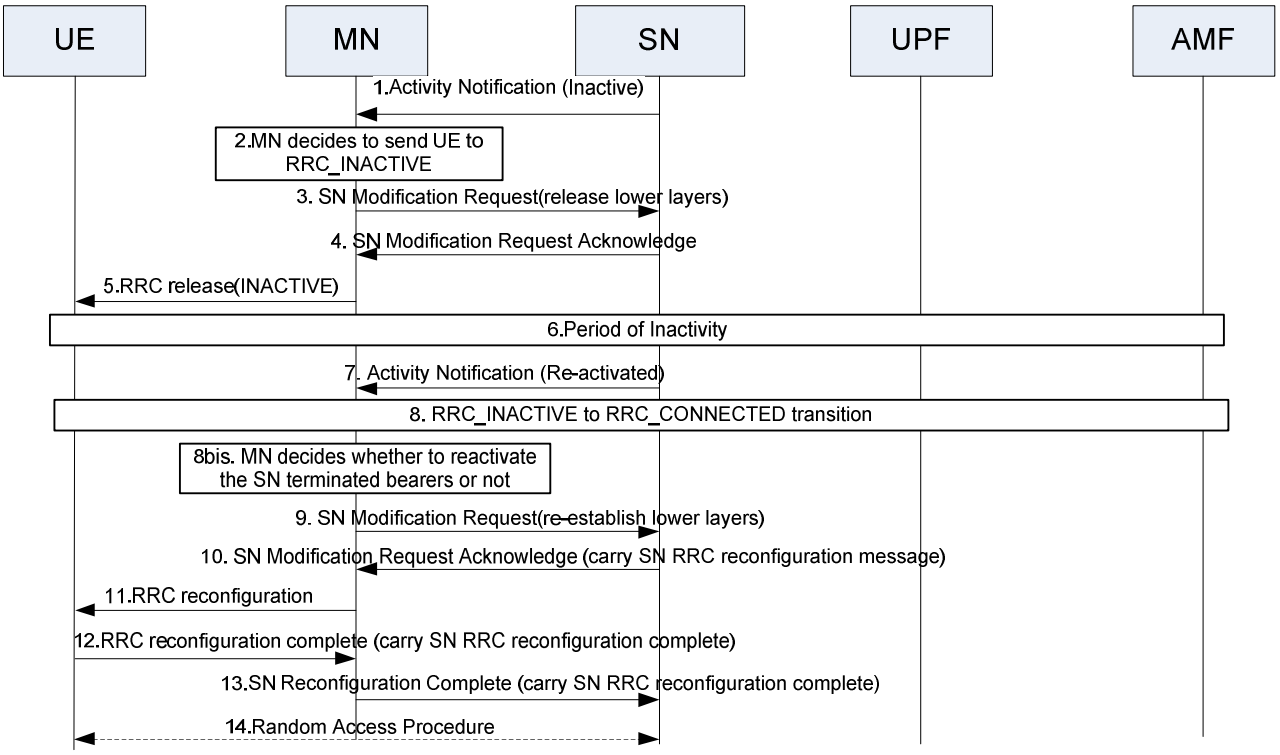


Figure 10.12.2-2: Support of Activity Notification in MR-DC with 5GC with RRC_Inactive – SCG configuration released in SN

Figure 10.12.2-2 shows how Activity Notification function interacts with NG-RAN functions for RRC_INACTIVE and SN Modification procedures in order to keep the higher layer MR-DC NG-RAN resources established for UEs in RRC_INACTIVE, including NG and Xn interface C-plane, U-plane and bearer contexts established while lower layer MCG and SCG resources are released. NG-RAN memorises the cell group configuration for MCG in order to apply delta signalling at resume, as specified in TS 38.331 [4]. After the UE has transited successfully back to RRC_CONNECTED, lower layer SCG resources are established afterwards by means of RRC Connection Reconfiguration.

1. The SN notifies the MN about user data inactivity for SN terminated bearers.
2. The MN decides to send the UE to RRC_INACTIVE.

3/4. The MN triggers the MN initiated SN Modification procedure, requesting the SN to release lower layers.

5. The UE is sent to RRC_INACTIVE.

6-8. After a period of inactivity, upon activity notification from the SN, the UE returns to RRC_CONNECTED.

8bis. MN decides whether to reactivate the SN terminated bearers. If (e.g. due to UE mobility), MN decides not to reactivate the SN terminated bearers, it initiates the MN initiated SN release procedure and the procedure ends.

9/10. The MN triggers the MN initiated SN Modification procedure to re-establish lower layers. The SN provides configuration data within an SN RRC reconfiguration message.

11-14. The RRC Connection Reconfiguration procedure commences.

MR-DC with 5GC with RRC_INACTIVE - SCG configuration suspended in SN

The Activity Notification function may be used to enable MR-DC with 5GC with RRC_INACTIVE operation. The MN node may decide, after inactivity is reported from the SN and also MN resources show no activity, to send the UE to RRC_INACTIVE, while keeping the SCG configuration. Resumption to RRC_CONNECTED may take place after activity is reported from the SN for SN terminated bearers.

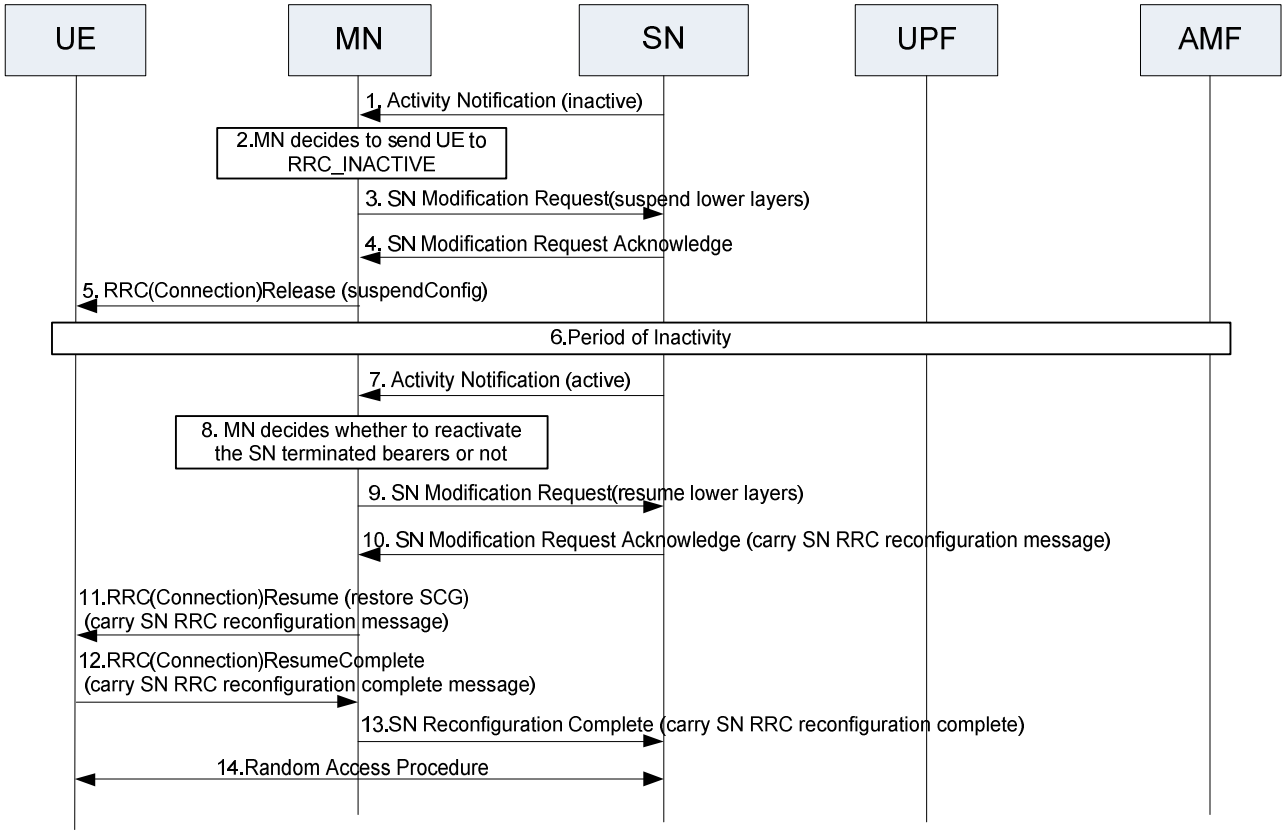


Figure 10.12.2-3: Support of Activity Notification in MR-DC with 5GC with RRC_Inactive - SCG configuration suspended in SN

Figure 10.12.2-3 shows how Activity Notification function interacts with NG-RAN functions for RRC_INACTIVE and SN Modification procedures in order to keep the full MR-DC NG-RAN resources established for UEs in RRC_INACTIVE. When the UE transits successfully back to RRC_CONNECTED, lower layer MCG and SCG configurations are restored or reconfigured by means of RRC (Connection) Resume.

1. The SN notifies the MN about user data inactivity for SN terminated bearers.

2. The MN decides to send the UE to RRC_INACTIVE.

3/4. The MN triggers the MN initiated SN Modification procedure, requesting the SN to suspend lower layers.

5. The UE is sent to RRC_INACTIVE.

6-7. After a period of inactivity, the MN receives activity notification from the SN.

8. The MN decides whether to reactivate the SN terminated bearers. If (e.g. due to UE mobility), the MN decides not to reactivate the SN terminated bearers, it initiates the MN initiated SN release procedure, rather than the MN initiated SN modification procedure in steps 9/10. If the MN decides to return the UE to RRC_CONNECTED, the network triggered state transition from RRC_INACTIVE to RRC_CONNECTED commences as described in clause 9.2.2.4.2 in TS 38.300 [3].

9/10. The MN triggers the MN initiated SN Modification procedure to resume the SCG lower layers. If the SCG configuration needs to be updated, the SN provides the configuration data within an SN RRC reconfiguration message.

11/12. The UE is instructed to resume both the MCG and the SCG. If the SCG configuration is to be updated, the new configuration is provided in the RRC(Connection)Resume message.

13. The MN informs the SN that the UE has completed the reconfiguration procedure successfully, via the *SN Reconfiguration Complete* message, including the SN RRC response message, if received from the UE.

14. The UE performs synchronisation towards the PSCell of the SN.

10.13 Notification Control Indication

10.13.1 EN-DC

Notification Control Indication procedure is not supported in EN-DC.

10.13.2 MR-DC with 5GC

The Notification Control Indication procedure may be initiated either by the MN or by the SN and is used to indicate that GFBR for one or several QoS flows cannot be fulfilled any more or can be fulfilled again by the reporting node.

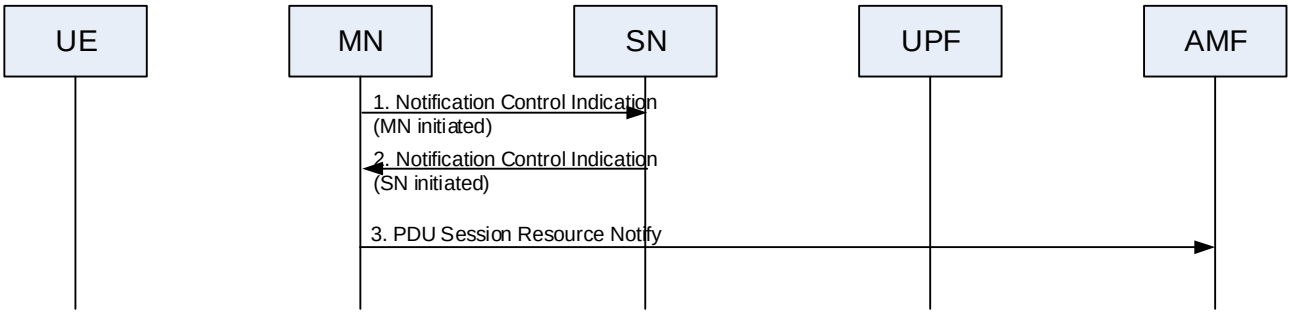


Figure 10.13.2-1: Notification Control Indication procedure

Figure 10.13.2-1 shows an example signalling flow for the Notification Control Indication procedure.

1. The MN may, for an SN terminated bearer, indicate, that the GFBR requested from the MN cannot be fulfilled anymore.
   In case the SN terminated bearer is configured as a split bearer, the SN may decide to increase the share provided by the SN or it may decide to notify the MN that resources requested for the SN terminated bearer cannot fulfill the GFBR any more.

2. Continuing the example message flow from step 1, the SN informs the MN that the GFBR for an SN terminated bearer cannot be fulfilled any more.

3. The MN decides to inform the 5GC that NG-RAN cannot fulfill the GFBR for a GBR QoS flow any more.

10.14 PDU Session Split at UPF

10.14.1 PDU Session Split at UPF during PDU session resource setup

When a new PDU session needs to be established, the 5GC may provide two UL TEID addresses during PDU Session Resource Setup in order to allow for PDU session split. The MN may perform the SN Addition or the MN-initiated SN Modification procedure. If the MN decides to split the PDU session, the MN provides two DL TEID addresses and also the QoS flows associated with each tunnel.

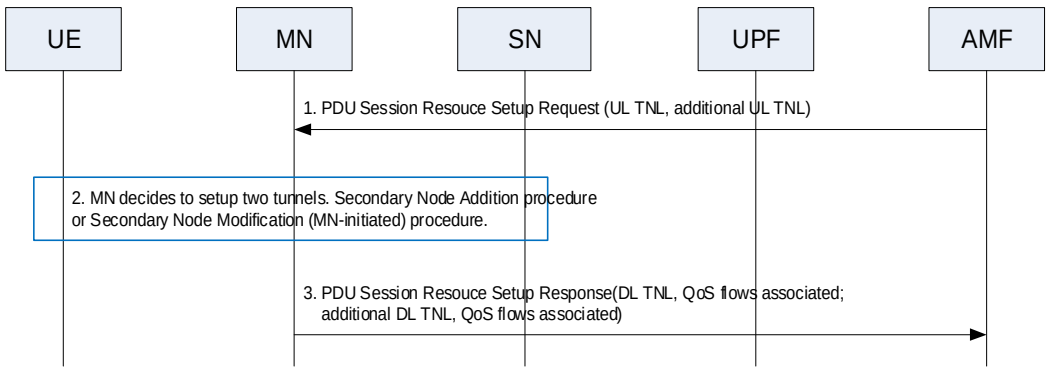


Figure 10.14.1-1: PDU Session Split at UPF during PDU session resource setup

1. The 5GC provides two UL TEID addresses during PDU Session Resource Setup, to be applied as the first UL tunnel on the NG-U interface and the additional NG-U tunnel in case the MN decides to split the PDU session.
2. The MN decides to setup two tunnels. The MN uses the SN Addition procedure (as described in 10.2.2) or the MN-initiated SN Modification procedure (as described in 10.3.2) up to step 6.
3. The MN provides a DL TEID address to be applied as the first and an additional DL tunnel address on the NG-U interface. The MN also provides which QoS flows are associated with which tunnel.

10.14.2 PDU Session Split at UPF during PDU session resource modify (5GC initiated)

The 5GC may provide an additional UL TEID address during PDU Session Resource Modify in order to allow the MN to split the PDU session. The MN may perform the SN Addition or the MN-initiated SN Modification procedure. If the MN decides to split the PDU session, the MN provides a DL TEID address to be applied as the additional DL tunnel address and the QoS flows associated with that tunnel.

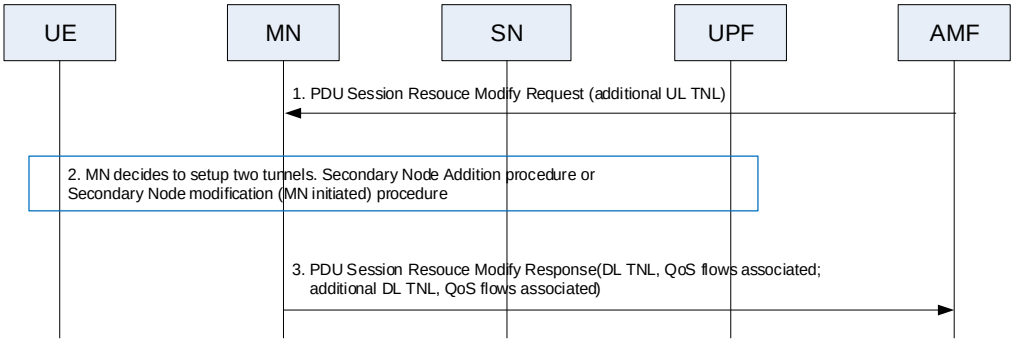


Figure 10.14.2-1: PDU Session Split at UPF during PDU session resource modify

1. The 5GC provides an additional UL TEID address during PDU Session Resource Modify, to be applied as the additional NG-U tunnel in case the MN decides to split the PDU session.
2. The MN decides to setup two tunnels. If the new tunnel is to be setup at the SN, the MN uses the SN Addition procedure (as described in 10.2.2) or the MN-initiated SN Modification procedure (as described in 10.3.2) up to step 6, or up to step 8 if a QoS flow is moved to the SN and data forwarding applies.
3. The MN provides a DL TEID address to be applied as the additional DL tunnel address on the NG-U interface and the QoS flows associated with that tunnel.

10.14.3 PDU Session Split at UPF (RAN initiated QoS flows offloading from MN to SN)

When some QoS flows are offloaded from the MN to the SN, the MN may decide to split the PDU session served by the MN into more than one NG-U tunnels. The MN sends the *SN Addition/Modification Request* message including UPF UL TEID address used at the MN. Later on, if the MN receives a new UL TEID in the *PDU Session Resource Modify Confirm* message, the MN may provide the new UL TEID to the SN.

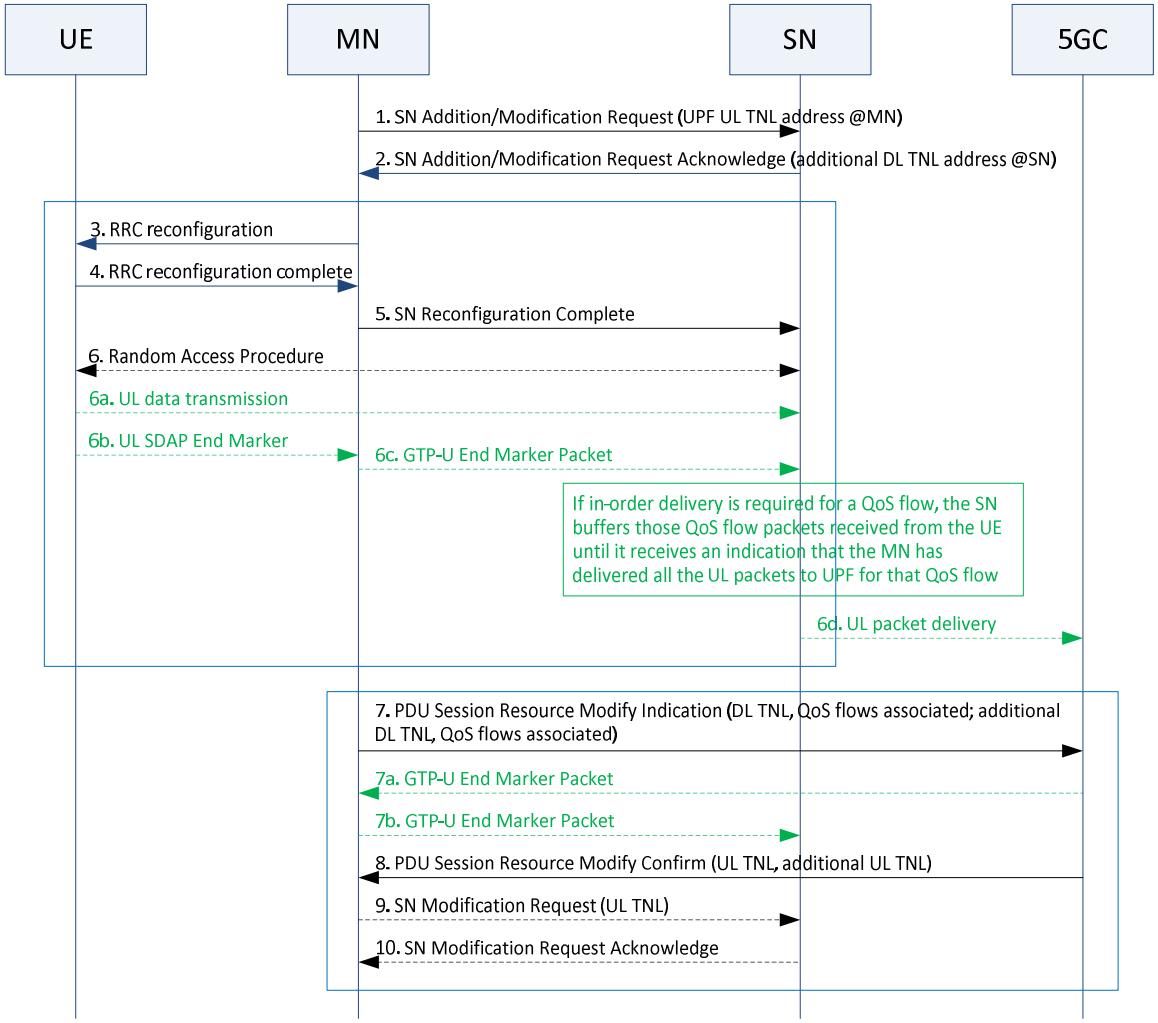


Figure 10.14.3-1: PDU Session Split at UPF during RAN initiated PDU session resource modify (QoS flows offloading from MN to SN)

1-2. If the MN decides to split a PDU session, it uses the SN Addition procedure or the MN-initiated SN Modification procedure, including current UPF UL NG-U tunnel used at the MN. If in-order delivery is required for some QoS flows, an UL forwarding tunnel may be setup for the PDU session at this stage.

NOTE 1: In case the MN offloads some QoS flows to the SN within a PDU session already split between the MN and the SN, the MN initiated SN Modification procedure is used.

3-6d. If in-order delivery is required, the SN buffers the first packets received from the UE for a certain QoS flow until it receives an GTP-U end marker packet over the UL forwarding tunnel indicating that the MN has delivered all UL packets from the source side to UPF for that QoS flow. Then the SN starts delivering UL packets to UPF for that QoS flow using the UPF UL TEID address used at the MN received at step 1.

7-8. The MN uses the *PDU Session Resource Modify Indication* message to inform 5GC that the PDU session is split into two tunnels and indicate which QoS flows are associated with which DL tunnel. The 5GC triggers the sending of DL End Marker packets without QFI tag at step 7a and confirms with the *PDU Session Resource Modify Confirm* message and allocates corresponding uplink tunnels.

After receiving the End Marker packet(s) from UPF at step 7a, the MN determines that the End Marker packets only work on the offloaded QoS flows, and may stop delivering and discard DL packets of the offloaded QoS flows, and the MN shall continue transmiting DL packets for the not offloaded QoS flows, if any.

7a./7b. After receiving the DL end marker from 5GC at step 7a, the MN may generate at step 7b DL End Marker packets without QFI tag towards the SN.

9-10. If the MN receives a new UL TEID in the *PDU Session Resource Modify Confirm* message for itself, the MN will use it to deliver UL packets to UPF. If the MN receives a new UL TEID for the SN, then the MN-initiated

SN Modification procedure (i.e., step 9 and step 10) is used to provide the new UL TEID to the SN and then the SN switches to use the new UL TEID to deliver UL packets.

10.14.4 PDU Session Split at UPF (RAN initiates QoS flows offloading from SN to MN)

When some QoS flows are offloaded from the SN to the MN, the MN may decide to split the PDU session served by the SN into more than one NG-U tunnels. If the MN requests to offload, the MN sends the *SN Modification Request* message to the SN. In case the SN requests to offload, the SN sends the *SN Modification Required* message to the MN.

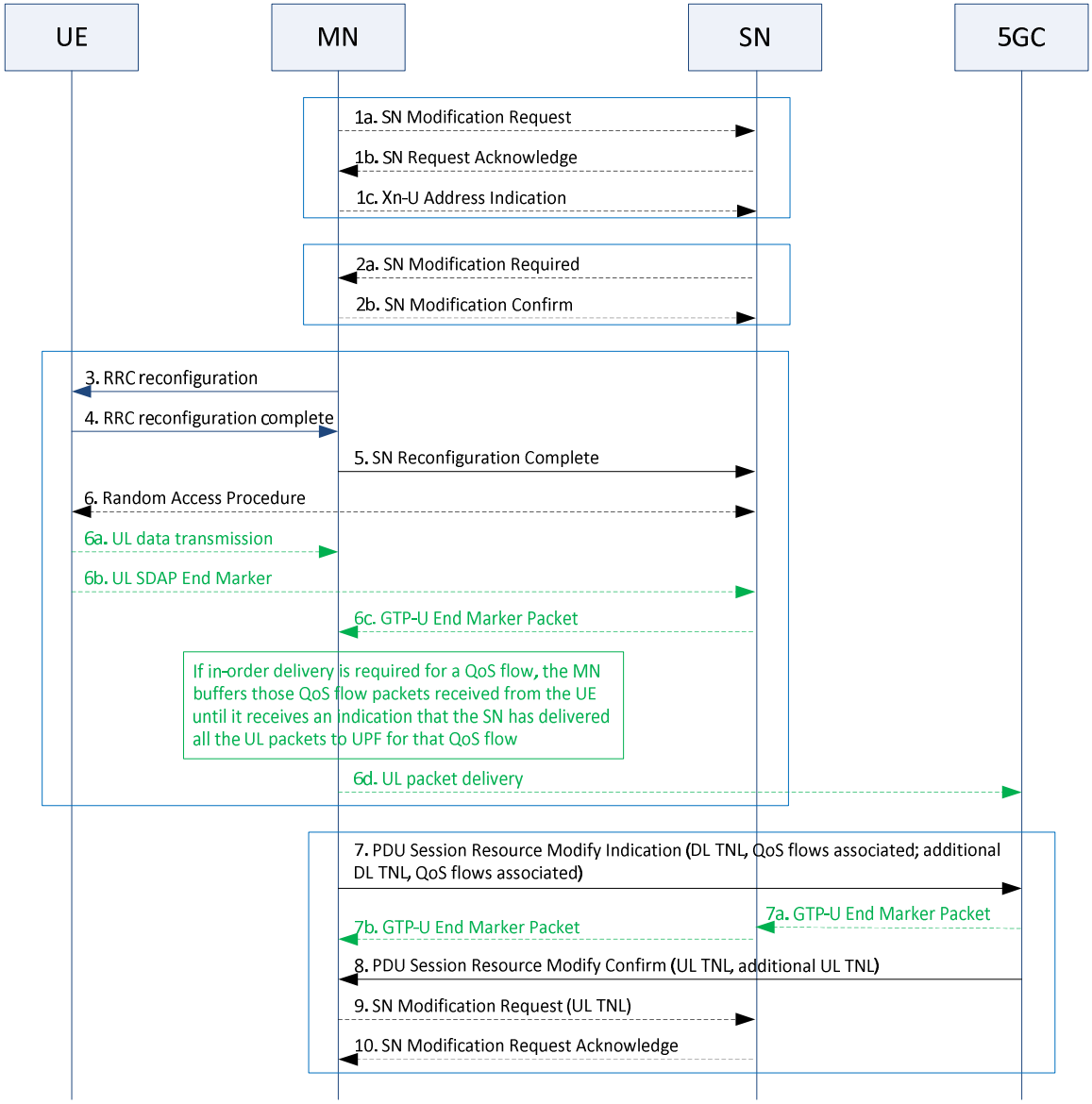


Figure 10.14.4-1: PDU Session Split at UPF during RAN initiated PDU session resource modify (QoS flows offloading from SN to MN)

1a-1c. When the MN requests to offload some QoS flows from the SN to the MN for a PDU session, it sends the *SN Modification Request* message. If in-order delivery is required for some of the QoS flows, an UL forwarding tunnel may be setup for the PDU session at this stage and the MN provides the UL forwarding tunnel address information in the *Xn-U Address Indication* message.

2a-2b. When the SN requests to offload some QoS flows to the MN for a PDU session, the SN sends the *SN Modification Required* message. If in-order delivery is required for some of the QoS flows, an UL forwarding tunnel may be setup for the PDU session at this stage and the MN provides the UL forwarding tunnel address information in the *SN Modification Confirm* message.

3-6d. If in-order delivery is required, the MN buffers the first packets received from the UE for a certain QoS flow until it receives an GTP-U end marker packet over the UL forwarding tunnel indicating that the SN has delivered all UL packets from the source side to UPF for that QoS flow.

7-8. The MN uses the *PDU Session Resource Modify Indication* message to inform 5GC that the PDU session is split into two tunnels and indicate which QoS flows are associated with which DL tunnel. The 5GC triggers the sending of DL End Marker packets without QFI tag at step 7a and confirms with the *PDU Session Resource Modify Confirm* message and allocates corresponding uplink tunnels.

After receiving the End Marker packet(s) from UPF at step 7a, the SN determines that the End Marker packets only work on the offloaded QoS flows, and may stop delivering and discard DL packets of the offloaded QoS flows, and the SN shall continue transmiting DL packets for the not offloaded QoS flows, if any.

7a./7b. After receiving the DL end marker from 5GC at step 7a, the SN may generate at step 7b DL End Marker packets without QFI tag towards the MN.

9-10. If the MN receives a new UL TEID in the *PDU Session Resource Modify Confirm* message for itself, the MN will use it to deliver UL packets to UPF. If the MN receives a new UL TEID for the SN, then the MN-initiated SN Modification procedure (i.e., the step 9 and step 10) is used to provide the new UL TEID to the SN and then the SN switches to use the new UL TEID to deliver UL packets.

10.15 F1-C Traffic Transfer

In EN-DC/NR-DC, the F1-C Traffic Transfer message is sent by the MN to the SN or by the SN to MN to transfer the F1-C traffic to and from an IAB-node.

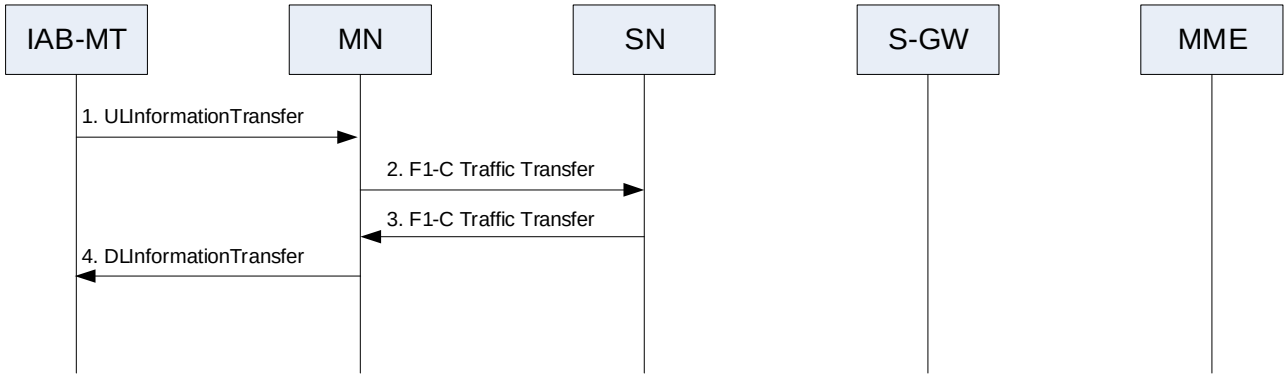


Figure 10.15-1: F1-C Traffic Transfer procedure in EN-DC

1. When the IAB-MT receives from its co-located IAB-DU an F1-AP message encapsulated in SCTP/IP or an F1-C related (SCTP/)IP packet, it forwards it to the MN in a container within *ULInformationTransfer* message as specified in TS 36.331 [10].

2. The MN initiates the F1-C Traffic Transfer procedure, in which it transfers the received F1-AP message encapsulated in (SCTP/)IP or the F1-C related (SCTP/)IP packet as an octet string.

3. When the SN sends an F1-AP message encapsulated in SCTP/IP or an F1-C related (SCTP/)IP packet, it sends it to the MN as an octet string by initiating the F1-C Traffic Transfer procedure.

4. The MN sends the received F1-AP message encapsulated in SCTP/IP or the F1-C related (SCTP/)IP packet to the IAB-MT in a container within *DLInformationTransfer* message as specified in TS 36.331 [10].

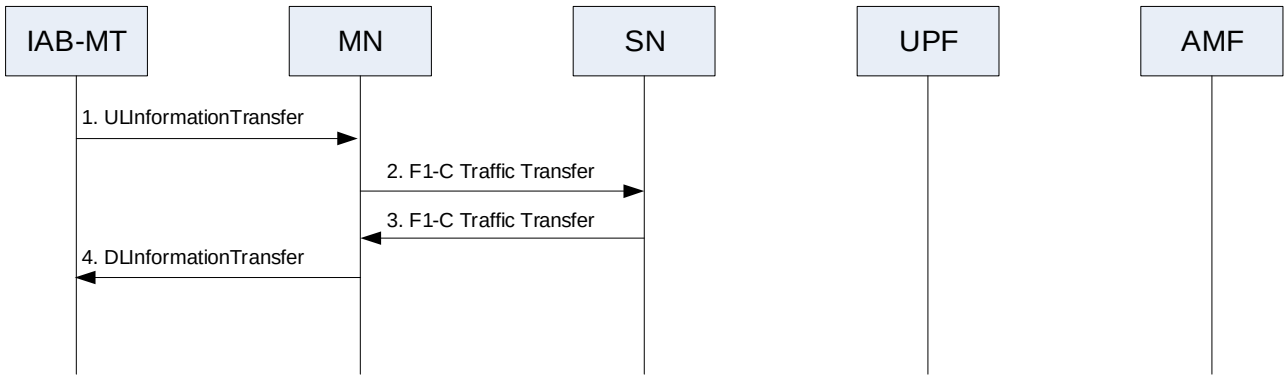


Figure 10.15-2: F1-C Traffic Transfer procedure for scenario 1 of F1-C traffic transfer in NR-DC

1. The IAB-MT receives from its co-located IAB-DU an F1-AP message encapsulated in SCTP/IP or an F1-C related (SCTP/)IP packet and forwards it to the MN via SRB2 in a container within *ULInformationTransfer* message as specified in TS 38.331 [4].
2. The MN initiates the F1-C Traffic Transfer procedure, in which it transfers the received F1-AP message encapsulated in (SCTP/)IP or the F1-C related (SCTP/)IP packet as an octet string.
3. The SN (IAB-donor) sends an F1-AP message encapsulated in SCTP/IP or an F1-C related (SCTP/)IP packet to the MN as an octet string by initiating the F1-C Traffic Transfer procedure.
4. The MN sends the received F1-AP message encapsulated in SCTP/IP or the F1-C related (SCTP/)IP packet to the IAB-MT via SRB2 in a container within *DLInformationTransfer* message as specified in TS 38.331 [4].

10.16 Support of inter-system handover involving EN-DC or MR-DC with 5GC

10.16.1 General

Inter-system handover is specified in TS 23.501 [11] and TS 23.502 [20]. Data forwarding for inter-system handover is specified in TS 38.300 [3] and clause 8.4.

Inter-system Inter-Master node handover with/without SN change is not supported in this version of the protocol (e.g. no transition from EN-DC to NGEN-DC or NR-DC).

Inter-system HO from NR to E-UTRA with EN-DC configuration is supported in this version of the specification. N26 based inter-system HO will be executed between source RAN and gNB.

Inter-system HO from E-UTRA connected to 5GC to E-UTRA with EN-DC configuration is not supported. Inter-system HO from E-UTRA with EPC to MR-DC with 5GC is not supported.

Inter-system handover with source gNB and the target en-gNB or the source en-gNB and the target gNB being realised within the same network entity is supported in this version of the specification as described in clause 10.16.2 and clause 10.16.3.

10.16.2 Inter-system handover from EPS to 5GS with the Secondary Node used as target

Inter-system handover from EPS to 5GS with the Secondary Node used as target refers to a deployment scenario where the source en-gNB and the target gNB are realised within the same network entity.

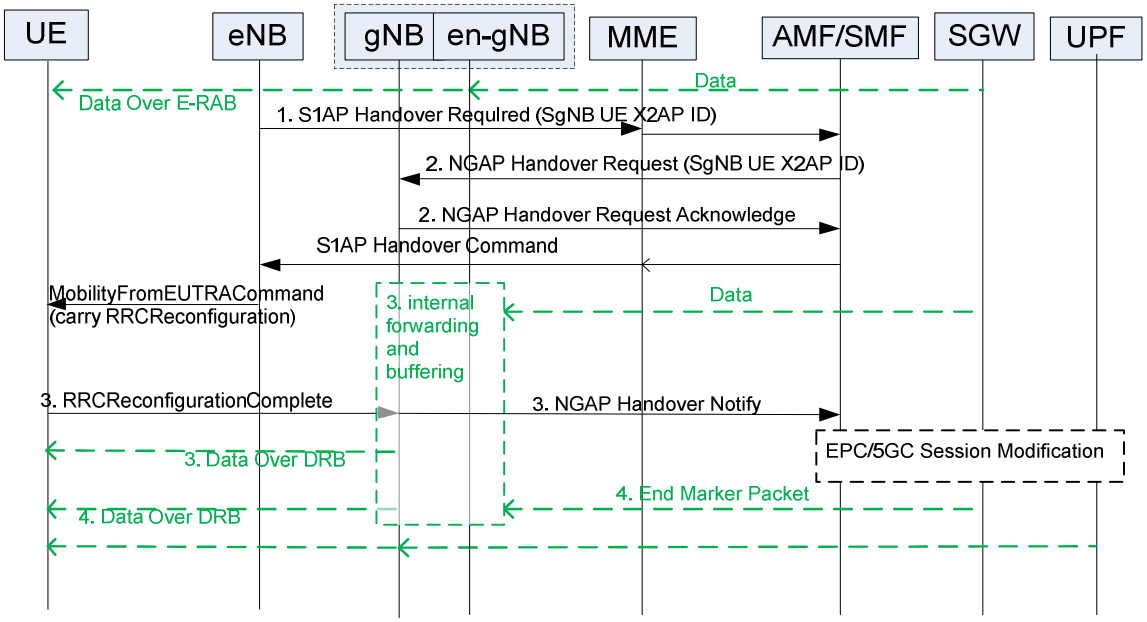


Figure 10.16.2-1: Inter-system handover from EPS to 5GS with the Secondary Node used as target

- Step 1: The (source) eNB, performing EN-DC with the (source) en-gNB triggers handover preparation including the SgNB UE X2AP ID within the Source NG-RAN to Target NG-RAN Transparent Container.
- Step 2: The target gNB infers from the received SgNB UE X2AP ID in the *Handover Request* message that direct data forwarding can be performed in a node-internal way.
- Step 3: DL UP data is forwarded in a node-internal way for the SN terminated bearers.
- Step 4: After the end marker has arrived from the SGW, the (target) gNB processes UP data from the UPF.

10.16.3 Inter-system handover from 5GS to EPS with the Source Node used as target Secondary Node

Inter-system handover from 5GS to EPS with the Source Node used as target Secondary Node refers to a deployment scenario where the source gNB and the target en-gNB are realised within the same network entity.

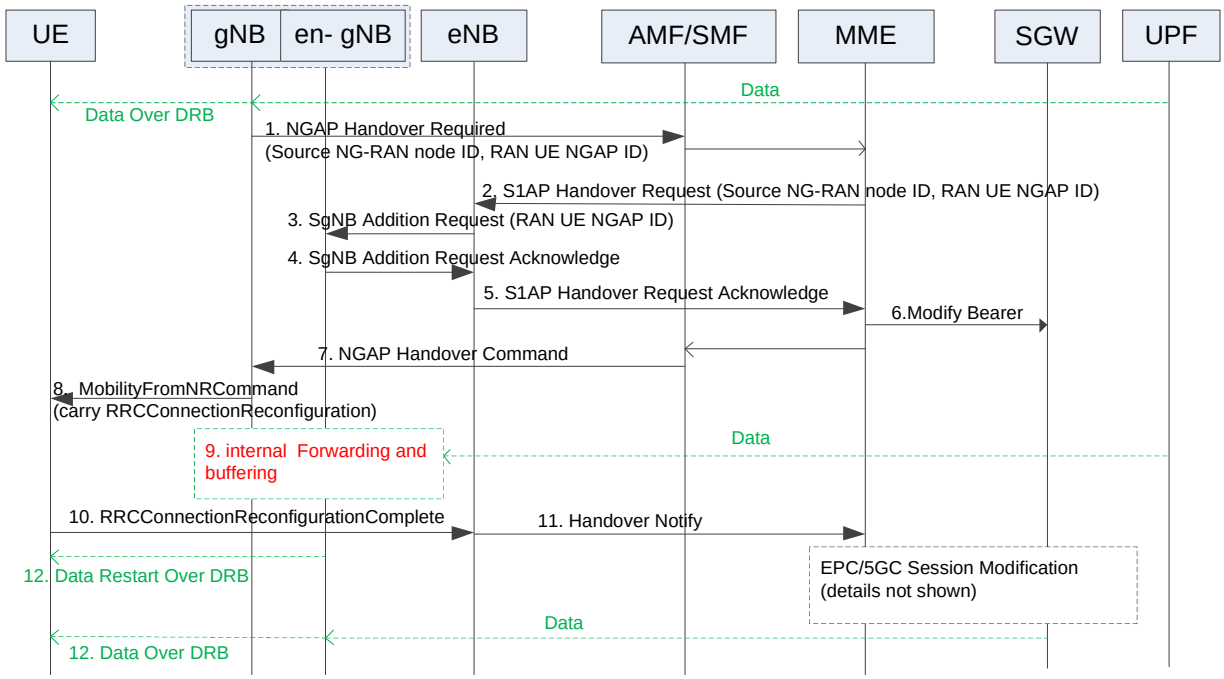


Figure 10.16.3-1: Inter-system handover from 5GS to EPS with the Source Node used as target Secondary Node

1. The (source) gNB triggers handover preparation phase including in the Source eNB to Target eNB Transparent Container the Source NG-RAN node ID and the RAN UE NGAP ID.

2. The target eNB receives the Source NG-RAN node ID and the RAN UE NGAP ID in the Source eNB to Target eNB Transparent Container.

3.-4. The X2AP SgNB Addition procedure is performed towards the (target) en-gNB indicated in the Source NG-RAN node ID received in step 2. The eNB includes the RAN UE NGAP ID received in step 2 in the X2 *SgNB Addition Request* message.

5.-8. Handover proceeds.

9. DL UP data is forwarded in a node-internal way for the SN terminated bearers.

10.17 Inter-Master Node RRC Resume without Secondary Node change

10.17.1 MR-DC with 5GC

Inter-MN RRC Resume without MN initiated SN change is used to transfer UE context data from a source MN to a target MN while the UE context at the SN is kept. During the procedure, the target MN may decide not to keep the SN.

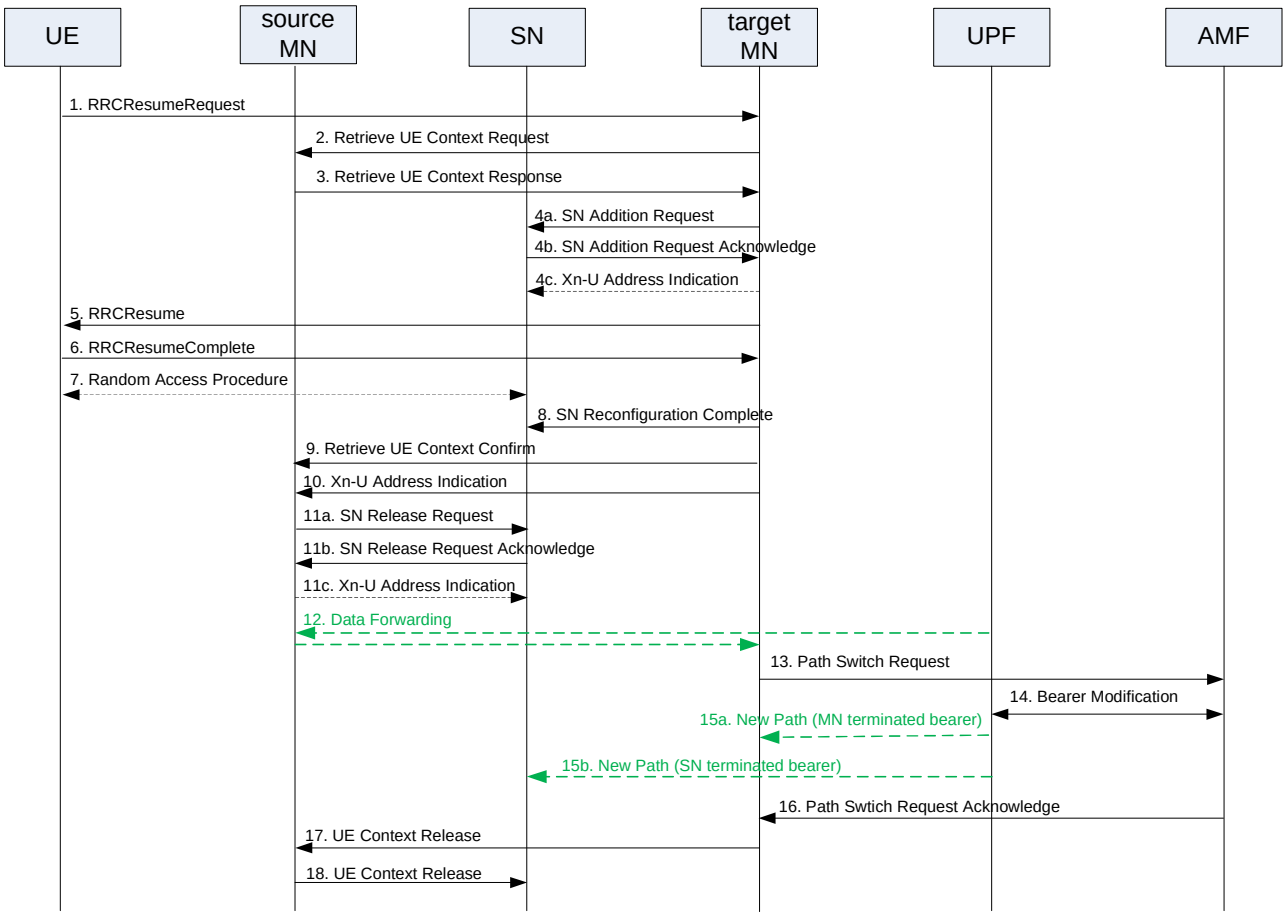


Figure 10.17.1-1: Inter-MN RRC Resume without MN initiated SN change procedure

Figure 10.17.1-1 shows an example signalling flow for inter-MN RRC Resume without MN initiated SN change:

1. The UE resumes from RRC_INACTIVE, providing the I-RNTI, allocated by the source MN, i.e., the last serving NG-RAN node.

2. The target MN, if able to resolve the NG-RAN node identity contained in the I-RNTI, requests the source MN to provide UE Context by initiating the Xn Retrieve UE Context procedure.

3. If the verification is successful, the source MN provides UE context data. The source MN includes the SN UE XnAP ID, SN ID and the UE context in the SN in the *Retrieve UE Context Response* message.

NOTE 1: The source MN may trigger the MN-initiated SN Modification procedure (to the SN) to retrieve the current SCG configuration and to allow provision of data forwarding related information before step 3.4a. If the target MN decides to keep the SN, the target MN sends *SN Addition Request* to the SN including the SN UE XnAP ID as a reference to the UE context in the SN that was established by the source MN.

4b. The SN replies with *SN Addition Request Acknowledge* message.

4c. For SN terminated bearers using MCG resources, the target MN provides Xn-U DL TNL address information in the *Xn-U Address Indication* message.

5/6. The target MN and UE complete the resumption of the RRC connection.

7. If configured with bearers requiring SCG radio resources, the UE synchronizes to the SN.

NOTE 2: The order the UE sends the *RRCResumeComplete* message towards the target MN (step 6) and performs the Random Access procedure towards the SN (step 7) is not defined.

8. If the RRC connection reconfiguration procedure was successful, the target MN informs the SN via *SN Reconfiguration Complete* message.

9. If the RRC connection reconfiguration procedure was successful, the target MN initiates the Xn Retrieve UE Context Confirm procedure and indicates to the source MN whether the UE context in the SN is kept or not.

10. The Xn-U Address Indication procedure may be invoked by the target MN to provide forwarding address information if loss of DL user data buffered in the source side needs to be avoided.

11a/11b. The source MN sends *SN Release Request* message to the SN including a Cause indicating MCG mobility. The SN acknowledges the release request. The source MN indicates to the SN that the UE context in the SN is kept, if it receives the indication from the target MN. If the indication as the UE context kept in the SN is included, the SN keeps the UE context.

11c. If received in step 10, the source MN sends the *Xn-U Address Indication* message to the SN to transfer data forwarding information. More than one data forwarding addresses may be provided if the PDU session is split in the target side.

12. If applicable, data forwarding takes place from the source side. If the SN is kept, data forwarding may be omitted for SN terminated bearers or QoS flows kept in the SN.

13-16. The target MN initiates the Path Switch procedure. If the target MN includes multiple DL TEIDs for one PDU session in the *Path Switch Request* message, multiple UL TEID of the UPF for the PDU session should be included in the *Path Switch Ack* message in case there is TEID update in UPF.

NOTE 3: If new UL TEIDs of the UPF for SN terminated bearers are included, the target MN performs MN initiated SN Modification procedure to provide them to the SN.

17. The target MN initiates the UE Context Release procedure towards the source MN.

18. Upon reception of the *UE Context Release* message from source MN, the SN releases C-plane related resources associated to the UE context towards the source MN. Any ongoing data forwarding may continue. The SN shall not release the UE context associated with the target MN if the UE context kept indication was included in the *SN Release Request* message in step 11.

10.18 Self-optimisation for PSCell addition/change

10.18.1 General

For analysis of PSCell addition/change failure, the UE makes the SCG Failure Information available to the MN. If it is SN-initiated PSCell change/CPC, the SN may make the SN mobility information available to the MN which can later send it back to the SN when the failure occurs.

10.18.2 PSCell change failure

One of the functions of self-optimization for PSCell change is to detect PSCell change failures that occur due to Too late PSCell change or Too early PSCell change, or Triggering PSCell change to wrong PSCell. These problems are defined as follows:

- Too late PSCell change: an SCG failure occurs after the UE has stayed for a long period of time in the PSCell; a suitable different PSCell is found based on the measurements reported from the UE.

- Too early PSCell change: an SCG failure occurs shortly after a successful PSCell change from a source PSCell to a target PSCell or a PSCell change failure occurs during the PSCell change procedure; source PSCell is still the suitable PSCell based on the measurements reported from the UE.

- Triggering PSCell change to wrong PSCell: an SCG failure occurs shortly after a successful PSCell change from a source PSCell to a target PSCell or a PSCell change failure occurs during the PSCell change procedure; a suitable PSCell different with source PSCell or target PSCell is found based on the measurements reported from the UE.

In the definition above, the "successful PSCell change" refers to the UE state, namely the successful completion of the RA procedure.

MN performs initial analysis to identify the node that caused the failure. The MN may use the SCG Failure Information Report procedure to verify whether intra-SN PSCell change has been triggered in the last serving SN and stores the SCG Failure Information for the time needed to receive possible response from the last serving SN. If the failure is caused by a source SN, the MN forwards then the SCG Failure Information to the source SN. The node responsible for the last PSCell change (the source SN, the last serving SN or the MN) performs the final root cause analysis.

10.18.3 Conditional PSCell addition or change failure

One of the functions of self-optimization for CPAC is to detect CPAC failures that occur due to Too late CPC execution or Too early CPC/CPA execution, or CPC/CPA execution to wrong PSCell. These problems are defined as follows:

- Too Late CPC Execution: UE receives CPC configuration, while a SCG failure occurs before CPC execution condition is satisfied; a suitable PSCell different from source PSCell is found based on the measurements reported from the UE.
- Too Early CPC/CPA Execution: CPC/CPA execution is not successful or an SCG failure occurs shortly after a successful CPC/CPA execution; in case of CPC, the source PSCell is still the suitable PSCell based on the measurements reported from the UE; in case of CPA, no suitable PSCell is found based on the measurements reported from the UE.
- CPC/CPA Execution to wrong PSCell: CPC/CPA execution is not successful or an SCG failure occurs shortly after a successful CPC/CPA execution; a suitable PSCell different from the source PSCell or the target PSCell is found based on the measurements reported from the UE.

For Too late CPC execution and CPC/CPA execution to wrong PSCell, there are two sub-cases for wrong candidate PSCell list selection:

- if the suitable PSCell is one of the candidate target PSCells provided by the node initiating the CPC or by the MN initiating the CPA, but not one of the candidate PSCells selected by the candidate or target SN, it is wrong target PSCell selection at the candidate or target SN;
- else, it is wrong candidate PSCell list selection at the node initiating the CPC or at the MN initiating the CPA.

In the definition above, the "successful CPC/CPA execution" refers to the UE state, namely the successful completion of the RA procedure.

Detection mechanism

The MN performs the initial analysis when *SCGFailureInformation* is received from the UE. In the first step, MN verifies whether intra-SN PSCell change has been triggered in the last serving SN. In case the intra-SN PSCell change has been triggered in the last serving SN, the MN forwards the SCG Failure Information Report message to this last serving SN, which performs the final root cause analysis. In case of no intra-SN PSCell change, the MN determines the type of PSCell addition/change, e.g., whether it is CPA or CPC in case of conditional mobility, if CPC whether it is MN initiated or SN initiated.

The detailed detection mechanisms for Too Late CPC Execution, Too Early CPC/CPA Execution and CPC/CPA Execution to wrong PSCell are carried out in the NG-RAN node which initiates the CPC/CPA procedure:

- Too Late CPC Execution: if CPC is configured and there is no recent CPC execution for the UE prior to the connection failure e.g. the UE reported timer is absent or larger than the configured threshold (e.g. Tstore_UE_cntxt) , and there is a suitable PSCell different from the PSCell where the UE is located at the time of the failure occurrence.
- Too Early CPC/CPA Execution: there is a recent CPC/CPA execution for the UE prior to the connection failure e.g. the UE reported timer is smaller than the configured threshold (e.g. Tstore_UE_cntxt), and in case of CPC, the source PSCell is a suitable PSCell, in case of CPA, no suitable PSCell is found.
- CPC/CPA Execution to wrong PSCell: there is a recent CPC/CPA execution for the UE prior to the connection failure e.g. the UE reported timer is smaller than the configured threshold (e.g. Tstore_UE_cntxt), and the suitable PSCell is not the source PSCell or the target PSCell.

The "UE reported timer" above indicates the time elapsed since the CPC/CPA execution until connection failure.

For CPA or MN initiated CPC, if the suitable PSCell is one of the candidate PSCells provided by the MN at CPAC preparation, but not one of the candidate PSCells selected by the candidate or target SN, MN sends the SCG Failure Information Report message to the candidate or target SN, which perform the final MRO related optimisation. Otherwise, the MN performs the final MRO related optimisation.

For SN initiated CPC, the MN sends the SCG Failure Information Report message to source SN, and source SN performs root cause analysis. If the suitable PSCell is one of the candidate PSCells provided by the source SN, but not one of the candidate PSCells selected by the candidate or target SN, the source SN indicates to MN that the root cause of the SCG failure may have occurred in the other nodes. MN then sends the SCG Failure Information Report message to the candidate or target SN. Otherwise, the source SN performs the final MRO related optimisation.

10.18.4 Successful PSCell Addition/Change Report

The objective of Successful PSCell addition/change Report (SPR) is to detect sub-optimal successful PSCell change/CPC or successful PSCell addition/CPA.

For analysis of such sub-optimal successful PSCell change/CPC and successful PSCell addition/CPA, the UE may collect SPR based on the triggers configured by the network and makes the SPR available to the network as specified in TS 38.331 [4]. If the SPR available indication via *SN RRCReconfigurationComplete* is received by SN, SN should inform MN that an SPR is available at the UE via S-NODE MODIFICATION REQUIRED message.

For PSCell addition/CPA and PSCell change/CPC (MN or SN initiated), the target SN always decides the T304 trigger for SPR and performs root cause analysis.

For SN-initiated PSCell change/CPC, the source SN decides the T310/T312 triggers for SPR and is responsible for SPR related optimizations e.g., to optimize PSCell change/CPC configuration or associated mobility thresholds or adjust T310/T312 timer values.

For MN-initiated PSCell change/CPC, the MN decides the T310/T312 triggers for SPR. MN may optimize PSCell change/CPC configuration or associated mobility thresholds or both. Source SN may optimize lower layer issues e.g., adjust T310/T312 timer values.

The SPR can be fetched from the UE by the MN only while the UE is still connected to the MN, or by a node different from the MN that was serving the UE when PSCell addition or PSCell change occurred if the UE is not connected to the MN anymore. In case the SPR is retrieved in a node different from the MN that was serving the UE when PSCell addition or PSCell change occurred, the SPR is first forwarded to that MN. The MN may forward the SPR to the appropriate SN(s) to perform the SPR related optimization.

10.18.5 RA Report retrieval

In MR-DC, when a UE performs successful random access attempts which are only known by the SN (e.g., beam failure recovery, UL synchronization issue, scheduling request failure, no PUCCH resource available), the SN may inform the MN about the occurrences of successful random access procedures in the SN via a RACH indication. The MN may then retrieve the RA Report from the UE(s) based on the RACH indication received from the SN.

When an E-UTRA node retrieves the E-UTRA RA Report, it can also request UE to include the NR RA Report(s). If available, the UE then includes the NR RA Report(s) in a container along with a list of cells associated to the NR RA Report(s) within the E-UTRA RA Report. The retrieving E-UTRA node may then forward the NR RA Report(s) to the corresponding nodes serving the indicated cells.

In case of NGEN-DC, in case there is no Xn connectivity between the ng-eNB retrieving the NR RA Report from the UE and the gNB serving the PSCells indicated by UE in the NR RA Report, the ng-eNB may forward the NR RA Report via Xn to an ng-eNB connected to a gNB serving the PSCells indicated in the RA Report.

In case of EN-DC, in case there is no X2 connectivity between the eNB retrieving the NR RA Report from the UE and the en-gNB serving the PSCells indicated by UE in the NR RA Report, the eNB may forward the NR RA Report via X2 to an eNB connected to an en-gNB serving the PSCells indicated in the RA Report.

10.19 Conditional Handover with Secondary Node

10.19.1 EN-DC

The Conditional Handover with Secondary Node procedure is used for configuration and execution of CHO with SN. This procedure includes the cases where the SN is kept, changed or added. If the SN is kept, the UE context at the SN is kept. If the SN is changed, the UE context at the source SN is moved to the target SN.

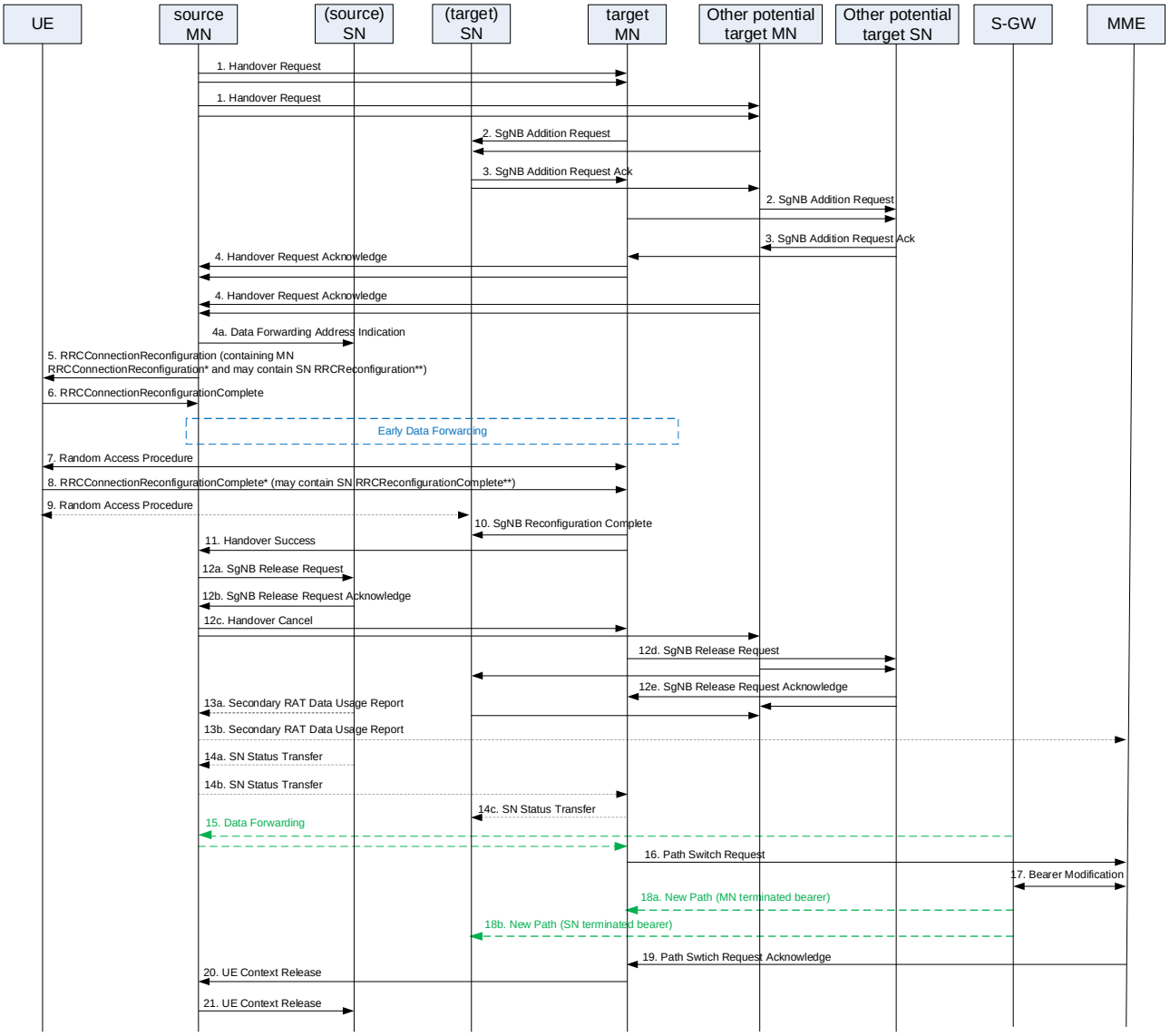


Figure 10.19.1-1: Conditional Handover with Secondary Node procedure

Figure 10.19.1-1 shows an example signaling flow for Conditional Handover with Secondary Node.

NOTE 1: For a CHO without SN change, the source SN and the target SN shown in Figure 10.19.1-1 are the same node.

NOTE 2: For a CHO with SN addition, the source SN and steps involving the source SN in Figure 10.19.1-1 are ignored.

1. The source MN starts the conditional handover procedure by initiating the X2 Handover Preparation procedure including MCG configuration and, if the UE is configured with an SCG, SCG configuration. The source MN may include the (source) SN UE X2AP ID, SN ID, the UE context in the (source) SN and the Conditional Handover Information Request IE in the *Handover Request* message.

NOTE 3: In case of the CHO with/without SN change, the source MN may trigger the MN-initiated SN Modification procedure (to the source SN) to retrieve the current SCG configuration, if configured, before step 1.

2. If the candidate MN decides to keep the UE context in the SN, the candidate MN sends the *SgNB Addition Request* message to the SN including the SN UE X2AP ID as a reference to the UE context in the SN that was established by the source MN. If the candidate MN decides to change the SN allowing delta configuration, the candidate MN sends the *SgNB Addition Request* message to the candidate SN including the UE context in the source SN that was established by the source MN. Otherwise, the candidate MN may send the *SgNB Addition Request* message to the candidate SN including neither the SN UE X2AP ID nor the UE context in the source SN that was established by the source MN. Within the *SgNB Addition Request* message, the candidate MN also includes the CHO related information, i.e., the source MN ID and the MN UE X2AP ID in the source MN, in order to indicate that the SgNB Addition Preparation procedure is triggered in relation to a CHO and to enable the SN to identify requests related to the same UE.

NOTE 3a: The target MN and other potential target MNs may trigger the SgNB Addition Preparation procedure to the same (target) SN.

NOTE 3b: The source MN may initiate additional X2 Handover Preparation procedures towards the same or other target MNs. Based on each X2 Handover Preparation procedure, each target MN may decide to trigger SgNB Addition Preparation procedure.

3. The (candidate) SN replies with the *SgNB Addition Request Acknowledge* message. The (candidate) SN may include the indication of full or delta RRC configuration.

NOTE 4: In CHO with SCG configuration, it is up to the candidate MN implementation to make sure that the CG-Config provided from the (candidate) SN can be used in all CHO preparations.

4. The candidate MN includes within the *Handover Request Acknowledge* message a transparent container to be sent to the UE as an RRC message to perform the conditional handover, and may also provide forwarding addresses to the source MN. The candidate MN indicates to the source MN that the UE context in the SN is kept if the candidate MN and the SN decided to keep the UE context in the SN in step 2 and step 3.

NOTE 4a0: Steps 1-4 may be produced in several instances, each instance initiated with a separate Handover Preparation procedure (step 1). The order of messages belonging to separate instances is not defined.

4a. The source MN sends the *Data Forwarding Address Indication* message to the (source) SN. This *Data Forwarding Address Indication* message notifies conditional handover to the (source) SN, which may decide to perform, if applicable, early data forwarding for SN-terminated bearers, together with the sending of an *Early Status Transfer* message to the source MN.

NOTE 4a: Separate Data Forwarding Address Indication procedures may be initiated to provide different forwarding addresses of the prepared conditional handovers. In this case, it is up to the source MN and SN implementations to make sure that the *Early Status Transfer* message(s) from the source SN, if any, is forwarded to the right target MN. The Data Forwarding Address Indication procedure may further be initiated to indicate to the (source) SN to stop already initiated early data forwarding for some SN-terminated bearers, if they are no longer subject to data forwarding due to the modification or cancellation of the prepared conditional handovers.

5. The source MN sends an *RRCConnectionReconfiguration* message to the UE, including the CHO configuration, i.e. a list of *RRCConnectionReconfiguration** messages and associated execution conditions, in which each *RRCConnectionReconfiguration** message contains an MCG configuration and possibly an SCG configuration in the *RRCReconfiguration*** message received from the candidate SN in step 3.

6. The UE applies the *RRCConnectionReconfiguration* message received in step 5, stores the CHO configuration and replies to the MN with an *RRCConnectionReconfigurationComplete* message.

7/8. The UE maintains connection with the source MN and, if the UE is configured with a PSCell, with the source PSCell, after receiving CHO configuration, and starts evaluating the CHO execution condition for the candidate cell(s). If at least one CHO candidate cell satisfies the corresponding CHO execution condition, the UE detaches from the source MN, applies the stored corresponding configuration for that selected candidate cell, synchronises to that candidate cell and completes the RRC handover procedure by sending *RRCConnectionReconfigurationComplete** message to the target MN. If the stored configuration for the selected candidate cell includes an SCG configuration, the UE includes an embedded SN

*RRCReconfigurationComplete*** message for the target SN. The UE releases stored CHO configurations after successful completion of RRC handover procedure.

NOTE 5: In case the target SN includes the indication of full RRC configuration, the MN performs release of the SN terminated radio bearer configuration and release and add of the NR SCG configuration part towards the UE.

9. If configured with bearers requiring SCG radio resources, the UE synchronizes to the (target) SN.

NOTE 6: The order the UE performs Random Access towards the MN (step 7) and performs the Random Access procedure towards the (target) SN (step 9) is not defined.

10. If the RRC connection reconfiguration procedure was successful, the target MN informs the (target) SN via *SgNB Reconfiguration Complete* message.

11. The target MN sends the *Handover Success* message to the source MN to inform that the UE has successfully accessed the target cell.

12a/b. The source MN sends *SgNB Release Request* message to the (source) SN including a Cause indicating MCG mobility and, if applicable, data forwarding information. The source MN indicates to the (source) SN that the UE context in SN is kept, if it receives the indication from the target MN. The (source) SN acknowledges the release request.

12c. The source MN sends the *Handover Cancel* message toward the other signalling connections or other candidate MNs, if any, to cancel CHO for the UE.

12d/e. If the target MN is configured with other candidate PCell(s) associated with other candidate SN(s) than the target SN, the target MN sends the *SgNB Release Request* message(s) to the corresponding candidate SN(s). Other candidate MN(s) send(s) the *SgNB Release Request* message(s) to other candidate SN(s), if configured. The other candidate SN(s) acknowledges the release request.

13a. The (source) SN sends the *Secondary RAT Data Usage Report* message to the source MN and includes the data volumes delivered to and received from the UE over the NR radio for the related E-RABs.

NOTE 7: The order the source SN sends the *Secondary RAT Data Usage Report* message and performs data forwarding with MN/target SN is not defined. The SgNB may send the report when the transmission of the related bearer is stopped.

13b. The source MN sends the *Secondary RAT Data Usage Report* message to MME to provide information on the used NR resource.

14. For bearers using RLC AM, the source MN sends the *SN Status Transfer* message, including, if needed, SN Status received from the source SN to the target MN. The target MN forwards the SN Status to the target SN, if needed.

15. If applicable, data forwarding takes place from the source side (i.e. source MN or source SN). If the SN is kept, data forwarding may be omitted for SN-terminated bearers kept in the SN.

16-19. The target MN initiates the S1 Path Switch procedure.

NOTE 8: If new UL TEIDs of the S-GW are included, the target MN performs the MN initiated SN Modification procedure to provide them to the SN.

20. The target MN initiates the UE Context Release procedure towards the source MN.

21. Upon reception of the *UE Context Release* message, the (source) SN releases C-plane related resources associated to the UE context towards the source MN. Any ongoing data forwarding may continue. The SN shall not release the UE context associated with the target MN if the UE context kept indication was included in the *SgNB Release Request* message in step 12a.

10.19.2 MR-DC with 5GC

The Conditional Handover with Secondary Node procedure is used for configuration and execution of CHO with SN or CHO with candidate SCG(s). This procedure includes the cases where the SN is kept, changed or added. If the SN is kept, the UE context at the SN is kept. If the SN is changed, the UE context at the source SN is moved to the target SN.

CHO with candidate SCG(s) is not supported for NE-DC and NGEN-DC.

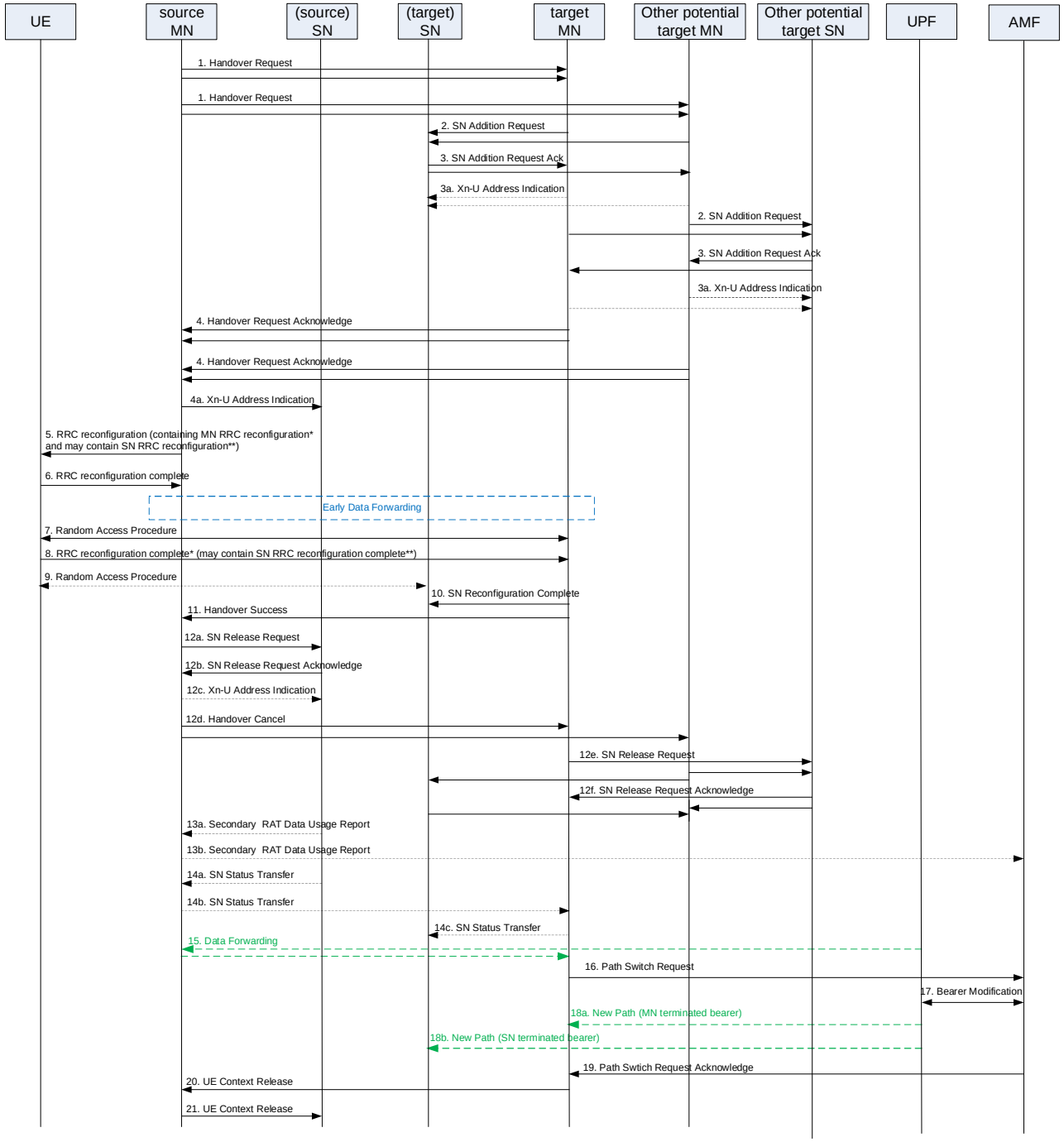


Figure 10.19.2-1: Conditional Handover with Secondary Node procedure

Figure 10.19.2-1 shows an example signaling flow for Conditional Handover with Secondary Node.

NOTE 1: For a CHO without SN change, the source SN and the target SN shown in Figure 10.19.2-1 are the same node.

NOTE 2: For a CHO with SN addition, the source SN and steps involving the source SN in Figure 10.19.2-1 are ignored.

1. The source MN starts the conditional handover procedure by initiating the Xn Handover Preparation procedure including MCG configuration and, if the UE is configured with an SCG, SCG configuration. The source MN includes the (source) SN UE XnAP ID, SN ID, the UE context in the (source) SN and the Conditional Handover Information Request IE in the *Handover Request* message. In case of CHO with candidate SCG(s), the source MN also provides the maximum number of conditional reconfigurations that the candidate MN can prepare for the UE in the *Handover Request* message.

NOTE 3: In case of the CHO with/without SN change or CHO with candidate SCG(s), the source MN may trigger the MN-initiated SN Modification procedure (to the source SN) to retrieve the current SCG configuration, if configured, before step 1.

2. If the candidate MN decides to keep the UE context in the SN, the candidate MN sends the *SN Addition Request* message to the SN including the SN UE XnAP ID as a reference to the UE context in the SN that was established by the source MN. If the candidate MN decides to change the SN allowing delta configuration, the candidate MN sends the *SN Addition Request* message to the candidate SN including the UE context in the source SN that was established by the source MN. Otherwise, the candidate MN may send the *SN Addition Request* message to the candidate SN including neither the SN UE XnAP ID nor the UE context in the source SN that was established by the source MN. Within the *SN Addition Request* message, the candidate MN also includes the CHO related information, i.e., the source MN ID and the MN UE XnAP ID in the source MN, in order to indicate that the SN Addition Preparation procedure is triggered in relation to a CHO and to enable the SN to identify requests related to the same UE. In case of CHO with candidate SCG(s), the candidate MN also provides the candidate PSCells recommended by the candidate MN via the latest measurement results for the candidate SN(s) to choose and configure the candidate SCG cell(s), and provides the maximum number of PSCells that the candidate SN can prepare for the UE in the *SN Addition Request* message.

NOTE 3a: The target MN and other potential target MNs may trigger the SN Addition Preparation procedure to the same (target) SN.

NOTE 3b: The source MN may initiate additional Xn Handover Preparation procedures towards the same or other target MNs. Based on each Xn Handover Preparation procedure, each target MN may decide to trigger SN Addition Preparation procedure.

3. The (candidate) SN replies with the *SN Addition Request Acknowledge* message. The (candidate) SN may include the indication of the full or delta RRC configuration. In case of CHO with candidate SCG(s), within the list of cells as indicated within the measurement results indicated by the candidate MN, the candidate SN decides the list of PSCell(s) to prepare (considering the maximum number indicated by the candidate MN) and, for each prepared PSCell, the candidate SN decides other SCG SCells and provides the new corresponding SCG radio resource configuration to the candidate MN in an NR RRC reconfiguration** message contained in the *SN Addition Request Acknowledge* message with the prepared PSCell ID(s).

NOTE 4: In CHO with SCG configuration, it is up to the candidate MN implementation to make sure that the CG-Config provided from the (candidate) SN can be used in all CHO preparations.

NOTE 4A1: In case of CHO with candidate SCG(s), the (candidate) SN assigns the same data forwarding addresses for multiple data forwarding requests from different candidate MNs and may set up only one bearer context. Then the (candidate) SN indicates to the candidate MN direct data forwarding path availability with the source SN and/or source MN, if applicable.

3a. For the SN terminated bearers using MCG resources, the candidate MN provides Xn-U DL TNL address information in the *Xn-U Address Indication* message.

4. The candidate MN includes within the *Handover Request Acknowledge* message the MN RRC reconfiguration message to be sent to the UE in order to perform the conditional handover, and may also provide forwarding addresses to the source MN. If PDU session split is performed in the target side during handover procedure, more than one data forwarding addresses corresponding to each node are included in the *Handover Request Acknowledge* message. The candidate MN indicates to the source MN that the UE context in the SN is kept if the candidate MN and the SN decided to keep the UE context in the SN in step 2 and step 3. In case of CHO with candidate SCG(s), the candidate MN includes a list of one or more (candidate) SNs in *Handover Request Acknowledge* message with the PDU Session admission results, data forwarding addresses and list of prepared PSCells for each prepared (candidate) SN. The candidate MN also indicates to the source MN the parameters of the execution condition of each prepared candidate PSCell.

NOTE 4A2: In case of CHO with candidate SCG(s), the candidate MN indicates direct data forwarding path availability between the target node and the source SN in per PDU session granularity in the *Handover Request Acknowledge* message, if applicable.

NOTE 4a0: Steps 1-4 may be produced in several instances, each instance initiated with a separate Handover Preparation procedure (step 1). The order of messages belonging to separate instances is not defined.

4a. The source MN sends the *Xn-U Address Indication* message to the (source) SN. This *Xn-U Address Indication* message notifies conditional handover to the (source) SN, which may decide to perform, if applicable, early data forwarding for SN-terminated bearers, together with the sending of an *Early Status Transfer* message to the source MN.

NOTE 4a: Separate Xn-U Address Indication procedures may be initiated to provide different forwarding addresses of the prepared conditional handovers. In this case, it is up to the source MN and SN implementations to make sure that the *Early Status Transfer* message(s) from the source SN, if any, is forwarded to the right target MN. The Xn-U Address Indication procedure may further be initiated to indicate to the (source) SN to stop already initiated early data forwarding for some SN-terminated bearers, if they are no longer subject to data forwarding due to the modification or cancellation of the prepared conditional handovers.

5. The source MN sends an RRC reconfiguration message to the UE, including the CHO configuration, i.e. a list of RRC reconfiguration* messages and associated execution conditions, in which each RRC reconfiguration* message contains an MCG configuration and possibly an SCG configuration in the RRC reconfiguration** message received from the candidate SN in step 3. For each configuration of CHO with candidate SCG(s), the source MN provides an execution condition for the candidate PCell and an execution condition for the candidate PSCell. Besides, each RRC reconfiguration* message contains an MCG configuration and an SCG configuration in the RRC reconfiguration** message received from the candidate SN in step 3.

NOTE 4b: In case of CHO with candidate SCG(s), the source MN can provide multiple CHO configurations for the same candidate PCell (i.e. without the SCG configuration or with the SCG configuration of different candidate PSCell).

6. The UE applies the RRC reconfiguration message received in step 5, stores the CHO configuration and replies to the MN with an RRC reconfiguration complete message.

7/8. The UE maintains connection with the source MN and, if the UE is configured with a PSCell, with the source PSCell, after receiving CHO configuration, and starts evaluating the execution condition for the candidate PCell(s) and if any, the execution condition for the candidate PSCell(s):

- If at least one candidate PCell satisfies the corresponding execution condition and the associated candidate PSCell satisfies the corresponding execution condition, the UE detaches from the source MN, applies the stored corresponding configuration for that selected candidate PCell and the associated candidate PSCell, synchronises to that candidate PCell, and completes the RRC handover procedure by sending RRC reconfiguration complete* message to the target MN. The UE includes an embedded SN RRCReconfigurationComplete** message for the target SN, and information enabling the target MN to identify the target SN of the selected candidate PSCell.

- Else if at least one candidate PCell satisfies the corresponding execution condition and there is no associated execution condition for a candidate PSCell, the UE detaches from the source MN, applies the stored corresponding configuration for that selected candidate PCell and, if included, the associated PSCell, synchronises to that candidate PCell and completes the RRC handover procedure by sending RRC reconfiguration complete* message to the target MN. If the stored configuration for the selected candidate PCell includes an SCG configuration, the UE includes an embedded SN *RRCReconfigurationComplete*** message for the target SN.

- The UE releases the stored CHO configurations after successful completion of the RRC handover procedure.

NOTE 5: In case the target SN includes the indication of the full RRC configuration, the MN performs release of the SN terminated radio bearer configuration and release and add of the NR SCG configuration part towards the UE.

9. If configured with bearers requiring SCG radio resources, the UE synchronizes to the (target) SN.

NOTE 6: The order the UE performs Random Access towards the MN (step 7) and performs the Random Access procedure towards the (target) SN (step 9) is not defined.

10. If the RRC connection reconfiguration procedure was successful, the target MN informs the (target) SN via *SN Reconfiguration Complete* message.

11. The target MN sends the *Handover Success* message to the source MN to inform that the UE has successfully accessed the target cell. In case of CHO with candidate SCG(s), the target PSCell ID may also be included in the *Handover Success* message.

12a/b. The source MN sends *SN Release Request* message to the (source) SN including a Cause indicating MCG mobility. The source MN indicates to the (source) SN that the UE context in SN is kept, if it receives the indication from the target MN. The (source) SN acknowledges the release request.

12c. The source MN sends *XN-U Address Indication* message to the (source) SN to transfer data forwarding information. More than one data forwarding addresses may be provided if the PDU session is split in the target side.

12d. The source MN sends the *Handover Cancel* message toward the other signalling connections or other candidate MNs, if any, to cancel CHO for the UE.

12e/f. If the target MN is configured with other candidate PCell(s) associated with other candidate SN(s) than the target SN, the target MN sends the *SN Release Request* message(s) to the corresponding candidate SN(s). Other candidate MN(s) send(s) the *SN Release Request* message(s) to all the associated candidate SN(s), if configured. The associated candidate SN(s) acknowledges the release request.

13a. The (source) SN sends the *Secondary RAT Data Usage Report* message to the source MN and includes the data volumes delivered to and received from the UE over the NR/E-UTRA radio as described in clause 10.11.2.

NOTE 7: The order the source SN sends the *Secondary RAT Data Usage Report* message and performs data forwarding with MN/target SN is not defined. The SN may send the report when the transmission of the related QoS is stopped.

13b. The source MN sends the *Secondary RAT Data Usage Report* message to AMF to provide information on the used NR/E-UTRA resource.

14. For bearers using RLC AM, the source MN sends the *SN Status Transfer* message to the target MN, including, if needed, SN Status received from the source SN. The target MN forwards the SN Status to the target SN, if needed.

15. If applicable, data forwarding takes place from the source side (i.e. source MN or source SN). If the SN is kept, data forwarding may be omitted for the SN terminated bearers or QoS flows kept in the SN.

16-19. The target MN initiates the Path Switch procedure. If the target MN includes multiple DL TEIDs for one PDU session in the *Path Switch Request* message, multiple UL TEID of the UPF for the PDU session should be included in the *Path Switch Ack* message in case there is TEID update in UPF.

NOTE 8: If new UL TEIDs of the UPF for SN are included, the target MN performs MN initiated SN Modification procedure to provide them to the SN.

20. The target MN initiates the UE Context Release procedure towards the source MN.

21. Upon reception of the *UE Context Release* message from source MN, the (source) SN releases C-plane related resources associated to the UE context towards the source MN. Any ongoing data forwarding may continue. The SN shall not release the UE context associated with the target MN if the UE contest kept indication was included in the *SN Release Request* message in step 12a.

10.19.3 CHO with candidate SCG(s)

A CHO with candidate SCG(s) is defined as a PCell change with PSCell addition/change that is executed by the UE when the execution conditions for both candidate PCell and the associated candidate PSCell are met. The UE starts evaluating the execution conditions for candidate PCell(s) and candidate PSCell(s) simultaneously upon receiving the CHO with candidate SCG(s) configuration, and stops evaluating the execution conditions once a PCell change or a PSCell change is triggered. The UE does not execute CHO with candidate SCG(s) until the execution conditions for both the candidate PCell and the associated candidate PSCell are met.

10.20 Subsequent Conditional PSCell Addition or Change

A Subsequent Conditional PSCell Addition or Change (subsequent CPAC) is defined as a conditional PSCell addition or change procedure that is executed based on pre-configured subsequent CPAC configuration of which is not implicitly released by the UE upon (conditional or non-conditional) PSCell addition, (conditional or non-conditional) PSCell change, (conditional or non-conditional) PCell change or SCG release. The UE keeps the configured subsequent CPAC configuration (unless the network indicates to release it) and evaluates the execution conditions of candidate PSCells (if provided for the following execution of subsequent CPAC) after completion of a PSCell addition, a PSCell change, a PCell change, or an SCG release (if subsequent CPAC configuration is received via an MN RRC message). Subsequent CPAC configuration can be initiated either by the MN or by the SN.

The following principles apply to subsequent CPAC:

- For MN initiated subsequent CPAC, the MN initially triggers the candidate cell preparation of subsequent CPAC procedure and generates the execution conditions for the initial execution of subsequent CPAC (e.g. CPA or CPC).

- For SN initiated subsequent CPAC, the source SN initially triggers the candidate cell preparation of subsequent CPAC procedure and generates the execution conditions for the initial execution of subsequent CPAC.

- For both MN and SN initiated subsequent CPAC, the candidate SN generates the execution conditions for the following execution of subsequent CPAC when the candidate SN prepares the candidate SCG configuration(s) for candidate PSCell(s). For SN initiated intra-SN subsequent CPAC, the source SN generates the execution conditions for the following execution of subsequent CPAC when the source SN prepares the candidate SCG configuration(s) for candidate PSCell(s).

- The subsequent CPAC configuration contains candidate SCG configuration(s) of candidate PSCell(s), execution conditions, and may contain the MCG configuration (to be applied when subsequent CPAC execution is triggered), the reference configuration and the security update configuration.

- The subsequent CPAC configuration can be included within an MN or an SN RRC message. A subsequent CPAC configuration that is included in an MN RRC message can be used for candidate PSCell(s) for CPA, for intra-SN or inter-SN candidate PSCell(s) for CPC. A subsequent CPAC configuration that is included in an SN RRC message can only be used for intra-SN candidate PSCell(s) for CPC.

- For one UE, the subsequent CPAC configurations for all candidate PSCells (including inter-SN and/or intra-SN) are included within either MN RRC message(s) or SN RRC message(s). It is up to OAM configuration to ensure only MN RRC message(s) or only SN RRC message(s) are used.

- Each candidate PSCell configuration is provided as a delta configuration on top of a reference configuration or a complete candidate configuration. Only one reference configuration is supported.

- The MN generates the MCG part of the reference configuration (if any), while the SN generates the SCG part of the reference configuration. The MN can request an SCG reference configuration from any one of the involved SNs.

- The network explicitly configures a subsequent CPAC configuration for the current serving PSCell if the network wants to use that PSCell as a candidate PSCell for subsequent CPAC.

- The network always explicitly releases the subsequent CPAC configuration for candidate PSCells after an inter-MN PCell change.

- Upon the release of SCG, the UE autonomously releases the stored subsequent CPAC configuration received via an SN RRC message. Upon the release of SCG, the UE releases or maintains the stored subsequent CPAC configuration received via an MN RRC message according to the network indication.

- The same candidate PSCell configuration can be used for CPA execution and CPC execution, but with different execution conditions of the candidate PSCell.

- The subsequent CPAC configuration with CPA execution condition(s) maintained after SCG release can be used for the subsequent CPA execution.

- Upon subsequent CPAC execution to a different SN, the UE uses the first unused sk-Counter value for S-KgNB generation, based on the per-SN pre-configured sk-Counter value list for that SN, if any.

- Upon PCell change, PSCell change or SCG release, if the subsequent CPAC configuration is maintained, the UE also maintains the unused sk-Counter values.
- The UE autonomously releases the subsequent CPAC configuration upon RRC re-establishment and upon RRC release.
- While executing subsequent CPAC, the UE is not required to continue evaluating the execution condition of other candidate PSCell(s) or PCell(s).
- The UE is not required to continue evaluating the execution conditions of other subsequent CPAC candidate PSCell(s) when PSCell change/addition or PCell change is triggered.

MN initiated subsequent CPAC

The subsequent CPAC procedure is initiated by the MN for subsequent CPAC configuration and subsequent CPAC execution.

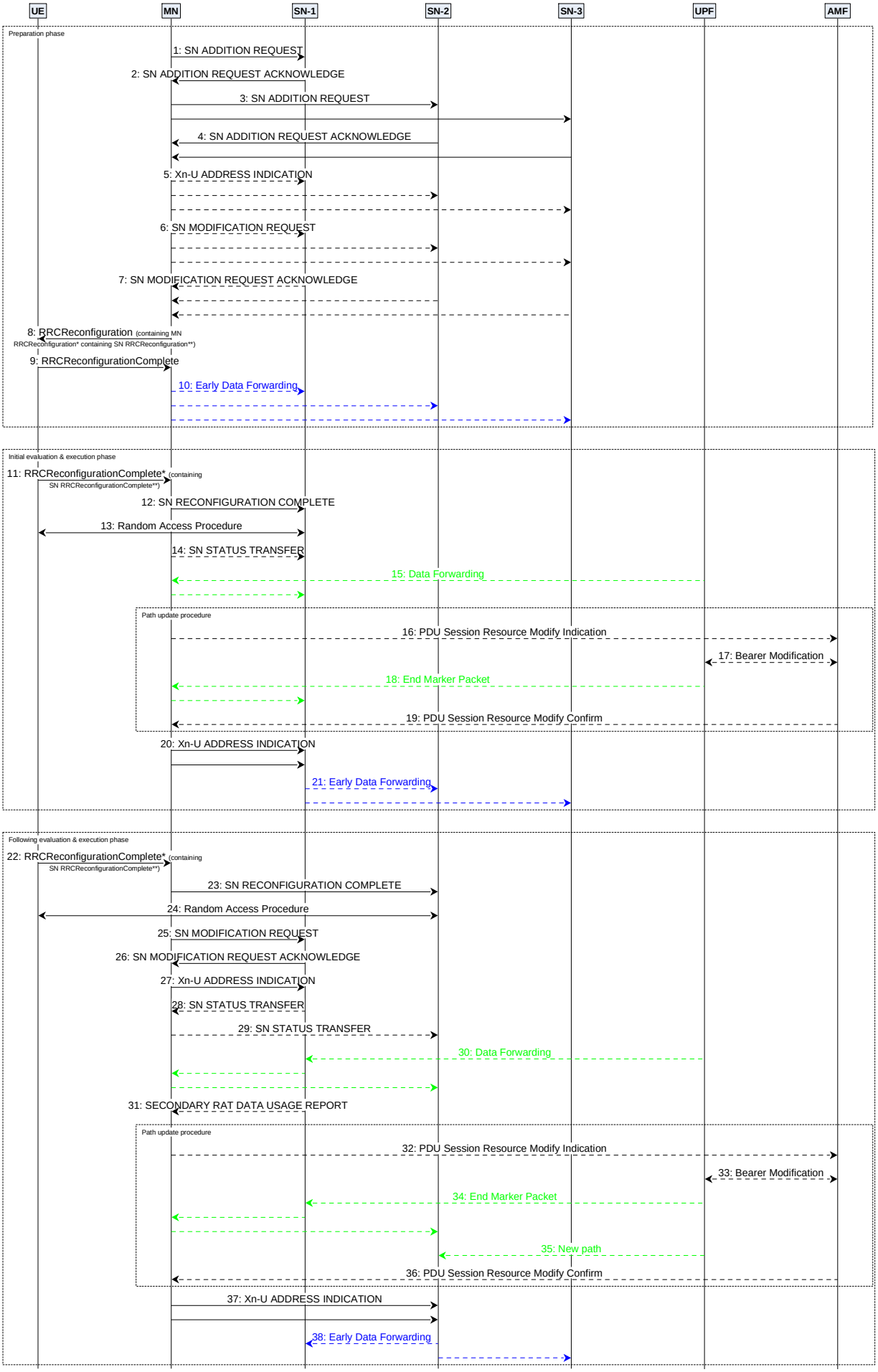

UE
MN
SN-1
SN-2
SN-3
UPF
AMF
Preparation phase
1: SN ADDITION REQUEST
2: SN ADDITION REQUEST ACKNOWLEDGE
3: SN ADDITION REQUEST
4: SN ADDITION REQUEST ACKNOWLEDGE
5: Xn-U ADDRESS INDICATION
6: SN MODIFICATION REQUEST
7: SN MODIFICATION REQUEST ACKNOWLEDGE
8: RRCReconfiguration (containing MN RRCReconfiguration* containing SN RRCReconfiguration**)
9: RRCReconfigurationComplete
10: Early Data Forwarding
Initial evaluation & execution phase
11: RRCReconfigurationComplete* (containing SN RRCReconfigurationComplete**)
12: SN RECONFIGURATION COMPLETE
13: Random Access Procedure
14: SN STATUS TRANSFER
15: Data Forwarding
Path update procedure
16: PDU Session Resource Modify Indication
17: Bearer Modification
18: End Marker Packet
19: PDU Session Resource Modify Confirm
20: Xn-U ADDRESS INDICATION
21: Early Data Forwarding
Following evaluation & execution phase
22: RRCReconfigurationComplete* (containing SN RRCReconfigurationComplete**)
23: SN RECONFIGURATION COMPLETE
24: Random Access Procedure
25: SN MODIFICATION REQUEST
26: SN MODIFICATION REQUEST ACKNOWLEDGE
27: Xn-U ADDRESS INDICATION
28: SN STATUS TRANSFER
29: SN STATUS TRANSFER
30: Data Forwarding
31: SECONDARY RAT DATA USAGE REPORT
Path update procedure
32: PDU Session Resource Modify Indication
33: Bearer Modification
34: End Marker Packet
35: New path
36: PDU Session Resource Modify Confirm
37: Xn-U ADDRESS INDICATION
38: Early Data Forwarding

Figure 10.20-1: Subsequent CPAC - MN initiated

Figure 10.20-1 shows an example signalling flow for the subsequent CPAC initiated by the MN:

1/2/3/4. The MN initiates the subsequent CPAC for candidate PSCell(s) in other candidate SN(s) by requesting the candidate SN(s) to allocate resources for the UE by means of the SN Addition procedure, indicating that the request is for subsequent CPAC. The MN also provides the candidate cells recommended by MN via the latest measurement results for the candidate SN(s) to choose and configure the SCG cell(s), provides the upper limit for the number of PSCells that can be prepared by each candidate SN, and provides a list of K_{SN} and associated sk-Counter values for each candidate SN. In the SN Addition procedure, the MN also includes information of other candidate SN(s), and for each candidate SN, a list of cells recommended by the MN via the latest measurement results for the candidate SN to select the PSCell(s) for the following execution of subsequent CPAC. Within the list of cells as indicated within the measurement results indicated by the MN, the candidate SN decides the list of PSCell(s) to prepare (considering the maximum number indicated by the MN) and, for each prepared PSCell, the candidate SN decides other SCG SCells and provides the new corresponding SCG radio resource configuration to the MN in an NR *RRCReconfiguration*** message contained in the *SN Addition Request Acknowledge* message with the prepared PSCell ID(s). For each prepared PSCell, the candidate SN also decides the list of PSCell(s) and associated execution conditions proposed for the following execution of subsequent CPAC. If data forwarding is needed, the candidate SN provides data forwarding addresses to the MN. The candidate SN may also propose data forwarding to the MN or other candidate SN(s) for subsequent CPAC. The candidate SN may include an indication that the SCG radio resource configuration of a prepared PSCell is a complete candidate configuration, i.e. that it is not a delta configuration with respect to the SCG reference configuration. For the prepared PSCell(s) and the proposed PSCell(s) for the following execution of subsequent CPAC, the candidate SN can either accept or reject each of the candidate cells listed within the measurement results indicated by the MN, i.e. it cannot configure any alternative candidates.

The MN may select one of the candidate SN(s) and requests providing the SCG reference configuration as part of the SN Addition procedure. Once obtained, the MN provides the SCG reference configuration to other candidate SN(s).

NOTE 1: If the UE was configured with SN-1 in Dual Connectivity operation (i.e. SN-1 is the source SN) and the MN decides to configure the SN-1 as a candidate SN for the subsequent CPAC, then the MN starts the subsequent CPAC operation with SN-1 via the MN-initiated SN Modification procedure instead of the SN Addition procedure.

NOTE 2: If the UE was configured with SN-1 in Dual Connectivity operation (i.e. SN-1 is the source SN), then the MN may trigger the MN-initiated SN Modification procedure to SN-1 to retrieve the current SCG configuration or request a SCG reference configuration for the subsequent CPAC, and to allow provision of data forwarding related information before step 1.

NOTE 3: If applicable, the MN stores the data forwarding addresses and data forwarding proposals provided from all the candidate SN(s).

5. For SN terminated bearers using MCG resources, the MN provides Xn-U DL TNL address information in the *Xn-U Address Indication* message to the candidate SN(s).

6/7. For each candidate SN, the MN may initiate the SN Modification procedure towards the candidate SN to inform the prepared PSCells in other candidate SN(s), e.g., when not all proposed PSCells by this candidate SN for the following execution of subsequent CPAC were prepared by the candidate SN(s). If requested, the candidate SN sends an *SN Modification Request Acknowledge* message and if needed, provides the updated candidate SCG configuration(s) and/or the execution conditions for the following execution of subsequent CPAC to the MN.

8. The MN sends to the UE an *RRCReconfiguration* message including the subsequent CPAC configuration, i.e. a list of *RRCReconfiguration** messages and associated execution conditions for the initial execution of subsequent CPAC and execution conditions for the following execution of subsequent CPAC, in which each *RRCReconfiguration** message contains the SCG configuration in the *RRCReconfiguration*** message received from one of the candidate SN(s) in steps 2 and 4, and possibly an MCG configuration. Besides, the *RRCReconfiguration* message can also include an updated source MCG configuration, e.g., to configure the required conditional measurements. The *RRCReconfiguration* message also includes a security update configuration and may also include a reference configuration.

9. The UE applies the *RRCReconfiguration* message received in step 8, stores the subsequent CPAC configuration and replies to the MN with an *RRCReconfigurationComplete* message. In case the UE is unable to comply with

(part of) the configuration included in the *RRCReconfiguration* message, it performs the reconfiguration failure procedure.

10. In case of SN terminated bearers, early data forwarding may take place. For the early data forwarding of SN terminated bearers, the MN forwards the PDCP SDU to the candidate SN(s). For the early transmission of MN terminated split/SCG bearers, the MN forwards the PDCP PDU to the candidate SN(s).

NOTE 3a: If the UE was configured with SN-1 in Dual Connectivity operation (i.e. SN-1 is the source SN), the MN may send the *Xn-U Address Indication* message to the source SN, which may decide to perform, if applicable, early data forwarding for SN-terminated bearers, together with the sending of an *Early Status Transfer* message to the MN. Separate Xn-U Address Indication procedures may be invoked to provide different forwarding addresses of the prepared subsequent CPAC. In this case, it is up to the MN and the source SN implementations to make sure that the EARLY STATUS TRANSFER message(s) from the source SN, if any, is forwarded to the right other candidate SN. The Xn-U Address Indication procedure may further be invoked to indicate to the source SN to stop already initiated early data forwarding for some SN-terminated bearers if they are no longer subject to data forwarding due to the modification or cancellation of the prepared subsequent CPAC.

11. The UE starts evaluating the execution conditions for the initial execution of subsequent CPAC. If the execution condition of one candidate PSCell is satisfied, the UE applies *RRCReconfiguration** message corresponding to the selected candidate PSCell, and sends an MN *RRCReconfigurationComplete** message, including an *RRCReconfigurationComplete*** message for the selected candidate PSCell, and information enabling the MN to identify the SN of the selected candidate PSCell. The *RRCReconfigurationComplete** message may also include the sk-Counter value associated with the selected candidate PSCell if a new sk-Counter value is selected.

12. The MN informs the SN of the selected candidate PSCell (i.e. the selected candidate SN) that the UE has completed the reconfiguration procedure successfully via *SN Reconfiguration Complete* message, including the *RRCReconfigurationComplete*** message. If the sk-Counter value is received by the *RRCReconfigurationComplete** message, the MN also indicates the received sk-Counter value to the SN.

13. The UE performs synchronisation towards the PSCell indicated in the *RRCReconfiguration** message applied in step 11. The order the UE sends the MN *RRCReconfigurationComplete** message and performs the Random Access procedure towards the SCG is not defined. The successful RA procedure towards the SCG is not required for a successful completion of the RRC Reconfiguration procedure.

NOTE 3b: If the UE was configured with SN-1 in Dual Connectivity operation (i.e. SN-1 is the source SN), the steps 14-16 in Figure 10.20-2 are executed before the step 14 in this figure.

14. If PDCP termination point is changed to the SN for bearers using RLC AM, the MN sends the *SN Status Transfer* message.

15. For SN terminated bearers or QoS flows moved from the MN, dependent on the characteristics of the respective bearer or QoS flow, the MN may take actions to minimise service interruption due to activation of MR-DC (Data forwarding).

16-19: If applicable, a PDU Session path update procedure is triggered by the MN.

20-21. If data forwarding is needed, the MN may send the *Xn-U Address Indication* message to the selected candidate SN. The SN may decide to perform, if applicable, early data forwarding for SN-terminated bearers, together with the sending of an *Early Status Transfer* message to the MN.

NOTE 4: Separate Xn-U Address Indication procedures may be initiated to provide different forwarding addresses of the prepared subsequent CPAC. In this case, it is up to the MN and the candidate SN implementations to make sure that the *Early Status Transfer* message(s) from the selected candidate SN, if any, is forwarded to the right other candidate SN.

22. The UE starts evaluating the execution conditions for the following execution of subsequent CPAC. If the execution condition of one candidate PSCell is satisfied, the UE applies *RRCReconfiguration** message corresponding to the selected candidate PSCell, and sends an MN *RRCReconfigurationComplete** message, including an *RRCReconfigurationComplete*** message for the selected candidate PSCell, and information enabling the MN to identify the SN of the selected candidate PSCell. The *RRCReconfigurationComplete** message may also include a sk-Counter value associated with the selected candidate PSCell if a new sk-Counter value is selected.

23. The MN informs the SN of the selected candidate PSCell that the UE has completed the reconfiguration procedure successfully via *SN Reconfiguration Complete* message, including the *RRCReconfigurationComplete*** message. If the sk-Counter value is received by the *RRCReconfigurationComplete** message, the MN also indicates the received sk-Counter value to the SN.

24. The UE performs synchronisation towards the PSCell indicated in the *RRCReconfiguration** message applied in step 22. The order the UE sends the MN *RRCReconfigurationComplete** message and performs the Random Access procedure towards the SCG is not defined. The successful RA procedure towards the SCG is not required for a successful completion of the RRC Reconfiguration procedure.

NOTE 4a: If the selected candidate PSCell that the UE executed in the step 22 belongs to the same last serving SN, the steps 10-11 in the Figure 10.20-3 are executed instead of the steps 25-30 in this figure.

25/26/27. The MN triggers the MN initiated SN Modification procedure to inform the last serving SN to stop providing user data to the UE, to switch to the prepared state, and if applicable, to allow provisioning of new data forwarding addresses based on the data forwarding proposals of the MN and the selected candidate SN. If applicable, the MN triggers the Xn-U Address Indication procedure to inform the last serving SN the address of the SN of the selected candidate PSCell, to start late data forwarding.

28/29. If PDCP termination point is changed for bearers using RLC AM, the SN sends the *SN Status Transfer* message to MN, which the MN sends then to the SN of the selected candidate PSCell, if needed.

30. If applicable, data forwarding from the last serving SN takes place. It may be initiated as early as the the last serving SN receives the early data forwarding address in step 21.

31: The source SN sends the *Secondary RAT Data Usage Report* message to the MN and includes the data volumes delivered to and received from the UE as described in clause 10.11.2.

NOTE 4b: The order the SN sends the *Secondary RAT Data Usage Report* message and performs data forwarding with MN is not defined. The SN may send the report when the transmission of the related bearer is stopped.

32-36: If applicable, a PDU Session path update procedure is triggered by the MN.

37-38. If data forwarding is needed, the MN may send the *Xn-U Address Indication* message to the selected candidate SN. The SN may decide to perform, if applicable, early data forwarding for SN-terminated bearers, together with the sending of an *Early Status Transfer* message to the MN.

NOTE 5: Separate Xn-U Address Indication procedures may be initiated to provide different forwarding addresses of the prepared subsequent CPAC. In this case, it is up to the MN and selected candidate SN implementations to make sure that the *Early Status Transfer* message(s) from the selected candidate SN, if any, is forwarded to the right other candidate SN.

NOTE 5a: The steps 22-38 can be performed multiple times for the following execution of subsequent CPAC, using the subsequent CPAC configuration provided in step 8.

SN initiated subsequent CPAC

The subsequent CPAC procedure is initiated by the SN for subsequent CPAC configuration and subsequent CPAC execution.

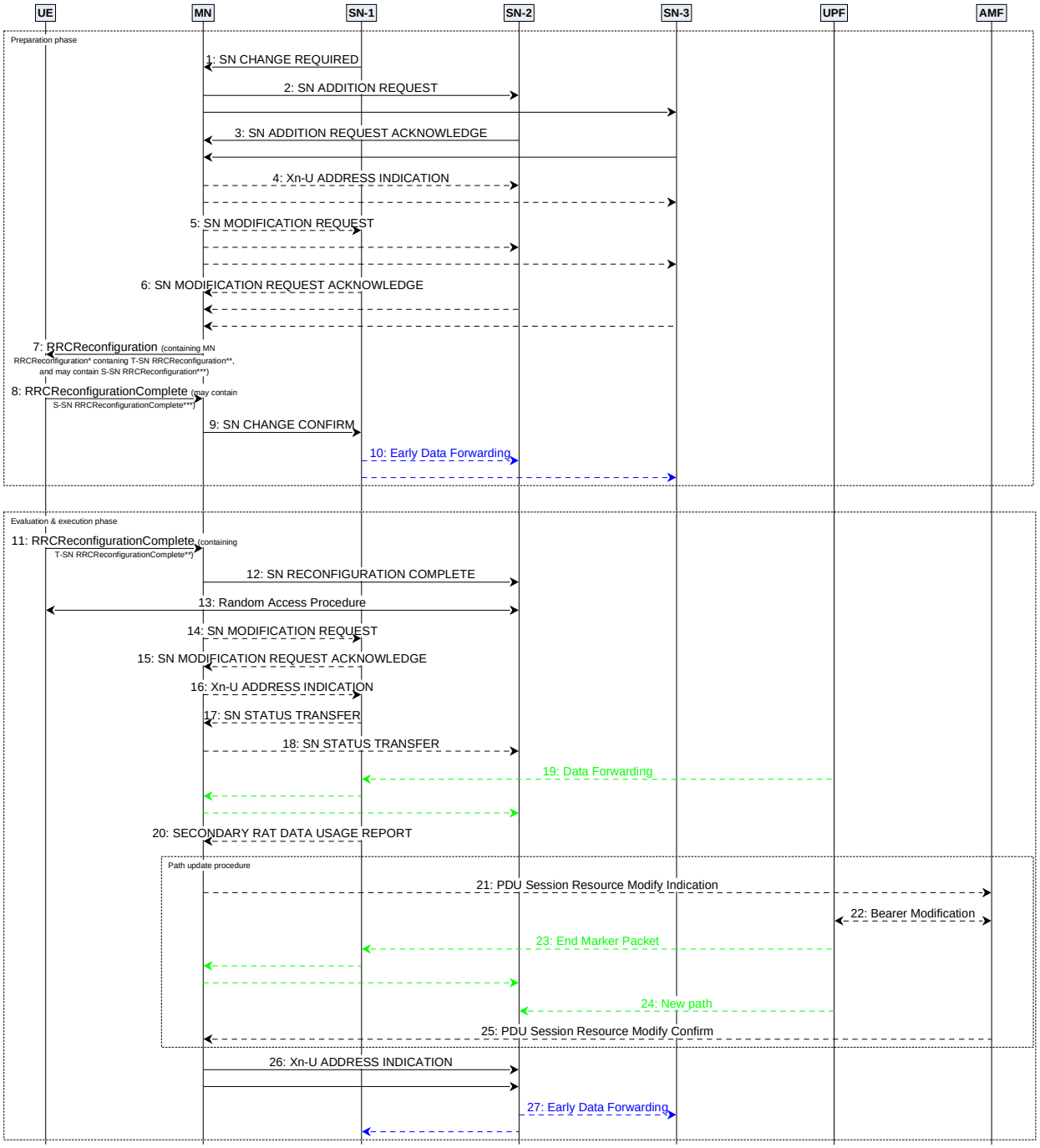


Figure 10.20-2: Subsequent CPAC - SN initiated

Figure 10.20-2 shows an example signalling flow for the subsequent CPAC initiated by the source SN:

1. The source SN (i.e. SN-1) initiates the subsequent CPAC procedure for candidate PSCell(s) in other (candidate) SN(s) by sending the *SN Change Required* message, which contains a subsequent CPAC initiation indication. The message also contains candidate node ID(s) and may include an SCG reference configuration (to support delta configuration), and contains the measurements results which may include cells that are not subsequent CPAC candidates. The message also includes a list of proposed PSCell candidates recommended by the source SN, including execution conditions for the initial evaluation, the upper limit for the number of PSCells that can be prepared by each candidate SN, and may also include the SCG measurement configurations for subsequent CPAC (e.g. measurement ID(s) to be used for subsequent CPAC). The source SN may also propose data forwarding to the MN or other candidate SN(s) for subsequent CPAC.

2/3. The MN requests each candidate SN(s) to allocate resources for the UE by means of the SN Addition procedure(s), indicating the request is for subsequent CPAC, and the measurements results which may include cells that are not subsequent CPAC candidates received from the source SN to the candidate SN, and indicating a

list of proposed PSCell candidates to the candidate SN(s) received from the source SN, but not including execution conditions. The MN also includes information of other candidate SN(s), and for each candidate SN, a list of proposed PSCell candidates recommended by the source SN for the candidate SN to select the PSCell(s) for the following execution of subsequent CPAC. The MN also provides the upper limit for the number of PSCells that can be prepared by each candidate SN and provides a list of K_{SN} and associated sk-Counter values for each candidate SN. Within the list of PSCells suggested by the source SN, the candidate SN decides the list of PSCell(s) to prepare (considering the maximum number indicated by the MN) and, for each prepared PSCell, the candidate SN decides other SCG SCells and provides the new corresponding SCG radio resource configuration to the MN in an NR *RRCReconfiguration*** message contained in the *SN Addition Request Acknowledge* message with the prepared PSCell ID(s). For each prepared PSCell, the candidate SN also decides the list of PSCell(s) and associated execution conditions proposed for the following execution of subsequent CPAC. If data forwarding is needed, the candidate SN provides data forwarding addresses to the MN. The candidate SN may also propose data forwarding to the MN or other candidate SN(s) for subsequent CPAC. The candidate SN may include an indication that the SCG radio resource configuration of a prepared PSCell is a complete candidate configuration, i.e. that it is not a delta configuration with respect to the SCG reference configuration. For the prepared PSCell(s) and the proposed PSCell(s) for the following execution of subsequent CPAC, the candidate SN can either accept or reject each of the candidate cells suggested by the source SN, i.e. it cannot configure any alternative candidates.

The MN may select one of the candidate SN(s) and requests providing the reference SCG configuration as part of the SN Addition procedure. Once obtained, the MN provides the reference configuration to other candidate SN(s).

NOTE 6: The MN may trigger the MN-initiated SN Modification procedure (to the source SN) to request a reference configuration for the subsequent CPAC before step 2, if not provided in step 1.

NOTE 7: If applicable, the MN stores the data forwarding addresses and data forwarding proposals provided from all the candidate SN(s) and the source SN.

NOTE 7a: The MN may decide to reconfigure the source SN as a candidate SN. In this case, the descriptions in the above steps 2-3 apply the same with the source SN, except that it is the MN that provides the list of proposed PSCell candidates for the source SN (as a candidate SN), and that the MN-initiated SN modification procedure is used with the source SN instead of the MN-initiated SN addition procedure. In the subsequent steps, the descriptions for any candidate SN also apply the same to the source SN (as one of candidate SN(s) for the subsequent CPAC) unless explicitly stated otherwise.

4. For SN terminated bearers using MCG resources, the MN provides Xn-U DL TNL address information in the *Xn-U Address Indication* message to the candidate SN(s).

5/6. The MN may indicate the candidate PSCells accepted by each candidate SN to the source SN via SN Modification Request message before it configures the UE, e.g., when not all candidate PSCells were accepted by the candidate SN(s). If requested, the source SN sends an SN Modification Request Acknowledge message and if needed, provides an updated measurement configuration and/or the execution conditions for the initial execution of subsequent CPAC to the MN.

For each candidate SN, the MN may initiate the SN Modification procedures towards the candidate SN to inform the prepared PSCells in other candidate SN(s), e.g., when not all proposed PSCells by this candidate SN for the following execution of subsequent CPAC were prepared by the candidate SN(s). If requested, the candidate SN sends an *SN Modification Request Acknowledge* message and if needed, provides the updated candidate SCG configuration(s) and/or the associated execution conditions for the following execution of subsequent CPAC of the list of PSCell(s) to the MN.

7. The MN sends to the UE an *RRCReconfiguration* message including the subsequent CPAC configuration, i.e. a list of *RRCReconfiguration** messages and associated execution conditions for the initial execution of subsequent CPAC and execution conditions for the following execution of subsequent CPAC, in which each *RRCReconfiguration** message contains the SCG configuration in the *RRCReconfiguration*** message received from one of the candidate SN(s) in steps 2 and 3, and possibly an MCG configuration. Besides, the *RRCReconfiguration* message can also include an updated MCG configuration, as well as the NR *RRCReconfiguration**** message generated by the source SN, e.g., to configure the required conditional measurements. The *RRCReconfiguration* message also includes a security update configuration and may also include a reference configuration.

8. The UE applies the *RRCReconfiguration* message received in step 7, stores the subsequent CPAC configuration and replies to the MN with an *RRCReconfigurationComplete* message, which can include an NR

*RRCReconfigurationComplete**** message. In case the UE is unable to comply with (part of) the configuration included in the *RRCReconfiguration* message, it performs the reconfiguration failure procedure.

9/10. If an SN RRC response message is included, the MN informs the source SN with the SN *RRCReconfigurationComplete**** message via *SN Change Confirm* message. If step 5 and 6 towards the source SN are skipped, the MN will indicate the candidate PSCells accepted by each candidate SN to the source SN in the *SN Change Confirm* message.

The MN sends the *SN Change Confirm* message towards the source SN to indicate that subsequent CPAC is prepared, and in such case the source SN continues providing user data to the UE. If early data forwarding is applied, the MN informs the source SN the data forwarding address(es), the source SN, if applicable, together with the Early Status Transfer procedure, starts early data forwarding. The PDCP SDU forwarding may take place during early data forwarding. In case multiple candidate SNs are prepared, the MN includes a list of Target SN ID and list of data forwarding addresses to the source SN.

NOTE 8: The Xn-U Address Indication procedure may further be invoked to indicate to the source SN to stop already initiated early data forwarding for some PDCP SDUs if they are no longer subject to data forwarding due to the modification or cancellation of the prepared subsequent CPAC.

NOTE 9: For the early transmission of MN terminated split/SCG bearers, the MN forwads the PDCP PDU to the candidate SN(s).

11. The UE starts evaluating the execution conditions for the initial execution of subsequent CPAC. If the execution condition of one candidate PSCell is satisfied, the UE applies *RRCReconfiguration** message corresponding to the selected candidate PSCell, and sends an MN *RRCReconfigurationComplete** message, including an *RRCReconfigurationComplete*** message for the selected candidate PSCell, and information enabling the MN to identify the SN of the selected candidate PSCell. The *RRCReconfigurationComplete** message may also include the sk-Counter value associated with the selected candidate PSCell if a new sk-Counter value is selected.

12. The MN informs the SN of the selected candidate PSCell (i.e. the selected candidate SN) that the UE has completed the reconfiguration procedure successfully via *SN Reconfiguration Complete* message, including the *RRCReconfigurationComplete*** message. If the sk-Counter value is received by the *RRCReconfigurationComplete** message, the MN also indicates the received sk-Counter value to the SN.

13. The UE performs synchronisation towards the PSCell indicated in the *RRCReconfiguration** message applied in step 11. The order the UE sends the MN *RRCReconfigurationComplete** message and performs the Random Access procedure towards the SCG is not defined. The successful RA procedure towards the SCG is not required for a successful completion of the RRC Reconfiguration procedure.

NOTE 9a: If the selected candidate PSCell that the UE executed in the step 13 belongs to the same last serving SN, the steps 10-11 in the Figure 10.20-3 are executed instead of the steps 14-19 in this figure.

14/15/16. If the source SN is configured as a candidate SN, the MN triggers the MN initiated SN Modification procedure to inform the source SN to stop providing user data to the UE, to switch to the prepared state, and if applicable, to allow provisioning of new data forwarding addresses based on the data forwarding proposals of the MN and the selected candidate SN. If applicable, the MN triggers the Xn-U Address Indication procedure to inform the source SN the address of the SN of the selected candidate PSCell, to start late data forwarding. If the source SN is not configured as a candidate SN, the MN triggers the MN initiated SN Release procedure to inform the source SN to stop providing user data to the UE, and triggers the Xn-U Address Indication procedure to inform the source SN the address of the SN of the selected candidate PSCell and if applicable, starts late data forwarding.

17/18. If PDCP termination point is changed for bearers using RLC AM, the SN sends the *SN Status Transfer* message to MN, which the MN sends then to the SN of the selected candidate PSCell, if needed.

19. If applicable, data forwarding from the source SN takes place. It may be initiated as early as the the source SN receives the early data forwarding address in step 10.

20. The source SN sends the *Secondary RAT Data Usage Report* message to the MN and includes the data volumes delivered to and received from the UE as described in clause 10.11.2.

NOTE 9b: The order the SN sends the *Secondary RAT Data Usage Report* message and performs data forwarding with MN is not defined. The SN may send the report when the transmission of the related bearer is stopped.

21-25: If applicable, a PDU Session path update procedure is triggered by the MN.

26-27. If data forwarding is needed, the MN may send the *Xn-U Address Indication* message to the selected candidate SN. The SN may decide to perform, if applicable, early data forwarding for SN-terminated bearers, together with the sending of an *Early Status Transfer* message to the MN.

NOTE 10: Separate Xn-U Address Indication procedures may be initiated to provide different forwarding addresses of the prepared subsequent CPAC. In this case, it is up to the MN and the candidate SN implementations to make sure that the *Early Status Transfer* message(s) from the selected candidate SN, if any, is forwarded to the right other candidate SN.

NOTE 11: The steps 11-27 can be performed multiple times for the following execution of subsequent CPAC, using the subsequent CPAC configuration provided in step 7. In step 11, the UE starts evaluating the execution conditions for the following execution of subsequent CPAC, instead of the execution conditions for the initial execution of subsequent CPAC.

SN initiated intra-SN subsequent CPAC with MN involvement

This procedure is initiated by the SN for intra-SN subsequent CPAC with MN involvement.

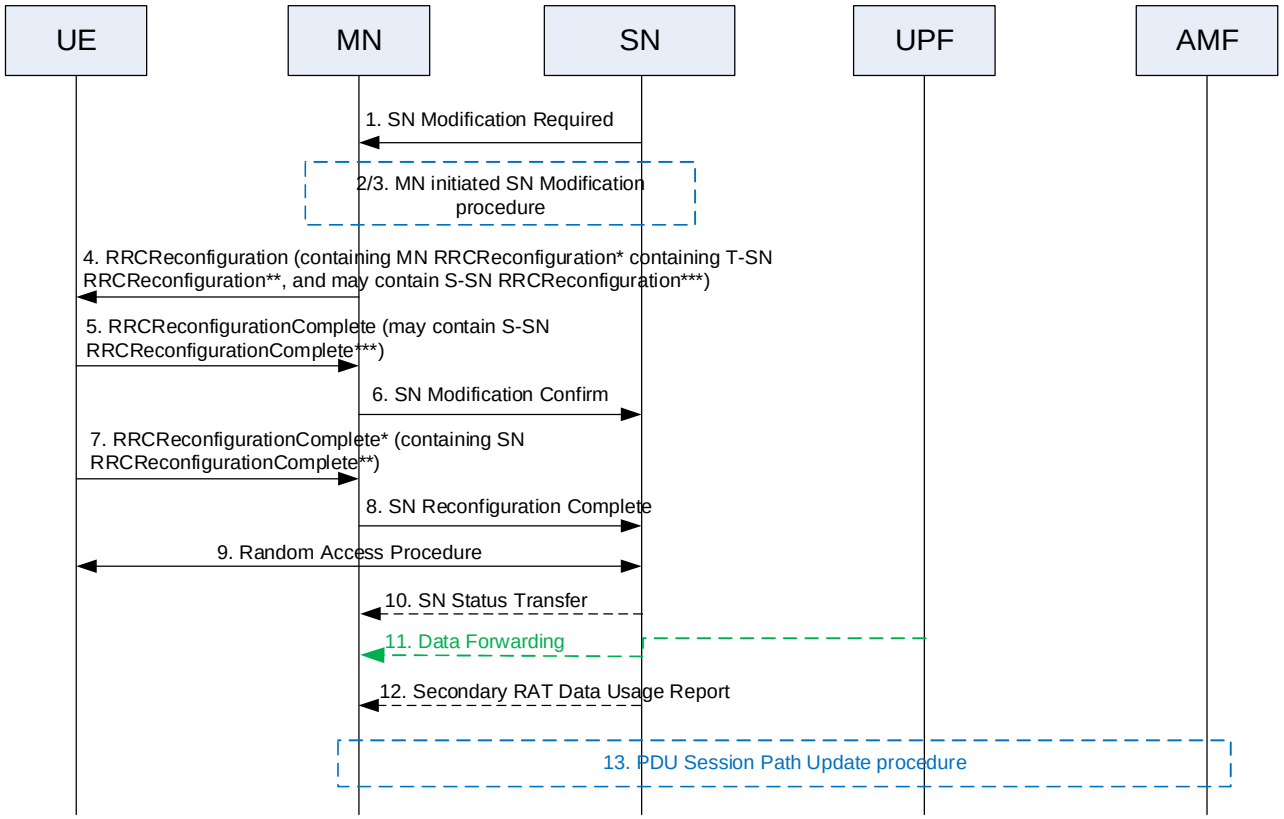


Figure 10.20-3: Intra-SN subsequent CPAC - SN initiated with MN involvement

Figure 10.20-3 shows an example signalling flow for intra-SN subsequent CPAC initiated by the SN with MN involvement:

1. The SN initiates the conditional SN modification procedure by sending the *SN Modification Required* message, which contains an intra-SN subsequent CPAC initiation indication. The message includes a list of PSCell(s) to prepare and:

   - either the associated execution conditions proposed for the initial execution of subsequent CPAC;

   - or execution conditions proposed for the following execution of subsequent CPAC, and for each prepared PSCell, the SN decides SCG SCells and provides the new corresponding SCG radio resource configuration to the MN in an NR *RRCReconfiguration*** message contained in the *SN Modification Required* message.

   The SN may include an indication that the SCG radio resource configuration of a prepared PSCell is a complete candidate configuration, i.e. that it is not a delta configuration with respect to the reference SCG configuration.

2/3. The MN initiated SN Modification procedure may be triggered by *SN Modification Required* message, e.g. when an SN security key change needs to be applied or, in case the *SN Modification Required* message in the step 1 is sent by the SN to initiate intra-SN subsequent CPAC, to retrieve additional configuration information.

NOTE 12: For SN terminated bearers to be setup for which PDCP duplication with CA is configured in NR MCG side, the SN allocates up to 4 separate Xn-U bearers and the MN provides a logical channel ID for primary or split secondary path to the SN via the nested MN-initiated SN modification procedure.

4. The MN sends to the UE an *RRCReconfiguration* message including the subsequent CPAC configuration, i.e. a list of *RRCReconfiguration** messages and associated execution conditions for the initial execution of subsequent CPAC and execution conditions for the following execution of subsequent CPAC, in which each *RRCReconfiguration** message contains the SCG configuration in the *RRCReconfiguration*** message received from the SN in step 1 and possibly an MCG configuration. Besides, the *RRCReconfiguration* message can also include an updated MCG configuration, as well as the NR *RRCReconfiguration**** message generated by the SN, e.g., to configure the required conditional measurements. The *RRCReconfiguration* message may also include a reference configuration and a security update configuration.

5. The UE applies the *RRCReconfiguration* message received in step 4, stores the subsequent CPAC configuration and replies to the MN with an *RRCReconfigurationComplete* message, which can include an NR *RRCReconfigurationComplete**** message. In case the UE is unable to comply with (part of) the configuration included in the *RRCReconfiguration* message, it performs the reconfiguration failure procedure.

6. If an SN RRC response message is included, the MN informs the SN with the SN *RRCReconfigurationComplete**** message via *SN Modification Confirm* message. The MN sends the *SN Modification Confirm* message towards the SN to indicate that subsequent CPAC is prepared.

7. The UE starts evaluating the execution conditions for the initial execution of subsequent CPAC. If the execution condition of one candidate PSCell is satisfied, the UE applies *RRCReconfiguration** message corresponding to the selected candidate PSCell, and sends an *RRCReconfigurationComplete** message, including an *RRCReconfigurationComplete*** message for the selected candidate PSCell, and information enabling the MN to identify the selected candidate PSCell.

8. If the RRC connection reconfiguration procedure was successful, the MN informs the SN of the selected candidate PSCell via *SN Reconfiguration Complete* message, including the SN *RRCReconfigurationComplete*** message.

9. The UE synchronizes to the PSCell indicated in the *RRCReconfiguration** message applied in step 7.

10. If PDCP termination point is changed for bearers using RLC AM, the SN Status Transfer takes place between the MN and the SN (Figure 10.20-3 depicts the case where a bearer context is transferred from the SN to the MN).

11. If applicable, data forwarding between MN and the SN takes place (Figure 10.20-3 depicts the case where a user plane resource configuration related context is transferred from the SN to the MN).

12. The SN sends the *Secondary RAT Data Usage Report* message to the MN and includes the data volumes delivered to and received from the UE as described in clause 10.11.2.

NOTE 13: The order the SN sends the *Secondary RAT Data Usage Report* message and performs data forwarding with MN is not defined. The SN may send the report when the transmission of the related QoS flow is stopped.

13. If applicable, a PDU Session path update procedure is performed.

NOTE 14: The steps 7-13 can be performed multiple times for the following execution of subsequent CPAC, using the subsequent CPAC configuration provided in step 4. In step 7, the UE starts evaluating the execution conditions for the following execution of subsequent CPAC, instead of the execution conditions for the initial execution of subsequent CPAC.

SN initiated intra-SN subsequent CPAC without MN involvement (SRB3 is not used)

The procedure follows the steps described in figure 10.3.2-5.

SN initiated intra-SN subsequent CPAC without MN involvement (SRB3 is used)

The procedure follows the steps described in figure 10.3.2-3a.

11 Service related aspects

11.1 Roaming and Access Restrictions

The principles for conveying roaming and access restriction info for EN-DC are described in TS 36.300 [2].

For MR-DC with 5GC, SCG (re)selection at the SN is based on roaming and access restriction information in SN. If roaming and access restriction information is not available at the SN, the SN shall consider that there is no restriction for SCG (re)selection. Therefore, the MN needs to convey the latest roaming and access restriction information as received from the Core Network or another NG-RAN node to the SN via XnAP messages.

11.2 Support of Network Sharing

E-UTRAN and NG-RAN aspects of network sharing are specified in TS 36.300 [2] and TS 38.300 [3].

11.3 ARPI/SPID Handling from MN

Usage of the Subscriber Profile ID for RAT/Frequency Priority (SPID) and the Additional RRM Policy Index (ARPI) in E-UTRAN is specified in TS 36.300 [2] and applies to EN-DC. Therefore, the MN needs to convey the up-to-date ARPI/SPID information to the SN via X2AP messages.

12 X2/Xn Interface related aspects

Stage 2 specification for X2-C procedures for EN-DC is contained in TS 36.300 [2].

Xn-C procedures for MR-DC with 5GC are specified in TS 38.423 [5].

X2-U procedures for EN-DC and Xn-U procedures for MR-DC with 5GC are specified in TS 38.425 [6].

13 Other aspects

13.1 Interference avoidance for in-device coexistence

IDC solution as described in TS 36.300 [2] and TS 38.300 [3] is extended to address EN-DC/NR-DC operation. For the FDM solution, the list of NR carriers or NR frequency ranges suffering from IDC problems is signalled in IDC report. For the TDM solution, a periodic pattern can be signalled per-CG in IDC report. In EN-DC, the MN can configure the UE to report FDM assistance information with affected carriers. In NR-DC, the MN can configure the UE to report FDM assistance information with affected carriers/frequency ranges and/or TDM assistance information. For both EN-DC and NR-DC, the SN can configure the UE to report FDM assistance information with affected carriers/frequency ranges and/or TDM assistance information to the SN via SRB1 or SRB3, if SRB3 is configured and the SCG is activated. The network can also configure autonomous denial per-CG for the UE to solve IDC problems. The requirement on RRM/RLM/CSI measurements in different phases of IDC interference defined in TS 36.300 [2] is applicable except that for NR serving cell, the requirements in TS 38.133 [8] and TS 38.101-1 [12], TS 38.101-2 [13], TS 38.101-3 [14] apply.

13.2 Sidelink

NR Sidelink Communication, V2X Sidelink Communication, NR Sidelink Discovery and Ranging/Sidelink Positioning cannot be configured in MR-DC in this release.

13.3 SCG UE history information

The MN stores and correlates the UE History Information from MN and SN(s) as long as the UE stays in MR-DC, forwards UE History Information and optional UE History Information from the UE to its connected SNs. The resulting information is then used by SN for dual-connectivity operation. The SN is in charge of collecting SCG UE history information and providing the collected information to the MN.

If the UE stays in a PSCell for a duration exceeding the maximum value of the Time Stay parameter, the SN may store the PSCell information with consecutive entries using the same PSCell identity. The total stay time in this PSCell is the sum of stay time for all consecutive PSCell with the same identity.

The SN shall provide the collected SCG UE history information, if available, to the MN in the following procedures:

- the SN Release, and SN initiated SN Change procedures
- the MN initiated SN Modification procedure if requested by the MN in this procedure
- the SN initiated SN modification procedure upon PSCell change if subscribed in the SN Addition procedure

When the target NG-RAN node receives the SCG UHI from the source NG-RAN node via Handover Request message for CHO, the target NG-RAN node updates the time UE stayed in cell of the latest PSCell entry (i.e. the source PSCell) when the UE successfully accesses to a candidate cell of the target NG-RAN node. The updated value of the time UE stayed in the source PSCell is equal to the value received from the source NG-RAN node during the Handover Preparation plus the time from receiving Handover Request message from the source NG-RAN node to receiving RRC Reconfiguration Complete message from the UE.

When the target SN receives the SCG UHI from the MN via SN Addition Request message for CPC, the target SN updates the time UE stayed in the cell of the latest PSCell entry (i.e. the source PSCell) when the UE successfully accesses to a candidate cell of the target SN. The updated value of the time UE stayed in the latest PSCell is equal to the value received from the MN via the SN Addition Request message plus the time from receiving SN Addition Request message from the MN to receiving SN Reconfiguration Complete from the MN.

13.4 Application Layer Measurement Collection

13.4.1 Overview

The QoE Measurement Collection function as described in TS 38.300 [3] is extended to address the NR-DC operation.

For a UE in (NG)EN-DC and NE-DC, only the MN can configure the QoE configuration.

13.4.2 SRB5

SRB5 is supported in NR-DC, but not in EN-DC, NGEN-DC and NE-DC.

The decision to establish SRB5 is taken by the SN, which provides the SRB5 configuration using an SN RRC message. SRB5 establishment and release can be done at Secondary Node Addition and Secondary Node Change. SRB5 reconfiguration can be done at Secondary Node Modification procedure.

SRB5 is used to send RRC messages (i.e., *MeasurementReportAppLayer* message) including application layer measurement report information directly to the SN.

SRB5 is modelled as one of the SRBs defined in TS 38.331 [4] and uses the NR-DCCH logical channel type.

When the SCG is released, SRB5 is released.

13.4.3 QoE Measurement Configuration

13.4.3.1 QoE Measurement Collection Activation and Reporting in NR-DC

For a UE in NR-DC, either the MN or the SN can generate QoE configuration(s) and transmit the configuration to the UE. If both the MN and the SN send QoE configurations to the UE, the MN and the SN do not use the same set of

application layer measurement configuration identities, which means there is a unique ID for QoE configurations across MN and SN.

The MN and the SN may coordinate management-based QoE measurement collection activation. During the coordination, the MN:

- Allocates the application layer measurement configuration ID for QoE measurement configurations to be configured at UEs served by the MN and the SN, and indicates it to the SN, if needed;
- Determines whether the MN or the SN sends the QoE configuration to the UE, in case the SN inquires the MN;
- Can inform the SN that a UE is configured with a management-based QoE.

For management-based QoE measurement configurations received directly by the SN from OAM, the SN may perform UE selection. For a selected UE, the SN indicates to the MN the QoE reference of the management-based QoE configuration and, separately for the QoE reports and RAN visible QoE reports, the SN indicates whether it is going to receive the corresponding reports directly using SRB5 or via the MN (using SRB4). Upon receiving the coordination request, the MN can decide and notify the SN whether the MN sends the QoE and RAN visible QoE configuration to the UE, or whether the SN should send the configuration(s) to the UE. The SN can send a QoE and/or a RAN visible QoE measurement configuration directly to the UE via SRB3, or in a transparent container to the MN, which then sends the configuration to the UE via SRB1.

For management-based QoE configurations received directly by the MN from the OAM and for signalling-based QoE configurations, the MN can only send the configuration to the UE via SRB1, and the UE can send the QoE reports via SRB4 or SRB5. The MN should inform the SN that the UE is configured with the management-based QoE/RAN visible QoE measurement configuration. When the MN has released the management-based QoE/RAN visible QoE measurement configuration, the MN should inform the SN.

For a UE in NR-DC, both SRB4 and SRB5 can be configured simultaneously for QoE reporting. The network explicitly and separately indicates to the UE whether to send encapsulated QoE reports and RAN visible QoE reports via SRB4 or SRB5, per QoE reference. The SRB for QoE reporting can be changed during the QoE measurement session. The command for changing the SRB used for reporting may be sent to the UE by the node that configured that specific QoE configuration. The node that currently receives the QoE reports via the Uu interface can request from the peer node that the QoE reporting path is changed to the peer node per QoE reference. The change of QoE reporting path needs to be approved by both nodes serving the UE.

If encapsulated QoE reports (sent in *measReportAppLayerContainer*) cannot be sent because the SRB configured for such reporting is not available, the UE continues to store the reports until the SRB is available or until the QoE configuration is released.

If the MN has configured the UE with QoE measurements, and if the UE is configured to send the QoE reports to the SN, then, if the MN decides that the SN forwards the reports directly to the MCE, the MN should indicate to the SN the QoE reference, the MCE IP address and the application layer measurement configuration ID.

If the SN has configured the UE with QoE measurements, and if the UE is configured to send the QoE reports to the MN, then, if the SN decides that the MN forwards the reports directly to the MCE, the SN should indicate to the MN the QoE reference and the MCE IP address.

QoE reports can be transferred between the MN and the SN via the RRC TRANSFER message.

If the SN has released a QoE configuration of a UE, the SN should inform the MN.

When SCG is deactivated, for QoE configurations configured to use SRB5 for QoE reporting, it is up to network implementation whether to reconfigure the reporting path to SRB4, release the QoE configuration or pause the QoE reporting. For UL data arrival on SRB5 while the SCG is deactivated, the UE does not indicate to the MN that it has QoE report to transmit over SRB5 for the purpose of SCG activation.

When the SCG is released, the UE releases all the QoE measurements configured by the SCG and discards the unsent QoE reports configured to be reported via SRB5.

In order to allow the transmission of application layer measurement reports which exceed the maximum PDCP SDU size, the network can inform the UE whether the MN allows RRC segmentation of *MeasurementReportAppLayer* message sent by the UE via SRB4 and whether the SN allows RRC segmentation of *MeasurementReportAppLayer* message sent by the UE via SRB5.

13.4.3.2 RAN Overload Handling

In NR-DC, when RAN overload happens in the node which receives the QoE reports from the UE, the node may either determine to pause the QoE reporting from the UE as specified in TS 38.300 [3] or the node may coordinate with its peer node to reconfigure the QoE reporting path and offload one or more of the QoE measurement sessions, by sending the QoE Reporting Path Request in the *QMC Coordination Request* IE, via the MN-initiated and SN-initiated SN modification procedure. The peer node may approve the reconfiguration of the QoE reporting path of the one or more QoE measurement sessions, by sending the QoE Reporting Path Response in the *QMC Coordination Response* IE in the response message for SN modification.

When the peer node is not able to accept the Reporting Path Request of one or more QoE measurement sessions, the node that is overloaded in NR-DC may pause the QoE reporting from the UE for those QoE measurement sessions as specified in TS 38.300 [3].

When neither the MN nor the SN is able to receive the QoE reports due to RAN overload, the network can indicate to the UE to pause QoE reporting, as specified in TS 38.300 [3].

13.4.3.3 Support for RAN visible QoE measurements and reporting in NR-DC

Either the MN or the SN can generate and send a RAN visible QoE configuration to the UE. The gNB that has initially configured a UE in NR-DC with a RAN visible QoE configuration can modify and release the RAN visible QoE configuration as long as the UE is connected to this gNB. The gNB that configures the encapsulated QoE measurements to UE is referred to as the RAN visible QoE-configuring gNB, and the peer node is referred to as the non-RAN visible QoE-configuring gNB. Upon mobility, the RAN visible QoE-configuring gNB may be changed.

The UE may send RAN visible QoE reports to the network using either SRB4 or SRB5. In addition, the gNB that received a RAN visible QoE report can forward the report to the other gNB (the SN or the MN). QoE reports and RAN visible QoE reports pertaining to the same QoE reference can be sent over the same SRB or they can be sent over different SRBs. If RAN visible QoE reports cannot be sent because the SRB configured for RAN visible QoE measurement reporting is not available, the UE discards the RAN visible QoE report.

The RAN visible QoE-configuring gNB can configure RAN visible QoE measurements at a UE without a priori knowledge about which gNB(s) will provide the bearer(s) for a future application session. During the lifetime of an application session, to ensure that the RAN visible QoE reports are sent to the gNB(s) that provide the bearer(s) which carry the data flow(s) associated with the RAN visible QoE measurement result in a RAN visible QoE report, the gNB receiving the RAN visible QoE reports determines the bearer(s) used to deliver the application session data flow(s) and the associated gNB (s). The determination may be based on the PDU session ID(s) and the QoS flow ID(s) indicated in a received RAN visible QoE report.

When the RAN visible QoE-configuring gNB receives a RAN visible QoE report and determines that the non-RAN visible QoE-configuring gNB provides at least one bearer for the application session, the RAN visible QoE-configuring gNB indicates that to the non-RAN visible QoE-configuring gNB. The non-RAN visible QoE-configuring gNB can then, if needed, indicate to the RAN visible QoE-configuring gNB its preference with respect to the reporting path for the subsequent RAN visible QoE reports and its preferred RAN visible QoE configuration parameters.

If a gNB receives a RAN visible QoE report from a UE in NR-DC, and determines that the bearer(s) for the application session data flow(s) is (are) also provided by the other gNB, or only provided by the other gNB, the gNB that received the RAN visible QoE report may forward the received RAN visible QoE report to the other gNB. The RAN visible QoE reports can be transferred between the MN and the SN via the RRC TRANSFER message.

13.4.4 QoE Measurement Continuity for Mobility

For ongoing QoE measurement sessions, QoE measurement continuity is ensured during mobility in NR-DC, e.g., during inter-MN handover (with/without SN change) and SN change scenarios.

To ensure QoE measurement continuity during SN change, the SN-initiated SN change procedure or the MN-initiated SN modification procedure can be used to provide to the MN the QMC configuration information managed by the SN, i.e., the *Source SN to Target SN QMC Information* IE as defined in TS 38.423 [5]. The MN can then transfer this information to the target SN during the SN Addition procedure.

To ensure QoE measurement continuity during inter-MN handover with SN change or without SN change, the source SN should provide to the MN about the QMC configuration information managed by the SN, i.e., the *Source SN to*

Target SN QMC Information IE. During the handover procedure, the target MN is provided with all the information known at the source MN about the QMC configurations managed by the SN.

If the MN configured the UE with QoE measurements, every subsequent MN serving the UE can configure and release the RAN visible QoE measurements pertaining to this QoE measurement configuration. If the SN configured the UE with QoE measurements, every subsequent SN serving the UE can configure and release the RAN visible QoE measurements pertaining to this QoE measurement configuration.

Annex A (informative): Layer 2 handling for bearer type change

This clause provides for information an overview on L2 handling for bearer type change in MR-DC, with and without a security key change due to a change of the termination point.

Table A-1: L2 handling for bearer type change with and without a security key change due to a change of the termination point.

Bearer type change from row to col	MCG		Split		SCG	
	no change of termination point (no key change)	change of termination point (key change)	no change of termination point (no key change)	change of termination point (key change)	no change of termination point (no key change)	change of termination point (key change)
MCG	N/A	PDCP: Re-establish MCG RLC: See Note 1 MCG MAC: See Note 1 SCG RLC: No action SCG MAC: No action	PDCP: Reconfigure MCG RLC: No action MCG MAC: No action SCG RLC: Establish SCG MAC: Reconfigure	PDCP: Re-establish MCG RLC: See Note 1 MCG MAC: See Note 1 SCG RLC: Establish SCG MAC: Reconfigure	PDCP: Recovery MCG RLC: See Note 3 MCG MAC: Reconfigure SCG RLC: Establish SCG MAC: Reconfigure	PDCP: Re-establish MCG RLC: See Note 3 MCG MAC: Reconfigure SCG RLC: Establish SCG MAC: Reconfigure
Split	PDCP: Recovery MCG RLC: No action MCG MAC: No action SCG RLC: See Note 4 SCG MAC: Reconfigure	PDCP: Re-establish MCG RLC: See Note 1 MCG MAC: See Note 1 SCG RLC: See Note 4 SCG MAC: Reconfigure	N/A	PDCP: Re-establish MCG RLC: See Note 1 MCG MAC: See Note 1 SCG RLC: See Note 1 SCG MAC: See Note 1	PDCP: Recovery MCG RLC: See Note 3 MCG MAC: Reconfigure SCG RLC: No action SCG MAC: No action	PDCP: Re-establish MCG RLC: See Note 3 MCG MAC: Reconfigure SCG RLC: See Note 1 SCG MAC: See Note 1
SCG	PDCP: Recovery MCG RLC: Establish MCG MAC: Reconfigure SCG RLC: See Note 4 SCG MAC: Reconfigure	PDCP: Re-establish MCG RLC: Establish MCG MAC: Reconfigure SCG RLC: See Note 4 SCG MAC: Reconfigure	PDCP: Reconfigure MCG RLC: Establish MCG MAC: Reconfigure SCG RLC: No action SCG MAC: No action	PDCP: Re-establish MCG RLC: Establish MCG MAC: Reconfigure SCG RLC: See Note 1 SCG MAC: See Note 1	N/A	PDCP: Re-establish MCG RLC: No action MCG MAC: No action SCG RLC: See Note 1 SCG MAC: See Note 1

NOTE 1: For EN-DC and NGEN-DC MCG, NE-DC SCG: the MAC/RLC behaviour depends on the solution selected by the network. It can be PCell handover (for EN-DC and NGEN-DC) or PSCell change (for NE-DC), which triggers MAC reset and RLC re-establishment. Alternatively, the logical channel identity can be changed, either via RLC bearer release and add for the same DRB (including RLC re-establishment), or via reconfiguration of the RLC bearer with RLC-re-establishment.

For EN-DC and NGEN-DC SCG, NE-DC MCG, NR-DC MCG and SCG: the MAC/RLC behaviour depends on the solution selected by the network. It can be reconfiguration with sync, with MAC reset and RLC re-establishment. Alternatively, the logical channel identity can be changed via RLC bearer release and add.

NOTE 2: Void

NOTE 3: For EN-DC and NGEN-DC: Re-establishment and release. For NE-DC and NR-DC: Release.

NOTE 4: For NE-DC: Re-establishment and release. For EN-DC, NGEN-DC and NR-DC: Release.

Annex B (informative): Handover Scenarios

Supported MR-DC

Table B-1 summarizes the supported handover scenarios involving MR-DC configurations.

Table B-1: Supported MR-DC handover scenarios.

HO from (row) \ To (column)	E-UTRA with EPC	E-UTRA with 5GC	NR	GERAN or UTRAN	EN-DC	NGEN-DC	NE-DC	NR-DC
E-UTRA with EPC	YES	YES	YES	YES	YES	NO	NO	NO
E-UTRA with 5GC	YES	YES	YES	NO	NO	YES	NO	NO
NR	YES	YES	YES	NOTE 1	YES	NO	YES	YES
GERAN or UTRAN	YES	NO	NO	YES	NO	NO	NO	NO
EN-DC	YES	YES	YES	YES	YES	NO	NO	NO
NGEN-DC	YES	YES	YES	NO	NO	YES	NO	NO
NE-DC	YES	YES	YES	NOTE 1	NO	NO	YES	NO
NR-DC	YES	YES	YES	NOTE 1	NO	NO	NO	YES

NOTE 1: Only SRVCC handover of IMS voice bearer to UTRAN is supported.

NOTE 2: All handover scenarios according to Table B-1 that have a DC option in the column "from" are supported during fast MCG failure recovery.

NOTE 3: Only intra-RAT conditional handover is supported except for E-UTRA with 5GC scenario.

NOTE 4: DAPS handover is only supported from E-UTRA with EPC to E-UTRA with EPC and from NR to NR.

Annex C (informative): Change history

Change history							
Date	Meeting	Tdoc	CR	Rev	Cat	Subject/Comment	New version
2017.04	RAN2#97bis	R2-1703828	-	-	-	Draft Skeleton	0.0.1
2017.04	RAN2#97bis	R2-1703923	-	-	-	Endorsed Skeleton	0.0.2
2017.05	RAN2#98	R2-1704898	-	-	-	Initial version, including: Agreements from TR38.912 Agreements from RAN2#97bis on: - System information handling - Measurements - UE capability coordination - Handling of combined MN/SN RRC messages - SCG SRB - MCG split SRB - SN/MN Failure handling - QoS aspects - Bearer type configuration - Security aspects	0.1.0
2017.06	RAN2 NR AdHoc2	R2-1706418	-	-	-	Agreements from RAN3#96 on: - Network interfaces - Initial EN-DC operation related aspects - UP related aspects Agreements from RAN2#98 on: - Measurement coordination - UE capability coordination - SCG SRB Further RAN2 agreements on EN-DC operation related aspects	0.1.1
2017.06	RAN2 NR AdHoc2	R2-1707467	-	-	-	Endorsed version at RAN2 NR AH2, also including: Initial description of procedures for MR-DC with 5GC Correction to SN initiated SN change procedure for EN-DC	0.2.0
2017.08	RAN2#99	R2-1708080	-	-	-	Agreements from RAN3 NR AH2 on: - Data forwarding for SCG split bearer - Path Update procedure Agreements from RAN2 NR AH2 on: - Bearer type harmonization / bearer type change - UE capability coordination - SRB3 (SCG SRB) - MCG Split SRB - SN failure handling - Security handling - SN Addition procedure - MN initiated SN Modification/Release procedures Miscellaneous corrections	0.2.1
2017.08	RAN2#99	R2-1709831	-	-	-	Endorsed version at RAN2#99	0.3.0
2017.08	RAN2#99	R2-1709939	-	-	-	Agreements from RAN2#99 on: - Bearer type harmonization / bearer type change - SN failure handling - Measurement result exchange - Security aspects - Embedded RRC transport - Other MR-DC procedures related aspects RAN3 endorsed TPs on miscellaneous corrections to MR-DC procedures (in R3-173187, R3-173380, R3-173381, R3-173384, R3-173386, R3-173388 and R3-173390),	0.4.0
2017.09	RAN#77	RP-171872	-	-	-	Provided for information to RAN	1.0.0
2017.09	RAN#77	RP-172036	-	-	-	Correction of some auto-formatting issues	1.0.1
2017.09	RAN2#99bis	R2-1711526	-	-	-	Alignment to the agreed terminology for the different nodes: - introduction of the en-gNB term - replacement of MeNB and SgNB with MN and SN Clarification on UE capabilities coordination Clarification in Figure 4.2.2-2 that there is one SDAP entity per cell group	1.0.2
2017.10	RAN2#99bis	R2-1711937	-	-	-	Endorsed version at RAN2#99bis	1.1.0
2017.10	RAN2#9	R2-1712072	-	-	-	Agreements from RAN2#99bis on:	1.1.1

	9bis					- Bearer type harmonization / bearer type change - SCG change and Pscell change - MN/SN measurement coordination - UE capabilities coordination - MR-DC procedures related aspects - Security aspects Agreed Text Proposals in: - R2-1711929 TP on SN modification without MN involvement - R2-1711942 TP on inter-MN HO with SN change Agreements from RAN3#97bis in R3-174254, collecting changes from: - R3-174214 Text Proposal for QoS Handling in 5GC DC - R3-174132 Completion of the RRC tunnelling in MR-DC - R3-174136 Stage 2 TP on bearer type change without MAC reset - R3-174221 TP for Supporting MN Initiate SN Change - R3-174194 UE-AMBR enforcement - R3-174234 Secondary RAT data volume reporting - R3-174160 MN and SN role for QoS flow to DRB mapping - R3-174101 Clean-up of 37.340 RAN3 Related Part	
2017.11	RAN2#100	R2-1712301	-	-	-	Clean version	1.2.0
2017.11	RAN2#100	R2-1712302	-	-	-	MR-DC related agreements moved from TS 38.300: - on two C-RNTIs independently allocated ot the UE - on RLF declared separately for the MCG and for the SCG - on roaming and access restrictions for MR-DC with 5GC - on SPS and BSR configuration, triggering and reporting Addition of a note on support of ideal backhaul. Clarification on use of SRB3. Clarification on security key handling. Editorial corrections in various Figures Removal of FFSs for MR-DC with 5GC (moved to a separate list)	1.2.1
2017.12	RAN2#100	R2-1714080	-	-	-	Agreed Text Proposals in: - R2-1713141 TP on 37.340 - R2-1713838 Bearer type change with PDPC version change - R2-1714176 PSCell change clarification and SCG Change removal - R2-1714183 Stage 2 TP to update bearer type description - R2-1714237 Clarification for the MR-DC QoS framework - R3-174308 Cleanup of reference/definitions for 37.340 - R3-174565 TP for SCG Change related to Bearer Type Change - R3-174661 TP for querying SCGconfig for MN to eNB/gNB Change - R3-174763 TP for a unified 5G User Plane protocol - R3-174876 Further Clean-up of TS37.340 RAN3 Related Part - R3-174913 Clarifications on Inter-MN handover with SN change - R3-174916 Clarification on the interface between gNB for Option 3 - R3-174917 Tunnel ID switching in case of reconfiguration - R3-174921 Introducing bearer harmonization – RAN3 parts - R3-174923 On security related IE in MN initiated SN modification - R3-174928 TP on UE-AMBR for EN-DC - R3-174930 Stage 2 for secondary RAT data volume reporting - R3-175009 Removing data forwarding from corresponding node - R3-175048 Stage 2 TP for bearer type change - R3-174975 Race conditions in case of SN release Other miscellaneous agreements from RAN2#100	1.2.2
2017.12	RAN2#100	R2-1714251	-	-	-	RAN2 agreed version	1.3.0
2017.12	RP-78	RP-172464	-	-	-	Provided for approval to RAN	2.0.0
2017/12	RP-78					Upgraded to Rel-15	15.0.0
2018/03	RP-79	RP-180440	0004	1	F	Miscellaneous corrections	15.1.0
	RP-79	RP-180440	0008	1	F	Baseline CR for TS 37.340 (RAN3 part) covering agreements of RAN3 #NR adhoc 1801 and RAN3 #99	15.1.0
2018/06	RP-80	RP-181214	0012	2	F	Further miscellaneus corrections	15.2.0
	RP-80	RP-181214	0014	1	F	CR on EN-DC bearer type changes in TS 37.340	15.2.0
	RP-80	RP-181214	0015	1	F	CR on EN-DC reconfiguration procedure via SRB3 in TS 37.340	15.2.0
	RP-80	RP-181214	0017	-	F	Radio Protocol Architecture figure clarification with SDAP	15.2.0
	RP-80	RP-181215	0018	1	F	Stage 2 CR on combined bearer type and termination point change	15.2.0
	RP-80	RP-181215	0021	1	F	Correction to TS 37.340 on PDCP version for SRB	15.2.0
	RP-80	RP-181215	0024	1	F	L2 handling for bearer type change when PDCP SN length changed	15.2.0
	RP-80	RP-181215	0025	1	F	Correction on SN configured NR measurements after SCG failure	15.2.0
	RP-80	RP-181215	0026	1	F	Clarification of the usage of SN Status Transfer	15.2.0
	RP-80	RP-181215	0027	-	F	Addition of the full config indicator in SN Change	15.2.0
	RP-80	RP-181216	0028	2	F	Coordination of Inactivity for EN-DC	15.2.0
	RP-80	RP-181216	0029	-	F	CR on maintaining the bearer type on wrap-around for TS37.340	15.2.0
	RP-80	RP-181216	0030	2	F	Enabling re-use of NR PCIs in cells served by the same SN in EN-DC	15.2.0
2018/09	RP-81	RP-181939	0037	2	F	Clarification on number of CC for NR CA	15.3.0
	RP-81	RP-181942	0039	2	F	CR for 37.340 for CA duplication of LTE bearer	15.3.0
	RP-81	RP-181942	0042	-	F	Capturing the agreement related to Count wrap around handling for	15.3.0

						split bearer type	
	RP-81	RP-181941	0043	1	F	Miscellaneous clarifications	15.3.0
	RP-81	RP-181941	0044	1	F	Inclusion of measurement gap related agreements	15.3.0
	RP-81	RP-181942	0046	2	F	Small correction about bear type change	15.3.0
	RP-81	RP-181942	0047	3	F	CR to 37.340 on the Layer 2 handling for bearer type change	15.3.0
	RP-81	RP-181939	0048	-	F	CR on the support of RLC mode reconfiguration	15.3.0
	RP-81	RP-181939	0051	-	F	Corrections on 37.340 for bearer type change support	15.3.0
	RP-81	RP-181941	0054	1	F	NR Corrections (37.340 Baseline CR covering RAN3-101 agreements)	15.3.0
2018/12	RP-82	RP-182650	0067	1	F	Split SRB UL configuration	15.4.0
	RP-82	RP-182656	0071	1	F	Miscellaneous clarifications	15.4.0
	RP-82	RP-182669	0073	4	B	Agreements for MR-DC	15.4.0
	RP-82	RP-182651	0079	-	F	Correction for SN terminated MCG bearer	15.4.0
	RP-82	RP-182667	0082	3	F	Updates to UE capability coordination for MR-DC	15.4.0
	RP-82	RP-182664	0084	2	F	Corrections on RRC transfer procedure in EN-DC	15.4.0
	RP-82	RP-182666	0085	3	F	Correction of SN Initiated SN Modification procedure for Measurement Gap	15.4.0
	RP-82	RP-182660	0086	1	F	Stage 2 CR on Measurement gap configuration scenarios	15.4.0
	RP-82	RP-182669	0092	1	B	Baseline CR for TS37.340	15.4.0
2019/03	RP-83	RP-190543	0090	3	F	Corrections for MR-DC procedures	15.5.0
	RP-83	RP-190543	0096	2	F	QoS flow offloading for MR-DC	15.5.0
	RP-83	RP-190540	0098	1	F	Introduction of IDC mechanism for EN-DC operation	15.5.0
	RP-83	RP-190543	0104	1	F	Correction on UP integrity protection in late drop	15.5.0
	RP-83	RP-190543	0106	1	F	Corrections to SN Modification Request in MR-DC	15.5.0
	RP-83	RP-190553	0107	-	F	PSCell information for LI purposes	15.5.0
	RP-83	RP-190544	0108	-	F	Correction of EN DC data volume reporting and relocation	15.5.0
	RP-83	RP-190544	0110	-	F	Data volume reporting for MR-DC with 5GC	15.5.0
	RP-83	RP-190544	0111	-	F	Correction of RAN triggered PDU session split	15.5.0
	RP-83	RP-190544	0112	-	F	Correction of PDU session split at handover	15.5.0
	RP-83	RP-190544	0113	-	F	TEID change in case of key change	15.5.0
	RP-83	RP-190545	0114	1	F	Support of PDU session split during inter-MN handover for MR-DC with 5GC	15.5.0
2019/06	RP-84	RP-191375	0116	1	F	MN-SN coordination for ANR in MR-DC	15.6.0
	RP-84	RP-191378	0118	3	F	CR on 37.340 for s-Measure in NR-DC and NE-DC	15.6.0
	RP-84	RP-191374	0120	-	F	Clarification on RLC bearer release and add	15.6.0
	RP-84	RP-191374	0122	-	F	Activation/deactivation of SCells in MR-DC	15.6.0
	RP-84	RP-191374	0123	-	F	Corrections on MN and SN inter-node resource coordination	15.6.0
	RP-84	RP-191376	0124	1	F	Measurement gap coordination in MR-DC	15.6.0
	RP-84	RP-191379	0125	2	F	Inter-RAT HO support	15.6.0
	RP-84	RP-191376	0126	1	F	Editorial clean-up	15.6.0
	RP-84	RP-191379	0133	-	F	Various Clean-ups for TS37.340	15.6.0
	RP-84	RP-191380	0134	-	F	Correction of RAN triggered PDU session split	15.6.0
	RP-84	RP-191381	0135	1	F	Allow MN to retrieve forwarding proposal from the source SN	15.6.0
	RP-84	RP-191380	0136	-	F	RAN paging failure handling in SN	15.6.0
	RP-84	RP-191380	0137	-	F	Rapporteur Clean-ups of Secondary RAT Data Volume Report	15.6.0
	RP-84	RP-191380	0138	-	F	Correction of the references to the GTP tunnel endpoint information	15.6.0
	RP-84	RP-191380	0139	-	F	In-order delivery when QoS flows offloaded from SN	15.6.0
	RP-84	RP-191380	0140	-	F	RAN sharing with multiple Cell ID broadcast	15.6.0
2019/09	RP-85	RP-192191	0141	1	F	PDCP configuration generation	15.7.0
	RP-85	RP-192190	0142	1	F	Clarification on selectedBandCombination	15.7.0
	RP-85	RP-192194	0143	3	F	Clarification about PSCell change between different SN nodes	15.7.0
	RP-85	RP-192193	0144	2	F	Clarification of handover terminology	15.7.0
	RP-85	RP-192191	0145	1	F	Default DRB handling	15.7.0
	RP-85	RP-192192	0148	1	F	Capability report and coordination in NR-DC	15.7.0
	RP-85	RP-192191	0151	1	F	LTE to NR-DC Inter-RAT HO support	15.7.0
	RP-85	RP-192190	0153	-	F	Correction of E-RAB Modification Indication	15.7.0
	RP-85	RP-192191	0154	1	F	TS37.340 Rapporteur Cleanups	15.7.0
2019/12	RP-86	RP-192934	0155	2	F	PDCP version in EN-DC	15.8.0
	RP-86	RP-192936	0157	3	F	SMTC setting for NR PSCell change in MR-DC	15.8.0
	RP-86	RP-192937	0158	3	F	PDCP configuration generation (email discussion of 107#25)	15.8.0
	RP-86	RP-192936	0159	3	F	Correction on sending Failure Information via SRB3	15.8.0
	RP-86	RP-192938	0160	2	F	Clarification of NR-DC synchronization	15.8.0
	RP-86	RP-192938	0163	2	F	Clarification on security key change and bearer termination point change	15.8.0
	RP-86	RP-192936	0168	1	F	Clarification regarding QoS handling in MRDC with 5G CN	15.8.0
	RP-86	RP-192936	0169	1	F	Missing RACH aspect for DC	15.8.0
	RP-86	RP-192937	0170	-	F	IP version on X2-U	15.8.0
	RP-86	RP-192937	0171	-	F	Correction to MR-DC with 5GC with RRC_INACTIVE	15.8.0
	RP-86	RP-192938	0172	-	F	Correction of SN Status Transfer during HO with DC	15.8.0
	RP-86	RP-192938	0174	1	F	DRB ID co-ordination between MN and SN	15.8.0
	RP-86	RP-192938	0175	-	F	Correcting misbehaviors and clean-ups on 37.340 related to PDU session spilt	15.8.0
	RP-86	RP-192938	0177	-	F	Stage2 Clarifications for RRC_Inactive with MR-DC@5GC	15.8.0

	RP-86	RP-192938	0178	-	F	Correction of NG connection in MR DC	15.8.0
	RP-86	RP-192938	0179	-	F	Correcting misbehaviors and clean-ups on 37.340 related to data forwarding and SN status transfer	15.8.0
	RP-86	RP-192945	0173	1	B	Stage2 Introduction of ARPI&SPID for EN-DC	16.0.0
	RP-86	RP-192943	0176	1	B	Resuming SCG in RRC Resume	16.0.0
	RP-86	RP-192943	0180	1	F	Clarification on the offered non-GBR resources	16.0.0
2020/03	RP-87	RP-200350	0165	3	B	Introduction of SRVCC from 5G to 3G	16.1.0
	RP-87	RP-200340	0182	1	B	Introduction of cross link interference management	16.1.0
	RP-87	RP-200341	0183	2	B	Introduction of NR-U to 37.340	16.1.0
	RP-87	RP-200344	0184	2	B	CR for supporting UE Power Saving in TS 37.340	16.1.0
	RP-87	RP-200357	0185	-	B	Stage 2 CR for Inter-RAT HO between NR to EN-DC in Rel-16	16.1.0
	RP-87	RP-200349	0186	2	B	Correction of TS 37.340 on the support of MR-DC for IAB	16.1.0
	RP-87	RP-200346	0187	-	B	Introduction of 5G V2X with NR Sidelink	16.1.0
	RP-87	RP-200348	0188	-	B	Introduction of CA/DC enhancements to 37.340	16.1.0
2020/07	RP-88	RP-201174	0189	4	F	SRB3 for reporting UAI for power saving	16.2.0
	RP-88	RP-201179	0192	3	F	Miscellaneous correction to 37.340 for IAB	16.2.0
	RP-88	RP-201160	0194	2	A	Correction on MN-SN measurements coordination in INM	16.2.0
	RP-88	RP-201181	0195	3	B	Introduction of IIOT features to TS 37.340	16.2.0
	RP-88	RP-201166	0198	2	F	Clarification on PDCP version change	16.2.0
	RP-88	RP-201162	0205	1	A	Corrections to MAC description	16.2.0
	RP-88	RP-201191	0208	1	F	Correction on MN-SN measurements coordination in INM	16.2.0
	RP-88	RP-201178	0209	-	F	DCCA corrections	16.2.0
	RP-88	RP-201177	0210	-	B	Introduction of Conditional PSCell Change for intra-SN without MN involvement	16.2.0
	RP-88	RP-201178	0211	-	B	Support of inter-RAT handover in response to MCGFailureInformation	16.2.0
	RP-88	RP-201177	0212	1	B	TS37.340 Stage2 Introduction of Rel-16 Mobility Enhancement in MR-DC	16.2.0
	RP-88	RP-201180	0213	-	B	Supporting of RACS for EN-DC and MR-DC	16.2.0
	RP-88	RP-201212	0214	-	C	Introduction of Inter-gNB CSI-RS Based Mobility	16.2.0
	RP-88	RP-201296	0216	1	A	Support of SN not broadcasting system information	16.2.0
2020/09	RP-89	RP-201930	0218	-	F	Minor Correction for CPC Configuration Related Procedure	16.3.0
	RP-89	RP-201932	0222	1	F	Mandatory support of full rate user plane integrity protection in MR-DC	16.3.0
	RP-89	RP-201930	0223	1	F	Correction of signalling flow for CPC	16.3.0
	RP-89	RP-201924	0225	1	F	Miscellaneous correction for TS 37.340 for IAB	16.3.0
	RP-89	RP-201922	0227	-	F	Miscellaneous corrections for DCCA	16.3.0
	RP-89	RP-201933	0228	-	F	Inter-system direct forwarding with shared en-gNB/gNB	16.3.0
	RP-89	RP-201938	0230	1	F	Further correction for CA-based PDCP duplication for Industrial IoT	16.3.0
	RP-89	RP-201931	0231	1	F	Introducing UE Radio Capability Mapping procedure for EN-DC	16.3.0
2020-12	RP-90	RP-202774	0220	2	F	Corrections to CPC with and without SRB3 involved	16.4.0
	RP-90	RP-202790	0233	1	A	UE Capabilities description	16.4.0
	RP-90	RP-202772	0234	-	F	CR to 37.340 on SRB3 description	16,4,0
	RP-90	RP-202770	0235	1	B	CR for 37.340 on power control for NR_DC	16.4.0
	RP-90	RP-202774	0236	1	F	Miscellaneous corrections for Mobility Enhancements	16.4.0
	RP-90	RP-202777	0238	-	F	Clarification for secondary DRX	16.4.0
	RP-90	RP-202777	0239	-	F	Full rate UP IP correction	16.4.0
	RP-90	RP-202790	0241	1	A	End marker handling in case of MR-DC NG-RAN initiated QoS Flow offloading	16.4.0
	RP-90	RP-202769	0242	-	F	Corrections on AQP for notification control	16.4.0
2021-03	RP-91	RP-210701	0244	-	A	Correction on the PDCP Change Indication for 37.340	16.5.0
	RP-91	RP-210689	0245	1	F	CR on co-configuration of sidelink and MR-DC	16.5.0
	RP-91	RP-210690	0246	1	F	CR on support of NR-DC within the same gNB-DU	16.5.0
	RP-91	RP-210703	0248	1	F	Corrections on UL power sharing	16.5.0
	RP-91	RP-210702	0249	1	A	Correction on user plane handling for full configuration in SN Change	16.5.0
	RP-91	RP-210698	0251	-	F	Non-support of CHO/CPC with LTE/5GC	16.5.0
	RP-91	RP-210701	0254	-	A	Correction of DL End Markers and QoS Flow Mobility	16.5.0
2021-06	RP-92	RP-211483	0256	1	A	CR on MN and SN configuration restriction coordination	16.6.0
	RP-92	RP-211471	0257	2	F	CR on SCG suspend in EN-DC	16.6.0
	RP-92	RP-211472	0258	1	F	Clarification on IP packet type in DedicatedInfoF1c	16.6.0
	RP-92	RP-211471	0261	3	F	Miscellaneous corrections on DCCA, 2-step RACH, IIOT	16.6.0
	RP-92	RP-211473	0262	2	F	Miscellaneous corrections to 37.340 on mobility enhancement	16.6.0
	RP-92	RP-211482	0264	1	A	CR on SCG release in EN-DC	16.6.0
	RP-92	RP-211485	0272	-	A	Correction on PSCell change without security key change and data forwarding upon SN change with full configuration	16.6.0
	RP-92	RP-211486	0274	-	A	Clarification on RRC full config for PSCell change	16.6.0
	RP-92	RP-211473	0275	-	F	37.340 correction for CHO early data forwarding in MN to eNB/gNB Change scenario	16.6.0
	RP-92	RP-211480	0276	-	F	Addition of sidelink MR-DC resource coordination	16.6.0
	RP-92	RP-211484	0278	-	A	No partial success in the SN initiated SN Modification procedure for EN-DC	16.6.0
	RP-92	RP-211484	0280	-	A	R16CR37.340 for SCG release	16.6.0
2021-09	RP-93	RP-212438	0266	2	A	Clarification on RACH procedure for HO with PSCell	16.7.0
	RP-93	RP-212438	0285	-	A	Clean-up on Xn-U Address Indication procedure	16.7.0

2021-12	RP-94	RP-213341	0288	-	F	Corrections on SCG/MCG failure handling	16.8.0
	RP-94	RP-213341	0291	-	A	Clarification for SgNB trigger SCG release in Rel-16 in TS 37.340	16.8.0
	RP-94	RP-213341	0292	-	F	Correction on SN-initiated SN Release	16.8.0
2022-03	RP-95	RP-220472	0300	1	A	Clarification on inter-MN handover without SN change	16.9.0
	RP-95	RP-220835	0303	1	F	CR on data forwarding between EN-DC/MR-DC and SA handover	16.9.0
2022-03	RP-95	RP-220495	0294	1	B	Introducing support of UP IP for EPC connected architectures using NR PDC	17.0.0
	RP-95	RP-220486	0296	1	B	Introduction of CP-UP separation support in NR eIAB	17.0.0
	RP-95	RP-220489	0298	-	B	Introduction of the support for UDC in NR	17.0.0
	RP-95	RP-220510	0301	-	B	Inter-MN RRC Resume without SN change [InterMNResume]	17.0.0
	RP-95	RP-220510	0302	1	C	On UE security capability to address SA3 request [UE_Sec_Caps]	17.0.0
	RP-95	RP-220510	0304	-	F	Support of CHO with SCG configuration[CHOwithDCkept]	17.0.0
	RP-95	RP-220490	0306	-	B	Enhancement of RAN Slicing	17.0.0
	RP-95	RP-220839	0308	-	B	Addition of SON features enhancement	17.0.0
	RP-95	RP-220485	0309	-	B	Introduction of further multi-RAT dual-connectivity enhancements	17.0.0
2022-06	RP-96	RP-221728	0310	3	F	Corrections on TS 37.340 for DCCA enhancement	17.1.0
	RP-96	RP-221718	0313	2	F	Miscellaneous Corrections to 37.340	17.1.0
	RP-96	RP-221712	0324	1	A	Correction for SCell activation	17.1.0
	RP-96	RP-221714	0326	2	F	Rapporteur Clean-up	17.1.0
	RP-96	RP-221713	0328	1	A	Support of 1Tx-2Tx UL Tx switching for EN-DC	17.1.0
	RP-96	RP-221736	0329	-	C	Support of CHO with SCG configuration - 37340 [CHOwithDCkept]	17.1.0
	RP-96	RP-221733	0330	-	F	Correction on MRO for SN Change Failure	17.1.0
	RP-96	RP-221728	0331	2	F	Stage-2 aspects for CPAC	17.1.0
	RP-96	RP-221733	0332	-	F	Corrections to UE History Information in MR-DC	17.1.0
	RP-96	RP-221727	0333	1	F	Introduction of UE power saving enhancements In 37.340	17.1.0
2022-09	RP-97	RP-222522	0340	2	F	Corrections for DCCA enhancement	17.2.0
	RP-97	RP-222521	0342	1	A	Rapporteur Clean-up	17.2.0
	RP-97	RP-222523	0343	1	F	Miscellaneous Corrections to 37.340	17.2.0
	RP-97	RP-222522	0346	-	F	Clarification on direct data forwarding for MN initiated CPC to TS37340	17.2.0
	RP-97	RP-222522	0347	-	F	Coordination of CHO and intra-SN SCG reconfiguration	17.2.0
2022-12	RP-98	RP-223414	0350	4	F	Corrections for DCCA enhancement	17.3.0
	RP-98	RP-223412	0351	1	F	Correction on Sidelink based U2N Relay	17.3.0
	RP-98	RP-223413	0353	1	F	Miscellaneous corrections on TS 37.340 for ePowSav	17.3.0
	RP-98	RP-223410	0356	-	F	Failure handling for SCG MRO	17.3.0
	RP-98	RP-223410	0357	-	F	Correction for TS 37.340 on UHI in MR-DC	17.3.0
	RP-98	RP-223409	0358	1	F	Interaction between CPC Cancel and SN Release	17.3.0
	RP-98	RP-223409	0359	-	F	Clarification on direct data forwarding for SN initiated CPC to TS37.340	17.3.0
2023-03	RP-99	RP-230688	0361	1	F	Corrections for DCCA enhancement	17.4.0
	RP-99	RP-230688	0362	-	F	Xn-U Address Information delivery in CPAC	17.4.0
	RP-99	RP-230688	0363	-	F	PDCP PDU early transmission in CPAC	17.4.0
	RP-99	RP-230687	0364	2	F	Correction to the description of the CHO	17.4.0
	RP-99	RP-230688	0365	1	F	Clarifications on prepared PSCell addition by candidate SN in CPC-A	17.4.0
	RP-99	RP-230688	0366	-	F	Correction on SCG reconfiguration when MN initiated conditional reconfiguration is prepared	17.4.0
2023-06	RP-100	RP-231412	0368	-	F	Modify the figures for MN/SN initiated CPC and CHO with SCG	17.5.0
2023-09	RP-101	RP-232565	0370	-	A	Correction on mobility restriction list for MR-DC with 5GC	17.6.0
2023-12	RP-102	RP-233887	0376	-	F	Correction of CPAC to clarify optional late data forwarding	17.7.0
2023-12	RP-102	RP-233905	0367	2	B	Introduction of In-Device Co-existence (IDC) Enhancements for NR	18.0.0
	RP-102	RP-233901	0371	1	B	Introduction of R18 positioning to MR-DC	18.0.0
	RP-102	RP-233910	0372	2	B	Introduction of QoE enhancement for NR-DC	18.0.0
	RP-102	RP-233903	0373	3	B	Introduction of DualTxRx_MUSIM	18.0.0
	RP-102	RP-233930	0375	-	B	Introduction of NR further mobility enhancements in TS 37.340	18.0.0
	RP-102	RP-233909	0377	-	B	Addition of SON Rel.18 features	18.0.0
2024-03	RP-103	RP-240692	0381	1	F	Miscellaneous corrections for NR further mobility enhancements in TS 37.340	18.1.0
	RP-103	RP-240687	0382	1	F	Correction on the IDC Reporting	18.1.0
	RP-103	RP-240697	0383	-	F	CR for RAN visible QoE measurements and reporting in NR-DC	18.1.0
	RP-103	RP-240674	0384	-	F	Correction on RACH Optimisation	18.1.0
	RP-103	RP-240674	0385	1	F	Correction to 37.340 for CPAC of SON feature	18.1.0
	RP-103	RP-240697	0386	1	F	Correction on 37.340 for stage-2 description of QoE in NR-DC	18.1.0
	RP-103	RP-240692	0387	-	F	Support intra-SN subsequent CPAC in MN format	18.1.0
	RP-103	RP-240674	0388	-	F	Correction for SPR optimizations	18.1.0
	RP-103	RP-240692	0389	-	F	Completion of the s tage-2 description of S-CPAC	18.1.0
	RP-103	RP-240692	0390	-	F	Handover Cancel in CHO with SCG(s)	18.1.0
2024-06	RP-104	RP-241574	0392	1	F	Miscellaneous corrections for mobility enhancements	18.2.0
	RP-104	RP-241575	0393	-	F	Corrections to TS 37.340 on collection of RA reports	18.2.0
	RP-104	RP-241574	0394	-	F	Clarification of the bearer menagement in case of CHO with SCG	18.2.0
	RP-104	RP-241574	0395	-	F	Stage2 correction on direct data forwarding	18.2.0
	RP-104	RP-241575	0396	-	F	Addition of CPAC detection in stage 2	18.2.0
	RP-104	RP-241544	0397	-	F	Correction on Handover Cancel in CHO with SN for EN-DC	18.2.0

	RP-104	RP-241575	0398	1	F	Correction on of PSCell List of RA report	18.2.0
2024-09	RP-105	RP-242238	0399	2	F	Miscellaneous corrections for mobility enhancements	18.3.0
	RP-105	RP-242237	0400	-	F	Correction on CPA failure states and detection mechanism in stage 2	18.3.0
	RP-105	RP-242237	0401	-	F	Correction on SPR retrieval and forwarding	18.3.0
	RP-105	RP-242238	0402	-	F	Correction on Complete Candidate Configuration	18.3.0
	RP-105	RP-242239	0403	1	F	Further miscellaneous corrections to QMC procedure	18.3.0
2024-12	RP-106	RP-243230	0404	4	F	Correction for mobility enhancements in stage-2	18.4.0
	RP-106	RP-243229	0407	-	F	Correction on conditional PSCell addition or change failure	18.4.0
	RP-106	RP-243225	0409	-	A	Correction of IAB F1-C transfer in NR-DC	18.4.0
	RP-106	RP-243230	0410	-	F	Stage-2 updates for intra-SN S-CPAC with MN involvement	18.4.0
2025-03	RP-107	RP-250661	0415	-	F	Corrections for mobility enhancements in stage-2	18.5.0
2025-06	RP-108	RP-251696	0416	1	F	Clean-up corrections on stage 2 description of QMC	18.6.0
	RP-108	RP-251694	0417	-	F	Correction of Conditional PSCell Change Cancel for S-CPAC	18.6.0
	RP-108	RP-251697	0418	-	F	Correction of CPC Cancel and SN Release	18.6.0

EXHIBIT H

What to Know About Motorola's New Flagship, the Edge Plus

The Motorola Edge Plus just debuted. The high-end smartphone offers great specs at a $1000 price tag, and is out May 14th.

Written by
Adam Rowe

Published on April 22, 2020

This website uses cookies and other tracking technologies to enhance user experience, to display personalized advertisements and to analyze performance and traffic on our website. We also share information about your use of our site with our social media, advertising and analytics partners. You can exercise your rights to opt-out of sale or processing personal data for targeted advertising by clicking the link on the right. For more details see our Cookie Notice **Cookie Policy**

Opt out of sale of personal data and Targeted Advertising

Reject All

Accept Cookies

Motorola also today revealed the Motorola Edge, a device in the same family but with slightly more limited abilities and no price yet set: We'll discuss it, too.

Motorola Edge Plus

The Motorola Edge Plus stands out for its top of the line Snapdragon 865 processing power, and a 6.7-inch FHD AMOLED display with curved "waterfall" edges — no bezels or notches anywhere. You'll also get great cameras and 256GB of storage alongside a 5,000 mAh battery.

Rounding out the list of everything needed to impress a smartphone buff in 2020, the Edge Plus is Motorola's first 5G phone, supporting mmWave 5G in the US and Sub-6GHz 5G globally.

The wireless charging ability is another crowd-pleaser, and the device includes the increasingly rare 3.5mm headphone jack as well.

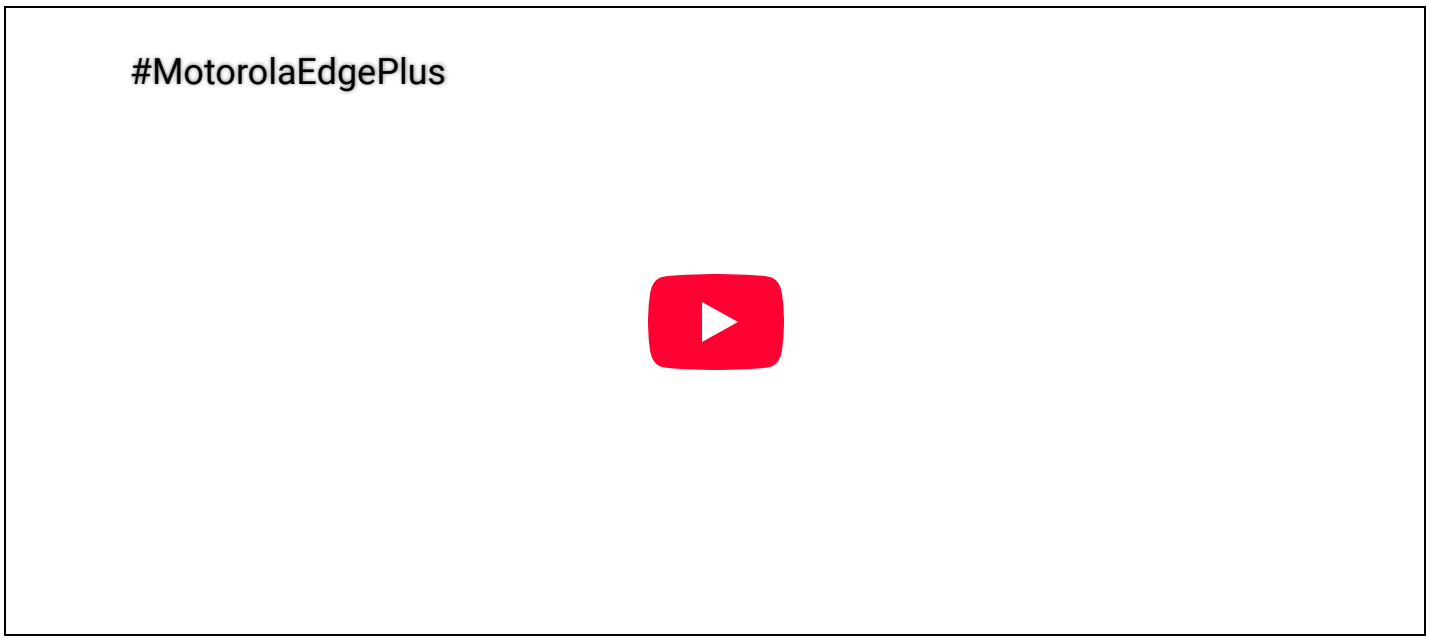
Motorola Edge Plus Specs

Take a look at the full list of specs to get a better idea of what the Motorola Edge Plus offers:

Display: 6.7-inch FHD AMOLED

This website uses cookies and other tracking technologies to enhance user experience, to display personalized advertisements and to analyze performance and traffic on our website. We also share information about your use of our site with our social media, advertising and analytics partners. You can exercise your rights to opt-out of sale or processing personal data for targeted advertising by clicking the link on the right. For more details see our Cookie Notice **Cookie Policy**

The Motorola Edge Plus **ships on May 14th**, exclusively from Verizon. Through Verizon, the phone's flat **$1,000** price shakes out to $41.66 per month, paid across two years.



This website uses cookies and other tracking technologies to enhance user experience, to display personalized advertisements and to analyze performance and traffic on our website. We also share information about your use of our site with our social media, advertising and analytics partners. You can exercise your rights to opt-out of sale or processing personal data for targeted advertising by clicking the link on the right. For more details see our Cookie Notice **Cookie Policy**

This website uses cookies and other tracking technologies to enhance user experience, to display personalized advertisements and to analyze performance and traffic on our website. We also share information about your use of our site with our social media, advertising and analytics partners. You can exercise your rights to opt-out of sale or processing personal data for targeted advertising by clicking the link on the right. For more details see our Cookie Notice **Cookie Policy**

Motorola Edge

The more limited Motorola Edge still looks the same, offering the same screen specs and general look. The storage, RAM, and processors all drop down a notch, but remain reasonable: The Edge has 128GB of storage, down from the Edge Plus's 256GB; 4GB or 6GB of RAM, down from 12GB; and a Snapdragon 765, down from a Snapdragon 865.

The three-lens array isn't too bad, either, keeping the same 16MP ultrawide and 8MP telephoto lens while dropping the primary lens down to 64MP from the Edge Plus's impressive 108MP. There's no mmWave 5G support, just Sub-6GHz 5G, and there's no wireless charging, either.

Motorola Edge Specs

Here are the full specs of the Motorola Edge, take a look to see what it offers:

Display: 6.7-inch FHD AMOLED
Refresh rate: 90Hz
Processor: Snapdragon 765
RAM: 4GB / 6GB
Storage: 128GB
Rear-facing camera system: 64MP, 16MP ultrawide, 8MP telephoto

This website uses cookies and other tracking technologies to enhance user experience, to display personalized advertisements and to analyze performance and traffic on our website. We also share information about your use of our site with our social media, advertising and analytics partners. You can exercise your rights to opt-out of sale or processing personal data for targeted advertising by clicking the link on the right. For more details see our Cookie Notice **Cookie Policy**

tech.co

Get the latest tech news, straight to your inbox

Stay informed on the top business tech stories with Tech.co's weekly highlights reel.

- Essential tech industry news
- Special features and interviews from industry experts
- Offers and discounts

Name

Name

Email Address

Email Address

By signing up to receive our newsletter, you agree to our Privacy Policy. You can **unsubscribe** at any time.

Subscribe

Brought to you by

tech.co

Should you get the Motorola Edge Plus?

Motorola has plenty of budget phones, like the Motorola G Power, which offers a great battery at the expense of a good screen, camera, and performance. The Motorola Moto G8 Plus in particular, which offers great budget specs are barely costs over $300, is a great pick if you're looking to

This website uses cookies and other tracking technologies to enhance user experience, to display personalized advertisements and to analyze performance and traffic on our website. We also share information about your use of our site with our social media, advertising and analytics partners. You can exercise your rights to opt-out of sale or processing personal data for targeted advertising by clicking the link on the right. For more details see our Cookie Notice **Cookie Policy**

Plus, with access to mmWave 5G, any Motorola Edge Plus owner will be able to proudly start complaining about how terrible 5G coverage is, long before everyone else.

Need more options? Check out **our Tech.co guide to the Best Phone Brands of the year**.

This website uses cookies and other tracking technologies to enhance user experience, to display personalized advertisements and to analyze performance and traffic on our website. We also share information about your use of our site with our social media, advertising and analytics partners. You can exercise your rights to opt-out of sale or processing personal data for targeted advertising by clicking the link on the right. For more details see our Cookie Notice **Cookie Policy**

Did you find this article helpful?

Click on one of the following buttons

Tags PRODUCT NEWS

Written by:

Adam Rowe
Writer

Adam has been a writer at Tech.co for nine years, covering fleet management and logistics. He has also worked at the logistics newletter Inside Lane, and has worked as a tech writer, blogger and copy editor for more than a decade. He was a Forbes Contributor on the publishing industry, for which he was named a Digital Book World 2018 award finalist. His work has appeared in publications including Popular Mechanics and IDG Connect, and his art history book on 1970s sci-fi, 'Worlds Beyond Time,' was a 2024 Locus Awards finalist. When not working on his next art collection, he's tracking the latest news on VPNs, POS systems, and the future of tech.

Explore More

See all news

Zoho Cracks US Payments Market with Zoho Payments

This website uses cookies and other tracking technologies to enhance user experience, to display personalized advertisements and to analyze performance and traffic on our website. We also share information about your use of our site with our social media, advertising and analytics partners. You can exercise your rights to opt-out of sale or processing personal data for targeted advertising by clicking the link on the right. For more details see our Cookie Notice **Cookie Policy**

Nicole Mousicos - 5 months ago

Load more articles

© 2025 Marketing VF Ltd. All Rights Reserved.

Registered Office: 1st & 2nd Floors, Wenlock Works, 1A Shepherdess Walk, London, N1 7QE, United Kingdom. Registered in England & Wales (no. 06951544)

This website uses cookies and other tracking technologies to enhance user experience, to display personalized advertisements and to analyze performance and traffic on our website. We also share information about your use of our site with our social media, advertising and analytics partners. You can exercise your rights to opt-out of sale or processing personal data for targeted advertising by clicking the link on the right. For more details see our Cookie Notice **Cookie Policy**

EXHIBIT I

ETSI TS 124 301 V15.3.0 (2018-06)

Universal Mobile Telecommunications System (UMTS);
LTE;
5G;
Non-Access-Stratum (NAS) protocol
for Evolved Packet System (EPS);
Stage 3
(3GPP TS 24.301 version 15.3.0 Release 15)

Reference
RTS/TSGC-0124301vf30

Keywords
5G,LTE,UMTS

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Important notice

The present document can be downloaded from:
http://www.etsi.org/standards-search

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the only prevailing document is the print of the Portable Document Format (PDF) version kept on a specific network drive within ETSI Secretariat.

Users of the present document should be aware that the document may be subject to revision or change of status.
Information on the current status of this and other ETSI documents is available at
https://portal.etsi.org/TB/ETSIDeliverableStatus.aspx

If you find errors in the present document, please send your comment to one of the following services:
https://portal.etsi.org/People/CommiteeSupportStaff.aspx

Copyright Notification

No part may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm except as authorized by written permission of ETSI.
The content of the PDF version shall not be modified without the written authorization of ETSI.
The copyright and the foregoing restriction extend to reproduction in all media.

© ETSI 2018.
All rights reserved.

DECT™, **PLUGTESTS**™, **UMTS**™ and the ETSI logo are trademarks of ETSI registered for the benefit of its Members.
3GPP™ and **LTE**™ are trademarks of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners.
oneM2M logo is protected for the benefit of its Members.
GSM® and the GSM logo are trademarks registered and owned by the GSM Association.

Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (https://ipr.etsi.org/).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

Foreword

This Technical Specification (TS) has been produced by ETSI 3rd Generation Partnership Project (3GPP).

The present document may refer to technical specifications or reports using their 3GPP identities, UMTS identities or GSM identities. These should be interpreted as being references to the corresponding ETSI deliverables.

The cross reference between GSM, UMTS, 3GPP and ETSI identities can be found under http://webapp.etsi.org/key/queryform.asp.

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

Contents

Intellectual Property Rights 2
Foreword 2
Modal verbs terminology 2
Foreword 19
1 Scope 20
2 References 20
3 Definitions and abbreviations 23
3.1 Definitions 23
3.2 Abbreviations 29
4 General 30
4.1 Overview 30
4.2 Linkage between the protocols for EPS mobility management and EPS session management 31
4.2A Handling of NAS signalling low priority indication 31
4.3 UE mode of operation 32
4.3.1 General 32
4.3.2 Change of UE mode of operation 33
4.3.2.1 General 33
4.3.2.2 Change of UE's usage setting 35
4.3.2.3 Change of voice domain preference for E-UTRAN 36
4.3.2.4 Change or determination of IMS registration status 37
4.3.2.5 Change of configuration regarding the use of SMS. 39
4.4 NAS security 39
4.4.1 General 39
4.4.2 Handling of EPS security contexts 40
4.4.2.1 General 40
4.4.2.2 Establishment of a mapped EPS security context during intersystem handover 41
4.4.2.3 Establishment of secure exchange of NAS messages 42
4.4.2.4 Change of security keys 43
4.4.2.5 Derivation of keys at CS to PS SRVCC handover from A/Gb mode to S1 mode or from Iu mode to S1 mode 43
4.4.3 Handling of NAS COUNT and NAS sequence number 44
4.4.3.1 General 44
4.4.3.2 Replay protection 45
4.4.3.3 Integrity protection and verification 45
4.4.3.4 Ciphering and deciphering 45
4.4.3.5 NAS COUNT wrap around 46
4.4.4 Integrity protection of NAS signalling messages 46
4.4.4.1 General 46
4.4.4.2 Integrity checking of NAS signalling messages in the UE 47
4.4.4.3 Integrity checking of NAS signalling messages in the MME 47
4.4.5 Ciphering of NAS signalling messages 49
4.5 Disabling and re-enabling of UE's E-UTRA capability 50
4.6 Applicability of procedures 51
4.6.1 Relay nodes 51
4.7 EPS mobility management and EPS session management in NB-S1 mode 51
4.8 EPS mobility management and EPS session management in WB-S1 mode for IoT 52
5 Elementary procedures for EPS mobility management 53
5.1 Overview 53
5.1.1 General 53
5.1.2 Types of EMM procedures 53
5.1.3 EMM sublayer states 55
5.1.3.1 General 55
5.1.3.2 EMM sublayer states in the UE 55
5.1.3.2.1 General 55

5.1.3.2.2 Main states 55
5.1.3.2.2.1 EMM-NULL 55
5.1.3.2.2.2 EMM-DEREGISTERED 55
5.1.3.2.2.3 EMM-REGISTERED-INITIATED 55
5.1.3.2.2.4 EMM-REGISTERED 55
5.1.3.2.2.5 EMM-DEREGISTERED-INITIATED 55
5.1.3.2.2.6 EMM-TRACKING-AREA-UPDATING-INITIATED 55
5.1.3.2.2.7 EMM-SERVICE-REQUEST-INITIATED 56
5.1.3.2.3 Substates of state EMM-DEREGISTERED 56
5.1.3.2.3.1 General 56
5.1.3.2.3.2 EMM-DEREGISTERED.NORMAL-SERVICE 56
5.1.3.2.3.3 EMM-DEREGISTERED.LIMITED-SERVICE 56
5.1.3.2.3.4 EMM-DEREGISTERED.ATTEMPTING-TO-ATTACH 57
5.1.3.2.3.5 EMM-DEREGISTERED.PLMN-SEARCH 57
5.1.3.2.3.6 EMM-DEREGISTERED.NO-IMSI 57
5.1.3.2.3.7 EMM-DEREGISTERED.ATTACH-NEEDED 57
5.1.3.2.3.8 EMM-DEREGISTERED.NO-CELL-AVAILABLE 57
5.1.3.2.3.9 EMM-DEREGISTERED.eCALL-INACTIVE 57
5.1.3.2.4 Substates of state EMM-REGISTERED 57
5.1.3.2.4.1 General 57
5.1.3.2.4.2 EMM-REGISTERED.NORMAL-SERVICE 57
5.1.3.2.4.3 EMM-REGISTERED.ATTEMPTING-TO-UPDATE 57
5.1.3.2.4.4 EMM-REGISTERED.LIMITED-SERVICE 58
5.1.3.2.4.5 EMM-REGISTERED.PLMN-SEARCH 58
5.1.3.2.4.6 EMM-REGISTERED.UPDATE-NEEDED 58
5.1.3.2.4.7 EMM-REGISTERED.NO-CELL-AVAILABLE 58
5.1.3.2.4.8 EMM-REGISTERED.ATTEMPTING-TO-UPDATE-MM 58
5.1.3.2.4.9 EMM-REGISTERED.IMSI-DETACH-INITIATED 58
5.1.3.3 EPS update status 58
5.1.3.4 EMM sublayer states in the MME 59
5.1.3.4.1 EMM-DEREGISTERED 59
5.1.3.4.2 EMM-COMMON-PROCEDURE-INITIATED 59
5.1.3.4.3 EMM-REGISTERED 59
5.1.3.4.4 EMM-DEREGISTERED-INITIATED 59
5.1.4 Coordination between EMM and GMM 60
5.1.5 Coordination between EMM and MM 60
5.2 Behaviour of the UE in state EMM-DEREGISTERED and state EMM-REGISTERED 61
5.2.1 General 61
5.2.2 UE behaviour in state EMM-DEREGISTERED 61
5.2.2.1 General 61
5.2.2.2 Primary substate selection 61
5.2.2.2.1 Selection of the substate after power on 61
5.2.2.3 Detailed description of UE behaviour in state EMM-DEREGISTERED 62
5.2.2.3.1 NORMAL-SERVICE 62
5.2.2.3.2 LIMITED-SERVICE 62
5.2.2.3.3 ATTEMPTING-TO-ATTACH 62
5.2.2.3.4 PLMN-SEARCH 62
5.2.2.3.5 NO-IMSI 62
5.2.2.3.6 ATTACH-NEEDED 62
5.2.2.3.7 NO-CELL-AVAILABLE 63
5.2.2.3.8 eCALL-INACTIVE 63
5.2.2.4 Substate when back to state EMM-DEREGISTERED from another EMM state 63
5.2.3 UE behaviour in state EMM-REGISTERED 64
5.2.3.1 General 64
5.2.3.2 Detailed description of UE behaviour in state EMM-REGISTERED 64
5.2.3.2.1 NORMAL-SERVICE 64
5.2.3.2.2 ATTEMPTING-TO-UPDATE 64
5.2.3.2.3 LIMITED-SERVICE 65
5.2.3.2.4 PLMN-SEARCH 65
5.2.3.2.5 UPDATE-NEEDED 65
5.2.3.2.6 NO-CELL-AVAILABLE 65
5.2.3.2.7 ATTEMPTING-TO-UPDATE-MM 65

5.2.3.2.8 IMSI-DETACH-INITIATED 66
5.3 General on elementary EMM procedures 66
5.3.1 EMM modes and NAS signalling connection 66
5.3.1.1 Establishment of the NAS signalling connection 66
5.3.1.2 Release of the NAS signalling connection 67
5.3.1.2.1 General 67
5.3.1.2.2 UE is using EPS services with control plane CIoT EPS optimization 70
5.3.1.3 Suspend and resume of the NAS signalling connection 70
5.3.2 Lists of forbidden tracking areas 71
5.3.3 List of forbidden PLMNs for attach in S101 mode 71
5.3.3a Forbidden PLMNs for EPS services 71
5.3.4 Equivalent PLMNs list 71
5.3.5 Handling of the periodic tracking area update timer and mobile reachable timer (S1 mode only) 71
5.3.6 Handling of timer T3402 73
5.3.7 Handling of the Local Emergency Numbers List and the Extended Local Emergency Numbers List 73
5.3.7a Specific requirements for UE configured to use timer T3245 74
5.3.7b Specific requirements for UE when receiving non-integrity protected reject messages 75
5.3.8 Abnormal cases in the UE 77
5.3.9 Handling of NAS level mobility management congestion control 77
5.3.9A Handling of congestion control for transport of user data via the control plane 78
5.3.10 Access class control 78
5.3.11 Power saving mode 79
5.3.12 Extended idle-mode DRX cycle 79
5.3.13 Interaction between power saving mode and extended idle mode DRX cycle 80
5.3.14 Dedicated core network 80
5.3.15 CIoT EPS optimizations 80
5.3.16 Restriction on use of enhanced coverage 82
5.3.17 Service Gap Control 82
5.4 EMM common procedures 83
5.4.1 GUTI reallocation procedure 83
5.4.1.1 General 83
5.4.1.2 GUTI reallocation initiation by the network 83
5.4.1.3 GUTI reallocation completion by the UE 84
5.4.1.4 GUTI reallocation completion by the network 84
5.4.1.5 Abnormal cases in the UE 84
5.4.1.6 Abnormal cases on the network side 84
5.4.2 Authentication procedure 86
5.4.2.1 General 86
5.4.2.2 Authentication initiation by the network 86
5.4.2.3 Authentication response by the UE 86
5.4.2.4 Authentication completion by the network 87
5.4.2.5 Authentication not accepted by the network 87
5.4.2.6 Authentication not accepted by the UE 88
5.4.2.7 Abnormal cases 89
5.4.3 Security mode control procedure 93
5.4.3.1 General 93
5.4.3.2 NAS security mode control initiation by the network 93
5.4.3.3 NAS security mode command accepted by the UE 95
5.4.3.4 NAS security mode control completion by the network 96
5.4.3.5 NAS security mode command not accepted by the UE 97
5.4.3.6 Abnormal cases in the UE 97
5.4.3.7 Abnormal cases on the network side 97
5.4.4 Identification procedure 98
5.4.4.1 General 98
5.4.4.2 Identification initiation by the network 98
5.4.4.3 Identification response by the UE 98
5.4.4.4 Identification completion by the network 98
5.4.4.5 Abnormal cases in the UE 98
5.4.4.6 Abnormal cases on the network side 99
5.4.5 EMM information procedure 100
5.4.5.1 General 100
5.4.5.2 EMM information procedure initiation by the network 100

5.4.5.3 EMM information procedure in the UE 100
5.4.5.4 Abnormal cases on the network side 100
5.5 EMM specific procedures 100
5.5.1 Attach procedure 100
5.5.1.1 General 100
5.5.1.2 Attach procedure for EPS services 102
5.5.1.2.1 General 102
5.5.1.2.2 Attach procedure initiation 102
5.5.1.2.3 EMM common procedure initiation 105
5.5.1.2.4 Attach accepted by the network 105
5.5.1.2.4A Attach successful for EPS services and not accepted for SMS services 110
5.5.1.2.5 Attach not accepted by the network 111
5.5.1.2.5A Attach for emergency bearer services not accepted by the network 115
5.5.1.2.5B Attach for initiating a PDN connection for emergency bearer services not accepted by the network 116
5.5.1.2.6 Abnormal cases in the UE 117
5.5.1.2.6A Abnormal cases in the UE, SMS services not accepted 120
5.5.1.2.7 Abnormal cases on the network side 121
5.5.1.3 Combined attach procedure for EPS services and non-EPS services (S1 mode only) 122
5.5.1.3.1 General 122
5.5.1.3.2 Combined attach procedure initiation 122
5.5.1.3.3 EMM common procedure initiation 122
5.5.1.3.4 Combined attach accepted by the network 123
5.5.1.3.4.1 General 123
5.5.1.3.4.2 Combined attach successful 123
5.5.1.3.4.3 Combined attach successful for EPS services only 124
5.5.1.3.5 Combined attach not accepted by the network 125
5.5.1.3.6 Abnormal cases in the UE 129
5.5.1.3.7 Abnormal cases on the network side 130
5.5.2 Detach procedure 130
5.5.2.1 General 130
5.5.2.2 UE initiated detach procedure 131
5.5.2.2.1 UE initiated detach procedure initiation 131
5.5.2.2.2 UE initiated detach procedure completion for EPS services only 132
5.5.2.2.3 UE initiated combined detach procedure completion 132
5.5.2.2.4 Abnormal cases in the UE 133
5.5.2.2.5 Abnormal cases on the network side 134
5.5.2.3 Network initiated detach procedure 135
5.5.2.3.1 Network initiated detach procedure initiation 135
5.5.2.3.2 Network initiated detach procedure completion by the UE 135
5.5.2.3.3 Network initiated detach procedure completion by the network 139
5.5.2.3.4 Abnormal cases in the UE 139
5.5.2.3.5 Abnormal cases on the network side 140
5.5.3 Tracking area updating procedure (S1 mode only) 141
5.5.3.1 General 141
5.5.3.2 Normal and periodic tracking area updating procedure 142
5.5.3.2.1 General 142
5.5.3.2.2 Normal and periodic tracking area updating procedure initiation 142
5.5.3.2.3 EMM common procedure initiation 147
5.5.3.2.4 Normal and periodic tracking area updating procedure accepted by the network 148
5.5.3.2.4A Tracking area updating successful for EPS services and not accepted for SMS services 155
5.5.3.2.5 Normal and periodic tracking area updating procedure not accepted by the network 156
5.5.3.2.5A Tracking area updating procedure for initiating a PDN connection for emergency bearer services not accepted by the network 161
5.5.3.2.6 Abnormal cases in the UE 161
5.5.3.2.6A Abnormal cases in the UE, SMS services not accepted 166
5.5.3.2.7 Abnormal cases on the network side 167
5.5.3.3 Combined tracking area updating procedure 168
5.5.3.3.1 General 168
5.5.3.3.2 Combined tracking area updating procedure initiation 168
5.5.3.3.3 EMM common procedure initiation 171
5.5.3.3.4 Combined tracking area updating procedure accepted by the network 171

5.5.3.3.4.1 General 171
5.5.3.3.4.2 Combined tracking area updating successful 171
5.5.3.3.4.3 Combined tracking area updating successful for EPS services only 172
5.5.3.3.5 Combined tracking area updating procedure not accepted by the network 173
5.5.3.3.6 Abnormal cases in the UE 179
5.5.3.3.7 Abnormal cases on the network side 180
5.5.4 eCall inactivity procedure 180
5.6 EMM connection management procedures (S1 mode only) 181
5.6.1 Service request procedure 181
5.6.1.1 General 181
5.6.1.2 Service request procedure initiation 185
5.6.1.2.1 UE is not using EPS services with control plane CIoT EPS optimization 185
5.6.1.2.2 UE is using EPS services with control plane CIoT EPS optimization 185
5.6.1.3 EMM common procedure initiation 186
5.6.1.4 Service request procedure accepted by the network 186
5.6.1.4.1 UE is not using EPS services with control plane CIoT EPS optimization 186
5.6.1.4.2 UE is using EPS services with control plane CIoT EPS optimization 188
5.6.1.5 Service request procedure not accepted by the network 192
5.6.1.5A Service request procedure for initiating a PDN connection for emergency bearer services not accepted by the network 199
5.6.1.6 Abnormal cases in the UE 199
5.6.1.7 Abnormal cases on the network side 206
5.6.2 Paging procedure 207
5.6.2.1 General 207
5.6.2.2 Paging for EPS services 207
5.6.2.2.1 Paging for EPS services through E-UTRAN using S-TMSI 207
5.6.2.2.1.1 General 207
5.6.2.2.1.2 Abnormal cases on the network side 209
5.6.2.2.2 Paging for EPS services through E-UTRAN using IMSI 209
5.6.2.3 Paging for CS fallback to A/Gb or Iu mode 210
5.6.2.3.1 General 210
5.6.2.3.2 Abnormal cases in the UE 210
5.6.2.3.3 Abnormal cases on the network side 211
5.6.2.4 Paging for SMS 211
5.6.3 Transport of NAS messages procedure 211
5.6.3.1 General 211
5.6.3.2 UE initiated transport of NAS messages 211
5.6.3.3 Network initiated transport of NAS messages 212
5.6.3.4 Abnormal cases in the UE 212
5.6.3.5 Abnormal cases on the network side 212
5.6.4 Generic transport of NAS messages procedure 212
5.6.4.1 General 212
5.6.4.2 UE initiated generic transport of NAS messages 212
5.6.4.3 Network initiated transport of NAS messages 213
5.6.4.4 Abnormal cases in the UE 213
5.6.4.5 Abnormal cases on the network side 213
5.7 Reception of an EMM STATUS message by an EMM entity 213

6 Elementary procedures for EPS session management 214
6.1 Overview 214
6.1.1 General 214
6.1.2 Types of ESM procedures 215
6.1.3 ESM sublayer states 216
6.1.3.1 General 216
6.1.3.2 ESM sublayer states in the UE 216
6.1.3.2.1 BEARER CONTEXT INACTIVE 216
6.1.3.2.2 BEARER CONTEXT ACTIVE 216
6.1.3.2.3 PROCEDURE TRANSACTION INACTIVE 216
6.1.3.2.4 PROCEDURE TRANSACTION PENDING 216
6.1.3.3 ESM sublayer states in the MME 217
6.1.3.3.1 BEARER CONTEXT INACTIVE 217
6.1.3.3.2 BEARER CONTEXT ACTIVE PENDING 217

6.1.3.3.3 BEARER CONTEXT ACTIVE 217
6.1.3.3.4 BEARER CONTEXT INACTIVE PENDING 217
6.1.3.3.5 BEARER CONTEXT MODIFY PENDING 217
6.1.3.3.6 PROCEDURE TRANSACTION INACTIVE 217
6.1.3.3.7 PROCEDURE TRANSACTION PENDING 217
6.1.4 Coordination between ESM and SM 218
6.1.4A Coordination between ESM and 5GSM 219
6.1.5 Coordination between ESM and EMM for supporting ISR 219
6.2 IP address allocation 219
6.2.1 General 219
6.2.2 IP address allocation via NAS signalling 219
6.2A IP header compression 221
6.3 General on elementary ESM procedures 221
6.3.1 Services provided by lower layers 221
6.3.2 Principles of address handling for ESM procedures 221
6.3.3 Abnormal cases in the UE 224
6.3.4 Abnormal cases in the network 224
6.3.5 Handling of APN based congestion control 225
6.3.5A Handling of group specific session management congestion control 225
6.3.6 Handling of network rejection not due to APN based congestion control 225
6.3.7 Handling of WLAN offload control 226
6.3.8 Handling of serving PLMN rate control 226
6.3.9 Handling of APN rate control 226
6.3.10 Handling of 3GPP PS data off 227
6.3.11 Handling of Reliable Data Service 227
6.4 Network initiated ESM procedures 228
6.4.1 Default EPS bearer context activation procedure 228
6.4.1.1 General 228
6.4.1.2 Default EPS bearer context activation initiated by the network 228
6.4.1.3 Default EPS bearer context activation accepted by the UE 228
6.4.1.4 Default EPS bearer context activation not accepted by the UE 229
6.4.1.5 Abnormal cases in the UE 230
6.4.1.6 Abnormal cases on the network side 230
6.4.2 Dedicated EPS bearer context activation procedure 230
6.4.2.1 General 230
6.4.2.2 Dedicated EPS bearer context activation initiated by the network 231
6.4.2.3 Dedicated EPS bearer context activation accepted by the UE 231
6.4.2.4 Dedicated EPS bearer context activation not accepted by the UE 232
6.4.2.5 Abnormal cases in the UE 233
6.4.2.6 Abnormal cases on the network side 234
6.4.3 EPS bearer context modification procedure 234
6.4.3.1 General 234
6.4.3.2 EPS bearer context modification initiated by the network 234
6.4.3.3 EPS bearer context modification accepted by the UE 235
6.4.3.4 EPS bearer context modification not accepted by the UE 236
6.4.3.5 Abnormal cases in the UE 238
6.4.3.6 Abnormal cases on the network side 238
6.4.4 EPS bearer context deactivation procedure 238
6.4.4.1 General 238
6.4.4.2 EPS bearer context deactivation initiated by the network 239
6.4.4.3 EPS bearer context deactivation accepted by the UE 240
6.4.4.4 Abnormal cases in the UE 241
6.4.4.5 Abnormal cases on the network side 242
6.4.4.6 Local EPS bearer context deactivation without NAS signalling 242
6.5 UE requested ESM procedures 244
6.5.0 General 244
6.5.1 UE requested PDN connectivity procedure 244
6.5.1.1 General 244
6.5.1.2 UE requested PDN connectivity procedure initiation 244
6.5.1.3 UE requested PDN connectivity procedure accepted by the network 246
6.5.1.4 UE requested PDN connectivity procedure not accepted by the network 247
6.5.1.4.1 General 247

6.5.1.4.2 Handling of network rejection due to ESM cause #26 249
6.5.1.4.3 Handling of network rejection due to ESM cause other than ESM cause #26 251
6.5.1.4A Handling the maximum number of active EPS bearer contexts 256
6.5.1.4B Void 257
6.5.1.5 Abnormal cases in the UE 257
6.5.1.6 Abnormal cases on the network side 257
6.5.1.7 Handling PDN connectivity request for UE configured for dual priority 258
6.5.2 UE requested PDN disconnect procedure 259
6.5.2.1 General 259
6.5.2.2 UE requested PDN disconnection procedure initiation 259
6.5.2.3 UE requested PDN disconnection procedure accepted by the network 259
6.5.2.4 UE requested PDN disconnection procedure not accepted by the network 260
6.5.2.5 Abnormal cases in the UE 260
6.5.2.6 Abnormal cases on the network side 260
6.5.3 UE requested bearer resource allocation procedure 261
6.5.3.1 General 261
6.5.3.2 UE requested bearer resource allocation procedure initiation 261
6.5.3.3 UE requested bearer resource allocation procedure accepted by the network 262
6.5.3.4 UE requested bearer resource allocation procedure not accepted by the network 262
6.5.3.4.1 General 262
6.5.3.4.2 Handling of network rejection due to ESM cause #26 264
6.5.3.4.3 Handling of network rejection due to ESM cause other than ESM cause #26 265
6.5.3.4A Handling the maximum number of active EPS bearer contexts 267
6.5.3.5 Abnormal cases in the UE 267
6.5.3.6 Abnormal cases on the network side 268
6.5.4 UE requested bearer resource modification procedure 268
6.5.4.1 General 268
6.5.4.2 UE requested bearer resource modification procedure initiation 268
6.5.4.3 UE requested bearer resource modification procedure accepted by the network 269
6.5.4.4 UE requested bearer resource modification procedure not accepted by the network 270
6.5.4.4.1 General 270
6.5.4.4.2 Handling of network rejection due to ESM cause #26 273
6.5.4.4.3 Handling of network rejection due to ESM cause other than ESM cause #26 274
6.5.4.5 Abnormal cases in the UE 276
6.5.4.6 Abnormal cases on the network side 276
6.5.5 Handling session management request for UE configured for dual priority 276
6.6 Miscellaneous procedures 277
6.6.1 Exchange of protocol configuration options 277
6.6.1.1 General 277
6.6.1.2 ESM information request procedure 278
6.6.1.2.1 General 278
6.6.1.2.2 ESM information request initiated by the network 278
6.6.1.2.3 ESM information request completion by the UE 279
6.6.1.2.4 ESM information request completion by the network 279
6.6.1.2.5 Abnormal cases in the UE 279
6.6.1.2.6 Abnormal cases on the network side 279
6.6.1.3 Exchange of protocol configuration options in other messages 279
6.6.2 Notification procedure 279
6.6.2.1 General 279
6.6.2.2 Notification procedure initiation by the network 279
6.6.2.3 Notification procedure in the UE 280
6.6.2.4 Abnormal cases on the network side 280
6.6.3 Remote UE Report procedure 280
6.6.3.1 General 280
6.6.3.2 Remote UE Report initiated by the UE 280
6.6.3.3 Remote UE Report completion by the network 281
6.6.3.4 Remote UE Report completion by the UE 281
6.6.3.5 Abnormal cases in the UE 281
6.6.3.6 Abnormal cases on the network side 281
6.6.4 Transport of user data via the control plane procedure 281
6.6.4.1 General 281
6.6.4.2 UE initiated transport of user data via the control plane 281

6.6.4.3 Network initiated transport of user data via the control plane 282
6.7 Reception of an ESM STATUS message by an ESM entity 283

7 Handling of unknown, unforeseen, and erroneous protocol data 284
7.1 General 284
7.2 Message too short 284
7.3 Unknown or unforeseen procedure transaction identity or EPS bearer identity 284
7.3.1 Procedure transaction identity 284
7.3.2 EPS bearer identity 286
7.4 Unknown or unforeseen message type 287
7.5 Non-semantical mandatory information element errors 288
7.5.1 Common procedures 288
7.5.2 EPS mobility management 288
7.5.3 EPS session management 288
7.6 Unknown and unforeseen IEs in the non-imperative message part 289
7.6.1 IEIs unknown in the message 289
7.6.2 Out of sequence IEs 289
7.6.3 Repeated IEs 289
7.7 Non-imperative message part errors 289
7.7.1 Syntactically incorrect optional IEs 289
7.7.2 Conditional IE errors 289
7.8 Messages with semantically incorrect contents 290

8 Message functional definitions and contents 290
8.1 Overview 290
8.2 EPS mobility management messages 291
8.2.1 Attach accept 291
8.2.1.1 Message definition 291
8.2.1.2 GUTI 292
8.2.1.3 Location area identification 293
8.2.1.4 MS identity 293
8.2.1.5 EMM cause 293
8.2.1.6 T3402 value 293
8.2.1.7 T3423 value 293
8.2.1.8 Equivalent PLMNs 293
8.2.1.9 Emergency number list 293
8.2.1.9A Extended emergency number list 293
8.2.1.10 EPS network feature support 293
8.2.1.11 Additional update result 293
8.2.1.12 T3412 extended value 293
8.2.1.13 T3324 value 293
8.2.1.14 Extended DRX parameters 294
8.2.1.15 DCN-ID 294
8.2.1.16 SMS services status 294
8.2.1.17 Non-3GPP NW provided policies 294
8.2.1.18 T3448 value 294
8.2.1.19 Network policy 294
8.2.1.20 T3447 value 294
8.2.1.21 Ciphering key data 294
8.2.2 Attach complete 294
8.2.3 Attach reject 295
8.2.3.1 Message definition 295
8.2.3.2 ESM message container 295
8.2.3.3 T3346 value 295
8.2.3.4 T3402 value 295
8.2.3.5 Extended EMM cause 295
8.2.4 Attach request 296
8.2.4.1 Message definition 296
8.2.4.2 Old P-TMSI signature 298
8.2.4.3 Additional GUTI 298
8.2.4.4 Last visited registered TAI 298
8.2.4.5 DRX parameter 298

8.2.4.6 MS network capability 298
8.2.4.7 Old location area identification 298
8.2.4.8 TMSI status 298
8.2.4.9 Mobile station classmark 2 298
8.2.4.10 Mobile station classmark 3 298
8.2.4.11 Supported Codecs 298
8.2.4.12 Additional update type 298
8.2.4.13 Voice domain preference and UE's usage setting 298
8.2.4.14 Device properties 298
8.2.4.15 Old GUTI type 299
8.2.4.16 MS network feature support 299
8.2.4.17 TMSI based NRI container 299
8.2.4.18 T3324 value 299
8.2.4.19 T3412 extended value 299
8.2.4.20 Extended DRX parameters 299
8.2.4.21 UE additional security capability 299
8.2.4.22 UE status 299
8.2.4.23 Additional information requested 299
8.2.5 Authentication failure 299
8.2.5.1 Message definition 299
8.2.5.2 Authentication failure parameter 300
8.2.6 Authentication reject 300
8.2.7 Authentication request 300
8.2.8 Authentication response 300
8.2.9 CS service notification 301
8.2.9.1 Message definition 301
8.2.9.2 CLI 301
8.2.9.3 SS Code 301
8.2.9.4 LCS indicator 301
8.2.9.5 LCS client identity 302
8.2.10 Detach accept 302
8.2.10.1 Detach accept (UE originating detach) 302
8.2.10.2 Detach accept (UE terminated detach) 302
8.2.11 Detach request 302
8.2.11.1 Detach request (UE originating detach) 302
8.2.11.2 Detach request (UE terminated detach) 303
8.2.11.2.1 Message definition 303
8.2.11.2.2 EMM cause 303
8.2.12 Downlink NAS Transport 303
8.2.13 EMM information 304
8.2.13.1 Message definition 304
8.2.13.2 Full name for network 304
8.2.13.3 Short name for network 304
8.2.13.4 Local time zone 304
8.2.13.5 Universal time and local time zone 305
8.2.13.6 Network daylight saving time 305
8.2.14 EMM status 305
8.2.15 Extended service request 305
8.2.15.1 Message definition 305
8.2.15.2 CSFB response 306
8.2.15.3 EPS bearer context status 306
8.2.15.4 Device properties 306
8.2.16 GUTI reallocation command 306
8.2.16.1 Message definition 306
8.2.16.2 TAI list 307
8.2.16.3 DCN-ID 307
8.2.17 GUTI reallocation complete 307
8.2.18 Identity request 307
8.2.19 Identity response 308
8.2.20 Security mode command 308
8.2.20.1 Message definition 308
8.2.20.2 IMEISV request 309

8.2.20.3 Replayed $nonce_{UE}$ 309
8.2.20.4 $Nonce_{MME}$ 309
8.2.20.5 $Hash_{MME}$ 309
8.2.20.6 Replayed UE additional security capability 309
8.2.21 Security mode complete 309
8.2.21.1 Message definition 309
8.2.21.2 IMEISV 310
8.2.21.3 Replayed NAS message container 310
8.2.22 Security mode reject 310
8.2.23 Security protected NAS message 310
8.2.24 Service reject 311
8.2.24.1 Message definition 311
8.2.24.2 T3442 value 311
8.2.24.3 T3346 value 311
8.2.24.4 T3448 value 311
8.2.25 Service request 311
8.2.26 Tracking area update accept 312
8.2.26.1 Message definition 312
8.2.26.2 T3412 value 314
8.2.26.3 GUTI 314
8.2.26.4 TAI list 314
8.2.26.5 EPS bearer context status 314
8.2.26.6 Location area identification 314
8.2.26.7 MS identity 314
8.2.26.8 EMM cause 314
8.2.26.9 T3402 value 314
8.2.26.10 T3423 value 314
8.2.26.11 Equivalent PLMNs 314
8.2.26.12 Emergency number list 314
8.2.26.12A Extended emergency number list 314
8.2.26.13 EPS network feature support 314
8.2.26.14 Additional update result 315
8.2.26.15 T3412 extended value 315
8.2.26.16 T3324 value 315
8.2.26.17 Extended DRX parameters 315
8.2.26.18 DCN-ID 315
8.2.26.19 SMS services status 315
8.2.26.20 Non-3GPP NW provided policies 315
8.2.26.21 T3448 value 315
8.2.26.22 Network policy 315
8.2.26.23 T3447 value 315
8.2.26.24 Ciphering key data 316
8.2.27 Tracking area update complete 316
8.2.28 Tracking area update reject 316
8.2.28.1 Message definition 316
8.2.28.2 T3346 value 316
8.2.28.3 Extended EMM cause 316
8.2.29 Tracking area update request 317
8.2.29.1 Message definition 317
8.2.29.2 Non-current native NAS key set identifier 320
8.2.29.3 GPRS ciphering key sequence number 320
8.2.29.4 Old P-TMSI signature 320
8.2.29.5 Additional GUTI 320
8.2.29.6 $Nonce_{UE}$ 320
8.2.29.7 UE network capability 320
8.2.29.8 Last visited registered TAI 320
8.2.29.9 DRX parameter 320
8.2.29.10 UE radio capability information update needed 320
8.2.29.11 EPS bearer context status 320
8.2.29.12 MS network capability 320
8.2.29.13 Old location area identification 320
8.2.29.14 TMSI status 321

8.2.29.15 Mobile station classmark 2 321
8.2.29.16 Mobile station classmark 3 321
8.2.29.17 Supported Codecs 321
8.2.29.18 Additional update type 321
8.2.29.19 Voice domain preference and UE's usage setting 321
8.2.29.20 Old GUTI type 321
8.2.29.21 Device properties 321
8.2.29.22 MS network feature support 321
8.2.29.23 TMSI based NRI container 321
8.2.29.24 T3324 value 321
8.2.29.25 T3412 extended value 321
8.2.29.26 Extended DRX parameters 321
8.2.29.27 UE additional security capability 321
8.2.29.28 UE status 322
8.2.29.29 Additional information requested 322
8.2.30 Uplink NAS Transport 322
8.2.31 Downlink generic NAS transport 322
8.2.31.1 Message definition 322
8.2.31.2 Additional information 323
8.2.32 Uplink generic NAS transport 323
8.2.32.1 Message definition 323
8.2.32.2 Additional information 323
8.2.33 CONTROL PLANE SERVICE REQUEST 323
8.2.33.1 Message definition 323
8.2.33.2 ESM message container 324
8.2.33.3 NAS message container 324
8.2.33.4 EPS bearer context status 324
8.2.33.5 Device properties 324
8.2.34 Service Accept 324
8.2.34.1 Message definition 324
8.2.34.2 EPS bearer context status 325
8.2.34.3 T3448 value 325
8.3 EPS session management messages 325
8.3.1 Activate dedicated EPS bearer context accept 325
8.3.1.1 Message definition 325
8.3.1.2 Protocol configuration options 325
8.3.1.3 NBIFOM container 325
8.3.1.4 Extended protocol configuration options 325
8.3.2 Activate dedicated EPS bearer context reject 326
8.3.2.1 Message definition 326
8.3.2.2 Protocol configuration options 326
8.3.2.3 NBIFOM container 326
8.3.2.4 Extended protocol configuration options 326
8.3.3 Activate dedicated EPS bearer context request 326
8.3.3.1 Message definition 326
8.3.3.2 Transaction identifier 327
8.3.3.3 Negotiated QoS 327
8.3.3.4 Negotiated LLC SAPI 327
8.3.3.5 Radio priority 327
8.3.3.6 Packet flow identifier 327
8.3.3.7 Protocol configuration options 328
8.3.3.8 WLAN offload indication 328
8.3.3.9 NBIFOM container 328
8.3.3.10 Extended protocol configuration options 328
8.3.3.11 Extended EPS QoS 328
8.3.4 Activate default EPS bearer context accept 328
8.3.4.1 Message definition 328
8.3.4.2 Protocol configuration options 328
8.3.4.3 Extended protocol configuration options 329
8.3.5 Activate default EPS bearer context reject 329
8.3.5.1 Message definition 329
8.3.5.2 Protocol configuration options 329

8.3.5.3 Extended protocol configuration options 329
8.3.6 Activate default EPS bearer context request 329
8.3.6.1 Message definition 329
8.3.6.2 Transaction identifier 330
8.3.6.3 Negotiated QoS 330
8.3.6.4 Negotiated LLC SAPI 330
8.3.6.5 Radio priority 331
8.3.6.6 Packet flow identifier 331
8.3.6.7 APN-AMBR 331
8.3.6.8 ESM cause 331
8.3.6.9 Protocol configuration options 331
8.3.6.10 Connectivity type 331
8.3.6.11 WLAN offload indication 331
8.3.6.12 NBIFOM container 331
8.3.6.13 Header compression configuration 331
8.3.6.14 Control plane only indication 331
8.3.6.15 Extended protocol configuration options 331
8.3.6.16 Serving PLMN rate control 332
8.3.6.17 Extended APN aggregate maximum bit rate 332
8.3.7 Bearer resource allocation reject 332
8.3.7.1 Message definition 332
8.3.7.2 Protocol configuration options 332
8.3.7.3 Back-off timer value 332
8.3.7.4 Re-attempt indicator 333
8.3.7.5 NBIFOM container 333
8.3.7.6 Extended protocol configuration options 333
8.3.8 Bearer resource allocation request 333
8.3.8.1 Message definition 333
8.3.8.2 Protocol configuration options 333
8.3.8.3 Device properties 334
8.3.8.4 NBIFOM container 334
8.3.8.5 Extended protocol configuration options 334
8.3.8.6 Extended EPS QoS 334
8.3.9 Bearer resource modification reject 334
8.3.9.1 Message definition 334
8.3.9.2 Protocol configuration options 334
8.3.9.3 Back-off timer value 335
8.3.9.4 Re-attempt indicator 335
8.3.9.5 NBIFOM container 335
8.3.9.6 Extended protocol configuration options 335
8.3.10 Bearer resource modification request 335
8.3.10.1 Message definition 335
8.3.10.2 Required traffic flow QoS 336
8.3.10.3 ESM cause 336
8.3.10.4 Protocol configuration options 336
8.3.10.5 Device properties 336
8.3.10.6 NBIFOM container 336
8.3.10.7 Header compression configuration 336
8.3.10.8 Extended protocol configuration options 337
8.3.10.9 Extended EPS QoS 337
8.3.11 Deactivate EPS bearer context accept 337
8.3.11.1 Message definition 337
8.3.11.2 Protocol configuration options 337
8.3.11.3 Void 337
8.3.11.4 Extended protocol configuration options 337
8.3.12 Deactivate EPS bearer context request 337
8.3.12.1 Message definition 337
8.3.12.2 Protocol configuration options 338
8.3.12.3 T3396 value 338
8.3.12.4 WLAN offload indication 338
8.3.12.5 NBIFOM container 338
8.3.12.6 Extended protocol configuration options 338

8.3.12A ESM dummy message 338
8.3.13 ESM information request 339
8.3.14 ESM information response 339
8.3.14.1 Message definition 339
8.3.14.2 Access point name 340
8.3.14.3 Protocol configuration options 340
8.3.14.4 Extended protocol configuration options 340
8.3.15 ESM status 340
8.3.16 Modify EPS bearer context accept 341
8.3.16.1 Message definition 341
8.3.16.2 Protocol configuration options 341
8.3.16.3 NBIFOM container 341
8.3.16.4 Extended protocol configuration options 341
8.3.17 Modify EPS bearer context reject 342
8.3.17.1 Message definition 342
8.3.17.2 Protocol configuration options 342
8.3.17.3 NBIFOM container 342
8.3.17.4 Extended protocol configuration options 342
8.3.18 Modify EPS bearer context request 342
8.3.18.1 Message definition 342
8.3.18.2 New EPS QoS 343
8.3.18.3 TFT 343
8.3.18.4 New QoS 343
8.3.18.5 Negotiated LLC SAPI 343
8.3.18.6 Radio priority 344
8.3.18.7 Packet flow identifier 344
8.3.18.8 APN-AMBR 344
8.3.18.9 Protocol configuration options 344
8.3.18.10 WLAN offload indication 344
8.3.18.11 NBIFOM container 344
8.3.18.12 Header compression configuration 344
8.3.18.13 Extended protocol configuration options 344
8.3.18.14 Extended APN-AMBR 344
8.3.18.15 Extended EPS QoS 344
8.3.18A Notification 344
8.3.19 PDN connectivity reject 345
8.3.19.1 Message definition 345
8.3.19.2 Protocol configuration options 345
8.3.19.3 Back-off timer value 345
8.3.19.4 Re-attempt indicator 346
8.3.19.5 Extended protocol configuration options 346
8.3.20 PDN connectivity request 346
8.3.20.1 Message definition 346
8.3.20.2 ESM information transfer flag 346
8.3.20.3 Access point name 347
8.3.20.4 Protocol configuration options 347
8.3.20.5 Device properties 347
8.3.20.6 NBIFOM container 347
8.3.20.7 Header compression configuration 347
8.3.20.8 Extended protocol configuration options 347
8.3.21 PDN disconnect reject 347
8.3.21.1 Message definition 347
8.3.21.2 Protocol configuration options 348
8.3.21.3 Extended protocol configuration options 348
8.3.22 PDN disconnect request 348
8.3.22.1 Message definition 348
8.3.22.2 Protocol configuration options 349
8.3.22.3 Extended protocol configuration options 349
8.3.23 Remote UE report 349
8.3.23.1 Message definition 349
8.3.23.2 Remote UE Context Connected 349
8.3.23.3 Remote UE Context Disconnected 349

8.3.23.4 ProSe Key Management Function Address 349
8.3.24 Remote UE report response 350
8.3.24.1 Message definition 350
8.3.25 ESM DATA TRANSPORT 350
8.3.25.1 Message definition 350
8.3.25.2 Release assistance indication 350

9 General message format and information elements coding 351
9.1 Overview 351
9.2 Protocol discriminator 352
9.3 Security header type and EPS bearer identity 352
9.3.1 Security header type 352
9.3.2 EPS bearer identity 352
9.4 Procedure transaction identity 353
9.5 Message authentication code 353
9.6 Sequence number 353
9.7 NAS message 353
9.8 Message type 353
9.9 Other information elements 355
9.9.1 General 355
9.9.2 Common information elements 356
9.9.2.0 Additional information 356
9.9.2.0A Device properties 356
9.9.2.1 EPS bearer context status 356
9.9.2.2 Location area identification 357
9.9.2.3 Mobile identity 357
9.9.2.4 Mobile station classmark 2 357
9.9.2.5 Mobile station classmark 3 357
9.9.2.6 NAS security parameters from E-UTRA 357
9.9.2.7 NAS security parameters to E-UTRA 358
9.9.2.8 PLMN list 358
9.9.2.9 Spare half octet 358
9.9.2.10 Supported codec list 359
9.9.3 EPS Mobility Management (EMM) information elements 359
9.9.3.0A Additional update result 359
9.9.3.0B Additional update type 359
9.9.3.1 Authentication failure parameter 360
9.9.3.2 Authentication parameter AUTN 360
9.9.3.3 Authentication parameter RAND 360
9.9.3.4 Authentication response parameter 360
9.9.3.4A Ciphering key sequence number 361
9.9.3.4B SMS services status 361
9.9.3.5 CSFB response 361
9.9.3.6 Daylight saving time 362
9.9.3.7 Detach type 362
9.9.3.8 DRX parameter 363
9.9.3.9 EMM cause 363
9.9.3.10 EPS attach result 364
9.9.3.11 EPS attach type 365
9.9.3.12 EPS mobile identity 365
9.9.3.12A EPS network feature support 367
9.9.3.13 EPS update result 371
9.9.3.14 EPS update type 372
9.9.3.15 ESM message container 373
9.9.3.16 GPRS timer 373
9.9.3.16A GPRS timer 2 373
9.9.3.16B GPRS timer 3 373
9.9.3.17 Identity type 2 374
9.9.3.18 IMEISV request 374
9.9.3.19 KSI and sequence number 374
9.9.3.20 MS network capability 374
9.9.3.20A MS network feature support 374

9.9.3.21 NAS key set identifier 374
9.9.3.22 NAS message container 375
9.9.3.23 NAS security algorithms 375
9.9.3.24 Network name 376
9.9.3.24A Network resource identifier container 376
9.9.3.25 Nonce 376
9.9.3.25A Paging identity 377
9.9.3.26 P-TMSI signature 377
9.9.3.26A Extended EMM cause 377
9.9.3.27 Service type 378
9.9.3.28 Short MAC 378
9.9.3.29 Time zone 379
9.9.3.30 Time zone and time 379
9.9.3.31 TMSI status 379
9.9.3.32 Tracking area identity 379
9.9.3.33 Tracking area identity list 380
9.9.3.34 UE network capability 385
9.9.3.35 UE radio capability information update needed 391
9.9.3.36 UE security capability 391
9.9.3.37 Emergency Number List 396
9.9.3.37A Extended Emergency Number List 396
9.9.3.38 CLI 397
9.9.3.39 SS Code 398
9.9.3.40 LCS indicator 398
9.9.3.41 LCS client identity 399
9.9.3.42 Generic message container type 399
9.9.3.43 Generic message container 400
9.9.3.44 Voice domain preference and UE's usage setting 400
9.9.3.45 GUTI type 400
9.9.3.46 Extended DRX parameters 401
9.9.3.47 Control plane service type 401
9.9.3.48 DCN-ID 402
9.9.3.49 Non-3GPP NW provided policies 402
9.9.3.50 $Hash_{MME}$ 402
9.9.3.51 Replayed NAS message container 402
9.9.3.52 Network policy 403
9.9.3.53 UE additional security capability 403
9.9.3.54 UE status 408
9.9.3.55 Additional information requested 408
9.9.3.56 Ciphering key data 408
9.9.4 EPS Session Management (ESM) information elements 413
9.9.4.1 Access point name 413
9.9.4.2 APN aggregate maximum bit rate 413
9.9.4.2A Connectivity type 416
9.9.4.3 EPS quality of service 416
9.9.4.4 ESM cause 422
9.9.4.5 ESM information transfer flag 424
9.9.4.6 Linked EPS bearer identity 424
9.9.4.7 LLC service access point identifier 425
9.9.4.7A Notification indicator 425
9.9.4.8 Packet flow identifier 425
9.9.4.9 PDN address 426
9.9.4.10 PDN type 426
9.9.4.11 Protocol configuration options 427
9.9.4.12 Quality of service 427
9.9.4.13 Radio priority 427
9.9.4.13A Re-attempt indicator 427
9.9.4.14 Request type 428
9.9.4.15 Traffic flow aggregate description 428
9.9.4.16 Traffic flow template 428
9.9.4.17 Transaction identifier 428
9.9.4.18 WLAN offload acceptability 428

9.9.4.19 NBIFOM container 428
9.9.4.20 Remote UE context list 428
9.9.4.21 PKMF address 430
9.9.4.22 Header compression configuration 431
9.9.4.23 Control plane only indication 435
9.9.4.24 User data container 435
9.9.4.25 Release assistance indication 436
9.9.4.26 Extended protocol configuration options 436
9.9.4.27 Header compression configuration status 436
9.9.4.28 Serving PLMN rate control 437
9.9.4.29 Extended APN aggregate maximum bit rate 437
9.9.4.30 Extended quality of service 438

10 List of system parameters 440
10.1 General 440
10.2 Timers of EPS mobility management 441
10.3 Timers of EPS session management 451

Annex A (informative): Cause values for EPS mobility management 453

A.1 Causes related to UE identification 453

A.2 Cause related to subscription options 453

A.3 Causes related to PLMN specific network failures and congestion/authentication failures 454

A.4 Causes related to nature of request 455

A.5 Causes related to invalid messages 455

Annex B (informative): Cause values for EPS session management 457

B.1 Causes related to nature of request 457

B.2 Protocol errors (e.g., unknown message) class 459

Annex C (normative): Storage of EMM information 461

Annex D (normative): Establishment cause (S1 mode only) 462

D.1 Mapping of NAS procedure to RRC establishment cause (S1 mode only) 462

Annex E (informative): Guidelines for enhancements to MS network capability IE and UE network capability IE 471

Annex F (normative): Application specific Congestion control for Data Communication (ACDC) 472

Annex G (informative): Change history 473

History 502

Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The present document specifies the procedures used by the protocols for mobility management and session management between User Equipment (UE) and Mobility Management Entity (MME) in the Evolved Packet System (EPS). These protocols belong to the non-access stratum (NAS).

The EPS Mobility Management (EMM) protocol defined in the present document provides procedures for the control of mobility when the User Equipment (UE) is using the Evolved UMTS Terrestrial Radio Access Network (E-UTRAN). The EMM protocol also provides control of security for the NAS protocols.

The EPS Session Management (ESM) protocol defined in the present document provides procedures for the handling of EPS bearer contexts. Together with the bearer control provided by the access stratum, this protocol is used for the control of user plane bearers.

For both NAS protocols the present document specifies procedures for the support of inter-system mobility between E-UTRAN and other 3GPP or non-3GPP access networks:

- For inter-system mobility between E-UTRAN and GERAN, UTRAN or NG-RAN, this includes rules for a mapping between parameters and procedures used by the NAS protocols defined in the present document and the NAS protocols specified in 3GPP TS 24.008 [13] for GERAN and UTRAN, and 3GPP TS 24.501 [54] for NG-RAN.

- For inter-system mobility between E-UTRAN and generic non-3GPP access networks, this includes specific NAS procedures to maintain IP connectivity to the PDN Gateway and to provide parameters needed by the UE when using mobility management based on Dual-Stack Mobile IPv6 (see 3GPP TS 24.303 [14]) or MIPv4 (see 3GPP TS 24.304 [15]).

The present document is applicable to the UE and to the Mobility Management Entity (MME) in the EPS.

The present document is also applicable to the relay node in the EPS (see 3GPP TS 23.401 [10]).

The present document also specifies NAS signalling enhancement for the support of efficient transport of IP, non-IP and SMS data of CIoT capable devices.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[1A] 3GPP TS 22.011: "Service accessibility".

[1B] Void.

[1C] 3GPP TS 22.278: "Service requirements for the Evolved Packet System (EPS)".

[2] 3GPP TS 23.003: "Numbering, addressing and identification".

[3] 3GPP TS 23.038: "Alphabets and language-specific information".

[4] 3GPP TS 23.060: "General Packet Radio Service (GPRS); Service Description; Stage 2".

[5] 3GPP TS 23.107: "Quality of Service (QoS) concept and architecture".

[6] 3GPP TS 23.122: "Non-Access-Stratum functions related to Mobile Station (MS) in idle mode".

[7] 3GPP TS 23.203: "Policy and charging control architecture".

[8] 3GPP TS 23.216: "Single Radio Voice Call Continuity (SRVCC); Stage 2".

[8A] 3GPP TS 23.221: "Architectural requirements".

[8B] 3GPP TS 23.251: "Network Sharing; Architecture and Functional Description".

[9] 3GPP TS 23.272: "Circuit Switched Fallback in Evolved Packet System; Stage 2".

[10] 3GPP TS 23.401: "GPRS enhancements for E-UTRAN access".

[11] 3GPP TS 23.402: "GPRS architecture enhancements for non-3GPP accesses".

[11A] 3GPP TS 23.682: "Architecture enhancements to facilitate communications with packet data networks and applications".

[12] 3GPP TS 24.007: "Mobile radio interface signalling layer 3; General aspects".

[13] 3GPP TS 24.008: "Mobile Radio Interface Layer 3 specification; Core Network Protocols; Stage 3".

[13A] 3GPP TS 24.011: "Point-to-Point Short Message Service (SMS) support on mobile radio interface".

[13B] 3GPP TS 24.167: "3GPP IMS Management Object (MO); Stage 3".

[13C] 3GPP TS 24.171: "NAS Signalling for Control Plane LCS in Evolved Packet System (EPS)".

[13D] 3GPP TS 24.229: "IP multimedia call control protocol based on Session Initiation Protocol (SIP) and Session Description Protocol (SDP); Stage 3".

[13E] 3GPP TS 24.173: "IMS Multimedia telephony communication service and supplementary services; Stage 3".

[14] 3GPP TS 24.303: "Mobility Management based on DSMIPv6; User Equipment (UE) to network protocols; Stage 3".

[15] 3GPP TS 24.304: "Mobility management based on Mobile IPv4; User Equipment (UE) - foreign agent interface; Stage 3".

[15A] 3GPP TS 24.368: "Non-Access Stratum (NAS) configuration Management Object (MO)".

[15B] 3GPP TS 25.304: "User Equipment (UE) procedures in idle mode and procedures for cell reselection in connected mode".

[15C] 3GPP TS 29.002: "Mobile Application Part (MAP) specification".

[15D] 3GPP TS 24.341: "Support of SMS over IP networks; Stage 3".

[16] 3GPP TS 29.061: "Interworking between the Public Land Mobile Network (PLMN) supporting packet based services and Packet Data Networks (PDN)".

[16A] 3GPP TS 29.118: "Mobility Management Entity (MME) – Visitor Location Register (VLR) SGs interface specification".

[16B] 3GPP TS 29.212: "Policy and Charging Control (PCC); Reference points".

[16C] 3GPP TS 29.272: "Evolved Packet System (EPS); Mobility Management Entity (MME) and Serving GPRS Support Node (SGSN) related interfaces based on Diameter protocol".

[16D] 3GPP TS 29.274: "Evolved Packet System (EPS); Evolved General Packet Radio Service (GPRS) Tunnelling Protocol for Control plane (GTPv2-C); Stage 3".

[17] 3GPP TS 31.102: "Characteristics of the Universal Subscriber Identity Module (USIM) application".

[18] 3GPP TS 33.102: "3G security; Security architecture".

[19] 3GPP TS 33.401: "3GPP System Architecture Evolution; Security architecture".

[20] 3GPP TS 36.300: "Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description".

[21] 3GPP TS 36.304: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) procedures in idle mode".

[22] 3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC) protocol specification".

[22A] 3GPP TS 36.355: "Evolved Universal Terrestrial Radio Access (E-UTRA); LTE Positioning Protocol (LPP)".

[23] 3GPP TS 36.413: "Evolved Universal Terrestrial Access Network (E-UTRAN); S1 Application Protocol (S1AP)".

[23A] 3GPP TS 45.008: "Radio Access Network; Radio subsystem link control".

[24] Void.

[24A] IETF RFC 3633: "IPv6 Prefix Options for Dynamic Host Configuration Protocol (DHCP) version 6".

[25] Void.

[26] Void.

[27] Void.

[28] Void.

[29] ISO/IEC 10646: "Information technology – Universal Multiple-Octet Coded Character Set (UCS)".

[30] ITU-T Recommendation E.212: "The international identification plan for mobile terminals and mobile users".

[31] 3GPP TS 23.303: "Proximity-based services (ProSe); Stage 2".

[32] 3GPP TS 24.334: "Proximity-services (ProSe) User Equipment (UE) to Proximity-services (ProSe) Function Protocol aspects; Stage 3".

[33] 3GPP TS 23.380: "IMS restoration procedures".

[34] 3GPP TS 23.161: "Network-Based IP Flow Mobility (NBIFOM); Stage 2".

[35] 3GPP TS 24.105: "Application specific Congestion control for Data Communication (ACDC) Management Object (MO)".

[36] 3GPP TS 24.161: "Network-Based IP Flow Mobility (NBIFOM); Stage 3".

[37] IETF RFC 5795: "The RObust Header Compression (ROHC) Framework".

[38] 3GPP TS 36.323: "Evolved Universal Terrestrial Radio Access (E-UTRA); Packet Data Convergence Protocol (PDCP) specification".

[39] IETF RFC 6846: "RObust Header Compression (ROHC): A Profile for TCP/IP (ROHC-TCP)".

[40] IETF RFC 3095: "RObust Header Compression (ROHC): Framework and four profiles: RTP, UDP, ESP and uncompressed".

[41] IETF RFC 3843: "RObust Header Compression (ROHC): A Compression Profile for IP".

[42] IETF RFC 4815: "RObust Header Compression (ROHC): Corrections and Clarifications to RFC 3095".

[43] IETF RFC 5225: "RObust Header Compression (ROHC) Version 2: Profiles for RTP, UDP, IP, ESP and UDP Lite".

[44] 3GPP TS 36.306: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio access capabilities".

[45] 3GPP TS 23.167: "IP Multimedia Subsystem (IMS) emergency sessions".

[46] 3GPP TS 22.101: "Service aspects; Service principles".

[47] 3GPP TS 23.285: "Architecture enhancements for V2X services".

[48] 3GPP TS 24.302: "Access to the 3GPP Evolved Packet Core (EPC) via non-3GPP access networks; Stage 3".

[49] 3GPP TS 36.321: "Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification".

[50] 3GPP TS 24.623: "Extensive Markup Language (XML) Configuration Access Protocol (XCAP) over the Ut interface for Manipulating Supplementary Services".

[51] 3GPP TS 24.250: "Protocol for Reliable Data Service between UE and SCEF; Stage 3".

[52] 3GPP TR 38.913: "Study on Scenarios and Requirements for Next Generation Access Technologies".

[53] 3GPP TS 38.323: "NR; Packet Data Convergence Protocol (PDCP) specification".

[54] 3GPP TS 24.501: "Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3".

[55] IETF RFC 5031: "A Uniform Resource Name (URN) for Emergency and Other Well-Known Services".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

The term "mobile station" (MS) in the present document is synonymous with the term "user equipment" (UE) as defined in 3GPP TR 21.905 [1].

1x CS fallback capable UE: A UE that uses a CS infrastructure for a voice call and other CS-domain services by falling back to cdma2000® 1x access network if the UE is served by E-UTRAN when a CS service is requested.

Aggregate maximum bit rate: The maximum bit rate that limits the aggregate bit rate of a set of non-GBR bearers of a UE. Definition derived from 3GPP TS 23.401 [10].

APN based congestion control: Congestion control in session management where the network can reject session management requests from UEs or deactivate PDN connections when the associated APN is congested.

Attached for emergency bearer services: A UE is attached for emergency bearer services if it has only a PDN connection for emergency bearer services established.

Chosen PLMN: The same as selected PLMN as specified in 3GPP TS 23.122 [6].

Control plane CIoT EPS optimization: signalling optimizations to enable efficient transport of user data (IP, non-IP or SMS) over control plane via the MME including optional header compression of IP data.

User plane CIoT EPS optimization: signalling optimizations to enable efficient transport of user data (IP or non-IP) over the user plane.

UE supporting CIoT EPS optimizations: A UE that supports control plane CIoT EPS optimization or user plane CIoT EPS optimization and one or more other CIoT EPS optimizations when the UE is in S1 mode.

Attached for EPS services with CP-CIoT EPS optimization: A UE supporting CIoT EPS optimizations is attached for EPS services, and control plane CIoT EPS optimization along with one or more other CIoT EPS optimizations have been accepted by the network.

Attached for EPS services with User plane CIoT EPS optimization: A UE supporting CIoT EPS optimizations is attached for EPS services, and user plane CIoT EPS optimization along with one or more other CIoT EPS optimizations have been accepted by the network.

Attached for EPS services with CIoT EPS optimization: A UE is attached for EPS services with CP-CIoT EPS optimization or attached for EPS services with user plane CIoT EPS optimization.

CS fallback cancellation request: A request received from the MM sublayer to cancel a mobile originating CS fallback.

CS fallback capable UE: A UE that uses a CS infrastructure for a voice call and other CS-domain services by falling back to A/Gb or Iu mode if the UE is served by E-UTRAN when a CS service is requested.

CSG cell: A cell in which only members of the CSG can get normal service. Depending on local regulation, the CSG cell can provide emergency bearer services also to subscribers who are not member of the CSG. Definition derived from 3GPP TS 23.401 [10].

CSG ID: A CSG ID is a unique identifier within the scope of one PLMN defined in 3GPP TS 23.003 [2] which identifies a Closed Subscriber Group (CSG) in the PLMN associated with a cell or group of cells to which access is restricted to members of the CSG.

CSG selection: A UE supporting CSG selection selects CSG cell either automatically based on the list of allowed CSG identities or manually based on user selection of CSG on indication of list of available CSGs. Definition derived from 3GPP TS 23.122 [6].

Dedicated bearer: An EPS bearer that is associated with uplink packet filters in the UE and downlink packet filters in the PDN GW where the filters only match certain packets. Definition derived from 3GPP TS 23.401 [10].

Default bearer: An EPS bearer that gets established with every new PDN connection. Its context remains established throughout the lifetime of that PDN connection. A default EPS bearer is a non-GBR bearer. Definition derived from 3GPP TS 23.401 [10].

Emergency EPS bearer context: A default EPS bearer context which was activated with request type "emergency" or "handover of emergency bearer services", or any dedicated EPS bearer context associated to this default EPS bearer context.

EMM context: An EMM context is established in the UE and the MME when an attach procedure is successfully completed.

EMM-CONNECTED mode: A UE is in EMM-CONNECTED mode when a NAS signalling connection between UE and network is established. The term EMM-CONNECTED mode used in the present document corresponds to the term ECM-CONNECTED state used in 3GPP TS 23.401 [10].

EMM-IDLE mode: A UE is in EMM-IDLE mode when no NAS signalling connection between UE and network exists or when RRC connection suspend has been indicated by lower layers. The term EMM-IDLE mode used in the present document corresponds to the term ECM-IDLE state used in 3GPP TS 23.401 [10].

EPS security context: In the present specification, EPS security context is used as a synonym for EPS NAS security context specified in 3GPP TS 33.401 [19].

EPS services: Services provided by PS domain. Within the context of this specification, EPS services is used as a synonym for GPRS services in 3GPP TS 24.008 [13].

Evolved packet core network: The successor to the 3GPP Release 7 packet-switched core network, developed by 3GPP within the framework of the 3GPP System Architecture Evolution (SAE).

Evolved packet system: The evolved packet system (EPS) or evolved 3GPP packet-switched domain consists of the evolved packet core network and the evolved universal terrestrial radio access network. Definition derived from 3GPP TS 23.401 [10].

GBR bearer: An EPS bearer that uses dedicated network resources related to a guaranteed bit rate (GBR) value, which are permanently allocated at EPS bearer establishment/modification. Definition derived from 3GPP TS 23.401 [10].

General NAS level mobility management congestion control: The type of congestion control that is applied at a general overload or congestion situation in the network, e.g. lack of processing resources.

Group specific session management congestion control: Type of congestion control at session management level that is applied to reject session management requests from UEs belonging to a particular group when one or more group congestion criteria as specified in 3GPP TS 23.401 [10] are met.

Highest ranked ACDC category: The ACDC category with the lowest value as defined in 3GPP TS 24.105 [35].

Initial NAS message: A NAS message is considered as an initial NAS message, if this NAS message can trigger the establishment of a NAS signalling connection. For instance, the ATTACH REQUEST message is an initial NAS message.

IPv4v6 capability: Capability of the IP stack associated with a UE to support a dual stack configuration with both an IPv4 address and an IPv6 address allocated.

Kilobit: 1000 bits.

Last Visited Registered TAI: A TAI which is contained in the TAI list that the UE registered to the network and which identifies the tracking area last visited by the UE.

Linked Bearer Identity: This identity indicates to which default bearer the additional bearer resource is linked.

LIPA PDN connection: A PDN connection, for which the default EPS bearer context or default PDP context was activated with an APN authorized to use LIPA. The network authorizes an APN for using LIPA based on the subscription profile (see 3GPP TS 29.272 [16C]) and subsequently the network considers this PDN connection a LIPA PDN connection.

Lower layer failure: A failure reported by the AS to the NAS that cannot be corrected on AS level. When the AS indicates a lower layer failure to NAS, the NAS signalling connection is not available.

Mapped EPS security context: A mapped security context to be used in EPS. Definition derived from 3GPP TS 33.401 [19].

Mapped GUTI: A GUTI which is mapped from a P-TMSI and an RAI allocated previously by an SGSN. Mapping rules are defined in 3GPP TS 23.003 [2]. Definition derived from 3GPP TS 23.401 [10].

Megabit: 1,000,000 bits.

Message header: A standard L3 message header as defined in 3GPP TS 24.007 [12].

MME area: An area containing tracking areas served by an MME.

MO MMTEL voice call is started: the MO-MMTEL-voice-started indication was received from upper layers (see 3GPP TS 24.173 [13E]) and after reception of the MO-MMTEL-voice-started indication, the MO-MMTEL-voice-ended indication has not been received.

MO MMTEL video call is started: the MO-MMTEL-video-started indication was received from upper layers (see 3GPP TS 24.173 [13E]) and after reception of the MO-MMTEL-video-started indication, the MO-MMTEL-video-ended indication has not been received.

MO SMSoIP is started: the MO-SMSoIP-attempt-started indication was received from upper layers (see 3GPP TS 24.341 [15D]) and after reception of the MO-SMSoIP-attempt-started indication, the MO-SMSoIP-attempt-ended indication has not been received.

NAS level mobility management congestion control: Congestion control mechanism in the network in mobility management. "NAS level mobility management congestion control" consists of "subscribed APN based congestion control" and "general NAS level mobility management congestion control".

NAS signalling connection: A peer to peer S1 mode connection between UE and MME. A NAS signalling connection consists of the concatenation of an RRC connection via the "LTE-Uu" interface and an S1AP connection via the S1 interface. Additionally, for the purpose of optimized handover or idle mode mobility from cdma2000® HRPD access to E-UTRAN (see 3GPP TS 23.402 [11]), the NAS signalling connection can consist of a concatenation of an S101-AP connection and a signalling tunnel over a cdma2000® HRPD access network.

NOTE 1: cdma2000® is a registered trademark of the Telecommunications Industry Association (TIA-USA).

NAS signalling connection recovery: A mechanism initiated by the NAS to restore the NAS signalling connection on indication of "RRC connection failure" by the lower layers.

Native GUTI: A GUTI previously allocated by an MME. Definition derived from 3GPP TS 23.401 [10].

Non-access stratum protocols: The protocols between UE and MSC or SGSN that are not terminated in the UTRAN, and the protocols between UE and MME that are not terminated in the E-UTRAN. Definition derived from 3GPP TR 21.905 [1].

Non-emergency EPS bearer context: Any EPS bearer context which is not an emergency EPS bearer context.

Non-EPS services: Services provided by CS domain. Within the context of this specification, non-EPS services is used as a synonym for non-GPRS services in 3GPP TS 24.008 [13]. A UE which camps on E-UTRAN can attach to both EPS services and non-EPS services.

Non-GBR bearer: An EPS bearer that uses network resources that are not related to a guaranteed bit rate (GBR) value. Definition derived from 3GPP TS 23.401 [10].

PDN address: An IP address assigned to the UE by the Packet Data Network Gateway (PDN GW).

PDN connection for emergency bearer services: A PDN connection for which the default EPS bearer context or default PDP context was activated with request type "emergency" or "handover of emergency bearer services".

Plain NAS message: A NAS message with a header including neither a message authentication code nor a sequence number.

Persistent EPS bearer context: either a non-emergency EPS bearer context representing a GBR bearer with QoS equivalent to QoS of teleservice 11 and where there is a radio bearer associated with that context, or an emergency EPS bearer context where there is a radio bearer associated with that context.

NOTE 2: An example of a persistent EPS bearer context is a non-emergency EPS bearer context with QCI = 1 where there is a radio bearer associated with that context.

Procedure Transaction Identity: An identity which is dynamically allocated by the UE for the UE requested ESM procedures. The procedure transaction identity is released when the procedure is completed.

RAT-related TMSI: When the UE is camping on an E-UTRAN cell, the RAT-related TMSI is the GUTI; when it is camping on a GERAN or UTRAN cell, the RAT-related TMSI is the P-TMSI.

Registered PLMN: The PLMN on which the UE is registered. The identity of the registered PLMN is provided to the UE within the GUTI.

Relay node: A network element in the E-UTRAN, wirelessly connected to an eNode B and providing relaying function to UEs served by the E-UTRAN. Definition derived from 3GPP TS 23.401 [10].

Removal of eCall only mode restriction: All the limitations as described in 3GPP TS 22.101 [46] for the eCall only mode do not apply any more.

The label **(S1 mode only)** indicates that this subclause or paragraph applies only to a system which operates in S1 mode, i.e. with a functional division that is in accordance with the use of an S1 interface between the radio access network and the core network. The S1 mode includes WB-S1 mode and NB-S1 mode. In a multi-access system this case is determined by the current serving radio access network.

In NB-S1 mode: Indicates this paragraph applies only to a system which operates in NB-S1 mode. For a multi-access system this case applies if the current serving radio access network provides access to network services via E-UTRA by NB-IoT (see 3GPP TS 36.300 [20], 3GPP TS 36.331 [22], 3GPP TS 36.306 [44]).

In WB-S1 mode: Indicates this paragraph applies only to a system which operates in WB-S1 mode. For a multi-access system this case applies if the system operates in S1 mode, but not in NB-S1 mode.

In WB-S1/CE mode: Indicates this paragraph applies only when a UE, which is a CE mode B capable UE (see 3GPP TS 36.306 [44]), is operating in CE mode A or B in WB-S1 mode.

SCEF PDN Connection: A PDN connection established between the UE and the Service Capability Exposure Function (SCEF) for transmitting the UE's non-IP data related to a specific application.

SGi PDN Connection: A PDN connection established between the UE and the Packet Gateway (P-GW) for transmitting the UE's IP or non-IP data related to a specific application.

S101 mode: Applies to a system that operates with a functional division that is in accordance with the use of an S101 interface. For the definition of the S101 reference point, see 3GPP TS 23.402 [11].

SIPTO at the local network PDN connection: A PDN connection, for which the default EPS bearer context or default PDP context was activated with an APN authorized to use SIPTO at the local network and it was activated such that the traffic of the PDN connection will be using an L-GW. The network authorizes an APN for using SIPTO at the local network based on the subscription profile (see 3GPP TS 29.272 [16C]) and subsequently the network considers this PDN connection a SIPTO at the local network PDN connection.

SIPTO at the local network PDN connection with a collocated L-GW: A SIPTO at the local network PDN connection which is established to a L-GW function collocated with the (H)(e)NodeB. The core-network entity (i.e. the MME or the SGSN) can be aware of whether the SIPTO at the local network PDN connection with a collocated L-GW is used when the PDN connection is established.

SIPTO at the local network PDN connection with a stand-alone GW: A SIPTO at the local network PDN connection which is established to a stand-alone GW (with collocated L-GW and S-GW). The core-network entity (i.e. the MME or the SGSN) can be aware of whether the SIPTO at the local network PDN connection with a stand-alone GW is used when the PDN connection is established.

"SMS only": A subset of services which includes only Short Message Service. A UE camping on E-UTRAN can attach to both EPS services and "SMS only".

SMS over NAS: refers to SMS in MME or SMS over SGs.

SMS over S102: refers to SMS which uses 1xCS procedures in EPS as defined in 3GPP TS 23.272 [9].

Subscribed APN based congestion control: Congestion control in mobility management where the network can reject attach requests from UEs with a certain APN in the subscription.

TAI list: A list of TAIs that identify the tracking areas that the UE can enter without performing a tracking area updating procedure. The TAIs in a TAI list assigned by an MME to a UE pertain to the same MME area.

Traffic flow aggregate: A temporary aggregate of packet filters that are included in a UE requested bearer resource allocation procedure or a UE requested bearer resource modification procedure and that is inserted into a traffic flow template (TFT) for an EPS bearer context by the network once the UE requested bearer resource allocation procedure or UE requested bearer resource modification procedure is completed.

UE configured for dual priority: A UE which provides dual priority support is configured for NAS signalling low priority and also configured to override the NAS signalling low priority indicator (see 3GPP TS 24.368 [15A], 3GPP TS 31.102 [17]).

UE configured to use AC11 – 15 in selected PLMN: A UE configured with at least one access class in the range 11-15 on the USIM, and the access class is applicable in the selected PLMN according to 3GPP TS 22.011 [1A].

UE's availability for voice calls in the IMS: The indication of this availability or non-availability is provided by the upper layers of the UE as specified in 3GPP TS 24.229 [13D] in the annex relevant to the IP-Connectivity Access Network in use or determined in the NAS layer, as specified in subclause 4.3.1. If availability is indicated, the UE uses the IM CN Subsystem and can terminate or originate requests for SIP sessions including an audio component with codecs suited for voice.

UE's usage setting: This is a UE setting that indicates whether the UE has preference for voice services over data services or vice-versa. If a UE has preference for voice services, then the UE's usage setting is "voice centric". If a UE has preference for data services, then the UE's usage setting is "data centric". A UE whose setting is "data centric" may

still require access to voice services. A UE whose setting is "voice centric" may still require access to data services. This definition is derived from 3GPP TS 23.221 [8A] and it applies to voice capable UEs. If the UE is capable of both S1 mode and N1 mode, there is a single UE's usage setting which applies to both 5GS and EPS (see 3GPP TS 24.501 [54]).

UE using EPS services with control plane CIoT EPS optimization: A UE that is attached for EPS services with the control plane CIOT EPS optimization accepted by the network.

For the purposes of the present document, the following terms and definitions given in 3GPP TS 23.401 [10] apply:

Cellular IoT (CIoT)
DCN-ID
eCall only mode
NarrowBand-IoT
Dedicated core network
PDN connection
Service Gap Control

For the purposes of the present document, the following terms and definitions given in 3GPP TS 23.272 [9] apply:

CS fallback
SMS in MME
SMS over SGs

For the purposes of the present document, the following terms and definitions given in 3GPP TS 23.682 [11A] apply:

SCEF

For the purposes of the present document, the following terms and definitions given in 3GPP TS 24.008 [13] apply:

A/Gb mode
Access domain selection
Default PDP context
Extended idle-mode DRX cycle
Iu mode
Power saving mode
PS signalling connection
RR connection
TFT

For the purposes of the present document, the following terms and definitions given in 3GPP TS 33.102 [18] apply:

UMTS security context

For the purposes of the present document, the following terms and definitions given in 3GPP TS 33.401 [19] apply:

Current EPS security context
Full native EPS security context
K_{ASME}
K'_{ASME}
Mapped security context
Native EPS security context
Non-current EPS security context
Partial native EPS security context
Data via MME

For the purposes of the present document, the following terms and definitions given in 3GPP TS 23.122 [6] apply:

Country
EHPLMN
HPLMN
Shared Network
Suitable Cell
VPLMN

For the purposes of the present document, the following terms and definitions given in 3GPP TS 23.216 [8] apply:

SRVCC
vSRVCC

For the purposes of the present document, the following terms and definitions given in 3GPP TS 22.011 [1A] apply:

Extended Access Barring
Application specific Congestion control for Data Communication (ACDC)

For the purposes of the present document, the following terms and definitions given in 3GPP TS 23.003 [10] apply:

Local Home Network Identifier

For the purposes of the present document, the following terms and definitions given in 3GPP TS 23.303 [31] apply:

ProSe direct communication
ProSe direct discovery
ProSe UE-to-Network Relay

For the purposes of the present document, the following terms and definitions given in 3GPP TS 24.161 [36] apply:

Multi-access PDN connection
NBIFOM

For the purposes of the present document, the following terms and definitions given in 3GPP TS 23.167 [45] apply:

eCall over IMS

For the purposes of the present document, the following terms and definitions given in 3GPP TS 24.501 [54] apply:

N1 mode

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

5G-GUTI	5G-Globally Unique Temporary Identifier
5GMM	5GS Mobility Management
5GS	5G System
ACDC	Application specific Congestion control for Data Communication
AKA	Authentication and Key Agreement
AMBR	Aggregate Maximum Bit Rate
APN	Access Point Name
APN-AMBR	APN Aggregate Maximum Bit Rate
ARP	Allocation Retention Priority
BCM	Bearer Control Mode
CIoT	Cellular IoT
CP-CIoT	Control Plane CIoT
CSG	Closed Subscriber Group
E-UTRA	Evolved Universal Terrestrial Radio Access
E-UTRAN	Evolved Universal Terrestrial Radio Access Network
EAB	Extended Access Barring
ECM	EPS Connection Management
eDRX	Extended idle-mode DRX cycle
eKSI	Key Set Identifier for E-UTRAN
EMM	EPS Mobility Management
eNode B	Evolved Node B
EPC	Evolved Packet Core Network
EPS	Evolved Packet System
ESM	EPS Session Management
GBR	Guaranteed Bit Rate
GUMMEI	Globally Unique MME Identifier

GUTI	Globally Unique Temporary Identifier
HeNB	Home eNode B
HRPD	High Rate Packet Data
IoT	Internet of Things
IP-CAN	IP-Connectivity Access Network
ISR	Idle mode Signalling Reduction
kbps	Kilobits per second
KSI	Key Set Identifier
L-GW	Local PDN Gateway
LHN-ID	Local Home Network Identifier
LIPA	Local IP Access
M-TMSI	M-Temporary Mobile Subscriber Identity
Mbps	Megabits per second
MBR	Maximum Bit Rate
MME	Mobility Management Entity
MMEC	MME Code
NB-IoT	Narrowband IoT
NR	New Radio
NSSAI	Network Slice Selection Assistance Information
PD	Protocol Discriminator
PDN GW	Packet Data Network Gateway
ProSe	Proximity-based Services
PSM	Power Saving Mode
PTI	Procedure Transaction Identity
QCI	QoS Class Identifier
QoS	Quality of Service
ROHC	RObust Header Compression
RRC	Radio Resource Control
S-NSSAI	Single NSSAI
S-TMSI	S-Temporary Mobile Subscriber Identity
S101-AP	S101 Application Protocol
S1AP	S1 Application Protocol
SAE	System Architecture Evolution
SCEF	Service Capability Exposure Function
SGC	Service Gap Control
SIPTO	Selected IP Traffic Offload
TA	Tracking Area
TAC	Tracking Area Code
TAI	Tracking Area Identity
TFT	Traffic Flow Template
TI	Transaction Identifier
TIN	Temporary Identity used in Next update
URN	Uniform Resource Name
V2X	Vehicle-to-Everything

4 General

4.1 Overview

The non-access stratum (NAS) described in the present document forms the highest stratum of the control plane between UE and MME at the radio interface (reference point "LTE-Uu"; see 3GPP TS 23.401 [10]).

Main functions of the protocols that are part of the NAS are:

- the support of mobility of the user equipment (UE); and
- the support of session management procedures to establish and maintain IP connectivity between the UE and a packet data network gateway (PDN GW).

NAS security is an additional function of the NAS providing services to the NAS protocols, e.g. integrity protection and ciphering of NAS signalling messages.

For the support of the above functions, the following procedures are supplied within this specification:

- elementary procedures for EPS mobility management in clause 5; and
- elementary procedures for EPS session management in clause 6.

Complete NAS transactions consist of specific sequences of elementary procedures. Examples of such specific sequences can be found in 3GPP TS 23.401 [10].

The NAS for EPS follows the protocol architecture model for layer 3 as described in 3GPP TS 24.007 [12]; however, due to the objective of EPS to provide the subscriber with a "ready-to-use" IP connectivity and an "always-on" experience, the protocol supports a linkage between mobility management and session management procedures during the attach procedure (see subclause 4.2).

Signalling procedures for the control of NAS security are described as part of the EPS mobility management in clause 5. In addition to that, principles for the handing of EPS security contexts and for the activation of ciphering and integrity protection, when a NAS signalling connection is established, are provided in subclause 4.4.

4.2 Linkage between the protocols for EPS mobility management and EPS session management

During the EPS attach procedure, the network can activate a default EPS bearer context (i.e. if the UE requests PDN connectivity in the attach request). Additionally, the network can activate one or several dedicated EPS bearer contexts in parallel for PDN connections of IP PDN type. To this purpose the EPS session management messages for the default EPS bearer context activation can be transmitted in an information element in the EPS mobility management messages. In this case, the UE and the network execute the attach procedure, the default EPS bearer context activation procedure, and the dedicated EPS bearer context activation procedure in parallel. The UE and network shall complete the combined default EPS bearer context activation procedure and the attach procedure before the dedicated EPS bearer context activation procedure is completed. If EMM-REGISTERED without PDN connection is not supported by the UE or the MME, then the success of the attach procedure is dependent on the success of the default EPS bearer context activation procedure. If the attach procedure fails, then the ESM procedures also fail.

A UE using EPS services with control plane CIoT EPS optimization can initiate transport of user data via the control plane. For this purpose a UE in EMM-IDLE mode can initiate the service request procedure and transmit the ESM DATA TRANSPORT message in an information element in the CONTROL PLANE SERVICE REQUEST message.

Except for the attach procedure and the service request procedure, during EMM procedures the MME shall suspend the transmission of ESM messages. During the service request procedure the MME may suspend the transmission of ESM messages.

Except for the attach procedure and the service request procedure for UE initiated transport of user data via the control plane, during EMM procedures the UE shall suspend the transmission of ESM messages.

4.2A Handling of NAS signalling low priority indication

A UE configured for NAS signalling low priority (see 3GPP TS 24.368 [15A], 3GPP TS 31.102 [17]) indicates this by including the Device properties IE in the appropriate NAS message and setting the low priority indicator to "MS is configured for NAS signalling low priority", except for the following cases in which the UE shall set the low priority indicator to "MS is not configured for NAS signalling low priority":

- the UE is performing an attach for emergency bearer services;
- the UE has a PDN connection for emergency bearer services established and is performing EPS mobility management procedures, or is establishing a PDN connection for emergency bearer services;
- the UE configured for dual priority is requested by the upper layers to establish a PDN connection with the low priority indicator set to "MS is not configured for NAS signalling low priority";
- the UE configured for dual priority is performing EPS session management procedures related to the PDN connection established with low priority indicator set to "MS is not configured for NAS signalling low priority";
- the UE configured for dual priority has a PDN connection established by setting the low priority indicator to "MS is not configured for NAS signalling low priority" and is performing EPS mobility management procedures;

- the UE is performing a service request procedure for a CS fallback emergency call or 1xCS fallback emergency call;
- the UE is a UE configured to use AC11 – 15 in selected PLMN; or
- the UE is responding to paging.

The network may use the NAS signalling low priority indication for NAS level mobility management congestion control and APN based congestion control.

If the NAS signalling low priority indication is provided in a PDN CONNECTIVITY REQUEST message, the MME stores the NAS signalling low priority indication within the default EPS bearer context activated due to the PDN connectivity request procedure.

4.3 UE mode of operation

4.3.1 General

A UE attached for EPS services shalloperate in one of the following operation modes:

- PS mode 1 of operation: the UE registers only to EPS services, and UE's usage setting is "voice centric";
- PS mode 2 of operation: the UE registers only to EPS services, and UE's usage setting is "data centric";
- CS/PS mode 1 of operation: the UE registers to both EPS and non-EPS services, and UE's usage setting is "voice centric"; and
- CS/PS mode 2 of operation: the UE registers to both EPS and non-EPS services, and UE's usage setting is "data centric".

A UE configured to use CS fallback, shall operate in CS/PS mode 1 or CS/PS mode 2. Such UE may also be configured to use IMS, in which case the voice domain preference for E-UTRAN as defined in 3GPP TS 24.167 [13B] shall be used for the selection of the domain for originating voice communication services.

NOTE 1: The domain selected for originating voice communication services can be ignored by attempting a CS emergency call.

Upon request from upper layers to establish a CS emergency call:

- if the UE needs to initiate a CS fallback emergency call but it is unable to perform CS fallback, the UE shall attempt to select GERAN or UTRAN radio access technology, and a UE with "IMS voice not available" should disable the E-UTRA capability (see subclause 4.5) to allow a potential callback, and then progress the CS emergency call establishment;
- if the UE needs to initiate a 1xCS fallback emergency call but it is unable to perform 1xCS fallback, the UE shall attempt to select cdma2000® 1x radio access technology to establish the call.

NOTE 2: Unable to perform CS fallback or 1xCS fallback means that either the UE was not allowed to attempt CS fallback or 1xCS fallback, or CS fallback or 1xCS fallback attempt failed.

A UE configured to use SMS over SGs shall operate in CS/PS mode 1 or CS/PS mode 2.

The behaviour of the UE in CS/PS mode 1 of operation, upon failure to access the CS domain or upon reception of a "CS fallback not preferred" or "SMS only" indication, will depend on the availability of voice over IMS. In the present document, "IMS voice not available" refers to one of the following conditions:

a) the UE is not configured to use IMS;

b) the UE is not configured to use IMS voice, i.e. when the voice domain preference for E-UTRAN, as defined in 3GPP TS 24.167 [13B], indicates that voice communication services are allowed to be invoked only over the CS domain;

c) the UE is configured to use IMS voice, but the network indicates in the ATTACH ACCEPT message or the TRACKING AREA UPDATE ACCEPT message that IMS voice over PS sessions are not supported; or

d) the UE is configured to use IMS voice, the network indicates in the ATTACH ACCEPT message or the TRACKING AREA UPDATE ACCEPT message that IMS voice over PS sessions are supported, but the upper layers:

- provide no indication that the UE is available for voice call in the IMS within a manufacturer determined period of time; or
- indicate that the UE is not available for voice calls in the IMS.

NOTE 3: If conditions a, b and c evaluate to false, the upper layers need time to attempt IMS registration. In the event an indication from the upper layers that the UE is available for voice calls in the IMS takes longer than the manufacturer determined period of time (e.g. due to delay when attempting IMS registration or due to delay obtaining an EPS bearer context for SIP signalling), the NAS layer assumes the UE is not available for voice calls in the IMS.

Other conditions may exist but these are implementation specific.

In the present document, "IMS voice available" refers to the conditions a, b, c and d, and other implementation specific conditions for "IMS voice not available" evaluate to false.

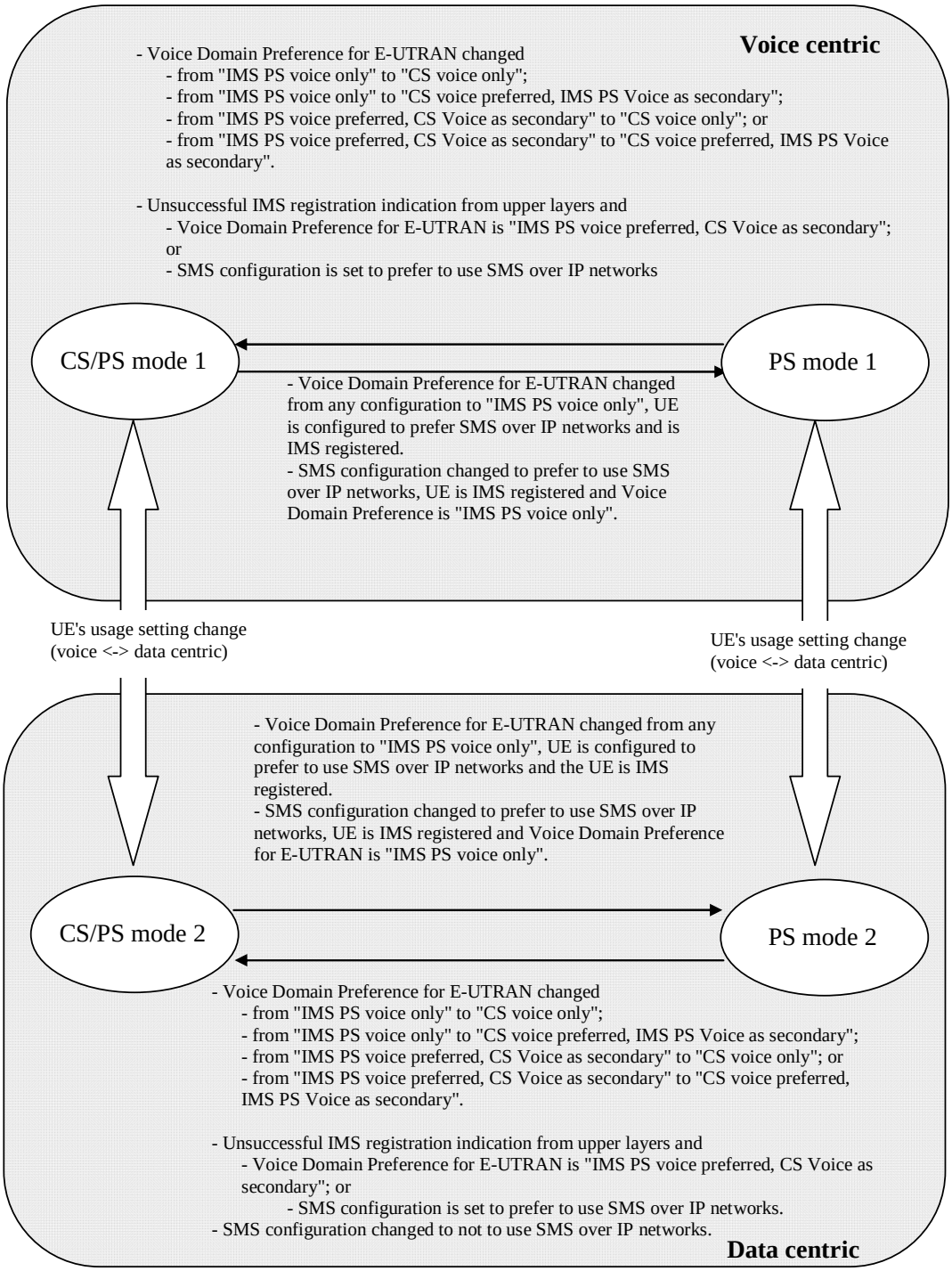
4.3.2 Change of UE mode of operation

4.3.2.1 General

The UE mode of operation can change as a result of e.g.:

- a change of UE's usage setting for a CS voice capable UE;
- a change of voice domain preference for E-UTRAN as defined in 3GPP TS 24.167 [13B] for a CS voice capable UE;
- a change in the UE's availability for voice calls in the IMS; or
- a change in UE configuration regarding the use of SMS as defined in 3GPP TS 24.167 [13B].

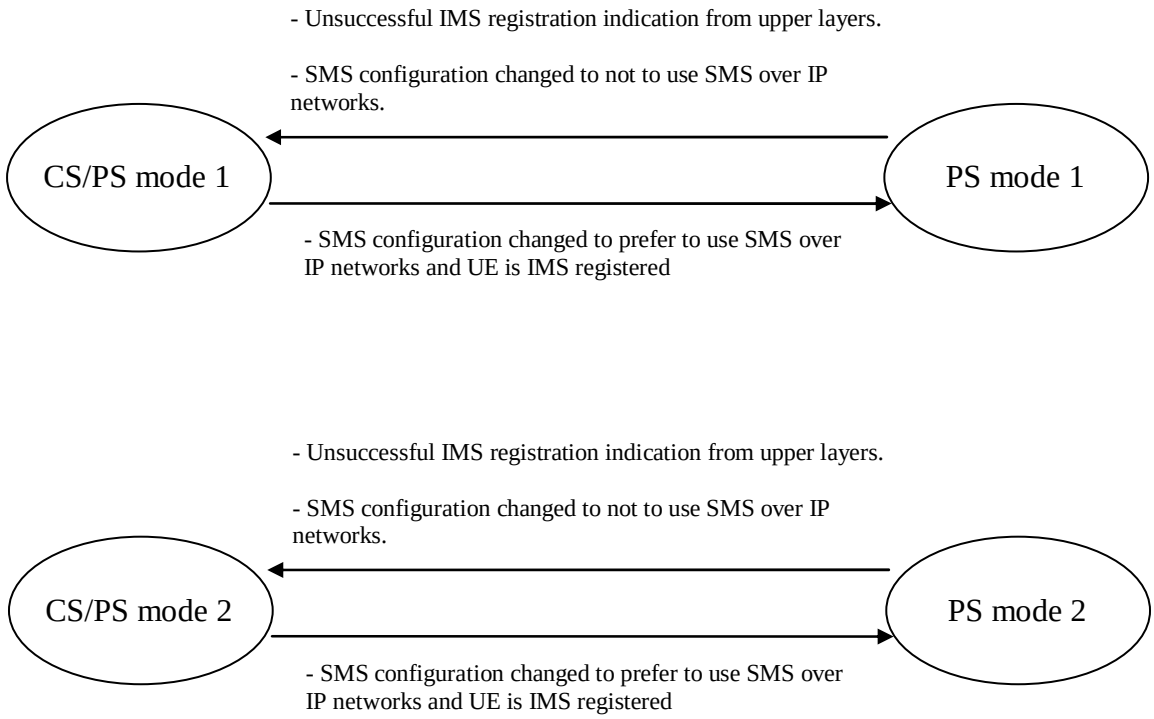
Figure 4.3.2.1.1 and figure 4.3.2.1.2 illustrate the transitions between different UE mode of operations when UE's usage settings, voice domain preference for E-UTRAN or configuration regarding SMS changes.



NOTE 1: The UE may transit from CS/PS mode 1 to PS mode 1 or from CS/PS mode 2 to PS mode 2 if "CS domain not available" is received. After the transition to PS mode 1 or PS mode 2 due to "CS domain not available", the UE can transit back to CS/PS mode 1 or CS/PS mode 2, e.g. due to change of PLMN which is not in the list of the equivalent PLMNs.

NOTE 2: Not all possible transitions are shown in this figure.

Figure 4.3.2.1.1: Change of UE mode of operation for a CS voice capable UE



NOTE: Not all possible transitions are shown in this figure.

Figure 4.3.2.1.2: Change of UE mode of operation for a UE with no CS voice capability

4.3.2.2 Change of UE's usage setting

Whenever the UE's usage setting changes, the UE dependent on its mode of operation shall execute procedures according to table 4.3.2.2.1 and table 4.3.2.2.2:

a) The UE is operating in PS mode 1 or PS mode 2

Table 4.3.2.2.1: Change of UE's usage setting for a UE in PS mode 1 or PS mode 2

UE's usage setting change	Procedure to execute
From data centric to voice centric and "IMS voice not available"	Disable the E-UTRA capability if voice domain selection results in a selection to a different RAT (see subclause 4.5), or combined tracking area update with IMSI attach if voice domain selection results in attempt to stay in E-UTRAN.
From voice centric to data centric and E-UTRA is disabled	Re-enable the E-UTRA capability (see subclause 4.5)

b) The UE is operating in CS/PS mode 1 or CS/PS mode 2

Table 4.3.2.2.2: Change of UE's usage setting for a UE in CS/PS mode 1 or CS/PS mode 2

UE's usage setting change	Procedure to execute
From data centric to voice centric, "CS fallback is not available" and "IMS voice not available" (NOTE 1)	Disable the E-UTRA capability (see subclause 4.5)
From data centric to voice centric, "IMS voice not available" and the UE received a "CS fallback not preferred" or "SMS only" indication during the last successful combined attach or combined tracking area updating procedure	Disable the E-UTRA capability (see subclause 4.5)
From voice centric to data centric and E-UTRA is disabled	Re-enable the E-UTRA capability (see subclause 4.5)
NOTE 1: "CS fallback is not available" includes EMM causes #16, #17, and #18	

4.3.2.3 Change of voice domain preference for E-UTRAN

Whenever the voice domain preference for E-UTRAN changes, the UE dependent on its mode of operation shall execute procedures according to table 4.3.2.3.1 and table 4.3.2.3.2:

a) The UE is operating in PS mode 1 or PS mode 2

Table 4.3.2.3.1: Change of voice domain preference for E-UTRAN for a UE in PS mode 1 or PS mode 2

Voice domain preference for E-UTRAN change	Procedure to execute
From "IMS PS voice only" to "CS voice only" or "CS voice preferred, IMS PS Voice as secondary"	Transit from PS mode 1 to CS/PS mode 1 or from PS mode 2 to CS/PS mode 2. Combined tracking area update with IMSI attach
From "IMS PS voice preferred, CS Voice as secondary" to "CS voice only" or "CS voice preferred, IMS PS Voice as secondary"	Transit from PS mode 1 to CS/PS mode 1 or from PS mode 2 to CS/PS mode 2. Combined tracking area update with IMSI attach

b) The UE is operating in CS/PS mode 1 or CS/PS mode 2

Table 4.3.2.3.2: Change of voice domain preference for E-UTRAN for a UE in CS/PS mode 1 or CS/PS mode 2

Voice domain preference for E-UTRAN change	Procedure to execute
From any configuration to "IMS PS voice only", UE is configured to prefer SMS over IP networks and the UE is available for voice calls in the IMS.	May: - transit from CS/PS mode 1 to PS mode 1 or from CS/PS mode 2 to PS mode 2; and - detach for non-EPS services
From any configuration to "CS voice only", UE is in CS/PS mode 1 of operation and "CS fallback is not available"(NOTE 1)	Disable the E-UTRA capability (see subclause 4.5)
From any configuration to "CS voice only", UE is in CS/PS mode 1 of operation and the UE received a "CS fallback not preferred" or "SMS only" indication during the last successful combined attach or combined tracking area updating procedure.	Disable the E-UTRA capability (see subclause 4.5)
NOTE 1: "CS fallback is not available" includes EMM causes #16, #17, and #18	

4.3.2.4 Change or determination of IMS registration status

Whenever the UE's availability for voice calls in the IMS is determined or changes (e.g. whenever the IMS registration status is determined or changes), the UE dependent on its mode of operation shall execute procedures according to table 4.3.2.4.1, 4.3.2.4.2 or 4.3.2.4.3:

a) The UE is operating in PS mode 1

Table 4.3.2.4.1: Change of IMS registration status for a UE in PS mode 1

Change of IMS registration status	Procedure to execute
UE is not available for voice calls in the IMS indication and voice domain preference for E-UTRAN is "IMS PS voice preferred, CS Voice as secondary"	Transit to CS/PS mode 1. Combined tracking area update with IMSI attach
UE is not available for voice calls in the IMS indication, SMS configuration is set to prefer to use SMS over IP networks, and voice domain preference for E-UTRAN is "IMS PS voice only"	Disable the E-UTRA capability (see subclause 4.5)
UE is not available for voice calls in the IMS indication, SMS configuration is set to prefer to use SMS over IP networks, and UE is not CS voice capable	May disable the E-UTRA capability (see subclause 4.5)

NOTE 1: If the UE in PS mode 1 transits to CS/PS mode 1 according to table 4.3.2.4.1, then the UE can return to PS mode 1 when the upper layer indicates the status of being available for voice over PS.

b) The UE is operating in PS mode 2

Table 4.3.2.4.2: Change of IMS registration status for a UE in PS mode 2

Change of IMS registration status	Procedure to execute
UE is not available for voice calls in the IMS indication and voice domain preference for E-UTRAN is "IMS PS voice preferred, CS Voice as secondary"	Transit to CS/PS mode 2. Combined tracking area update with IMSI attach
Unsuccessful IMS registration indication from upper layers, SMS configuration is set to prefer to use SMS over IP networks, and voice domain preference for E-UTRAN is "IMS PS voice only"	Transit to CS/PS mode 2. Combined tracking area update with "SMS only"
Unsuccessful IMS registration indication from upper layers, SMS configuration is set to prefer to use SMS over IP networks, and UE is not CS voice capable	Transit to CS/PS mode 2. Combined tracking area update with "SMS only"

NOTE 2: If the UE in PS mode 2 transits to CS/PS mode 2 according to table 4.3.2.4.2, then the UE can return to PS mode 2 when the upper layer indicates the status of being available for voice over PS.

c) The UE is operating in CS/PS mode 1

Table 4.3.2.4.3: Change of IMS registration status for a UE in CS/PS mode 1

Change of IMS registration status	Procedure to execute
UE is not available for voice calls in the IMS indication, and any of: - "CS fallback is not available" (NOTE 1); or - the UE received a "CS fallback not preferred" or "SMS only" indication during the last successful combined attach or combined tracking area updating procedure	Disable the E-UTRA capability (see subclause 4.5)
UE is not available for voice calls in the IMS indication, UE is in state EMM-REGISTERED.ATTEMPTING-TO-UPDATE-MM and timer T3402 is running	May disable the E-UTRA capability (see subclause 4.5)
NOTE 1: "CS fallback is not available" includes EMM causes #16, #17, and #18	

4.3.2.5 Change of configuration regarding the use of SMS.

Whenever the UE's configuration on use of SMS changes, the UE dependent on its mode of operation shall execute procedures according to table 4.3.2.5.1 and table 4.3.2.5.2:

a) The UE is operating in PS mode 1 or PS mode 2

Table 4.3.2.5.1: Change of configuration regarding the use of SMS in PS mode 1 or PS mode 2

SMS configuration change	Procedure to execute
Change to "SMS service is not preferred to be invoked over IP networks" or the UE is unable to use SMS using IMS (see 3GPP TS 24.229 [13D]).	Transit from PS mode 1 to CS/PS mode 1 or from PS mode 2 to CS/PS mode 2. Combined tracking area update with IMSI attach, (with or without "SMS only")

b) The UE is operating in CS/PS mode 1 or CS/PS mode 2

Table 4.3.2.5.2: Change of configuration regarding the use of SMS in CS/PS mode 1 or CS/PS mode 2

SMS configuration change	Procedure to execute
Change to "SMS service is preferred to be invoked over IP networks", the UE is able to use SMS using IMS (see 3GPP TS 24.229 [13D]), and UE has no CS voice capability	May: - transit from CS/PS mode 1 to PS mode 1 or from CS/PS mode 2 to PS mode 2; and - detach for non-EPS services
Change to "SMS service is preferred to be invoked over IP networks", UE is able to use SMS using IMS (see 3GPP TS 24.229 [13D]), and the voice domain preference for E-UTRAN is "IMS PS voice only"	May: - transit from CS/PS mode 1 to PS mode 1 or from CS/PS mode 2 to PS mode 2; and - detach for non-EPS services

4.4 NAS security

4.4.1 General

This clause describes the principles for the handling of EPS security contexts in the UE and in the MME and the procedures used for the security protection of EPS NAS messages between UE and MME. Security protection involves integrity protection and ciphering of the EMM and ESM NAS messages.

The signalling procedures for the control of NAS security are part of the EMM protocol and are described in detail in clause 5.

NOTE: The use of ciphering in a network is an operator option. In this subclause, for the ease of description, it is assumed that ciphering is used, unless explicitly indicated otherwise. Operation of a network without ciphering is achieved by configuring the MME so that it always selects the "null ciphering algorithm", EEA0.

4.4.2 Handling of EPS security contexts

4.4.2.1 General

The security parameters for authentication, integrity protection and ciphering are tied together in an EPS security context and identified by a key set identifier for E-UTRAN (eKSI). The relationship between the security parameters is defined in 3GPP TS 33.401 [19].

Before security can be activated, the MME and the UE need to establish an EPS security context. Usually, the EPS security context is created as the result of an EPS authentication procedure between MME and UE. Alternatively:

- during inter-system handover from A/Gb mode to S1 mode or from Iu mode to S1 mode, the MME and the UE derive a mapped EPS security context from a UMTS security context that has been established while the UE was in A/Gb mode or Iu mode; or

- during CS to PS SRVCC handover from A/Gb mode to S1 mode or from Iu mode to S1 mode, the MME and the UE derive a mapped EPS security context from a CS UMTS security context that has been established while the UE was in A/Gb mode or Iu mode.

The EPS security context is taken into use by the UE and the MME, when the MME initiates a security mode control procedure or during the inter-system handover procedure from A/Gb mode to S1 mode or Iu mode to S1 mode. The EPS security context which has been taken into use by the network most recently is called current EPS security context. This current EPS security context can be of type native or mapped, i.e. originating from a native EPS security context or mapped EPS security context.

The key set identifier eKSI is assigned by the MME either during the EPS authentication procedure or, for the mapped EPS security context, during the inter-system handover procedure. The eKSI consists of a value and a type of security context parameter indicating whether an EPS security context is a native EPS security context or a mapped EPS security context. When the EPS security context is a native EPS security context, the eKSI has the value of KSI_{ASME}, and when the current EPS security context is of type mapped, the eKSI has the value of KSI_{SGSN}.

The EPS security context which is indicated by an eKSI can be taken into use to establish the secure exchange of NAS messages when a new NAS signalling connection is established without executing a new EPS authentication procedure (see subclause 4.4.2.3) or when the MME initiates a security mode control procedure. For this purpose the initial NAS messages (i.e. ATTACH REQUEST, TRACKING AREA UPDATE REQUEST, DETACH REQUEST, SERVICE REQUEST, EXTENDED SERVICE REQUEST, and CONTROL PLANE SERVICE REQUEST) and the SECURITY MODE COMMAND message contain an eKSI in the NAS key set identifier IE or the value part of eKSI in the KSI and sequence number IE indicating the current EPS security context used to integrity protect the NAS message.

In the present document, when the UE is required to delete an eKSI, the UE shall set the eKSI to the value "no key is available" and consider also the associated keys K_{ASME} or K'_{ASME}, EPS NAS ciphering key and EPS NAS integrity key invalid (i.e. the EPS security context associated with the eKSI as no longer valid).

NOTE: In some specifications the term ciphering key sequence number might be used instead of the term Key Set Identifier (KSI).

The UE and the MME need to be able to maintain two EPS security contexts simultaneously, i.e. a current EPS security context and a non-current EPS security context, since:

- after an EPS re-authentication, the UE and the MME can have both a current EPS security context and a non-current EPS security context which has not yet been taken into use (i.e. a partial native EPS security context); and

- after an inter-system handover from A/Gb mode to S1 mode or Iu mode to S1 mode, the UE and the MME can have both a mapped EPS security context, which is the current EPS security context, and a non-current native EPS security context that was created during a previous access in S1 mode or S101 mode.

The number of EPS security contexts that need to be maintained simultaneously by the UE and the MME is limited by the following requirements:

- After a successful EPS (re-)authentication, which creates a new partial native EPS security context, the MME and the UE shall delete the non-current EPS security context, if any.

- When a partial native EPS security context is taken into use through a security mode control procedure, the MME and the UE shall delete the previously current EPS security context.

- When the MME and the UE create an EPS security context using null integrity and null ciphering algorithm during an attach procedure for emergency bearer services, or a tracking area updating procedure for a UE that has a PDN connection for emergency bearer services (see subclause 5.4.3.2), the MME and the UE shall delete the previous current EPS security context.

- When a new mapped EPS security context or EPS security context created using null integrity and null ciphering algorithm is taken into use during the inter-system handover from A/Gb mode to S1 mode or Iu mode to S1 mode, the MME and the UE shall not delete the previously current native EPS security context, if any. Instead, the previously current native EPS security context shall become a non-current native EPS security context, and the MME and the UE shall delete any partial native EPS security context.

  If no previously current native EPS security context exists, the MME and the UE shall not delete the partial native EPS security context, if any.

- When the MME and the UE derive a new mapped EPS security context during inter-system handover from A/Gb mode to S1 mode or Iu mode to S1 mode, the MME and the UE shall delete any existing current mapped EPS security context.

- When a non-current full native EPS security context is taken into use by a security mode control procedure, then the MME and the UE shall delete the previously current mapped EPS security context.

- When the UE or the MME moves from EMM-REGISTERED to EMM-DEREGISTERED state, if the current EPS security context is a mapped EPS security context and a non-current full native EPS security context exists, then the non-current EPS security context shall become the current EPS security context. Furthermore, the UE and the MME shall delete any mapped EPS security context or partial native EPS security context.

The UE shall mark the EPS security context on the USIM or in the non-volatile memory as invalid when the UE initiates an attach procedure as described in subclause 5.5.1 or when the UE leaves state EMM-DEREGISTERED for any other state except EMM-NULL.

The UE shall store the current native EPS security context as specified in annex C and mark it as valid only when the UE enters state EMM-DEREGISTERED from any other state except EMM-NULL or when the UE aborts the attach procedure without having left EMM-DEREGISTERED.

4.4.2.2 Establishment of a mapped EPS security context during intersystem handover

In order for the UE to derive a mapped EPS security context for an inter-system change from A/Gb mode or Iu mode to S1 mode in EMM-CONNECTED mode, the MME shall generate a KSI_{SGSN}, create a $nonce_{MME}$ and generate the K'_{ASME} using the created $nonce_{MME}$ as indicated in 3GPP TS 33.401 [19]. The MME shall include the selected NAS algorithms, $nonce_{MME}$ and generated KSI_{SGSN} (associated with the K'_{ASME}) in the NAS security transparent container for handover to E-UTRAN. The MME shall derive the EPS NAS keys from K'_{ASME}.

When the UE receives the command to perform handover to E-UTRAN, the UE shall derive $K'_{ASME,}$ as indicated in 3GPP TS 33.401 [19], using the $nonce_{MME}$ received in the NAS security transparent container. Furthermore, the UE shall associate the derived K'_{ASME} with the received KSI_{SGSN} and derive the EPS NAS keys from K'_{ASME}.

When the UE has a PDN connection for emergency bearer services and has no current UMTS security context, the MME shall set EIA0 and EEA0 as the selected NAS security algorithms in the NAS security transparent container for handover to E-UTRAN. The MME shall create a locally generated K'_{ASME}. The MME shall set the KSI value of the associated security context to "000" and the type of security context flag to "mapped security context" in the NAS security transparent container for handover to E-UTRAN.

When the UE receives the command to perform handover to E-UTRAN and has a PDN connection for emergency bearer services, if EIA0 and EEA0 as the selected NAS security algorithms are included in the NAS security transparent

container for handover to E-UTRAN, the UE shall create a locally generated K'_{ASME}. The UE shall set the KSI value of the associated security context to the KSI value received.

If the inter-system change from A/Gb mode or Iu mode to S1 mode in EMM-CONNECTED mode is not completed successfully, the MME and the UE shall delete the new mapped EPS security context.

4.4.2.3 Establishment of secure exchange of NAS messages

Secure exchange of NAS messages via a NAS signalling connection is usually established by the MME during the attach procedure by initiating a security mode control procedure. After successful completion of the security mode control procedure, all NAS messages exchanged between the UE and the MME are sent integrity protected using the current EPS security algorithms, and except for the messages specified in subclause 4.4.5, all NAS messages exchanged between the UE and the MME are sent ciphered using the current EPS security algorithms.

During inter-system handover from A/Gb mode to S1 mode or Iu mode to S1 mode, secure exchange of NAS messages is established between the MME and the UE by:

- the transmission of NAS security related parameters encapsulated in the AS signalling from the MME to the UE triggering the inter-system handover (see 3GPP TS 33.401 [19]). The UE uses these parameters to generate the mapped EPS security context; and,

- after the handover, the transmission of a TRACKING AREA UPDATE REQUEST message from the UE to the MME. The UE shall send this message integrity protected using the mapped EPS security context, but unciphered. From this time onward, all NAS messages exchanged between the UE and the MME are sent integrity protected using the mapped EPS security context, and except for the messages specified in subclause 4.4.5, all NAS messages exchanged between the UE and the MME are sent ciphered using the mapped EPS security context.

The secure exchange of NAS messages shall be continued after S1 mode to S1 mode handover. It is terminated after inter-system handover from S1 mode to A/Gb mode or Iu mode or when the NAS signalling connection is released.

When a UE in EMM-IDLE mode establishes a new NAS signalling connection and has a valid current EPS security context, secure exchange of NAS messages can be re-established in the following ways:

1) Except for the cases described in items 3 and 4 below, the UE shall transmit the initial NAS message integrity protected with the current EPS security context, but unciphered. The UE shall include the eKSI indicating the current EPS security context value in the initial NAS message. The MME shall check whether the eKSI included in the initial NAS message belongs to an EPS security context available in the MME, and shall verify the MAC of the NAS message. If the verification is successful, the MME may re-establish the secure exchange of NAS messages:

   - by replying with a NAS message that is integrity protected and ciphered using the current EPS security context. From this time onward, all NAS messages exchanged between the UE and the MME are sent integrity protected and except for the messages specified in subclause 4.4.5, all NAS messages exchanged between the UE and the MME are sent ciphered; or

   - by initiating a security mode control procedure. This can be used by the MME to take a non-current EPS security context into use or to modify the current EPS security context by selecting new NAS security algorithms; or

2) If the initial NAS message was a SERVICE REQUEST message or EXTENDED SERVICE REQUEST message, secure exchange of NAS messages is triggered by the indication from the lower layers that the user plane radio bearers are successfully set up. After successful completion of the procedure, all NAS messages exchanged between the UE and the MME are sent integrity protected and except for the messages specified in subclause 4.4.5, all NAS messages exchanged between the UE and the MME are sent ciphered.

3) If the UE has no current EPS security context and performs a tracking area updating procedure after an inter-system change in idle mode from A/Gb mode to S1 mode or Iu mode to S1 mode, the UE shall send the TRACKING AREA UPDATE REQUEST message without integrity protection and encryption. The UE shall include a nonce and a GPRS ciphering key sequence number for creation of a mapped EPS security context. The MME creates a fresh mapped EPS security context and takes this context into use by initiating a security mode control procedure and this context becomes the current EPS security context in both the UE and the MME. This re-establishes the secure exchange of NAS messages.

4) If the initial NAS message is a CONTROL PLANE SERVICE REQUEST message, the UE shall send the message integrity protected. If an ESM message container information element or a NAS message container information element is included the message shall be sent partially ciphered (see subclause 4.4.5) , otherwise the message shall be sent unciphered. Secure exchange of NAS messages is re-established in the UE:

   - by the indication from the lower layers that the user plane radio bearers are successfully set up;
   - upon receipt of a NAS message (e.g. a SERVICE ACCEPT message or ESM DATA TRANSPORT message) that is integrity protected and ciphered using the current EPS security context; or
   - upon receipt of a SECURITY MODE COMMAND message that has successfully passed the integrity check.

4.4.2.4 Change of security keys

When the MME initiates a re-authentication to create a new EPS security context, the messages exchanged during the authentication procedure are integrity protected and ciphered using the current EPS security context, if any.

Both UE and MME shall continue to use the current EPS security context, until the MME initiates a security mode control procedure. The SECURITY MODE COMMAND message sent by the MME includes the eKSI of the new EPS security context to be used. The MME shall send the SECURITY MODE COMMAND message integrity protected with the new EPS security context, but unciphered. When the UE responds with a SECURITY MODE COMPLETE, it shall send the message integrity protected and ciphered with the new EPS security context.

The MME can also modify the current EPS security context or take the non-current native EPS security context, if any, into use, by sending a SECURITY MODE COMMAND message including the eKSI of the EPS security context to be modified and including a new set of selected NAS security algorithms. In this case the MME shall send the SECURITY MODE COMMAND message integrity protected with the modified EPS security context, but unciphered. When the UE replies with a SECURITY MODE COMPLETE message, it shall send the message integrity protected and ciphered with the modified EPS security context.

4.4.2.5 Derivation of keys at CS to PS SRVCC handover from A/Gb mode to S1 mode or from Iu mode to S1 mode

At change from A/Gb mode to S1 mode or from Iu mode to S1 mode due to CS to PS SRVCC handover (see 3GPP TS 23.216 [8]), the UE shall derive a mapped EPS security context for the PS domain from the UMTS security context for the CS domain.

At change from A/Gb mode to S1 mode due to CS to PS SRVCC handover, ciphering may be started and integrity protection shall be started (see 3GPP TS 36.331 [22]) without any new authentication procedure.

NOTE 1: CS to PS SRVCC handover from A/Gb mode to S1 mode or from Iu mode to S1 mode is not supported if the current CS security context is a GSM security context.

NOTE 2: For emergency calls, CS to PS SRVCC handover from A/Gb mode to S1 mode or from Iu mode to S1 mode is not supported.

In order to derive a mapped EPS security context for a CS to PS SRVCC handover from A/Gb mode or Iu mode to S1 mode, the MSC creates a $NONCE_{MSC}$ and generates the CK'_{PS} and IK'_{PS} using the CS UMTS integrity key, the CS UMTS ciphering key and the created $NONCE_{MSC}$ as specified in annex B.6 in 3GPP TS 33.102 [18]. The MSC associates the CK'_{PS} and IK'_{PS} with a KSI'_{PS}. The KSI'_{PS} is set to the value of the KSI_{CS} associated with the CS UMTS integrity key and the CS UMTS ciphering key. The MSC transfers the CK'_{PS}, IK'_{PS} and the KSI'_{PS} to the MME. The MME shall create a mapped EPS security context by setting the K'_{ASME} to the concatenation of the CK'_{PS} and IK'_{PS} received from the MSC (i.e. $CK'_{PS} \| IK'_{PS}$). The MME shall associate the K'_{ASME} with a KSI_{SGSN}. The MME shall set KSI_{SGSN} to the value of the KSI'_{PS} received from the MSC. The MME shall include the selected NAS algorithms, $NONCE_{MME}$ and generated KSI_{SGSN} (associated with the K'_{ASME}) in the NAS security transparent container for the handover to E-UTRAN. The MME shall derive the EPS NAS keys from K'_{ASME}.

When the UE receives the command to perform CS to PS SRVCC handover to S1 mode, the ME shall generate the CK'_{PS} and IK'_{PS} using the CS UMTS integrity key, the CS UMTS ciphering key and the received $NONCE_{MSC}$ value in the transparent container in the CS to PS SRVCC handover command as specified in annex B.6 in 3GPP TS 33.102 [18]. The ME shall ignore the $NONCE_{MME}$ value received in the NAS Security Transparent Container in the CS to PS SRVCC handover command.

NOTE 3: The $NONCE_{MME}$ value received in the NAS Security Transparent Container for the handover to E-UTRAN is not used by the ME or MME in any key derivation in this handover.

The ME shall create the key K'_{ASME} by concatenating the derived CK'_{PS} and IK'_{PS} (i.e. $CK'_{PS} \| IK'_{PS}$). The ME shall associate the derived key K'_{ASME} with a KSI_{SGSN}.The ME shall set the KSI_{SGSN} associated to K'_{ASME} to the KSI_{SGSN} value received in the NAS Security Transparent Container from the network.

NOTE 4: Although this case is related to the MSC server enhanced for SRVCC, the name KSI_{SGSN} is kept to avoid introducing a new name for the same domain.

The ME shall derive the EPS NAS keys (CK' and IK') from the K'_{ASME} as specified in 3GPP TS 33.401 [19]. The ME shall apply these derived EPS NAS security keys (CK' and IK'), reset the uplink and downlink NAS COUNT values for the mapped EPS security context (i.e. to the value 0), and replace an already established mapped EPS security context for the PS domain, if any, in the ME, when the CS to PS SRVCC handover from A/Gb mode or Iu mode has been completed successfully. If the already established current EPS security context is of type native, then it shall become the non-current native EPS security context and overwrite any existing non-current native EPS security context in the ME.

The network shall replace an already established mapped EPS security context for the PS domain, if any, when the CS to PS SRVCC handover from A/Gb mode or Iu mode has been completed successfully. If the already established current EPS security context is of type native, then it shall become the non-current native EPS security context and overwrite any existing non-current native EPS security context in the MME.

If the CS to PS SRVCC handover from A/Gb mode or Iu mode has not been completed successfully, the UE and the network shall delete the new derived mapped EPS security context for the PS domain. Additionally, the network shall delete an already established mapped EPS security context for the PS domain, if any, if the eKSI of the already established EPS security context is equal to the KSI_{SGSN} of the new derived EPS security context for the PS domain.

4.4.3 Handling of NAS COUNT and NAS sequence number

4.4.3.1 General

Each EPS security context shall be associated with two separate counters NAS COUNT: one related to uplink NAS messages and one related to downlink NAS messages. The NAS COUNT counters use 24 bit internal representation and are independently maintained by UE and MME. The NAS COUNT shall be constructed as a NAS sequence number (8 least significant bits) concatenated with a NAS overflow counter (16 most significant bits).

When NAS COUNT is input to NAS ciphering or NAS integrity algorithms it shall be considered to be a 32-bit entity which shall be constructed by padding the 24-bit internal representation with 8 zeros in the most significant bits.

The value of the uplink NAS COUNT that is stored or read out of the USIM or non-volatile memory as described in annex C, is the value that shall be used in the next NAS message.

The value of the downlink NAS COUNT that is stored or read out of the USIM or non-volatile memory as described in annex C, is the largest downlink NAS COUNT used in a successfully integrity checked NAS message.

The NAS sequence number part of the NAS COUNT shall be exchanged between the UE and the MME as part of the NAS signalling. After each new or retransmitted outbound security protected NAS message, the sender shall increase the NAS COUNT number by one, except for the initial NAS messages if the lower layers indicated the failure to establish the RRC connection (see 3GPP TS 36.331 [22]). Specifically, on the sender side, the NAS sequence number shall be increased by one, and if the result is zero (due to wrap around), the NAS overflow counter shall also be incremented by one (see subclause 4.4.3.5). The receiving side shall estimate the NAS COUNT used by the sending side. Specifically, if the estimated NAS sequence number wraps around, the NAS overflow counter shall be incremented by one.

After the derivation of a NAS token due to an inter-system change from S1mode to A/Gb mode or Iu mode in idle mode as specified in 3GPP TS 24.008 [13], the UE shall increase the uplink NAS COUNT by one.

When the MME receives a NAS token via SGSN during an idle mode inter-system change from S1 mode to A/Gb mode or Iu mode, the MME shall check the NAS token as specified in 3GPP TS 33.401 [19], subclause 9.1.1, and update its uplink NAS COUNT with the uplink NAS COUNT value used for the successful check of the NAS token.

NOTE 1: The MME does not check the NAS token if it is received via SGSN during a connected mode inter-system change from S1 mode to A/Gb mode or Iu mode.

During the handover from UTRAN/GERAN to E-UTRAN, when a mapped EPS security context is derived and taken into use, the MME shall set both the uplink and downlink NAS COUNT counters of this EPS security context to zero. The UE shall set both the uplink and downlink NAS COUNT counters to zero.

During the handover from E-UTRAN to UTRAN/GERAN the MME signals the current downlink NAS COUNT value in a NAS security transparent container (see subclause 9.9.2.6).

During handover to or from E-UTRAN, the MME shall increment downlink NAS COUNT by one after it has created a NAS security transparent container (see subclause 9.9.2.6 and 9.9.2.7).

NOTE 2: During the handover from UTRAN/GERAN to E-UTRAN, the NAS security transparent container (see subclause 9.9.2.7) is treated as an implicit SECURITY MODE COMMAND message for the UE and the MME, and therefore the MME regards the sending of the NAS security transparent container as the sending of an initial SECURITY MODE COMMAND message in order to derive and take into use a mapped EPS security context for the purpose of the NAS COUNT handling.

In some NAS messages only 5 of the 8 NAS sequence number bits are transmitted. When this is the case, the receiver shall estimate the remaining 3 most significant bits of the sequence number.

4.4.3.2 Replay protection

Replay protection shall be supported for received NAS messages both in the MME and the UE. However, since the realization of replay protection does not affect the interoperability between nodes, no specific mechanism is required for implementation.

Replay protection must assure that one and the same NAS message is not accepted twice by the receiver. Specifically, for a given EPS security context, a given NAS COUNT value shall be accepted at most one time and only if message integrity verifies correctly.

Replay protection is not applicable when EIA0 is used.

4.4.3.3 Integrity protection and verification

The sender shall use its locally stored NAS COUNT as input to the integrity protection algorithm.

The receiver shall use the NAS sequence number included in the received message (or estimated from the 5 bits of the NAS sequence number received in the message) and an estimate for the NAS overflow counter as defined in subclause 4.4.3.1 to form the NAS COUNT input to the integrity verification algorithm.

The algorithm to calculate the integrity protection information is specified in 3GPP TS 33.401 [19], and the integrity protection shall include octet 6 to n of the security protected NAS message, i.e. the sequence number IE and the NAS message IE. The integrity protection of the SERVICE REQUEST message is defined in subclause 9.9.3.28. In addition to the data that is to be integrity protected, the constant BEARER ID, DIRECTION bit, NAS COUNT and NAS integrity key are input to the integrity protection algorithm. These parameters are described in 3GPP TS 33.401 [19].

After successful integrity protection validation, the receiver shall update its corresponding locally stored NAS COUNT with the value of the estimated NAS COUNT for this NAS message.

Integrity verification is not applicable when EIA0 is used.

4.4.3.4 Ciphering and deciphering

The sender shall use its locally stored NAS COUNT as input to the ciphering algorithm.

The receiver shall use the NAS sequence number included in the received message (or estimated from the 5 bits of the NAS sequence number received in the message) and an estimate for the NAS overflow counter as defined in subclause 4.4.3.1 to form the NAS COUNT input to the deciphering algorithm.

The input parameters to the NAS ciphering algorithm are the constant BEARER ID, DIRECTION bit, NAS COUNT, NAS encryption key and the length of the key stream to be generated by the encryption algorithm. When an initial plain NAS message for transport of user data via control plane (i.e. CONTROL PLANE SERVICE REQUEST message) is to be partially ciphered, the length of the key stream is set to the length of the part of the initial plain NAS message (i.e. the value part of the ESM message container IE or the value part of the NAS message container) that is to be ciphered.

4.4.3.5 NAS COUNT wrap around

If, when increasing the NAS COUNT as specified above, the MME detects that either its downlink NAS COUNT or the UE's uplink NAS COUNT is "close" to wrap around, (close to 2^{24}), the MME shall take the following actions:

- If there is no non-current native EPS security context with sufficiently low NAS COUNT values, the MME shall initiate a new AKA procedure with the UE, leading to a new established EPS security context and the NAS COUNT being reset to 0 in both the UE and the MME when the new EPS security context is activated;
- Otherwise, the MME can activate a non-current native EPS security context with sufficiently low NAS COUNT values or initiate a new AKA procedure as specified above.

If for some reason a new K_{ASME} has not been established using AKA before the NAS COUNT wraps around, the node (MME or UE) in need of sending a NAS message shall instead release the NAS signalling connection. Prior to sending the next uplink NAS message, the UE shall delete the eKSI indicating the current EPS security context.

When the EIA0 is used as the NAS integrity algorithm, the UE and the MME shall allow NAS COUNT wrap around. If NAS COUNT wrap around occurs, the following requirements apply:

- the UE and the MME shall continue to use the current security context;
- the MME shall not initiate the EPS AKA procedure;
- the MME shall not release the NAS signalling connection; and
- the UE shall not perform a local release of the NAS signalling connection.

4.4.4 Integrity protection of NAS signalling messages

4.4.4.1 General

For the UE, integrity protected signalling is mandatory for the NAS messages once a valid EPS security context exists and has been taken into use. For the network, integrity protected signalling is mandatory for the NAS messages once a secure exchange of NAS messages has been established for the NAS signalling connection. Integrity protection of all NAS signalling messages is the responsibility of the NAS. It is the network which activates integrity protection.

The use of "null integrity protection algorithm" EIA0 (see subclause 9.9.3.23) in the current security context is only allowed for an unauthenticated UE for which establishment of emergency bearer services is allowed. For setting the security header type in outbound NAS messages, the UE and the MME shall apply the same rules irrespective of whether the "null integrity protection algorithm" or any other integrity protection algorithm is indicated in the security context.

If the "null integrity protection algorithm" EIA0 has been selected as a integrity protection algorithm, the receiver shall regard the NAS messages with the security header indicating integrity protection as integrity protected.

Details of the integrity protection and verification of NAS signalling messages are specified in 3GPP TS 33.401 [19].

When a NAS message needs to be sent both ciphered and integrity protected, the NAS message is first ciphered and then the ciphered NAS message and the NAS sequence number are integrity protected by calculating the MAC. The same applies when an initial NAS message needs to be sent partially ciphered and integrity protected.

NOTE: NAS messages that are ciphered or partially ciphered with the "null ciphering algorithm" EEA0 are regarded as ciphered or partially ciphered, respectively (see subclause 4.4.5).

When a NAS message needs to be sent only integrity protected and unciphered, the unciphered NAS message and the NAS sequence number are integrity protected by calculating the MAC.

When during the EPS attach procedure or service request procedure an ESM message is piggybacked in an EMM message, there is only one sequence number IE and one message authentication code IE, if any, for the combined NAS message.

4.4.4.2 Integrity checking of NAS signalling messages in the UE

Except the messages listed below, no NAS signalling messages shall be processed by the receiving EMM entity in the UE or forwarded to the ESM entity, unless the network has established secure exchange of NAS messages for the NAS signalling connection:

- EMM messages:
  - IDENTITY REQUEST (if requested identification parameter is IMSI);
  - AUTHENTICATION REQUEST;
  - AUTHENTICATION REJECT;
  - ATTACH REJECT (if the EMM cause is not #25);
  - DETACH ACCEPT (for non switch off);
  - TRACKING AREA UPDATE REJECT (if the EMM cause is not #25);
  - SERVICE REJECT (if the EMM cause is not #25).

NOTE: These messages are accepted by the UE without integrity protection, as in certain situations they are sent by the network before security can be activated.

All ESM messages are integrity protected.

Once the secure exchange of NAS messages has been established, the receiving EMM or ESM entity in the UE shall not process any NAS signalling messages unless they have been successfully integrity checked by the NAS. If NAS signalling messages, having not successfully passed the integrity check, are received, then the NAS in the UE shall discard that message. The processing of the SECURITY MODE COMMAND message that has not successfully passed the integrity check is specified in subclause 5.4.3.5. If any NAS signalling message is received as not integrity protected even though the secure exchange of NAS messages has been established by the network, then the NAS shall discard this message.

4.4.4.3 Integrity checking of NAS signalling messages in the MME

Except the messages listed below, no NAS signalling messages shall be processed by the receiving EMM entity in the MME or forwarded to the ESM entity, unless the secure exchange of NAS messages has been established for the NAS signalling connection:

- EMM messages:
  - ATTACH REQUEST;
  - IDENTITY RESPONSE (if requested identification parameter is IMSI);
  - AUTHENTICATION RESPONSE;
  - AUTHENTICATION FAILURE;
  - SECURITY MODE REJECT;
  - DETACH REQUEST;
  - DETACH ACCEPT;
  - TRACKING AREA UPDATE REQUEST.

NOTE 1: The TRACKING AREA UPDATE REQUEST message is sent by the UE without integrity protection, if the tracking area updating procedure is initiated due to an inter-system change in idle mode and no current EPS security context is available in the UE. The other messages are accepted by the MME without integrity protection, as in certain situations they are sent by the UE before security can be activated.

NOTE 2: The DETACH REQUEST message can be sent by the UE without integrity protection, e.g. if the UE is attached for emergency bearer services and there is no shared EPS security context available, or if due to user interaction an attach procedure is cancelled before the secure exchange of NAS messages has been established. For these cases the network can attempt to use additional criteria (e.g. whether the UE is subsequently still performing periodic tracking area updating or still responding to paging) before marking the UE as EMM-DEREGISTERED.

All ESM messages are integrity protected except a PDN CONNECTIVITY REQUEST message if it is sent piggybacked in ATTACH REQUEST message and NAS security is not activated.

Once a current EPS security context exists, until the secure exchange of NAS messages has been established for the NAS signalling connection, the receiving EMM entity in the MME shall process the following NAS signalling messages, even if the MAC included in the message fails the integrity check or cannot be verified, as the EPS security context is not available in the network:

- ATTACH REQUEST;
- IDENTITY RESPONSE (if requested identification parameter is IMSI);
- AUTHENTICATION RESPONSE;
- AUTHENTICATION FAILURE;
- SECURITY MODE REJECT;
- DETACH REQUEST;
- DETACH ACCEPT;
- TRACKING AREA UPDATE REQUEST;
- SERVICE REQUEST;
- EXTENDED SERVICE REQUEST;
- CONTROL PLANE SERVICE REQUEST.

NOTE 3: These messages are processed by the MME even when the MAC that fails the integrity check or cannot be verified, as in certain situations they can be sent by the UE protected with an EPS security context that is no longer available in the network.

If an ATTACH REQUEST message is received without integrity protection or fails the integrity check and it is not an attach request for emergency bearer services, the MME shall authenticate the subscriber before processing the attach request any further. Additionally, if the MME initiates a security mode control procedure, the MME shall include a $HASH_{MME}$ IE in the SECURITY MODE COMMAND message as specified in subclause 5.4.3.2. For the case when the attach procedure is for emergency bearer services see subclause 5.5.1.2.3 and subclause 5.4.2.5.

If a DETACH REQUEST message fails the integrity check, the MME shall proceed as follows:

- If it is not a detach request due to switch off, and the MME can initiate an authentication procedure, the MME should authenticate the subscriber before processing the detach request any further.
- If it is a detach request due to switch off, or the MME does not initiate an authentication procedure for any other reason, the MME may ignore the detach request and remain in state EMM-REGISTERED.

NOTE 4: The network can attempt to use additional criteria (e.g. whether the UE is subsequently still performing periodic tracking area updating or still responding to paging) before marking the UE as EMM-DEREGISTERED.

If a TRACKING AREA UPDATE REQUEST message is received without integrity protection or fails the integrity check and the UE provided a $nonce_{UE}$, GPRS ciphering key sequence number, P-TMSI and RAI in the TRACKING AREA UPDATE REQUEST message, the MME shall initiate a security mode control procedure to take a new mapped EPS security context into use; otherwise if the UE has only a PDN connection for non-emergency bearer services established, the MME shall initiate an authentication procedure. Additionally, if the MME initiates a security mode control procedure, the MME shall include a $HASH_{MME}$ IE in the SECURITY MODE COMMAND message as specified

in subclause 5.4.3.2. For the case when the UE has a PDN connection for emergency bearer services see subclause 5.5.3.2.3 and subclause 5.4.2.5.

If a SERVICE REQUEST, EXTENDED SERVICE REQUEST or CONTROL PLANE SERVICE REQUEST message fails the integrity check and the UE has only PDN connections for non-emergency bearer services established, the MME shall send the SERVICE REJECT message with EMM cause #9 "UE identity cannot be derived by the network" and keep the EMM-context and EPS security context unchanged. For the case when the UE has a PDN connection for emergency bearer services and integrity check fails, the MME may skip the authentication procedure even if no EPS security context is available and proceed directly to the execution of the security mode control procedure as specified in subclause 5.4.3. After successful completion of the service request procedure, the network shall deactivate all non-emergency EPS bearers locally. The emergency EPS bearers shall not be deactivated.

Once the secure exchange of NAS messages has been established for the NAS signalling connection, the receiving EMM or ESM entity in the MME shall not process any NAS signalling messages unless they have been successfully integrity checked by the NAS. If any NAS signalling message, having not successfully passed the integrity check, is received, then the NAS in the MME shall discard that message. If any NAS signalling message is received, as not integrity protected even though the secure exchange of NAS messages has been established, then the NAS shall discard this message.

4.4.5 Ciphering of NAS signalling messages

The use of ciphering in a network is an operator option subject to MME configuration. When operation of the network without ciphering is configured, the MME shall indicate the use of "null ciphering algorithm" EEA0 (see subclause 9.9.3.23) in the current security context for all UEs. For setting the security header type in outbound NAS messages, the UE and the MME shall apply the same rules irrespective of whether the "null ciphering algorithm" or any other ciphering algorithm is indicated in the security context.

When the UE establishes a new NAS signalling connection, it shall send the initial NAS message

- partially ciphered, if it is a CONTROL PLANE SERVICE REQUEST message including an ESM message container information element or a NAS message container information element; and
- unciphered, if it is any other initial NAS message.

The UE shall partially cipher the CONTROL PLANE SERVICE REQUEST message by ciphering the value part of the ESM message container IE or the value part of the NAS message container, using the ciphering algorithm of the current EPS security context.

The UE shall send the ATTACH REQUEST message always unciphered.

The UE shall send the TRACKING AREA UPDATE REQUEST message always unciphered.

Except for the CONTROL PLANE SERVICE REQUEST message including an ESM message container information element or a NAS message container information element, the UE shall start the ciphering and deciphering of NAS messages when the secure exchange of NAS messages has been established for a NAS signalling connection. From this time onward, unless explicitly defined, the UE shall send all NAS messages ciphered until the NAS signalling connection is released, or the UE performs intersystem handover to A/Gb mode or Iu mode.

The MME shall start ciphering and deciphering of NAS messages as described in subclause 4.4.2.3. From this time onward, except for the SECURITY MODE COMMAND message, the MME shall send all NAS messages ciphered until the NAS signalling connection is released, or the UE performs intersystem handover to A/Gb mode or Iu mode.

Once the encryption of NAS messages has been started between the MME and the UE, the receiver shall discard the unciphered NAS messages which shall have been ciphered according to the rules described in this specification. The MME shall discard any CONTROL PLANE SERVICE REQUEST message including an ESM message container information element or a NAS message container information element which has not been partially ciphered according to the rules described above.

If the "null ciphering algorithm" EEA0 has been selected as a ciphering algorithm, the NAS messages with the security header indicating ciphering are regarded as ciphered.

Details of ciphering and deciphering of NAS signalling messages are specified in 3GPP TS 33.401 [19].

4.5 Disabling and re-enabling of UE's E-UTRA capability

When the UE is disabling the E-UTRA capability, it should proceed as follows:

a) select another RAT (GERAN or UTRAN) of the registered PLMN or a PLMN from the list of equivalent PLMNs;

b) if another RAT of the registered PLMN or a PLMN from the list of equivalent PLMNs cannot be found, or the UE does not have a registered PLMN, then perform PLMN selection as specified in 3GPP TS 23.122 [6]. As an implementation option, instead of performing PLMN selection, the UE may select another RAT of the chosen PLMN. If disabling of E-UTRA capability was not due to UE initiated detach procedure for EPS services only, the UE may re-enable the E-UTRA capability for this PLMN selection; or

c) if no other allowed PLMN and RAT combinations are available, then the UE may re-enable the E-UTRA capability and remain registered for EPS services in E-UTRAN of the registered PLMN. If the UE chooses this option, then it may periodically attempt to select another PLMN and RAT combination that can provide non-EPS services. How this periodic scanning is done, is UE implementation dependent.

The UE shall re-enable the E-UTRA capability when performing a PLMN selection unless:

- the disabling of E-UTRA capability was due to UE initiated detach procedure for EPS services only; or
- the UE has already re-enabled the E-UTRA capability when performing bullets b) or c) above.

If due to handover, the UE moves to a new PLMN in A/Gb or Iu mode which is not in the list of equivalent PLMNs and not a PLMN memorized by the UE for which E-UTRA capability was disabled, and the disabling of E-UTRA capability was not due to UE initiated detach procedure for EPS services only, the UE shall re-enable the E-UTRA capability after the RR/RRC connection is released.

If UE that has disabled its E-UTRA capability due to IMS voice not available and CS fallback not available re-enables it when PLMN selection is performed, then it should memorize the identity of the PLMNs where E-UTRA capability was disabled and use that stored information in subsequent PLMN selections as specified in 3GPP TS 23.122 [6].

The UE may support "E-UTRA Disabling for EMM cause #15" and implement the following behaviour:

- if the "E-UTRA Disabling Allowed for EMM cause #15" parameter as specified in 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17] is present and set to enabled; and
- if the UE receives an ATTACH REJECT or TRACKING AREA UPDATE REJECT message including both EMM cause #15 "no suitable cells in tracking area" and an Extended EMM cause IE with value "E-UTRAN not allowed";

then the UE shall disable the E-UTRA capability, memorize the identity of the PLMN where the E-UTRA capability was disabled and use that stored information in subsequent PLMN selections as specified in 3GPP TS 23.122 [6].

When the UE supporting the A/Gb and/or Iu mode together with the S1 mode needs to stay in A/Gb or Iu mode, in order to prevent unwanted handover or cell reselection from UTRAN/GERAN to E-UTRAN, the UE shall disable the E-UTRA capability.

- The UE shall not set the E-UTRA support bits of the MS Radio Access capability IE (see 3GPP TS 24.008 [13], subclause 10.5.5.12a), the E-UTRA support bits of Mobile Station Classmark 3 IE (see 3GPP TS 24.008 [13], subclause 10.5.1.7), the PS inter-RAT HO from GERAN to E-UTRAN S1 mode capability bit and the ISR support bit of the MS network capability IE (see 3GPP TS 24.008 [13], subclause 10.5.5.12) in the ATTACH REQUEST message and the ROUTING AREA UPDATE REQUEST message after it selects GERAN or UTRAN;
- the UE shall use the same value of the EPC capability bit of the MS network capability IE (see 3GPP TS 24.008 [13], subclause 10.5.5.12) in the ATTACH REQUEST message and the ROUTING AREA UPDATE REQUEST message; and
- the UE NAS layer shall indicate the access stratum layer(s) of disabling of the E-UTRA capability.

NOTE 1: The UE can only disable the E-UTRA capability when in EMM-IDLE mode.

NOTE 2: Disabling and re-enabling the UE's E-UTRA capability does not affect the UE's capability to access the 5GC via E-UTRA.

If the UE is disabling its E-UTRA capability before selecting to GERAN or UTRAN radio access technology, the UE shall not perform the detach procedure of subclause 5.5.2.1.

If the UE is required to disable the E-UTRA capability and select GERAN or UTRAN radio access technology, and the UE is in the EMM-CONNECTED mode, the UE shall locally release the established NAS signalling connection and enter the EMM-IDLE mode before selecting GERAN or UTRAN radio access technology.

If the E-UTRA capability was disabled due to the attempt to select GERAN or UTRAN radio access technology progressing the CS emergency call establishment (see subclause 4.3.1), the criteria to enable the E-UTRA capability again is UE implementation specific.

If the E-UTRA capability was disabled due to the UE initiated detach procedure for EPS services only (see subclause 5.5.2.2.2), upon request of the upper layers to re-attach for EPS services the UE shall enable the E-UTRA capability again. If the E-UTRA capability was disabled due to receipt of EMM cause #14 "EPS services not allowed in this PLMN", then the UE shall enable the E-UTRA capability when the UE powers off and powers on again or the USIM is removed. If E-UTRA capability was disabled for any other reason, the UE shall enable the E-UTRA capability in the following cases:

- the UE mode of operation changes from CS/PS mode 1 of operation to CS/PS mode 2 of operation;
- the UE mode of operation changes from PS mode 1 of operation to PS mode 2 of operation; or
- the UE powers off and powers on again or the USIM is removed;

As an implementation option, the UE may start a timer for enabling E-UTRA when the UE's attach attempt counter or tracking area updating attempt counter reaches 5 and the UE disables E-UTRA capability for cases described in subclauses 5.5.1.2.6, 5.5.1.3.4.3, 5.5.1.3.6, 5.5.3.2.6, 5.5.3.3.4.3 and 5.5.3.3.6. The UE should memorize the identity of the PLMNs where E-UTRA capability were disabled. On expiry of this timer:

- if the UE is in Iu mode or A/Gb mode and is in idle mode as specified in 3GPP TS 24.008 [13] on expiry of the timer, the UE should enable the E-UTRA capability;
- if the UE is in Iu mode or A/Gb mode and an RR connection exists, the UE shall delay enabling E-UTRA capability until the RR connection is released; and
- if the UE is in Iu mode and a PS signalling connection exists but no RR connection exists, the UE may abort the PS signalling connection before enabling E-UTRA capability.

If the UE attempts to establish an emergency bearer service in a PLMN where the E-UTRA capability was disabled due to the UE's attach attempt counter or tracking area updating attempt counter have reached 5, the UE may enable the E-UTRA capability for that PLMN memorized by the UE.

For other cases, it is up to the UE implementation when to enable the E-UTRA capability.

NOTE 3: If the UE is not operating in CS/PS mode 1 operation, the value of the timer for enabling E-UTRA capability is recommended to be not larger than the default value of T3402.

4.6 Applicability of procedures

4.6.1 Relay nodes

A relay node shall support all procedures that are mandatory for a UE supporting S1 mode only.

There is also functionality which is only applicable to a relay node, in which case the specification uses the term "relay node" instead of "UE".

4.7 EPS mobility management and EPS session management in NB-S1 mode

A UE in NB-S1 mode (see 3GPP TS 36.331 [22]) shall calculate the value of the applicable NAS timer:

- indicated in table 10.2.1 plus 240s; and
- indicated in table 10.3.1 plus 180s.

The timer value obtained is used as described in the appropriate procedure subclause of this specification. The NAS timer value shall be calculated at start of a NAS procedure and shall not re-calculate the use of the NAS timer value until the NAS procedure is completed, restarted or aborted.

When an MME that supports NB-S1 mode performs NAS signaling with a UE, which is using NB-S1 mode, the MME shall calculate the value of the applicable NAS timer:

- indicated in table 10.2.2 plus 240s; and
- indicated in table 10.3.2 plus 180s.

The timer value obtained is used as described in the appropriate procedure subclause of this specification. The NAS timer value shall be calculated at start of a NAS procedure and shall not re-calculate the use of the NAS timer value until the NAS procedure is completed, restarted or aborted.

NOTE: If the tracking area update procedure is initiated in EMM-CONNECTED mode, the MME can stop any running implementation specific supervision timer if it is started when sending an ESM DATA TRANSPORT message to the UE.

4.8 EPS mobility management and EPS session management in WB-S1 mode for IoT

In WB-S1 mode, a UE operating in category CE can operate in either CE mode A or CE mode B (see 3GPP TS 36.306 [44]). If a UE that supports CE mode B and operates in WB-S1 mode and the UE's usage setting is not set to "voice centric" (see 3GPP TS 23.401 [10]), the UE shall apply the value of the applicable NAS timer indicated in tables 10.2.1 and indicated in table 10.3.1 for WB-S1/CE mode.

The NAS timer value obtained is used as described in the appropriate procedure subclause of this specification. The NAS timer value shall be calculated at start of a NAS procedure, and shall not be re-calculated until the NAS procedure is completed, restarted or aborted.

The support of CE mode B by a UE is indicated to the MME by lower layers and shall be stored by the MME. When an MME that supports WB-S1 mode performs NAS signaling with a UE, which supports CE mode B and operates in WB-S1 mode and the MME determines that

- the use of enhanced coverge is not restricted for the UE; or
- CE mode B is not restricted for the UE (see 3GPP TS 23.401 [10])

the MME shall calculate the value of the applicable NAS timer indicated in tables 10.2.2 and indicated in table 10.3.2 for WB-S1/CE mode.

The NAS timer value obtained is used as described in the appropriate procedure subclause of this specification. The NAS timer value shall be calculated at start of a NAS procedure and shall not be re-calculated until the NAS procedure is completed, restarted or aborted.

4.9 Disabling and re-enabling of UE's NB-IoT capability

If the UE supports disabling and re-enabling of UE's NB-IoT capability and the UE in NB-S1 mode is disabling the NB-IoT capability, it should proceed as follows:

a) select E-UTRAN of the registered PLMN or a PLMN from the list of equivalent PLMNs;

b) if E-UTRAN of the registered PLMN or a PLMN from the list of equivalent PLMNs cannot be found, select another RAT (GERAN or UTRAN) of the registered PLMN or a PLMN from the list of equivalent PLMNs;

c) if another RAT of the registered PLMN or a PLMN from the list of equivalent PLMNs cannot be found, or the UE does not have a registered PLMN, then perform PLMN selection as specified in 3GPP TS 23.122 [6]. As an implementation option, instead of performing PLMN selection, the UE may select another RAT of the chosen PLMN; or

d) if no other allowed PLMN and RAT combinations are available, then the UE may re-enable the NB-IoT capability and remain registered for EPS services in NB-IoT of the registered PLMN. If the UE chooses this option, then it may periodically attempt to select another PLMN and RAT combination that can provide non-EPS services. How this periodic scanning is done, is UE implementation dependent.

If the the NB-IoT capability is disabled the UE shall re-enable the NB-IoT capability when:

- performing a PLMN selection unless the UE has already re-enabled the NB-IoT capability when performing bullets c) or d) above; or
- the UE powers off and powers on again or the USIM is removed.

If the UE receives an ATTACH REJECT or TRACKING AREA UPDATE REJECT message including both EMM cause #15 "no suitable cells in tracking area" and an Extended EMM cause IE with value "NB-IoT not allowed" after the UE requests access to the NB-IoT, in order to prevent unwanted cell reselection from GERAN or UTRAN or E-UTRAN to NB-IoT, the UE may:

- disable the NB-IoT capability:
- indicate the access stratum layer(s) of disabling of the NB-IoT capability; and
- memorize the identity of the PLMN where the NB-IoT capability was disabled and use that stored information in subsequent PLMN selections as specified in 3GPP TS 23.122 [6].

NOTE: The UE can only disable the NB-IoT capability when in EMM-IDLE mode.

If the UE is required to disable the NB-IoT capability and select E-UTRAN radio access technology, and the UE is in the EMM-CONNECTED mode, the UE shall locally release the established NAS signalling connection and enter the EMM-IDLE mode before selecting E-UTRAN radio access technology.

As an implementation option, the UE may start a timer for enabling the NB-IoT capability. On expiry of this timer, the UE may enable the NB-IoT capability.

5 Elementary procedures for EPS mobility management

5.1 Overview

5.1.1 General

This clause describes the procedures used for mobility management for EPS services (EMM) at the radio interface (reference point "LTE-Uu").

The main function of the mobility management sublayer is to support the mobility of a user equipment, such as informing the network of its present location and providing user identity confidentiality.

A further function of the mobility management sublayer is to provide connection management services to the session management (SM) sublayer and the short message services (SMS) entity of the connection management (CM) sublayer.

All the EMM procedures described in this clause can only be performed if a NAS signalling connection has been established between the UE and the network. Else, the EMM sublayer has to initiate the establishment of a NAS signalling connection (see 3GPP TS 36.331 [22]).

5.1.2 Types of EMM procedures

Depending on how they can be initiated, three types of EMM procedures can be distinguished:

1) EMM common procedures:

   An EMM common procedure can always be initiated whilst a NAS signalling connection exists. The procedures belonging to this type are:

      Initiated by the network:

- GUTI reallocation;
- authentication;
- security mode control;
- identification;
- EMM information.

2) EMM specific procedures:

At any time only one UE initiated EMM specific procedure can be running. The procedures belonging to this type are:

Initiated by the UE and used to attach the IMSI in the network for EPS services and/or non-EPS services, and to establish an EMM context and if requested by the UE, a default bearer:

- attach and combined attach.

Initiated by the UE and used to attach the IMSI or IMEI for emergency bearer services, and to establish an EMM context and a default bearer to a PDN that provides emergency bearer services:

- attach.

Initiated by the UE or the network and used to detach the IMSI in the network for EPS services and/or non-EPS services and to release an EMM context and all bearers, if any:

- detach and combined detach.

Initiated by the UE and used to detach the IMSI in the network for EPS services or non-EPS services and to release an EMM context and all bearers, if any:

- eCall inactivity procedure.

Initiated by the UE when an EMM context has been established:

- normal tracking area updating and combined tracking area updating (S1 mode only);
- periodic tracking area updating (S1 mode only).

The tracking area updating procedure can be used to request also the resource reservation for sending data.

3) EMM connection management procedures (S1 mode only):

Initiated by the UE and used to establish a secure connection to the network or to request the resource reservation for sending data, or both:

- service request.

The service request procedure can only be initiated if no UE initiated EMM specific procedure is ongoing.

Initiated by the network and used to request the establishment of a NAS signalling connection or to prompt the UE to re-attach if necessary as a result of a network failure:

- paging procedure.

Initiated by the UE or the network and used to transport NAS messages:

- transport of NAS messages;
- generic transport of NAS messages.

The transport of NAS messages procedure and the generic transport of NAS messages procedure cannot be initiated while an EMM specific procedure or a service request procedure is ongoing.

5.1.3 EMM sublayer states

5.1.3.1 General

In the following subclauses, the EMM protocol of the UE and the network is described by means of two different state machines. In subclause 5.1.3.2, the states of the EMM entity in the UE are introduced. The behaviour of the UE depends on an EPS update status that is described in subclause 5.1.3.3. The states for the MME side are described in subclause 5.1.3.4.

5.1.3.2 EMM sublayer states in the UE

5.1.3.2.1 General

In the following subclauses, the possible EMM states of an EMM entity in the UE are described. Subclause 5.1.3.2.2 summarizes the main states of an EMM entity. The substates that have been defined are described in subclause 5.1.3.2.3 and subclause 5.1.3.2.4.

It should be noted, however, that this subclause does not include a description of the detailed behaviour of the UE in the single states and does not cover abnormal cases. A detailed description of the behaviour of the UE is given in subclause 5.2. For the behaviour of the UE in abnormal cases refer to the description of the elementary EMM procedures in subclauses 5.4, 5.5, 5.6 and 5.7.

5.1.3.2.2 Main states

5.1.3.2.2.1 EMM-NULL

EPS services are disabled in the UE. No EPS mobility management function shall be performed in this state.

5.1.3.2.2.2 EMM-DEREGISTERED

In the state EMM-DEREGISTERED, no EMM context has been established and the UE location is unknown to an MME and hence it is unreachable by an MME. In order to establish an EMM context, the UE shall start the attach or combined attach procedure (see subclause 5.5.1).

5.1.3.2.2.3 EMM-REGISTERED-INITIATED

A UE enters the state EMM-REGISTERED-INITIATED after it has started the attach or the combined attach procedure and is waiting for a response from the MME (see subclause 5.5.1).

5.1.3.2.2.4 EMM-REGISTERED

In the state EMM-REGISTERED an EMM context has been established. Additionally a default EPS bearer context has been activated in the UE:

- if EMM-REGISTERED without PDN connection is not supported by the UE or the MME; or
    - if EMM-REGISTERED without PDN connection is supported by the UE and the MME, the UE has requested connectivity to a PDN and a default EPS bearer context is successfully established.

When the UE is in EMM-IDLE mode, the UE location is known to the MME with an accuracy of a list of tracking areas containing a certain number of tracking areas. When the UE is in EMM-CONNECTED mode, the UE location is known to the MME with an accuracy of a serving eNodeB. The UE may initiate sending and receiving user data and signalling information and reply to paging. Additionally, tracking area updating or combined tracking area updating procedure is performed (see subclause 5.5.3).

5.1.3.2.2.5 EMM-DEREGISTERED-INITIATED

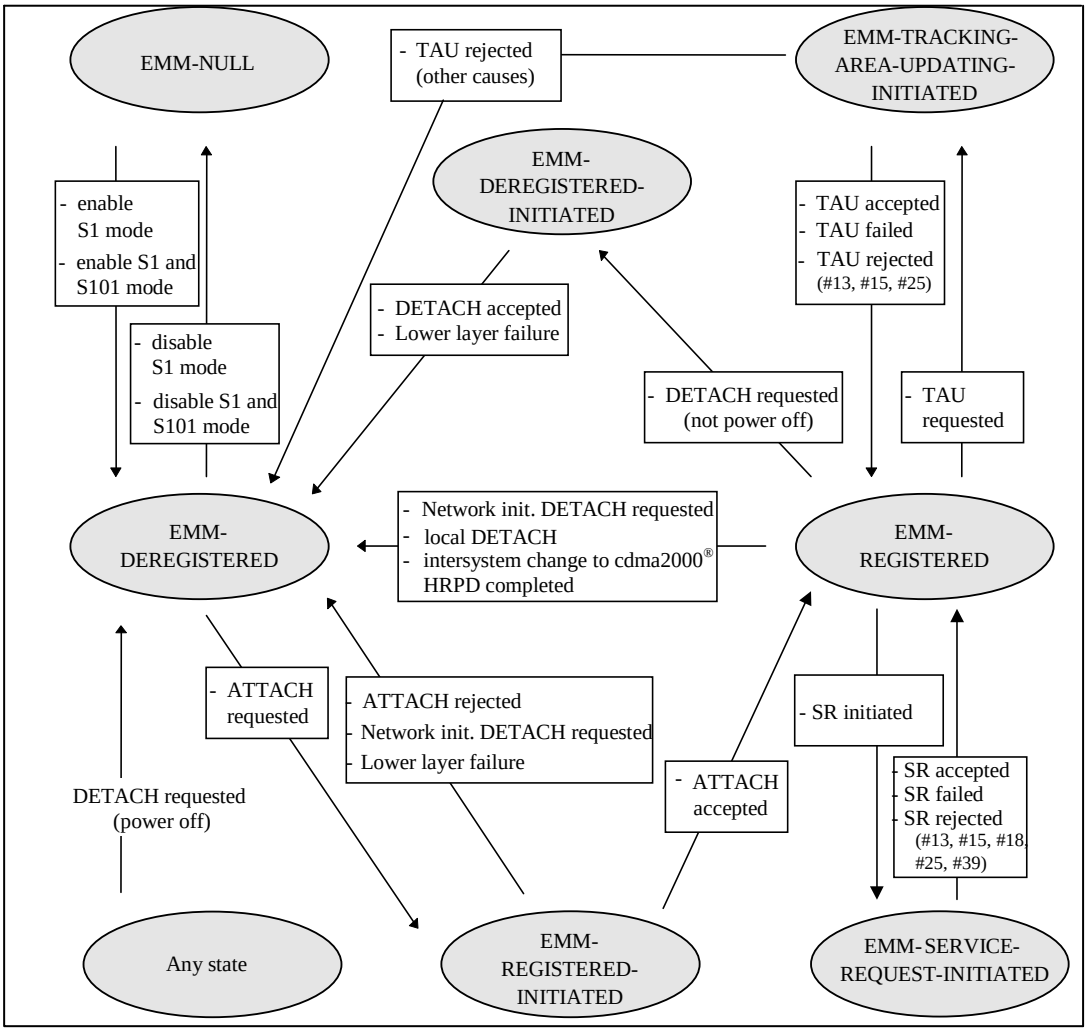
A UE enters the state EMM-DEREGISTERED-INITIATED after it has requested release of the EMM context by starting the detach or combined detach procedure and is waiting for a response from the MME (see subclause 5.5.2).

5.1.3.2.2.6 EMM-TRACKING-AREA-UPDATING-INITIATED

A UE enters the state EMM-TRACKING-AREA-UPDATING-INITIATED after it has started the tracking area updating or combined tracking area updatingprocedure and is waiting for a response from the MME (see subclause 5.5.3).

5.1.3.2.2.7 EMM-SERVICE-REQUEST-INITIATED

A UE enters the state EMM-SERVICE-REQUEST-INITIATED after it has started the service request procedure and is waiting for a response from the MME (see subclause 5.6.1).



NOTE: Not all possible transitions are shown in this figure.

Figure 5.1.3.2.2.7.1: EMM main states in the UE

5.1.3.2.3 Substates of state EMM-DEREGISTERED

5.1.3.2.3.1 General

The state EMM-DEREGISTERED is subdivided into a number of substates as described in this subclause. Valid subscriber data are available for the UE before it enters the substates, except for the substate EMM-DEREGISTERED.NO-IMSI.

5.1.3.2.3.2 EMM-DEREGISTERED.NORMAL-SERVICE

The substate EMM-DEREGISTERED.NORMAL-SERVICE is chosen in the UE when a suitable cell has been found and the PLMN or tracking area is not in the forbidden list.

5.1.3.2.3.3 EMM-DEREGISTERED.LIMITED-SERVICE

The substate EMM-DEREGISTERED.LIMITED-SERVICE is chosen in the UE, when it is known that a selected cell is unable to provide normal service (e.g. the selected cell is in a forbidden PLMN, is in a forbidden tracking area or the selected cell is a CSG cell whose CSG ID and associated PLMN identity are not included in the UE's Allowed CSG list or in the UE's Operator CSG List).

5.1.3.2.3.4 EMM-DEREGISTERED.ATTEMPTING-TO-ATTACH

The substate EMM-DEREGISTERED.ATTEMPTING-TO-ATTACH is chosen in the UE if the attach or combined attach procedure failed due to a missing response from the network or due to the circumstances described in subclauses 5.5.1.2.5, 5.5.1.2.6 and 5.5.1.3.5.

5.1.3.2.3.5 EMM-DEREGISTERED.PLMN-SEARCH

The substate EMM-DEREGISTERED.PLMN-SEARCH is chosen in the UE, if the UE is searching for PLMNs. This substate is left either when a cell has been selected (the new substate is NORMAL-SERVICE or LIMITED-SERVICE) or when it has been concluded that no cell is available at the moment (the new substate is NO-CELL-AVAILABLE).

5.1.3.2.3.6 EMM-DEREGISTERED.NO-IMSI

The substate EMM-DEREGISTERED.NO-IMSI is chosen in the UE, if the UE has no valid subscriber data available (SIM/USIM not available, or the SIM/USIM is considered invalid by the UE) and a cell has been selected.

5.1.3.2.3.7 EMM-DEREGISTERED.ATTACH-NEEDED

Valid subscriber data are available for the UE and for some reason an attach must be performed as soon as possible. This substate can be entered if the access class is blocked due to access class control, or if the network rejects the NAS signalling connection establishment.

5.1.3.2.3.8 EMM-DEREGISTERED.NO-CELL-AVAILABLE

No E-UTRAN cell can be selected. This substate is entered after a first intensive search failed when in substate EMM-DEREGISTERED.PLMN-SEARCH. Cells are searched for at a low rhythm. No EPS services are offered.

5.1.3.2.3.9 EMM-DEREGISTERED.eCALL-INACTIVE

The substate EMM-DEREGISTERED.eCALL-INACTIVE is chosen in the UE when:

- the UE is configured for eCall only mode as specified in 3GPP TS 31.102 [17];
- timer T3444 and timer T3445 have expired or are not running;
- a PLMN has been selected as specified in 3GPP TS 23.122 [6];
- the UE does not need to perform an eCall over IMS; and
- the UE does not need to perform a call to a non-emergency MSISDN or URI for test or terminal reconfiguration service.

In this substate, the UE shall not initiate any signalling towards the network, except to originate an eCall over IMS, or a call to a non-emergency MSISDN or URI for test or terminal reconfiguration service.

5.1.3.2.4 Substates of state EMM-REGISTERED

5.1.3.2.4.1 General

The state EMM-REGISTERED is subdivided into a number of substates as described in this subclause.

5.1.3.2.4.2 EMM-REGISTERED.NORMAL-SERVICE

The substate EMM-REGISTERED.NORMAL-SERVICE is chosen by the UE as the primary substate when the UE enters the state EMM-REGISTERED.

5.1.3.2.4.3 EMM-REGISTERED.ATTEMPTING-TO-UPDATE

The substate EMM-REGISTERED.ATTEMPTING-TO-UPDATE is chosen by the UE if the tracking area updating or combined tracking area updating procedure failed due to a missing response from the network or due to the circumstances described in subclauses 5.5.3.2.5, 5.5.3.2.6, 5.5.3.3.5, 5.6.1.5 and 5.6.1.6. No EMM procedure except the tracking area updating or combined tracking area updating procedure shall be initiated by the UE in this substate. No data shall be sent or received.

5.1.3.2.4.4 EMM-REGISTERED.LIMITED-SERVICE

The substate EMM-REGISTERED.LIMITED-SERVICE is chosen in the UE, if the cell the UE selected is known not to be able to provide normal service.

5.1.3.2.4.5 EMM-REGISTERED.PLMN-SEARCH

The substate EMM-REGISTERED.PLMN-SEARCH is chosen in the UE, while the UE is searching for PLMNs.

5.1.3.2.4.6 EMM-REGISTERED.UPDATE-NEEDED

The UE has to perform a tracking area updating or combined tracking area updating procedure, but access to the current cell is barred. This state can be entered if the access class is blocked due to access class control, or if the network rejects the NAS signalling connection establishment.

No EMM procedure except:

- tracking area updating;
- combined tracking area updating; or
- service request as a response to paging

shall be initiated by the UE in this substate.

5.1.3.2.4.7 EMM-REGISTERED.NO-CELL-AVAILABLE

E-UTRAN coverage has been lost or PSM is active in the UE. If PSM is active, the UE can deactivate PSM at any time by activating the AS layer when the UE needs to send mobile originated signalling or user data. Otherwise, the UE shall not initiate any EMM procedure except for cell and PLMN reselection.

5.1.3.2.4.8 EMM-REGISTERED.ATTEMPTING-TO-UPDATE-MM

A combined attach procedure or a combined tracking area updating procedure was successful for EPS services only. User data and signalling information may be sent and received.

5.1.3.2.4.9 EMM-REGISTERED.IMSI-DETACH-INITIATED

The UE performs a combined detach procedure for non-EPS services only (detach type "IMSI detach"). This substate is entered if the UE is attached for EPS and non-EPS services and wants to detach for non-EPS services only. User data and signalling information may be sent and received.

5.1.3.3 EPS update status

In order to describe the detailed UE behaviour, the EPS update (EU) status pertaining to a specific subscriber is defined.

The EPS update status is stored in a non-volatile memory in the USIM if the corresponding file is present in the USIM, else in the non-volatile memory in the ME, as described in annex C.

The EPS update status value is changed only after the execution of an attach or combined attach, network initiated detach, authentication, tracking area update or combined tracking area update, service request or paging for EPS services using IMSI procedure or due to change in TAI which is not part of TAI list while timer T3346 is running.

EU1: UPDATED

The last attach or tracking area updating attempt was successful.

EU2: NOT UPDATED

The last attach, service request or tracking area updating attempt failed procedurally, e.g. no response or reject message was received from the MME.

EU3: ROAMING NOT ALLOWED

The last attach, service request or tracking area updating attempt was correctly performed, but the answer from the MME was negative (because of roaming or subscription restrictions).

5.1.3.4 EMM sublayer states in the MME

5.1.3.4.1 EMM-DEREGISTERED

In the state EMM-DEREGISTERED, the MME has no EMM context or the EMM Context is marked as detached. The UE is detached. The MME may answer to an attach or a combined attach procedure initiated by the UE (see subclause 5.5.1). The MME may also answer to a tracking area updating procedure or combined tracking area updating procedure initiated by a UE if the EMM context is marked as detached. The MME may also answer to a detach procedure initiated by the UE (see subclause 5.5.1.2.7).

If ISR is not activated or ISR is deactivated during a routing area updating or combined routing area updating procedure or an inter-system handover to A/Gb mode or Iu mode, the MME enters the state EMM-DEREGISTERED after the successful completion of the procedure.

5.1.3.4.2 EMM-COMMON-PROCEDURE-INITIATED

The MME enters the state EMM-COMMON-PROCEDURE-INITIATED, after it has started a common EMM procedure (see subclause 5.4) and is waiting for a response from the UE.

5.1.3.4.3 EMM-REGISTERED

In the state EMM-REGISTERED, an EMM context has been established. Additionally a default EPS bearer context has been activated in the MME:

- if EMM-REGISTERED without PDN connection is not supported by the UE or the MME; or
- if EMM-REGISTERED without PDN connection is supported by the UE and the MME, the UE has requested connectivity to a PDN and a default EPS bearer context is successfully established.

5.1.3.4.4 EMM-DEREGISTERED-INITIATED

The MME enters the state EMM-DEREGISTERED-INITIATED after it has started a detach procedure and is waiting for a response from the UE (see subclause 5.5.2).

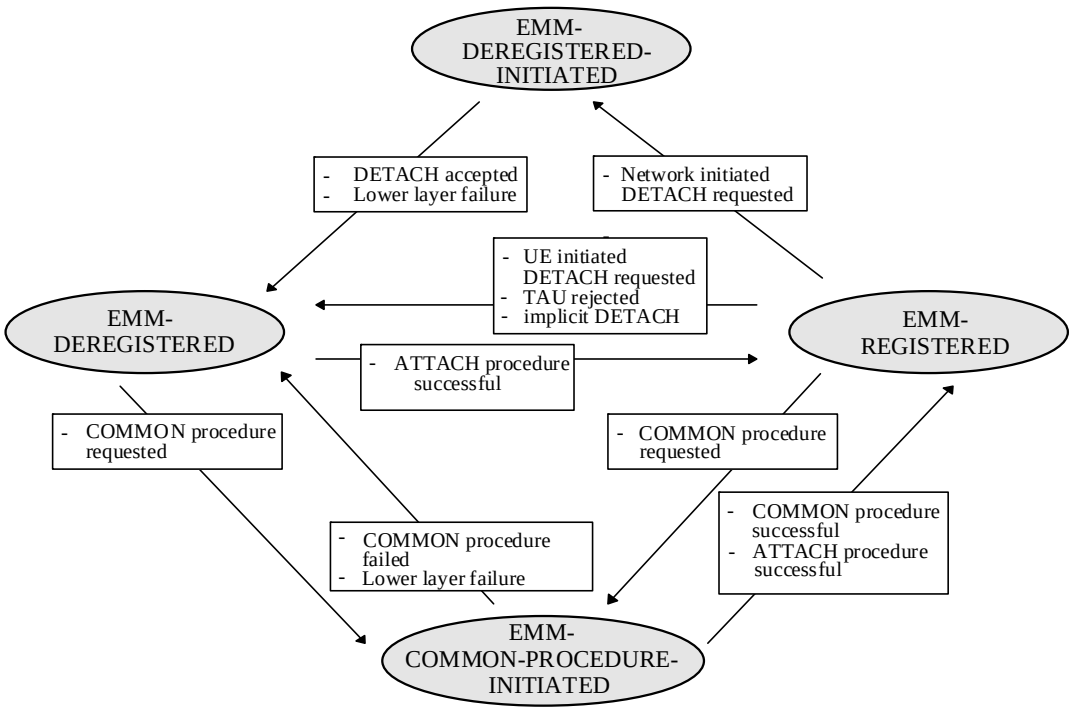


Figure 5.1.3.4.4.1: EMM main states in the MME

5.1.4 Coordination between EMM and GMM

If GMM and EMM are both enabled, a UE capable of S1 mode and A/Gb mode or Iu mode or both shall maintain one common registration for GMM and EMM indicating whether the UE is registered for packet services or not.

A UE that is not registered shall be in state GMM-DEREGISTERED and in state EMM-DEREGISTERED.

If the UE performs a successful attach or combined attach procedure in S1 mode, it shall enter substates GMM-REGISTERED.NO-CELL-AVAILABLE and EMM-REGISTERED.NORMAL-SERVICE. The UE resets the attach attempt counter and the GPRS attach attempt counter (see 3GPP TS 24.008 [13]).

If the UE performs a successful GPRS attach or combined GPRS attach procedure in A/Gb or Iu mode, it shall enter substates GMM-REGISTERED.NORMAL-SERVICE and EMM-REGISTERED.NO-CELL-AVAILABLE. The UE resets the attach attempt counter and the GPRS attach attempt counter (see 3GPP TS 24.008 [13]).

At intersystem change from A/Gb or Iu mode to S1 mode when no PDP context is active, if EMM-REGISTERED without PDN connection is not supported by the UE or the MME, the UE shall move to state EMM-DEREGISTERED and state GMM-DEREGISTERED and then initiate an attach procedure. If EMM-REGISTERED without PDN connection is supported by the UE and the MME, the UE shall enter substates EMM-REGISTERED.NORMAL-SERVICE and GMM-REGISTERED.NO-CELL-AVAILABLE and initiate a tracking area updating procedure.

After successful completion of routing area updating or combined routing area updating and tracking area updating or combined tracking area updating procedures in both S1 mode and A/Gb or Iu mode, if the network has indicated that ISR is activated, the UE shall maintain registration and related periodic update timers in both GMM and EMM.

NOTE: As specified in subclause 5.5.3.2.4 of this document or subclause 4.7.5.1.3 of 3GPP TS 24.008 [13], the UE does not activate the ISR even if the network has indicated that the ISR is activated e.g. in the tracking area updating procedure triggered due to a change in UE network capability. In these scenarios, the UE only maintains one registration and related periodic update timer in GMM or EMM.

5.1.5 Coordination between EMM and MM

UEs that operate in CS/PS mode 1 or CS/PS mode 2 of operation shall use the combined EPS/IMSI attach procedure in order to attach to both EPS and non-EPS services.

UEs that operate in CS/PS mode 1 or CS/PS mode 2 of operation and are already attached to both EPS and non-EPS services shall use the combined tracking area updating and periodic tracking area updating procedures.

UEs that operate in CS/PS mode 1 or CS/PS mode 2 of operation and are already attached to both EPS and non-EPS services shall perform a combined detach procedure in order to detach for non-EPS services.

UEs that operate in CS/PS mode 1 or CS/PS mode 2 of operation should not use any MM timers related to MM specific procedures (e.g. T3210, T3211, T3212, T3213) while camped on E-UTRAN, unless the re-activation of these timers is explicitly described. If the MM timers are already running, the UE should not react on the expiration of the timers.

If the UE is configured for eCall only mode as specified in 3GPP TS 31.102 [17] and moves from GERAN/UTRAN to E-UTRAN, the UE shall:

- if timer T3242 is running, start timer T3444 with the time left on T3242 and stop timer T3242;
- if timer T3243 is running, start timer T3445 with the time left on T3243 and stop timer T3243;
- if the UE is attached for both EPS services and non-EPS services and timer T3242 or timer T3243 is running, perform a combined tracking area updating procedure; and

NOTE 1: A UE configured for eCall only mode as specified in 3GPP TS 31.102 [17] being attached for both EPS services and non-EPS services upon moving from GERAN/UTRAN to E-UTRAN is only possible in the case when the UE has performed a combined attach in E-UTRAN, subsequently moved to GERAN/UTRAN and returned to E-UTRAN before timer T3242 or timer T3243 expires.

- if the UE is attached for non-EPS services only and timer T3242 or timer T3243 is running, perform a combined attach procedure.

NOTE 2: Timers T3242 and T3243 are specified in 3GPP TS 24.008 [13].

5.2 Behaviour of the UE in state EMM-DEREGISTERED and state EMM-REGISTERED

5.2.1 General

In this subclause, the detailed behaviour of the UE in the states EMM-DEREGISTERED and EMM-REGISTERED is described.

5.2.2 UE behaviour in state EMM-DEREGISTERED

5.2.2.1 General

The state EMM-DEREGISTERED is entered in the UE, when:

- the detach or combined detach is performed either by the UE or by the MME (see subclause 5.5.2);
- the attach request is rejected by the MME (see subclause 5.5.1);
- the tracking area update request is rejected by the MME (see subclause 5.5.3);
- the service request procedure is rejected by the MME (see subclause 5.6.1);
- the UE deactivates all EPS bearer contexts locally (see subclause 6.4.4.6);
- the UE is switched on;
- an inter-system change from S1 mode to non-3GPP access is completed and the non-3GPP access network provides PDN connectivity to the same EPC; or
- the UE attached for emergency bearer services is in EMM-IDLE mode and its periodic tracking area update timer expires (see subclause 5.3.5).

In state EMM-DEREGISTERED, the UE shall behave according to the substate as explained in subclause 5.2.2.3.

5.2.2.2 Primary substate selection

5.2.2.2.1 Selection of the substate after power on

For a UE configured for eCall only mode as specified in 3GPP TS 31.102 [17], timers T3444 and T3445 are considered to have expired at power on. When the UE is switched on, the substate shall be PLMN-SEARCH if the USIM is available and valid. See 3GPP TS 23.122 [6] for further details.

The substate chosen after PLMN-SEARCH, following power on is:

- if no cell can be selected, the substate shall be NO-CELL-AVAILABLE;
- if no USIM is present, the substate shall be NO-IMSI;
- if a suitable cell has been found and the PLMN or tracking area is not in the forbidden list, then the substate shall be NORMAL-SERVICE;
- if the selected cell is known not to be able to provide normal service, then the UE shall enter the substate LIMITED-SERVICE;
- if the UE is in manual network selection mode and no cell of the selected PLMN has been found, the UE shall enter the substate NO-CELL-AVAILABLE;
- if the selected cell is a non-3GPP cell, the substate shall be NO-CELL-AVAILABLE; and
- if the UE is configured for eCall only mode as specified in 3GPP TS 31.102 [17], the substate shall be eCALL-INACTIVE.

5.2.2.3 Detailed description of UE behaviour in state EMM-DEREGISTERED

5.2.2.3.1 NORMAL-SERVICE

The UE shall initiate an attach or combined attach procedure.

5.2.2.3.2 LIMITED-SERVICE

The UE shall initiate an attach or combined attach procedure when entering a cell which provides normal service.

The UE may initiate attach for emergency bearer services.

5.2.2.3.3 ATTEMPTING-TO-ATTACH

The UE:

- shall initiate an attach or combined attach procedure on the expiry of timers T3411, T3402 or T3346 (see 3GPP TS 24.008 [13]);
- may initiate an attach for emergency bearer services even if timer T3346 is running;
- shall initiate an attach or combined attach procedure when entering a new PLMN, if timer T3346 is running and the new PLMN is not equivalent to the PLMN where the UE started timer T3346, the PLMN identity of the new cell is not in one of the forbidden PLMN lists and the tracking area is not in one of the lists of forbidden tracking areas;
- shall initiate an attach or combined attach procedure when the tracking area of the serving cell has changed, if timer T3346 is not running, the PLMN identity of the new cell is not in one of the forbidden PLMN lists and the tracking area of the new cell is not in one of the lists of forbidden tracking areas;
- shall use requests for non-EPS services for non-emergency call from CM layers to trigger a combined attach procedure, if timer T3346 is not running (see subclause 5.5.1.3), or to attempt to select GERAN or UTRAN radio access technology and proceed with the appropriate MM and CC specific procedures;
- shall use requests for non-EPS services for emergency call from CM layers to attempt to select GERAN or UTRAN radio access technology and proceed with the appropriate MM and CC specific procedures;
- may initiate an attach procedure upon receiving a request from upper layers to transmit user data related to an exceptional event and the UE is allowed to use exception data reporting (see the ExceptionDataReportingAllowed leaf of the NAS configuration MO in 3GPP TS 24.368 [15A]) if timer T3346 is not already running for "MO exception data" and even if timer T3402 or timer T3411 is running; and
- may initiate an attach procedure upon request of the upper layers to establish a PDN connection for emergency bearer services, if timer T3346 is not running.

5.2.2.3.4 PLMN-SEARCH

The UE shall perform PLMN selection. If a new PLMN is selected, the UE shall reset the attach attempt counter and initiate the attach or combined attach procedure (see subclause 5.5.1).

If the selected cell is known not to be able to provide normal service, the UE may initiate attach for emergency bearer services.

5.2.2.3.5 NO-IMSI

The UE shall perform cell selection according to 3GPP TS 36.304 [21].

The UE may initiate attach for emergency bearer services.

5.2.2.3.6 ATTACH-NEEDED

The UE shall initiate the attach or combined attach procedure, if still needed, as soon as the access is allowed in the selected cell for one of the access classes of the UE.

The UE may initiate attach for emergency bearer services.

5.2.2.3.7 NO-CELL-AVAILABLE

The UE shall perform cell selection according to 3GPP TS 36.304 [21] and choose an appropriate substate when a cell is found. When the lower layers indicate to prepare for an S101 mode to S1 mode handover and the PLMN identity of the target cell provided with this indication is not in one of forbidden PLMN lists, the UE shall enter substate NORMAL-SERVICE.

NOTE: It is assumed that the UE can determine the PLMN identity of networks supporting cdma2000® HRPD access from the information broadcast over the radio interface. For the purpose of S101 mode to S1 mode handover, the UE can use the PLMN identity of the visited cdma2000® HRPD network also as PLMN identity of the target cell.

5.2.2.3.8 eCALL-INACTIVE

The UE camps on a suitable cell or an acceptable cell in a PLMN selected as specified in 3GPP TS 23.122 [6] but initiates no EMM signalling with the network and ignores any paging requests.

The UE shall leave substate EMM-DEREGISTERED.eCALL-INACTIVE state only when one of the following events occur:

- if the USIM is removed, the UE enters substate EMM-DEREGISTERED.NO-IMSI;
- if coverage is lost, the UE enters substate EMM-DEREGISTERED.PLMN-SEARCH;
- if the UE is deactivated (e.g. powered off) by the user, the UE enters state EMM-NULL;
- if the UE receives a request from upper layers to establish an eCall over IMS, the UE enters state EMM-DEREGISTERED.ATTEMPTING-TO-ATTACH. The UE then uses the relevant EMM and ESM procedures to establish the eCall over IMS at the earliest opportunity; or
- if the UE receives a request from upper layers to establish a call to an HPLMN designated non-emergency MSISDN or URI for test or terminal reconfiguration service, the UE enters state EMM-DEREGISTERED.ATTEMPTING-TO-ATTACH. Once the attach procedure is completed, the UE uses the relevant EMM and ESM procedures to establish the non-emergency call.

5.2.2.4 Substate when back to state EMM-DEREGISTERED from another EMM state

When returning to state EMM-DEREGISTERED, the UE shall select a cell as specified in 3GPP TS 36.304 [21].

The substate depends on the result of the cell selection procedure, the outcome of the previously performed EMM specific procedures, on the EPS update status of the UE, on the tracking area data stored in the UE, on the presence of the USIM, on the UE configuration and on the reason for moving to EMM-DEREGISTERED:

- If no cell has been found, the substate is NO-CELL-AVAILABLE, until a cell is found.
- If no USIM is present or if the inserted USIM is considered invalid by the UE, the substate shall be NO-IMSI.
- If a suitable cell has been found and the PLMN or tracking area is not in the forbidden list, the substate shall be NORMAL-SERVICE.
- If an attach shall be performed (e.g. network requested re-attach), the substate shall be ATTEMPTING-TO-ATTACH.
- If a PLMN reselection (according to 3GPP TS 23.122 [6]) is needed, the substate shall be PLMN-SEARCH.
- If the selected cell is known not to be able to provide normal service, the substate shall be LIMITED-SERVICE;
- If the selected cell is a non-3GPP cell, the substate shall be NO-CELL-AVAILABLE; and
- If the UE is configured for eCall only mode as specified in 3GPP TS 31.102 [17], T3444 and T3445 have expired or are not running, and substate PLMN-SEARCH is not required, the substate shall be eCALL-INACTIVE.

5.2.3 UE behaviour in state EMM-REGISTERED

5.2.3.1 General

The state EMM-REGISTERED is entered at the UE, when:

- the attach or combined attach procedure is performed by the UE (see subclause 5.5.1).

In state EMM-REGISTERED, the UE shall behave according to the substate as explained in subclause 5.2.3.2.

5.2.3.2 Detailed description of UE behaviour in state EMM-REGISTERED

5.2.3.2.1 NORMAL-SERVICE

The UE:

- shall initiate normal and combined tracking area updating (according to conditions given in subclause 5.5.3);
- shall perform periodic tracking area updating (see subclause 5.5.3) except when attached for emergency bearer services (see subclause 5.3.5);
- shall respond to paging; and
- if configured for eCall only mode as specified in 3GPP TS 31.102 [17], shall perform the eCall inactivity procedure at expiry of timer T3444 or T3445 (see subclause 5.5.4).

5.2.3.2.2 ATTEMPTING-TO-UPDATE

The UE:

- shall not send any user data;
- shall initiate tracking area updating on the expiry of timers T3411, T3402 or T3346;
- shall initiate tracking area updating when entering a new PLMN, if timer T3346 is running and the new PLMN is not equivalent to the PLMN where the UE started timer T3346, the PLMN identity of the new cell is not in one of the forbidden PLMN lists, and the tracking area is not in one of the lists of forbidden tracking areas;
- shall initiate tracking area updating when the tracking area of the serving cell has changed, if timer T3346 is not running, the PLMN identity of the new cell is not in one of the forbidden PLMN lists and the tracking area is not in one of the lists of forbidden tracking areas;
- may initiate a tracking area updating procedure upon request of the upper layers to establish a PDN connection for emergency bearer services;
- shall initiate tracking area updating procedure upon request of the upper layers to establish a PDN connection without the NAS signalling low priority indication as specified in subclause 5.5.3.2.6, item l), if timer T3346 is running due to a NAS request message (TRACKING AREA UPDATE REQUEST, CONTROL PLANE SERVICE REQUEST or EXTENDED SERVICE REQUEST) which contained the low priority indicator set to "MS is configured for NAS signalling low priority"and timer T3402 and timer T3411 are not running;
- may detach locally and initiate an attach for emergency bearer services even if timer T3346 is running;
- shall use requests for non-EPS services from CM layers to trigger a combined tracking area updating procedure, if timer T3346 is not running (see subclause 5.5.3.3), or to attempt to select GERAN, UTRAN or cdma2000® 1xRTT radio access technology and proceed with the appropriate MM and CC specific procedures;
- may use requests for an MMTEL voice call or MMTEL video call from the upper layers to initiate tracking area updating, if timer T3346 is not running;
- shall initiate tracking area updating in response to paging with S-TMSI or paging with IMSI and domain indicator set to ″CS″;
- shall initiate tracking area updating if the EPS update status is set to EU2 NOT UPDATED, and timers T3411, T3402 and T3346 are not running;

- if configured for eCall only mode as specified in 3GPP TS 31.102 [17], shall perform the eCall inactivity procedure at expiry of timer T3444 or T3445 (see subclause 5.5.4); and

- may initiate tracking area updating upon receiving a request from upper layers to transmit user data related to an exceptional event and the UE is allowed to use exception data reporting (see the ExceptionDataReportingAllowed leaf of the NAS configuration MO in 3GPP TS 24.368 [15A]) if timer T3346 is not already running for "MO exception data" and even if timer T3402 or timer T3411 is running.

5.2.3.2.3 LIMITED-SERVICE

The UE:

- shall perform cell selection/reselection according to 3GPP TS 36.304 [21];

- may respond to paging (with IMSI);

- may initiate attach for emergency bearer services; and

- if configured for eCall only mode as specified in 3GPP TS 31.102 [17], shall perform the eCall inactivity procedure at expiry of timer T3444 or T3445 (see subclause 5.5.4).

5.2.3.2.4 PLMN-SEARCH

The UE may enter this substate when it is in automatic network selection mode and the maximum allowed number of subsequently unsuccessful tracking area updating have been performed. The UE may also enter this substate as a result of a tracking area update rejected by the network (see subclause 5.5.3) or as a result of a service request rejected by the network (see subclause 5.6.1). If a new PLMN is selected, the UE shall reset the tracking area updating attempt counter and initiate the tracking area updating or combined tracking area updating procedure (see subclause 5.5.3).

If the selected cell is known not to be able to provide normal service, the UE may initiate attach for emergency bearer services.

5.2.3.2.5 UPDATE-NEEDED

The UE:

- shall not send any user data;

- shall not send signalling information, unless it is a service request as a response to paging or a tracking area updating or combined tracking area updating procedure upon request by the upper layers to establish a PDN connection for emergency bearer services or upon a request from the upper layers for an MMTEL voice call, MMTEL video call, SMSoIP, SMS over NAS or SMS over S102;

- shall perform cell selection/reselection according to 3GPP TS 36.304 [21];

- shall enter the appropriate new substate depending on the EPS update status as soon as the access is allowed in the selected cell for one of the access classes of the UE; and

- if configured for eCall only mode as specified in 3GPP TS 31.102 [17], shall perform the eCall inactivity procedure at expiry of timer T3444 or T3445 (see subclause 5.5.4).

5.2.3.2.6 NO-CELL-AVAILABLE

The UE shall perform cell selection/reselection according to 3GPP TS 36.304 [21].

5.2.3.2.7 ATTEMPTING-TO-UPDATE-MM

The UE:

- shall perform cell selection/reselection according to 3GPP TS 36.304 [21];

- shall be able to receive and transmit user data and signalling information;

- shall initiate combined tracking area updating procedure indicating "combined TA/LA updating with IMSI attach" on the expiry of timers T3411 or T3402 or when the UE enters a tracking area not in the list of registered tracking areas;

- shall respond to paging with IMSI for the PS domain;
- shall use requests for non-EPS services from CM layers to attempt to select GERAN or UTRAN radio access technology and proceed with the appropriate MM and CC specific procedures, unless T3402 is running due to receipt of an ATTACH ACCEPT or TRACKING AREA UPDATING ACCEPT message with EMM cause #22 "congestion"; and
- if configured for eCall only mode as specified in 3GPP TS 31.102 [17], shall perform the eCall inactivity procedure at expiry of timer T3444 or T3445 (see subclause 5.5.4).

5.2.3.2.8 IMSI-DETACH-INITIATED

The UE:

- shall be able to receive and transmit user data and signalling information;
- shall initiate combined tracking area updating procedure (according to conditions given in subclause 5.5.3.3 or subclause 5.5.2.2.4); and
- if configured for eCall only mode as specified in 3GPP TS 31.102 [17], shall perform the eCall inactivity procedure at expiry of timer T3444 or T3445 (see subclause 5.5.4).

5.3 General on elementary EMM procedures

5.3.1 EMM modes and NAS signalling connection

5.3.1.1 Establishment of the NAS signalling connection

When the UE is in EMM-IDLE mode without suspend indication and needs to transmit an initial NAS message, the UE shall request the lower layer to establish a RRC connection. In this request to the lower layer the NAS shall provide to the lower layer the RRC establishment cause and the call type as specified in annex D of this specification.

Initial NAS messages are:

- ATTACH REQUEST;
- DETACH REQUEST;
- TRACKING AREA UPDATE REQUEST;
- SERVICE REQUEST;
- EXTENDED SERVICE REQUEST; and
- CONTROL PLANE SERVICE REQUEST.

When the UE is in EMM-IDLE mode with suspend indication, the UE shall proceed the behaviour as specified in subclauses 5.3.1.3.

For the routing of the initial NAS message to the appropriate MME, the UE NAS provides the lower layers with either the S-TMSI or the registered globally unique MME identifier (GUMMEI) that consists of the PLMN ID, the MME group ID, and the MME code (see 3GPP TS 23.003 [2]) according to the following rules:

- If the TIN indicates "GUTI" or "RAT-related TMSI", or the TIN is not available, and the UE holds a valid GUTI:

  a) When the UE in EMM-IDLE mode initiates a tracking area updating or combined tracking area updating procedure for load balancing purposes, the UE NAS shall provide the lower layers with neither S-TMSI nor registered MME identifier;

  b) When the tracking area of the current cell is in the list of tracking areas that the UE previously registered in the MME during the NAS signalling connection establishment, the UE NAS shall provide the lower layers with the S-TMSI, but shall not provide the registered MME identifier to the lower layers; or

c) When the tracking area of the current cell is not in the list of tracking areas that the UE previously registered in the MME during the NAS signalling connection establishment, the UE NAS shall provide the lower layers with the MME identifier part of the valid GUTI with an indication that the identifier is a native GUMMEI.

- If the TIN indicates "P-TMSI" and the UE holds a valid P-TMSI and RAI, the UE NAS shall provide the lower layers with the MME identifier part of the mapped GUTI, which is generated from the P-TMSI and RAI with an indication that the identifier is a mapped GUMMEI.

The UE NAS also provides the lower layers with the identity of the selected PLMN (see 3GPP TS 36.331 [22]). In a shared network, the UE shall choose one of the PLMN identities as specified in 3GPP TS 23.122 [6].

When an ATTACH REQUEST message, or a TRACKING AREA UPDATE REQUEST message when the TAI of the current cell is not included in the TAI list, is sent to establish a signalling connection, the UE NAS also provides the lower layers with the DCN-ID according to the following rules:

a) if a DCN-ID for the PLMN code of the selected PLMN is available in the UE, the UE NAS shall provide this DCN-ID to the lower layers; or

b) if no DCN-ID for the PLMN code of the selected PLMN is available but a Default_DCN_ID value is avaialble in the UE, as specified in 3GPP TS 24.368 [15A] or in USIM file NAS_{CONFIG} as specified in 3GPP TS 31.102 [17], the UE NAS shall provide this DCN-ID to the lower layers.

If a relay node is attaching for relay node operation (see 3GPP TS 23.401 [10]), the NAS in the relay node shall indicate to the lower layers that the establishment of the NAS signalling connection is for a relay node.

In S1 mode, when the RRC connection has been established successfully, the UE shall enter EMM-CONNECTED mode and consider the NAS signalling connection established.

In S101 mode, when the cdma2000® HRPD access network resources are available for tunnelled NAS signalling, the UE shall enter EMM-CONNECTED mode and consider the S101 mode NAS signalling connection established.

5.3.1.2 Release of the NAS signalling connection

5.3.1.2.1 General

The signalling procedure for the release of the NAS signalling connection is initiated by the network.

In S1 mode, when the RRC connection has been released, the UE shall enter EMM-IDLE mode and consider the NAS signalling connection released.

If the UE is configured for eCall only mode as specified in 3GPP TS 31.102 [17] then:

- if the NAS signalling connection that was released had been established for eCall over IMS, the UE shall start timer T3444; and

- if the NAS signalling connection that was released had been established for a call to an HPLMN designated non-emergency MSISDN or URI for test or terminal reconfiguration service, the UE shall start timer T3445.

The UE shall start the SGC timer T3447 with the service gap time value available in the UE when the NAS signalling connection is released if:

- the UE supports SGC feature, and the service gap timer value is available in the UE and does not indicate zero; and

- the NAS signalling connection that was released had been established for mobile originated request for transfer of uplink data.

If the UE receives the "Extended wait time" from the lower layers when no attach, tracking area updating or service request procedure is ongoing, the UE shall ignore the "Extended wait time".

To allow the network to release the NAS signalling connection, the UE:

a) shall start the timer T3440 if the UE receives any of the EMM cause values #11, #12, #13, #14 (not applicable to the service request procedure), #15, #25 or #35;

b) shall start the timer T3440 if:

- the UE receives a TRACKING AREA UPDATE ACCEPT message;
- the UE has not set the "active" flag in the TRACKING AREA UPDATE REQUEST message;
- the UE has not set the "signalling active" flag in the TRACKING AREA UPDATE REQUEST message;
- the tracking area updating or combined tracking area updating procedure has been initiated in EMM-IDLE mode; and
- the user plane radio bearers have not been set up;

c) shall start the timer T3440 if the UE receives a DETACH ACCEPT message and the UE has set the detach type to "IMSI detach" in the DETACH REQUEST message and user plane radio bearers have not been set up;

d) shall start the timer T3440 if the UE receives a TRACKING AREA UPDATE REJECT message indicating:

- any of the EMM cause values #9 or #10 and the UE has no CS fallback emergency call, CS fallback call, 1xCS fallback emergency call, or 1xCS fallback call pending; or
- the EMM cause values #40, the TRACKING AREA UPDATE message was not triggered due to receiving a paging for CS fallback or a paging for 1xCS fallback, and the UE has no CS fallback emergency call, CS fallback call, 1xCS fallback emergency call, or 1xCS fallback call pending;

e) shall start the timer T3440 if the UE receives a SERVICE REJECT message indicating any of the EMM cause values #9, #10 or #40 as a response to a SERVICE REQUEST message CONTROL PLANE SERVICE REQUEST message, or an EXTENDED SERVICE REQUEST message with service type set to "packet services via S1";

f) may start the timer T3440 if the UE receives any of the EMM cause values #7 or #8; or

g) shall start the timer T3440 if the UE receives a SERVICE REJECT message indicating the EMM cause value #39 and the UE has initiated EXTENDED SERVICE REQUEST in EMM-IDLE and the user plane radio bearers have not been set up.

h) shall start the timer T3440 if the UE receives a SERVICE REJECT, SERVICE ACCEPT, ATTACH ACCEPT or TRACKING AREA UPDATE ACCEPT message with control plane data back-off timer.

Upon expiry of T3440,

- in cases a, b, c, f and h, the UE shall locally release the established NAS signalling connection; or
- in cases d and e, the UE shall locally release the established NAS signalling connection and the UE shall initiate the attach procedure as described in subclause 5.5.3.2.5, 5.5.3.3.5 or 5.6.1.5.

In cases b, c and g,

- upon an indication from the lower layers that the user plane radio bearers are set up, the UE shall stop timer T3440 and may send uplink signalling via the existing NAS signalling connection or user data via the user plane bearers. If the uplink signalling is for CS fallback for emergency call, or for establishing a PDN connection for emergency bearer services, the UE shall send the uplink signalling via the existing NAS signalling connection; or
- upon receipt of a DETACH REQUEST message, the UE shall stop timer T3440 and respond to the network initiated detach as specified in subclause 5.5.2.3.

In case b,

- upon receiving a request from upper layers to send NAS signalling not associated with establishing either a CS emergency call or a PDN connection for emergency bearer services, the UE shall wait for the the local release of the established NAS signalling connection upon expiry of timer T3440 or T3440 being stopped before proceeding;
- upon receiving a request from upper layers to establish either a CS emergency call or a PDN connection for emergency bearer services, the UE shall stop timer T3440 and shall locally release the NAS signalling connection, before proceeding as specified in subclause 5.6.1;

- upon receipt of ESM DATA TRANSPORT message, as an implementation option, the UE may reset and restart timer T3440;

- upon receipt of a DOWNLINK NAS TRANSPORT or DOWNLINK GENERIC NAS TRANSPORT message, the UE which is in EMM-REGISTERED without PDN connections shall stop timer T3440 and may send uplink signalling via the existing NAS signalling connection; or

- upon receipt of an ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST, MODIFY EPS BEARER CONTEXT REQUEST, DEACTIVATE EPS BEARER CONTEXT REQUEST, DOWNLINK NAS TRANSPORT or DOWNLINK GENERIC NAS TRANSPORT message, if the UE is using control plane CIoT EPS optimization, the UE shall stop timer T3440 and may send uplink signalling via the existing NAS signalling connection.

In case c,

- upon receiving a request from upper layers to send NAS signalling not associated with establishing a PDN connection for emergency bearer services, the UE shall wait for the the local release of the established NAS signalling connection upon expiry of timer T3440 or T3440 being stopped before proceeding; or

- upon receiving a request from upper layers to establish a PDN connection for emergency bearer services, the UE shall stop timer T3440 and shall locally release the NAS signalling connection, before proceeding as specified in subclause 5.6.1.

In cases d and e,

- upon an indication from the lower layers that the RRC connection has been released, the UE shall stop timer T3440 and perform a new attach procedure as specified in subclause 5.5.3.2.5, 5.5.3.3.5 or 5.6.1.5; or

- upon receiving a request from upper layers to establish a PDN connection for emergency bearer services, the UE shall stop timer T3440 and shall locally release the NAS signalling connection, before proceeding as specified in subclause 5.5.1.

In cases a and f,

- upon receiving a request from upper layers to establish a PDN connection for emergency bearer services, the UE shall stop timer T3440 and shall locally release the NAS signalling connection, before proceeding as specified in subclause 5.5.1.

In case g,

- upon receiving a request from upper layers to send NAS signalling not associated with establishing either a CS emergency call or a PDN connection for emergency bearer services, the UE shall wait for the the local release of the established NAS signalling connection upon expiry of timer T3440 or T3440 being stopped before proceeding; or

- upon receiving a request from upper layers to establish either a CS emergency call or a PDN connection for emergency bearer services, the UE shall stop timer T3440 and shall locally release the NAS signalling connection, before proceeding as specified in subclause 5.6.1.

In case h,

- upon an indication from the lower layers that the user plane radio bearers are set up or upon receiving a request from upper layers to send NAS signalling not associated with ESM DATA TRANSPORT, the UE shall stop timer T3440; or

- the UE shall not send ESM DATA TRANSPORT message until expiry of timer T3440 or times T3440 being stopped.

In EMM-CONNECTED mode, if the UE moves to EMM-SERVICE-REQUEST-INITIATED state upon receipt of a CS SERVICE NOTIFICATION message, the UE shall stop timer T3440.

In S101 mode, when the cdma2000® HRPD radio access connection has been released, the UE shall enter EMM-IDLE mode and consider the S101 mode NAS signalling connection released.

5.3.1.2.2 UE is using EPS services with control plane CIoT EPS optimization

Upon receipt of the indication from the ESM layer to release the NAS signalling connection (see subclause 6.6.4.2), unless the MME has additional downlink user data or signalling pending, the MME shall initiate release of the NAS signalling connection.

5.3.1.3 Suspend and resume of the NAS signalling connection

Suspend of the NAS signalling connection can be initiated by the network in EMM-CONNECTED mode when user plane CIoT EPS optimization is used. Resume of the suspended NAS signalling connection is initiated by the UE.

In the UE, when user plane CIoT EPS optimization is used:

- Upon indication from the lower layers that the RRC connection has been suspended, the UE shall enter EMM-IDLE mode with suspend indication, shall not consider the NAS signalling connection released and shall not consider the secure exchange of NAS messages terminated (see subclause 4.4.2.3 and 4.4.5). Based on further indications provided by the lower layers, the UE shall update the status of the suspend indication for the EMM-IDLE mode;

- Upon trigger of a procedure using an initial NAS message when in EMM-IDLE mode with suspend indication, the UE shall request the lower layer to resume the RRC connection. In this request to the lower layer the NAS shall provide to the lower layer the RRC establishment cause and the call type according to annex D of this document;

NOTE 1: In NB-S1 mode, in the request to the lower layer the data volume information of the initial NAS message is provided to the lower layers. Interactions between the NAS and the lower layers in order to obtain the data volume information of the initial NAS message (see 3GPP TS 36.321 [49], 3GPP TS 36.331 [22]) is left to implementations.

- Upon indication from the lower layers that the RRC connection has been resumed when in EMM-IDLE mode with suspend indication, the UE shall enter EMM-CONNECTED mode. If the pending NAS message is:

  i) a SERVICE REQUEST message;

  ii) a CONTROL PLANE SERVICE REQUEST message, and the UE did not include any ESM message container, NAS message container or EPS bearer context status information elements; or

  iii) an EXTENDED SERVICE REQUEST message, and the Service type information element indicates "packet services via S1" and the UE did not include any EPS bearer context status information element,

  the message shall not be sent. Otherwise the UE shall cipher the message as specified in subclause 4.4.5 and send the pending initial NAS message upon entering EMM-CONNECTED mode;

NOTE 2: If a NAS message is discarded and not sent to the network, the uplink NAS COUNT value corresponding to that message is reused for the next uplink NAS message to be sent.

- Upon indication from the lower layers that the RRC connection resume has been fallbacked when in EMM-IDLE mode with suspend indication, the UE shall enter EMM-IDLE mode without suspend indication, send any pending initial NAS message and proceed as if RRC connection establishment had been requested;

- Upon indication from the lower layers that the RRC connection resume has failed and indication from the lower layers that the RRC connection is suspended, the UE shall enter EMM-IDLE mode with suspend indication and restart the ongoing NAS procedure if required; and

- Upon indication from the lower layers that the RRC connection resume has failed and indication from the lower layers that the RRC connection is not suspended, the UE shall enter EMM-IDLE mode without suspend indication and restart the ongoing NAS procedure if required.

In the network, when user plane CIoT EPS optimization is used:

- Upon indication from the lower layers that the RRC connection has been suspended, the network shall enter EMM-IDLE mode with suspend indication, shall not consider the NAS signalling connection released and shall not consider the secure exchange of NAS messages terminated; and

- Upon indication from the lower layers that the RRC connection has been resumed when in EMM-IDLE mode with suspend indication, the network shall enter EMM-CONNECTED mode.

For the case that not all suspended bearers are resumed, see subclause 6.4.4.6.

5.3.2 Lists of forbidden tracking areas

The UE shall store a list of "forbidden tracking areas for roaming", as well as a list of "forbidden tracking areas for regional provision of service". These lists shall be erased when the UE is switched off or when the UICC containing the USIM is removed, and periodically (with a period in the range 12 to 24 hours). When the lists are erased, the UE performs cell selection according to 3GPP TS 36.304 [21]. One or more tracking areas is removed from the list of "forbidden tracking areas for roaming" in the UE, as well as the list of "forbidden tracking areas for regional provision of service" if, after a subsequent procedure e.g. attach procedure, tracking area updating procedure and GUTI reallocation procedure, one or more tracking areas in the lists is received from the network. If the UE has only one PDN connection established which is for emergency bearer services, the tracking areas shall not be removed from these lists if one or more tracking areas in the lists are received from the network.

In S1 mode, the UE shall update the suitable list whenever an ATTACH REJECT, TRACKING AREA UPDATE REJECT, SERVICE REJECT or DETACH REQUEST message is received with the EMM cause #12 "tracking area not allowed", #13 "roaming not allowed in this tracking area", or #15 "no suitable cells in tracking area".

Each list shall accommodate 40 or more TAIs. When the list is full and a new entry has to be inserted, the oldest entry shall be deleted.

5.3.3 List of forbidden PLMNs for attach in S101 mode

A UE supporting S101 mode shall store a list of "forbidden PLMNs for attach in S101 mode". The UE shall erase this list when the UE is switched off or when the USIM is removed.

In S101 mode, the UE shall add to the "forbidden PLMNs for attach in S101 mode" list the PLMN identity provided with the indication from the lower layers to prepare for an S101 mode to S1 mode handover whenever an ATTACH REJECT message is received with the EMM cause #11 "PLMN not allowed", #12 "tracking area not allowed", #13 "roaming not allowed in this tracking area", #14 "EPS services not allowed in this PLMN", #15 "no suitable cells in tracking area", or #35 "Requested service option not authorized in this PLMN" as specified in subclause 5.5.1.2.5.

The maximum number of possible entries in the "forbidden PLMNs for attach in S101 mode" list is implementation dependent, but the list shall accommodate at least one PLMN identity. When the list is full and a new PLMN identity has to be inserted, the UE shall delete the oldest PLMN identity.

5.3.3a Forbidden PLMNs for EPS services

The forbidden PLMNs for EPS services are contained in the "forbidden PLMNs for GPRS service" list, as defined in 3GPP TS 24.008 [13]. The UE updates this list as part of the attach procedure, tracking area updating procedure and network initiated detach procedure as described respectively in subclauses 5.5.1, 5.5.3 and 5.5.2.3.2.

5.3.4 Equivalent PLMNs list

The UE shall store a list of equivalent PLMNs. These PLMNs shall be regarded by the UE as equivalent to each other for PLMN selection and cell selection/re-selection. The same list is used by EMM, GMM and MM.

The UE shall update or delete this list at the end of each attach or combined attach or tracking area updating or combined tracking area updating procedure. The stored list consists of a list of equivalent PLMNs as downloaded by the network plus the PLMN code of the registered PLMN that downloaded the list. When the UE is switched off, it shall keep the stored list so that it can be used for PLMN selection after switch on. The UE shall delete the stored list if the USIM is removed or when the UE attached for emergency bearer services enters the state EMM-DEREGISTERED. The maximum number of possible entries in the stored list is 16.

5.3.5 Handling of the periodic tracking area update timer and mobile reachable timer (S1 mode only)

The periodic tracking area updating procedure is used to periodically notify the availability of the UE to the network. The procedure is controlled in the UE by timer T3412. The value of timer T3412 is sent by the network to the UE in the

ATTACH ACCEPT message and can be sent in the TRACKING AREA UPDATE ACCEPT message. The UE shall apply this value in all tracking areas of the list of tracking areas assigned to the UE until a new value is received.

If timer T3412 received by the UE in an ATTACH ACCEPT or TRACKING AREA UPDATE ACCEPT message contains an indication that the timer is deactivated or the timer value is zero, then timer T3412 is deactivated and the UE shall not perform the periodic tracking area updating procedure.

Timer T3412 is reset and started with its initial value, when the UE changes from EMM-CONNECTED to EMM-IDLE mode. Timer T3412 is stopped when the UE enters EMM-CONNECTED mode or the EMM-DEREGISTERED state.

If the UE is attached for emergency bearer services, and timer T3412 expires, the UE shall not initiate a periodic tracking area updating procedure, but shall locally detach from the network. When the UE is camping on a suitable cell, it may re-attach to regain normal service.

When a UE is not attached for emergency bearer services, and timer T3412 expires, the periodic tracking area updating procedure shall be started and the timer shall be set to its initial value for the next start.

If the UE is not attached for emergency bearer services, and is in a state other than EMM-REGISTERED.NORMAL-SERVICE when timer T3412 expires, the periodic tracking area updating procedure is delayed until the UE returns to EMM-REGISTERED.NORMAL-SERVICE.

If ISR is activated, the UE shall keep both timer T3412 and timer T3312. The two separate timers run in the UE for updating MME and SGSN independently. The UE shall start timer T3423, if timer T3412 expires, and timer T3346 is running or the UE is in one of the following states:

- EMM-REGISTERED.NO-CELL-AVAILABLE;
- EMM-REGISTERED.PLMN-SEARCH;
- EMM-REGISTERED.UPDATE-NEEDED; or
- EMM-REGISTERED.LIMITED-SERVICE.

The UE shall initiate the tracking area updating procedure and stop timer T3423 when it enters state EMM-REGISTERED.NORMAL-SERVICE before timer T3423 expires. After expiry of timer T3423 the UE shall set its TIN to "P-TMSI".

If timer T3423 expires the UE shall memorize that it has to initiate a tracking area updating procedure when it returns to state EMM-REGISTERED.NORMAL-SERVICE.

If the UE is attached to both EPS and non-EPS services, and if timer T3412 expires or timer T3423 expires when the UE is in EMM-REGISTERED.NO-CELL-AVAILABLE state, then the UE shall initiate the combined tracking area updating procedure indicating "combined TA/LA updating with IMSI attach" when the UE returns to EMM-REGISTERED.NORMAL-SERVICE state.

When the network includes T3412 extended value IE in the ATTACH ACCEPT message or TRACKING AREA UPDATE ACCEPT message, the network uses timer T3412 extended value IE as the value of timer T3412.

The network supervises the periodic tracking area updating procedure of the UE by means of the mobile reachable timer.

If the UE is not attached for emergency bearer services, the mobile reachable timer shall be longer than T3412. In this case, by default, the mobile reachable timer is 4 minutes greater than timer T3412.

If ISR is not activated, the network behaviour upon expiry of the mobile reachable timer is network dependent, but typically the network stops sending paging messages to the UE on the first expiry, and may take other appropriate actions.

If the UE is attached for emergency bearer services, the MME shall set the mobile reachable timer with a value equal to timer T3412. When the mobile reachable timer expires, the MME shall locally detach the UE.

The mobile reachable timer shall be reset and started with the value as indicated above, when the MME releases the NAS signalling connection for the UE. The mobile reachable timer shall be stopped when a NAS signalling connection is established for the UE.

Upon expiry of the mobile reachable timer the network shall start the implicit detach timer. The value of the implicit detach timer is network dependent. If ISR is activated, the default value of the implicit detach timer is 4 minutes greater than timer T3423. If the implicit detach timer expires before the UE contacts the network, the network shall implicitly detach the UE. If the MME includes timer T3346 in the TRACKING AREA UPDATE REJECT message or the SERVICE REJECT message and timer T3346 is greater than timer T3412, the MME sets the mobile reachable timer and the implicit detach timer such that the sum of the timer values is greater than timer T3346.

If the network includes the T3324 value IE in the ATTACH ACCEPT message or TRACKING AREA UPDATE ACCEPT message,and if the UE is not attached for emergency bearer services and has no PDN connection for emergency bearer services the MME shall set the active timer to a value equal to the value of timer T3324.

NOTE 1: Timer T3324 is specified in 3GPP TS 24.008 [13].

If the UE has established a PDN connection for emergency services after receiving the timer T3324 value IE in the ATTACH ACCEPT message or the last TRACKING AREA UPDATE ACCEPT message, the active timer shall not be started.

The active timer shall be reset and started with the value as indicated above, when the MME releases the NAS signalling connection for the UE. The active timer shall be stopped when an NAS signalling connection is established for the UE.

The network behaviour upon expiry of the active timer is network dependent, but typically the network stops sending paging messages to the UE on the first expiry, and may take other appropriate actions.

NOTE 2: ISR is not activated when the network includes the T3324 value IE in the ATTACH ACCEPT message or TRACKING AREA UPDATE ACCEPT message.

The implicit detach timer shall be stopped when a NAS signalling connection is established for the UE.

5.3.6 Handling of timer T3402

The value of timer T3402 can be sent by the network to the UE in the ATTACH ACCEPT message and TRACKING AREA UPDATE ACCEPT message. If the value is different from "deactivated", the UE shall apply this value in all tracking areas of the list of tracking areas assigned to the UE, until a new value is received.

The value of timer T3402 can be sent by the network to the UE in the ATTACH REJECT message. If an ATTACH REJECT message including timer T3402 value different from "deactivated", was received integrity protected, the UE shall apply this value until a new value is received with integrity protection or a new PLMN is selected. Otherwise, the default value of this timer is used.

The default value of this timer is also used by the UE in the following cases:

- ATTACH ACCEPT message or TRACKING AREA UPDATE ACCEPT message is received without a value specified;
- the UE does not have a stored value for this timer;
- a new PLMN which is not in the list of equivalent PLMNs has been entered, the tracking area updating fails and the tracking area updating attempt counter is equal to 5; or
- a new PLMN which is not in the list of equivalent PLMNs has been entered, the attach procedure fails, the attach attempt counter is equal to 5 and no ATTACH REJECT message was received from the new PLMN.

5.3.7 Handling of the Local Emergency Numbers List and the Extended Local Emergency Numbers List

The Local Emergency Numbers List and the Extended Local Emergency Numbers list contain additional local emergency numbers used by the serving network. These lists can be downloaded by the network to the UE at successful registration and subsequent registration updates. There is only one Local Emergency Numbers List and only one Extended Local Emergency Numbers list in the UE. The Local Emergency Numbers List can be updated with EMM procedures if the UE is in S1 mode, with GMM and MM procedures if the UE is in A/Gb or Iu mode, and with 5GMM procedures, as specified in 3GPP TS 24.501 [cc], if UE is in N1 mode. The Extended Local Emergency Numbers List can be updated with EMM procedures if the UE is in S1 mode and with 5GMM procedures, as specified in 3GPP TS 24.501 [cc], if UE is in N1 mode.

The UE shall use the stored Local Emergency Numbers List and the stored Extended Local Emergency Numbers List received from the network in addition to the emergency numbers stored on the USIM or user equipment to detect that the number dialled is an emergency number.

If the UE determines that the number dialled is an emergency number, the procedures specified in 3GPP TS 23.167 [45] and 3GPP TS 24.229 [13D] are utilised to select a domain for the emergency session attempt.

If the domain selected for the emergency session attempt is the PS domain, then the UE shall perform the session establishment procedures specified in 3GPP TS 24.229 [13D] to initiate an emergency session.

If the domain selected for the emergency session attempt is the CS domain, then the UE shall use the stored Local Emergency Numbers List, in addition to the emergency numbers stored on the USIM and the ME, to determine if the call control procedures specified in 3GPP TS 24.008 [13] is to initiate an emergency call or not.

NOTE 1: The checking of whether the dialled number is an emergency number and the determination of whether an emergency call is to be initiated in the CS domain, can end once a match is found. The Extended Local Emergency Numbers List does not apply when the CS domain is selected.

NOTE 2: The user equipment can use the emergency numbers in each of the stored lists to assist the end user in determining whether the dialled number is intended for an emergency service or for another destination, e.g. a local directory service. The possible interactions with the end user are implementation specific.

NOTE 3: A UE that supports procedures specified in 3GPP TS 24.302 [48], can get additional local emergency numbers through those procedures, which can be used based on operator policy, see 3GPP TS 24.302 [48].

The network may send a Local Emergency Numbers List or an Extended Local Emergency Numbers List or both, in the ATTACH ACCEPT or in the TRACKING AREA UPDATE ACCEPT messages, by including the Emergency number list IE and the Extended emergency number list IE, respectively. The user equipment shall store the Local Emergency Numbers List and the Extended Local Emergency Numbers List, as provided by the network. The Local Emergency Numbers List stored in the user equipment shall be replaced on each receipt of the Emergency number list IE. The Extended Local Emergency Numbers List stored in the user equipment shall be replaced on each receipt of the Extended emergency number list IE.

Editor's note: It is FFS if the Extended Local Emergency Numbers List is deleted if upon a registration update the PLMN provide only the Emergency number list IE.

The emergency number(s) received in the Emergency number list IE and the Extended emergency number list IE are valid only in networks in the same country as the cell on which this IE is received. If no Local Emergency Numbers List or ExtendedLocal Emergency Numbers List is contained in the ATTACH ACCEPT or in the TRACKING AREA UPDATE ACCEPT message, then the stored Local Emergency Numbers List or the Extended Local Emergency Numbers List, respectively, in the user equipment shall be kept, except if the user equipment has successfully registered to a PLMN in a country different from that of the PLMN that sent the list.

The Local Emergency Numbers List and the Extended Local Emergency Numbers List shall be deleted at switch off and removal of the USIM. The user equipment shall be able to store up to ten entries in the Local Emergency Numbers List and up to twenty entries in the Extended Local Emergency Numbers List, received from the network.

5.3.7a Specific requirements for UE configured to use timer T3245

The following requirement applies for an UE that is configured to use timer T3245 (see 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17]):

When the UE adds a PLMN identity to the "forbidden PLMN list", the "forbidden PLMNs for attach in S101 mode" list, or the "forbidden PLMNs for GPRS service" list or sets the USIM as invalid for non-EPS services or EPS services or both, and timer T3245 (see 3GPP TS 24.008 [13]) is not running, the UE shall start timer T3245 as specified in 3GPP TS 24.008 [13], subclause 4.1.1.6.

Upon expiry of the timer T3245, the UE shall erase the "forbidden PLMN list", the "forbidden PLMNs for GPRS service" list, and the "forbidden PLMNs for attach in S101 mode" list and set the USIM to valid for non-EPS and EPS services. When the lists are erased, the UE performs cell selection according to 3GPP TS 36.304 [21].

If the UE is switched off when the timer T3245 is running, the UE shall behave as follows when the UE is switched on and the USIM in the UE remains the same:

- let t1 be the time remaining for T3245 timeout at switch off and let t be the time elapsed between switch off and switch on. If t1 is greater than t, then the timer shall be restarted with the value t1 – t. If t1 is equal to or less than t, then the UE will follow the behaviour as defined in the paragraph above upon expiry of the timer T3245. If the UE is not capable of determining t, then the UE shall restart the timer with the value t1.

5.3.7b Specific requirements for UE when receiving non-integrity protected reject messages

This subclause specifies the requirements for a UE that is not configured to use timer T3245 (see 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17]) and receives an ATTACH REJECT, TRACKING AREA UPDATE REJECT or SERVICE REJECT message without integrity protection with specific EMM causes.

NOTE 1: Additional UE requirements for this case, requirements for other EMM causes, and requirements for the case when the UE receives an integrity protected reject message are specified in subclauses 5.5.1, 5.5.3 and 5.6.1.

The UE may maintain a list of PLMN-specific attempt counters and a list of PLMN-specific PS-attempt counters (see 3GPP TS 24.008 [13]). The maximum number of possible entries in each list is implementation dependent.

Additionally, the UE may maintain one counter for "SIM/USIM considered invalid for non-GPRS services" events and one counter for "SIM/USIM considered invalid for GPRS services" events (see 3GPP TS 24.008 [13]).

If the UE receives an ATTACH REJECT, TRACKING AREA UPDATE REJECT or SERVICE REJECT message without integrity protection with EMM cause value #3, #6, #7, #8, #11, #12, #13, #14, #15 or #35 before the network has established secure exchange of NAS messages for the NAS signalling connection, the UE shall start timer T3247 (see 3GPP TS 24.008 [13]) with a random value uniformly drawn from the range between 30 minutes and 60 minutes, if the timer is not running, and take the following actions:

1) if the EMM cause value received is #3, #6, #7 or #8, and

   a) if the UE maintains a counter for "SIM/USIM considered invalid for GPRS services" events and the counter has a value less than a UE implementation-specific maximum value, the UE shall:

      i) set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and eKSI;

      - delete the list of equivalent PLMNs;

      - increment the counter for "SIM/USIM considered invalid for GPRS services" events;

      - if the EMM cause value received is #3, #6 or #8, and if the UE maintains a counter for "SIM/USIM considered invalid for non-GPRS services" and the counter has a value less than a UE implementation-specific maximum value, increment the counter;

      - if an attach or tracking area updating procedure was performed, reset the attach attempt counter or the tracking area updating attempt counter, respectively;

      - if A/Gb mode or Iu mode is supported by the UE, handle the GMM parameters GPRS attach attempt counter or routing area updating attempt counter, GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI, GPRS ciphering key sequence number as specified in 3GPP TS 24.008 [13] for the case when the GPRS attach or routing area updating procedure is rejected with the GMM cause of the same value in a NAS message without integrity protection;

      - store the current TAI in the list of "forbidden tracking areas for roaming" and enter the state EMM-DEREGISTERED.LIMITED-SERVICE; and

      - search for a suitable cell in another tracking area or in another location area according to 3GPP TS 36.304 [21]; or

      ii) proceed as specified in subclauses 5.5.1, 5.5.3 and 5.6.1;

      - increment the counter for "SIM/USIM considered invalid for GPRS services" events; and

- if the EMM cause value received is #3, #6 or #8, and if the UE maintains a counter for "SIM/USIM considered invalid for non-GPRS services" and the counter has a value less than a UE implementation specific maximum value, increment the counter; and

b) else the UE shall proceed as specified in subclauses 5.5.1, 5.5.3 and 5.6.1;

2) if the EMM cause value received is #12, #13 or #15, the UE shall additionally proceed as specified in subclauses 5.5.1, 5.5.3 and 5.6.1;

3) if the EMM cause value received is #11, #14 or #35 and the UE is in its HPLMN or EHPLMN,

- the UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and eKSI. The UE shall delete the list of equivalent PLMNs. Additionally, if an attach or tracking area updating procedure was performed, the UE shall reset the attach attempt counter or the tracking area updating attempt counter, respectively.

- if A/Gb mode or Iu mode is supported by the UE, the UE shall in addition handle the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI, GPRS ciphering key sequence number and GPRS attach attempt counter or routing area updating attempt counter as specified in 3GPP TS 24.008 [13] for the case when the procedure is rejected with the GMM cause with the same value in a NAS message without integrity protection;

- the UE shall store the current TAI in the list of "forbidden tracking areas for roaming" and enter the state EMM-DEREGISTERED.LIMITED-SERVICE; and

- the UE shall search for a suitable cell in another tracking area or in another location area in the same PLMN according to 3GPP TS 36.304 [21];

4) if the EMM cause value received is #11 or #35 and the UE is not in its HPLMN or EHPLMN, in addition to the UE requirements specified in subclause 5.5.1, 5.5.3 and 5.6.1,

if the UE maintains a list of PLMN-specific attempt counters and the PLMN-specific attempt counter for the PLMN sending the reject message has a value less than a UE implementation-specific maximum value, the UE shall increment the PLMN-specific attempt counter for the PLMN; and

5) if the EMM cause value received is #14 and the UE is not roaming in its HPLMN or EHPLMN, in addition to the UE requirements specified in subclause5.5.1, 5.5.3 and 5.6.1,

if the UE maintains a list of PLMN-specific PS-attempt counter and the PLMN-specific PS-attempt counter of the PLMN sending the reject message has a value less than a UE implementation-specific maximum value, the UE shall increment the PS-attempt counter of the PLMN.

Upon expiry of timer T3247, the UE shall

- erase the list of "forbidden tracking areas for regional provision of service" and the list of "forbidden tracking areas for roaming";

- set the USIM to valid for EPS services, if

  - the UE does not maintain a counter for "SIM/USIM considered invalid for GPRS services" events; or

  - the UE maintains a counter for "SIM/USIM considered invalid for GPRS services" events and this counter has a value less than a UE implementation-specific maximum value;

- set the USIM to valid for non-EPS services, if

  - the UE does not maintain a counter for "SIM/USIM considered invalid for non-GPRS services" events; or

  - the UE maintains a counter for "SIM/USIM considered invalid for non-GPRS services" events and this counter has a value less than a UE implementation-specific maximum value;

- if the UE maintains a list of PLMN-specific attempt counters, for each PLMN-specific attempt counter that has a value greater than zero and less than a UE implementation-specific maximum value, remove the respective PLMN from the forbidden PLMN list;

- if the UE maintains a list of PLMN-specific PS-attempt counters, for each PLMN-specific PS-attempt counter that has a value greater than zero and less than a UE implementation-specifc maximum value, remove the respective PLMN from the "forbidden PLMNs for GPRS service" list. If the resulting "forbidden PLMNs for GPRS service" list is empty, the UE shall re-enable the E-UTRA capability (see subclause 4.5);

- if the UE is supporting A/Gb mode or Iu mode, handle the list of "forbidden location areas for regional provision of service" and the list of "forbidden location areas for roaming" as specified in 3GPP TS 24.008 [13] for the case when timer T3247 expires;

- if the UE is supporting A/Gb mode or Iu mode and maintains a list of "forbidden location areas for non-GPRS services" and a list of "forbidden location areas for GPRS services", handle these lists as specified in 3GPP TS 24.008 [13] for the case when timer T3247 expires; and

- initiate an EPS attach procedure or tracking area updating procedure, if still needed, dependent on EMM state and EPS update status, or perform PLMN selection according to 3GPP TS 23.122 [6].

If the UE maintains a list of PLMN-specific attempt counters and PLMN-specific PS-attempt counters, when the UE is switched off, the UE shall, for each PLMN-specific attempt counter that has a value greater than zero and less than the UE implementation-specific maximum value, remove the respective PLMN from the forbidden PLMN list. When the USIM is removed, the UE should perform this action.

NOTE 2: If the respective PLMN was stored in the extension of the "forbidden PLMNs" list, then according to 3GPP TS 23.122 [6] the UE will delete the contents of this extension when the USIM is removed.

5.3.8 Abnormal cases in the UE

The following abnormal case can be identified:

a) EMM uplink message transmission failure indication by lower layers

When it is specified in the relevant procedure that it is up to the UE implementation to rerun the ongoing procedure that triggered that procedure, the procedure can typically be re-initiated using a retransmission mechanism of the uplink message (the one that has previously failed to be transmitted) with new sequence number and message authentication code information thus avoiding to restart the whole procedure.

5.3.9 Handling of NAS level mobility management congestion control

The network may detect EMM signalling congestion and perform NAS level mobility management congestion control. NAS level mobility management congestion control consists of general NAS level mobility management congestion control and subscribed APN based congestion control.

Under general overload conditions the network may reject mobility management signalling requests from UEs as specified in 3GPP TS 23.401 [10]. The network should not reject the following requests:

- requests for emergency bearer services;

- requests from UEs that were received via NAS signalling connections established with RRC establishment cause "High priority access AC 11 – 15"; and

- requests for CS fallback emergency call or 1xCS fallback emergency call.

When subscribed APN based mobility management congestion control is active for a particular APN, the network may reject attach requests from UEs with a subscription to this APN.

In mobility management the network may detect NAS signalling congestion and start or stop performing the subscribed APN based congestion control based on mobility management level criteria such as:

- rate of mobility management NAS messages from a group of UEs with a subscription to a particular APN exceeds or falls below certain thresholds; and/or

- setting in network management.

When the NAS level mobility management congestion control is active, the network may include a value for the mobility management back-off timer T3346 in the reject messages. The UE starts the timer T3346 with the value received in the mobility management reject messages. To avoid that large numbers of UEs simultaneously initiate

deferred requests, the network should select the value for the timer T3346 for the rejected UEs so that timeouts are not synchronised.

For subscribed APN based congestion control the value of timer T3346 for a particular APN may be APN dependent.

If the timer T3346 is running when the UE enters state EMM-DEREGISTERED, the UE remains switched on, and the USIM in the UE remains the same, then timer T3346 is kept running until it expires or it is stopped.

If the UE is switched off when the timer T3346 is running, the UE shall behave as follows when the UE is switched on and the USIM in the UE remains the same:

- let t1 be the time remaining for T3346 timeout at switch off and let t be the time elapsed between switch off and switch on. If t1 is greater than t, then the timer shall be restarted with the value t1 – t. If t1 is equal to or less than t, then the timer need not be restarted. If the UE is not capable of determining t, then the UE shall restart the timer with the value t1; and

- if prior to switch off, timer T3346 was started due to a NAS request message (ATTACH REQUEST, TRACKING AREA UPDATE REQUEST, CONTROL PLANE SERVICE REQUEST or EXTENDED SERVICE REQUEST) which contained the low priority indicator set to "MS is configured for NAS signalling low priority", then if timer T3346 is restarted at switch on, the UE configured for dual priority shall handle mobility management requests as indicated in subclauses 5.5.1.2.6, 5.5.3.2.6 and 5.6.1.6.

If the UE enters a new PLMN while timer T3346 is running, and the new PLMN is not equivalent to the PLMN where the UE started timer T3346, the UE shall stop timer T3346 when initiating mobility management procedures in the new PLMN.

After change in TAI which is not part of TAI list, if the timer T3346 is running and EMM update status is EU1 UPDATED then UE shall set the EMM update status to EU2 NOT UPDATED and enter state EMM-REGISTERED.ATTEMPTING-TO-UPDATE.

5.3.9A Handling of congestion control for transport of user data via the control plane

The network may activate congestion control for transport of user data via the control plane, as specified in 3GPP TS 23.401 [10].

If the congestion control for transport of user data via the control plane is active and if the UE has indicated support for the control plane data back-off timer, the network shall include a value for the control plane data back-off timer T3448 in ATTACH ACCEPT, TRACKING AREA UPDATE ACCEPT, SERVICE ACCEPT or SERVICE REJECT message, and shall store an control plane data back-off time on a per UE basis. The UE starts the timer T3448 with the value informed in the message. To avoid that large numbers of UEs simultaneously initiate deferred requests, the network should select the value for the timer T3448 for the informed UEs so that timeouts are not synchronised.

The network sends TRACKING AREA UPDATE ACCEPT message or SERVICE ACCEPT message without T3448 value IE to stop the timer T3448 running in the UE as specified in subclause 5.5.3.2.4 and subclause 5.6.1.4.2.

Based on the stored control plane data back-off time for the UE, the network may reject the transfer of user data via the control plane initiated by the UE.

While the timer T3448 is running, the UE in EMM-IDLE mode shall not initiate the transport of user data via the control plane procedure (see subclause 6.6.4), except if the UE is allowed to use exception data reporting (see the ExceptionDataReportingAllowed leaf of the NAS configuration MO in 3GPP TS 24.368 [15A] or the USIM file $EF_{NASCONFIG}$ in 3GPP TS 31.102 [17]) and the user data is related to an exceptional event.

Upon entering the state EMM-DEREGISTERED or a new PLMN which is not equivalent to the PLMN where the UE started the timer T3448, or upon being switched off while the timer T3448 is running, the UE shall stop the timer T3448. For further criteria to stop of timer T3448, refer to subclause 5.5.3.2.4 and subclause 5.6.1.4.2.

5.3.10 Access class control

The network can restrict the access for certain groups of UEs by means of barring their access class.

The UE shall evaluate the access control information as specified in 3GPP TS 36.331 [22] for:

- Access Class Barring;
- Access Control for CSFB and Extended Access Barring (EAB);
- Access Control for Application specific Congestion control for Data Communication (ACDC), if the UE supports ACDC; and
- Access Barring.

5.3.11 Power saving mode

The UE can request the use of power saving mode (PSM) during an attach or tracking area updating procedure (see 3GPP TS 23.682 [11A] and 3GPP TS 23.401 [10]). The UE shall not request the use of PSM during:

- an attach for emergency bearer services procedure;
- an attach procedure for initiating a PDN connection for emergency bearer services with attach type not set to "EPS emergency attach";
- a tracking area updating procedure for initiating a PDN connection for emergency bearer services; or
- a tracking area updating procedure when the UE has a PDN connection established for emergency bearer services.

The network accepts the use of PSM by providing a specific value for timer T3324 when accepting the attach or tracking area updating procedure. The UE may use PSM only if the network has provided the T3324 value IE during the last attach or tracking area updating procedure with a value different from "deactivated".

NOTE: Timer T3324 is specified in 3GPP TS 24.008 [13].

Upon expiry of the timer T3324 or if the T3324 value provided by the network is zero, the UE may deactivate the AS layer and activate PSM by entering the state EMM-REGISTERED.NO-CELL-AVAILABLE if:

a) the UE is not attached for emergency bearer services;
b) the UE has no PDN connection for emergency bearer services;
c) the UE is in EMM-IDLE mode; and
d) in the EMM-REGISTERED.NORMAL-SERVICE state.

If conditions a, b and c are fulfilled, but the UE is in a state other than EMM-REGISTERED.NORMAL-SERVICE when timer T3324 expires, the UE may activate PSM when the MS returns to state EMM-REGISTERED.NORMAL-SERVICE.

A UE that has already been allocated timer T3324 with a value different from "deactivated" and the timer T3324 has expired, may activate PSM if it receives an "Extended wait time" from lower layers.

When PSM is activated all NAS timers are stopped and associated procedures aborted except for T3412, T3346, T3396, any backoff timers, and the timer T controlling the periodic search for HPLMN or EHPLMN or higher prioritized PLMNs (see 3GPP TS 23.122 [6]).

If the UE is attached for emergency bearer services or has a PDN connection for emergency bearer services, the UE shall not activate PSM.

The UE may deactivate PSM and activate the AS layerat any time. Upon deactivating PSM, the UE may initiate EMM procedures (e.g. for the transfer of mobile originated signalling or user data).

5.3.12 Extended idle-mode DRX cycle

The UE may request the use of extended idle-mode DRX cycle (eDRX) during an attach or tracking area updating procedure by including the extended DRX parameters IE (see 3GPP TS 23.682 [11A] and 3GPP TS 23.401 [10]). The UE shall not request the use of eDRX during:

- an attach for emergency bearer services procedure; or

- a tracking area updating procedure for the UE attached for emergency bearer services.

The UE and the network may negotiate eDRX parameters during a tracking area updating procedure when the UE has a PDN connection for emergency bearer services.

The network accepts the request to use the eDRX by providing the extended DRX parameters IE when accepting the attach or the tracking area updating procedure. The UE shall use eDRX only if it received the extended DRX parameters IE during the last attach or tracking area updating procedure and the UE does not have a PDN connection for emergency bearer services.

NOTE: If the UE wants to keep using eDRX, the UE includes the extended DRX parameters IE in each attach or tracking area updating procedure.

If the UE received the extended DRX parameters IE during the last attach or tracking area updating procedure, upon successful completion of the PDN disconnect procedure of the PDN connection for emergency bearer services or EPS bearer context deactivation procedure of the EPS bearer context for emergency, the UE shall resume eDRX.

If the network has provided the extended DRX parameters IE during the last attach or tracking area updating procedure, upon successful completion of the PDN disconnect procedure of the PDN connection for emergency bearer services or EPS bearer context deactivation procedure of the EPS bearer context for emergency, the network shall resume eDRX.

If the UE or the network locally releases the PDN connection for emergency bearer service, the UE or the network shall not use eDRX until the UE receives eDRX parameters during a tracking area updating procedure with EPS bearer context synchronization or upon successful completion of a service request procedure.

If the UE did not receive the extended eDRX parameters IE, or if the UE has a PDN connection for emergency bearer services, the UE shall use the stored UE specific DRX parameter, if available.

If the network did not accept the request to use eDRX, or if the UE has a PDN connection for emergency bearer services, the network shall use the stored UE specific DRX parameter, if available.

If the network provided the extended DRX parameters IE which was different from the one requested by the UE and also assigned a new GUTI for the UE as described in subclause 5.5.3.2.4 during the last tracking area updating procedure, the network shall use the stored UE specific DRX parameter, if available, with the old GUTI and use the eDRX provided by the network with the new GUTI until the old GUTI can be considered as invalid by the network (see subclause 5.4.1.4).

5.3.13 Interaction between power saving mode and extended idle mode DRX cycle

The UE can request the use of both PSM and eDRX during an attach or tracking area update procedure but it is up to the network to decide to enable none, one of them or both (see 3GPP TS 23.682 [11A] and 3GPP TS 23.401 [10]).

If the network accepts the use of both PSM (see subclause 5.3.11) and eDRX (see subclause 5.3.12), the extended DRX parameters IE provided to the UE should allow for multiple paging occasions before the active timer expires.

5.3.14 Dedicated core network

The network may reject mobility management signalling requests from UEs due to dedicated core network as specified in 3GPP TS 23.401 [10]. When the network rejects mobility management signalling requests due to dedicated core network, the mechanism for general NAS level mobility management congestion control as specified in subclause 5.3.9 shall be followed.

5.3.15 CIoT EPS optimizations

CIoT EPS optimizations provide improved support of small data and SMS transfer. A UE supporting CIoT EPS optimizations can indicate the CIoT network behaviour the UE can support and prefer to use during attach or tracking area updating procedure (see 3GPP TS 23.401 [10]). The UE may indicate the support for control plane CIoT EPS optimization, user plane CIoT EPS optimization, EMM-REGISTERED without PDN connection, S1-U data transfer and header compression (see subclause 9.9.3.34). The UE may also request to use SMS transfer without combined attach procedure during the attach procedure. Furthermore, the UE may, separately from the indication of support, indicate preference for control plane CIoT EPS optimization or user plane CIoT EPS optimization (see subclause 9.9.3.0B). The indication of preference is also considered as the request to use.

NOTE 1: The UE supporting control plane CIoT EPS optimization and S1-U data transfer but not user plane CIoT EPS optimization does not indicate preference for user plane CIoT EPS optimization.

The UE can be in NB-S1 mode or WB-S1 mode when requesting the use of CIoT EPS optimizations during an attach or tracking area updating procedure. A UE in NB-S1 mode always indicates support for control plane CIoT EPS optimization. A UE in NB-S1 mode can also request SMS transfer without combined procedure by using the normal attach or tracking area updating procedure (see subclause 5.5.1 and 5.5.3).

In NB-S1 mode, the UE, when requesting the use of CIoT EPS optimization, does not:

- request an attach for emergency bearer services procedure;
- request an attach procedure for initiating a PDN connection for emergency bearer services with attach type not set to "EPS emergency attach"; or
- indicate voice domain preference and UE's usage setting.

The network does not indicate to the UE support of emergency bearer services when the UE is in NB-S1 mode (see subclause 5.5.1.2.4 and 5.5.3.2.4).

The control plane CIoT EPS optimization enables support of efficient transport of user data (IP, non-IP) or SMS messages over control plane via the MME without triggering data radio bearer establishment. The support of control plane CIoT EPS optimization is mandatory for the network in NB-S1 mode and optional in WB-S1 mode. Optional header compression of IP data can be applied to IP PDN type PDN connections that are configured to support header compression.

The user plane CIoT EPS optimization enables support for change from EMM-IDLE mode to EMM-CONNECTED mode without the need for using the service request procedure (see subclause 5.3.1.3).

If the UE indicates support of EMM-REGISTERED without PDN connection in the attach request, the UE may include an ESM DUMMY MESSAGE instead of a PDN CONNECTIVITY REQUEST message as part of the attach procedure. If the EMM-REGISTERED without PDN connection is supported by the network, the UE and the network can at any time release all the PDN connections and the UE still remains EPS attached.

NOTE 2: For both the UE and the network, the term "EMM-REGISTERED without PDN connection" is equivalent to the term "EPS attach without PDN connectivity" as specified in 3GPP TS 23.401 [10].

In NB-S1 mode, if the UE indicates "SMS only" during a normal attach or tracking area updating procedure, the MME supporting CIoT EPS optimisations provides SMS so that the UE is not required to perform a combined attach or tracking area updating procedure.

If the UE supports user plane CIoT EPS optimization, it shall also support S1-U data transfer.

If the UE indicates support of one or more CIoT EPS optimizations and the network supports one or more CIoT EPS optimizations and decides to accept the attach or tracking area update request, the network indicates the supported CIoT EPS optimizations to the UE per TAI list when accepting the UE request. Network indication of support is interpreted by the UE as the acceptance to use the respective feature. After completion of the attach or tracking area updating procedure, the UE and the network can then use the accepted CIoT EPS optimizations for the transfer of user data (IP, non-IP and SMS).

If the UE and the network support both the control plane CIoT EPS optimization and S1-U data transfer, then when receiving the UE's request for a PDN connection, the MME decides whether the PDN connection should be SCEF PDN connection or SGi PDN connection as specified in 3GPP TS 23.401 [10]:

- if SCEF PDN connection is to be established for non-IP data type, the MME shall include Control plane only indication for the requested PDN connection;
- if SGi PDN connection is to be established and existing SGi PDN connections for this UE were established with Control plane only indication, the MME shall include Control plane only indication for the newly requested SGi PDN connection;
- if SGi PDN connection is to be established and existing SGi PDN connections for this UE were established without Control plane only indication, the MME shall not include Control plane only indication for the newly requested SGi PDN connection; and

- if SGi PDN connection is to be established and no SGi PDN connection for this UE exists, the MME determine whether to include Control plane only indication for the requested SGi PDN connection based on local policies, the UE's preferred CIoT network behaviour and the supported CIoT network behaviour.

If the network supports user plane CIoT EPS optimization, it shall also support S1-U data transfer.

Broadcast system information may provide information about support of CIoT EPS optimizations (see 3GPP TS 36.331 [22]). At reception of new broadcast system information, the lower layers deliver it to the EMM layer in the UE. The information provided by lower layers is per PLMN and used by the UE to determine whether certain CIoT EPS optimizations are supported in the cell.

The UE shall not attempt to use CIoT EPS optimizations which are indicated as not supported.

In NB-S1 mode, when the UE requests the lower layer to establish a RRC connection and the UE requests the use of EMM-REGISTERED without PDN connection or user plane CIoT EPS optimization, the UE shall pass an indication of the requested CIoT EPS optimizations to the lower layers. If the UE requests the use of S1-U data transfer without user plane CIoT optimization, then the UE shall also pass an indication of user plane CIoT EPS optimization to lower layers.

In WB-S1 mode, when the UE requests the lower layer to establish a RRC connection and the UE requests the use of EMM-REGISTERED without PDN connection, control plane CIoT EPS optimization or user plane CIoT EPS optimization, the UE shall pass an indication of the requested CIoT EPS optimizations to the lower layers.

5.3.16 Restriction on use of enhanced coverage

In order to deal with use of extensive resources from the network, the operator may prevent specific subscribers from using enhanced coverage (see 3GPP TS 23.401 [10]). When in NB-S1 mode, the UE shall indicate support for restriction on use of enhanced coverage. When in WB-S1 mode, the UE supporting either CE mode A or CE mode B shall indicate support for restriction on use of enhanced coverage. The UE supporting restriction on use of enhanced coverage indicates its support for restriction on use of enhanced coverage in the ATTACH REQUEST and TRACKING AREA UPDATE REQUEST message. If the UE supports restriction on use of enhanced coverage, the MME indicates whether the use of enhanced coverage is restricted or not in the ATTACH ACCEPT message and TRACKING AREA UPDATE ACCEPT message (see subclause 5.5.1.2 and subclause 5.5.3.2). If the use of enhanced coverage is restricted, the UE shall not use enhanced coverage in the registered PLMN and in any PLMN which is in the list of equivalent PLMNs.

If the UE supports CE mode B and the network determines that

- the use of enhanced coverge is not restricted for the UE; or
- CE mode B is not restricted for the UE;

the applicable NAS timer values shall be calculated by the network as described in subclause 4.8.

5.3.17 Service Gap Control

The network may control the frequency UEs can access the network via the service gap control (SGC) as specified in 3GPP TS 23.401 [10]. If the network supports service gap control (SGC) feature and the service gap time value is available in the EMM context of the UE, the MME shall consider SGC as active for the UE.

The UE and the network negotiate usage of the service gap control (SGC) feature during the attach and tracking area update procedures:

- the UE supporting service gap control indicates its support for service gap control in the ATTACH REQUEST and TRACKING AREA UPDATE REQUEST message. If the UE supports service gap control and the the SGC is active for the UE, the MME shall include service gap timer T3447 value in the ATTACH ACCEPT message and TRACKING AREA UPDATE ACCEPT message (see subclause 5.5.1.2 and subclause 5.5.3.2). The UE shall store the service gap time value; and
- for UEs that do not support the optional SGC feature when the network rejects mobility management signalling requests due to service gap control is active in the network, the mechanism for general NAS level mobility management congestion control as specified in subclause 5.3.9 applies.

The UE shall start the SGC timer T3447 when the NAS signalling connection is released and if:

- the UE supports SGC feature, and the service gap timer value is available in the UE and does not indicate zero; and

- the NAS signalling connection released was mobile originated request for transfer of uplink data.

If the SGC is active in the network, when the NAS signalling connection is released after a mobile originated service request for transfer of uplink data, the network shall:

- if the UE supports SGC feature and the service gap time value has been sent to the UE, start the SGC timer T3447 with the service gap time value available in the EMM context minus 4 minutes; and

- if the UE does not support SGC feature, the network shall start the timer T3447 with the service gap time value available in the EMM context.

When the SGC timer is active, the network allows:

- attach requests for emergency bearer services;

- attach requests without PDN connection request;

- tracking area update requests without "active" or "signalling active" flag set.

- requests from UEs that were received via NAS signalling connections established with RRC establishment cause "High priority access AC 11 – 15";

- mobile terminated service requests triggered by paging.

If the timer T3447 is running when the UE enters state EMM-DEREGISTERED, the UE remains switched on, and the USIM in the UE remains the same, then timer T3447 is kept running until it expires.

If the UE is switched off when the timer T3447 is running, the UE shall behave as follows when the UE is switched on and the USIM in the UE remains the same:

- let t1 be the time remaining for T3447 timeout at switch off and let t be the time elapsed between switch off and switch on. If t1 is greater than t, then the timer shall be restarted with the value t1 – t. If t1 is equal to or less than t, then the timer need not be restarted. If the UE is not capable of determining t, then the UE shall restart the timer with the value t1.

5.4 EMM common procedures

5.4.1 GUTI reallocation procedure

5.4.1.1 General

The purpose of the GUTI reallocation procedure is to allocate a GUTI and optionally to provide a new TAI list or a new DCN-ID or both to a particular UE.

The reallocation of a GUTI is performed by the unique procedure defined in this subclause. This procedure can only be initiated by the MME in state EMM-REGISTERED.

The GUTI can also be implicitly reallocated at attach or tracking area updating procedures. The implicit reallocation of a GUTI is described in the subclauses which specify these procedures (see subclause 5.5.1 and 5.5.3).

The PLMN identity in the GUTI indicates the current registered PLMN.

NOTE 1: The GUTI reallocation procedure is usually performed in ciphered mode.

NOTE 2: Normally, the GUTI reallocation will take place in conjunction with another mobility management procedure, e.g. as part of tracking area updating.

5.4.1.2 GUTI reallocation initiation by the network

The MME shall initiate the GUTI reallocation procedure by sending a GUTI REALLOCATION COMMAND message to the UE and starting the timer T3450 (see example in figure 5.4.1.2.1).

The GUTI REALLOCATION COMMAND message shall include a GUTI and may include a TAI list or a DCN-ID or both.

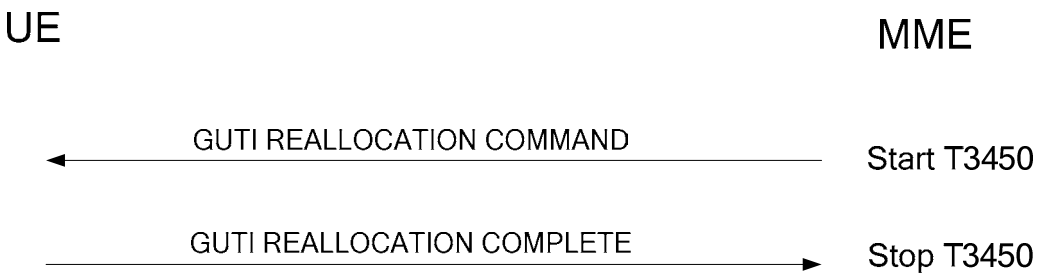


Figure 5.4.1.2.1: GUTI reallocation procedure

5.4.1.3 GUTI reallocation completion by the UE

Upon receipt of the GUTI REALLOCATION COMMAND message, the UE shall store the GUTI and the TAI list and the DCN-ID, if provided, and send a GUTI REALLOCATION COMPLETE message to the MME. The UE considers the new GUTI as valid and the old GUTI as invalid. If the UE receives a new TAI list in the GUTI REALLOCATION COMMAND message, the UE shall consider the new TAI list as valid and the old TAI list as invalid; otherwise, the UE shall consider the old TAI list as valid.

If the GUTI REALLOCATION COMMAND message contains the DCN-ID IE, then the UE shall store the included DCN-ID value together with the PLMN code of the registered PLMN in a DCN-ID list in a non-volatile memory in the ME as specified in annex C.

5.4.1.4 GUTI reallocation completion by the network

Upon receipt of the GUTI REALLOCATION COMPLETE message, the MME shall stop the timer T3450 and consider the new GUTI as valid and the old GUTI as invalid. If a new TAI list is provided in the GUTI REALLOCATION COMMAND message, the MME shall consider the new TAI list as valid and the old TAI list as invalid.

5.4.1.5 Abnormal cases in the UE

The following abnormal cases can be identified:

a) Transmission failure of GUTI REALLOCATION COMPLETE message indication with TAI change from lower layers

   If the current TAI is not in the TAI list, the GUTI reallocation procedure shall be aborted and a tracking area updating procedure shall be initiated.

   If the current TAI is still part of the TAI list, it is up to the UE implementation how to re-run the ongoing procedure that triggered the GUTI reallocation procedure.

b) Transmission failure of GUTI REALLOCATION COMPLETE message indication without TAI change from lower layers

   It is up to the UE implementation how to re-run the ongoing procedure that triggered the GUTI reallocation procedure.

5.4.1.6 Abnormal cases on the network side

The following abnormal cases can be identified:

a) Lower layer failure

   If a lower layer failure is detected before the GUTI REALLOCATION COMPLETE message is received, the old and the new GUTI shall be considered as valid until the old GUTI can be considered as invalid by the network. If a new TAI list was provided in the GUTI REALLOCATION COMMAND message, the old and new TAI list shall also be considered as valid until the old TAI list can be considered as invalid by the network.

During this period the network:

- may first use the old S-TMSI from the old GUTI for paging within the area defined by the old TAI list for an implementation dependent number of paging attempts for network originated transactions. If a new TAI list was provided with old GUTI in the GUTI REALLOCATION COMMAND message, the new TAI list should also be used for paging. Upon response from the UE, the network may re-initiate the GUTI reallocation. If the response is received from a tracking area within the old and new TAI list, the network shall re-initiate the GUTI reallocation. If no response is received to the paging attempts, the network may use the new S-TMSI from the new GUTI for paging for an implementation dependent number of paging attempts. In this case, if a new TAI list was provided with new GUTI in the GUTI REALLOCAITON COMMAND message, the new TAI list shall be used instead of the old TAI list. Upon response from the UE the network shall consider the new GUTI as valid and the old GUTI as invalid. If no response is received to the paging attempts, the network may use the IMSI for paging for an implementation dependent number of paging attempts;

NOTE 1: Paging with IMSI causes the UE to re-attach as described in subclause 5.6.2.2.2.

- shall consider the new GUTI as valid if it is used by the UE and, additionally, the new TAI list as valid if it was provided with this GUTI in the GUTI REALLOCATION COMMAND message;

- may use the identification procedure followed by a new GUTI reallocation if the UE uses the old GUTI; and

- if the network accepted to use eDRX for the UE, may determine the next paging window from both old GUTI and new GUTI, and may first use the S-TMSI from the GUTI which led the first eDRX for paging. If no response is received to the paging attempts for the first eDRX, the network may use the other S-TMSI from the other GUTI which led the second eDRX for paging. For this paging procedure, the network shall start timer T3415 long enough to care the paging attempts for both eDRXs.

NOTE 2: If the second eDRX comes during the first eDRX ongoing, the paging attempts for the second eDRX can be initiated with stopping further paging attempts for the first eDRX.

b) Expiry of timer T3450

The GUTI reallocation procedure is supervised by the timer T3450. The network shall, on the first expiry of timer T3450, reset and restart timer T3450 and shall retransmit the GUTI REALLOCATION COMMAND. This retransmission is repeated four times, i.e. on the fifth expiry of timer T3450, the network shall abort the reallocation procedure and shall follow the rules described for case a above.

c) GUTI reallocation and attach procedure collision

If the network receives an ATTACH REQUEST message before the ongoing GUTI reallocation procedure has been completed the network shall proceed with the attach procedure after deletion of the EMM context.

d) GUTI reallocation and UE initiated detach procedure collision

If the network receives a DETACH REQUEST message before the ongoing GUTI reallocation procedure has been completed, the network shall abort the GUTI reallocation procedure and shall progress the detach procedure.

e) GUTI reallocation and tracking area updating procedure collision

If the network receives a TRACKING AREA UPDATE REQUEST message before the ongoing GUTI reallocation procedure has been completed, the network shall abort the GUTI reallocation procedure and shall progress the tracking area updating procedure. The network may then perform a new GUTI reallocation.

f) GUTI reallocation and service request procedure collision

If the network receives an EXTENDED SERVICE REQUEST message for CS fallback or 1xCS fallback before the ongoing GUTI reallocation procedure has been completed, the network shall progress both procedures.

g) Lower layer indication of non-delivered NAS PDU due to handover

If the GUTI REALLOCATION COMMAND message could not be delivered due to an intra MME handover and the target TA is included in the TAI list, then upon successful completion of the intra MME handover the MME shall retransmit the GUTI REALLOCATION COMMAND message. If a failure of the handover procedure is reported by the lower layer and the S1 signalling connection exists, the MME shall retransmit the GUTI REALLOCATION COMMAND message.

If there is a different new GUTI and optionally a new TAI list included in a subsequent GUTI REALLOCATION COMMAND message, the UE always regards the newest GUTI and the newest TAI list as valid for the recovery time.

5.4.2 Authentication procedure

5.4.2.1 General

The purpose of the EPS authentication and key agreement (AKA) procedure is to provide mutual authentication between the user and the network and to agree on a key K_{ASME} (see 3GPP TS 33.401 [19]). The cases when the EPS AKA procedure should be used are defined in 3GPP TS 33.401 [19].

The EPS AKA procedure is always initiated and controlled by the network. However, the UE can reject the EPS authentication challenge sent by the network.

The UE shall proceed with an EPS authentication challenge only if a USIM is present.

A partial native EPS security context is established in the UE and the network when an EPS authentication is successfully performed. During a successful EPS authentication procedure, the CK and IK are computed by the USIM. CK and IK are then used by the ME as key material to compute a new key, K_{ASME}. K_{ASME} is stored in the EPS security contexts (see 3GPP TS 33.401 [19]) of both the network and in the volatile memory of the ME while attached to the network, and is the root for the EPS integrity protection and ciphering key hierarchy.

5.4.2.2 Authentication initiation by the network

When a NAS signalling connection exists, the network can initiate an authentication procedure at any time. For restrictions applicable after handover or inter-system handover to S1 mode see subclause 5.5.3.2.3.

The network initiates the authentication procedure by sending an AUTHENTICATION REQUEST message to the UE and starting the timer T3460 (see example in figure 5.4.2.2.1). The AUTHENTICATION REQUEST message contains the parameters necessary to calculate the authentication response (see 3GPP TS 33.401 [19]).

If an eKSI is contained in an initial NAS message during an EMM procedure, the network shall include a different eKSI value in the AUTHENTICATION REQUEST message when it initiates an authentication procedure.

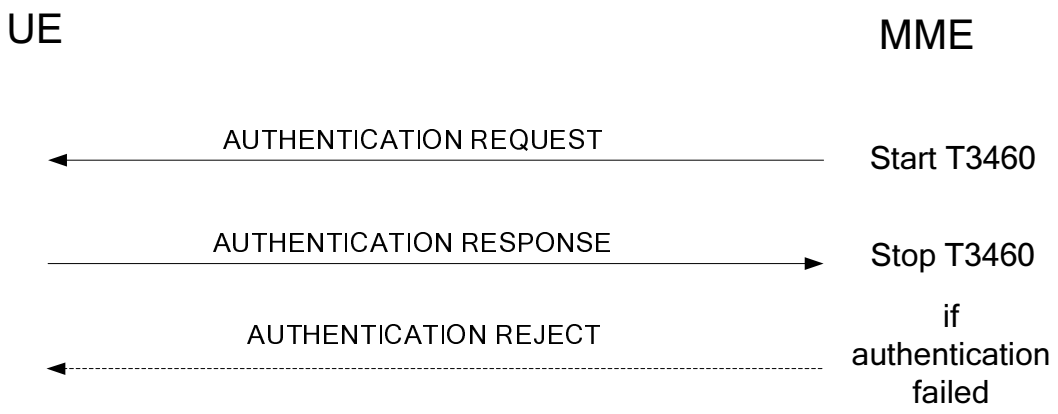


Figure 5.4.2.2.1: Authentication procedure

5.4.2.3 Authentication response by the UE

The UE shall respond to an AUTHENTICATION REQUEST message. With the exception of the cases described in subclause 5.4.2.6, the UE shall process the authentication challenge data and respond with an AUTHENTICATION RESPONSE message to the network.

Upon a successful EPS authentication challenge, the UE shall determine the PLMN identity to be used for the calculation of the new K_{ASME} from the authentication challenge data according to the following rules:

a) When the UE moves from EMM-IDLE mode to EMM-CONNECTED mode, until the first handover, the UE shall use the PLMN identity of the selected PLMN; and

b) After handover or inter-system handover to S1-mode,

- if the target cell is not a shared network cell, the UE shall use the PLMN identity received as part of the broadcast system information;
- if the target cell is a shared network cell and the UE has a valid GUTI, the UE shall use the PLMN identity that is part of the GUTI; and
- if the target cell is a shared network cell and the UE has a valid P-TMSI and RAI, but not a valid GUTI, the UE shall use the PLMN identity that is part of the RAI.

Upon a successful EPS authentication challenge, the new K_{ASME} calculated from the authentication challenge data shall be stored in a new EPS security context in the volatile memory of the ME.

The USIM will compute the authentication response (RES) using the authentication challenge data received from the ME, and pass RES to the ME.

In order to avoid a synchronisation failure, when the UE receives an AUTHENTICATION REQUEST message, the UE shall store the received RAND together with the RES returned from the USIM in the volatile memory of the ME. When the UE receives a subsequent AUTHENTICATION REQUEST message, if the stored RAND value is equal to the new received value in the AUTHENTICATION REQUEST message, then the ME shall not pass the RAND to the USIM, but shall send the AUTHENTICATION RESPONSE message with the stored RES. If there is no valid stored RAND in the ME or the stored RAND is different from the new received value in the AUTHENTICATION REQUEST message, the ME shall pass the RAND to the USIM, shall override any previously stored RAND and RES with the new ones and start, or reset and restart timer T3416.

The RAND and RES values stored in the ME shall be deleted and timer T3416, if running, shall be stopped:

- upon receipt of a
  - SECURITY MODE COMMAND,
  - SERVICE REJECT,
  - TRACKING AREA UPDATE REJECT,
  - TRACKING AREA UPDATE ACCEPT, or
  - AUTHENTICATION REJECT message;
- upon expiry of timer T3416;
- if the UE enters the EMM state EMM-DEREGISTERED or EMM-NULL; or
- if the UE enters EMM-IDLE mode.

5.4.2.4 Authentication completion by the network

Upon receipt of an AUTHENTICATION RESPONSE message, the network stops the timer T3460 and checks the correctness of RES (see 3GPP TS 33.401 [19]).

If the authentication procedure has been completed successfully and the related eKSI is stored in the EPS security context of the network, the network shall include a different eKSI value in the AUTHENTICATION REQUEST message when it initiates a new authentication procedure.

Upon receipt of an AUTHENTICATION FAILURE message, the network stops the timer T3460. In the case where the EMM cause #21 "synch failure" is received, the core network may renegotiate with the HSS/AuC and provide the UE with new authentication parameters.

5.4.2.5 Authentication not accepted by the network

If the authentication response (RES) returned by the UE is not valid, the network response depends upon the type of identity used by the UE in the initial NAS message, that is:

- if the GUTI was used; or
- if the IMSI was used.

If the GUTI was used, the network should initiate an identification procedure. If the IMSI given by the UE during the identification procedure differs from the IMSI the network had associated with the GUTI, the authentication should be restarted with the correct parameters. Otherwise, if the IMSI provided by the UE is the same as the IMSI stored in the network (i.e. authentication has really failed), the network should send an AUTHENTICATION REJECT message to the UE.

If the IMSI was used for identification in the initial NAS message, or the network decides not to initiate the identification procedure after an unsuccessful authentication procedure, the network should send an AUTHENTICATION REJECT message to the UE.

Upon receipt of an AUTHENTICATION REJECT message,

a) if the message has been successfully integrity checked by the NAS, the UE shall set the update status to EU3 ROAMING NOT ALLOWED, delete the stored GUTI, TAI list, last visited registered TAI and KSI_{ASME}. The USIM shall be considered invalid until switching off the UE or the UICC containing the USIM is removed. If the UE maintains a counter for "SIM/USIM considered invalid for GPRS services", then the UE shall set this counter to UE implementation-specific maximum value. If the UE maintains a counter for "SIM/USIM considered invalid for non-GPRS services", then the UE shall set this counter to UE implementation-specific maximum value.

   If A/Gb or Iu mode is supported by the UE, the UE shall in addition handle the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI and GPRS ciphering key sequence number and the MM parameters update status, TMSI, LAI and ciphering key sequence number as specified in 3GPP TS 24.008 [13] for the case when the authentication and ciphering procedure is not accepted by the network; and

b) if the message is received without integrity protection, the UE shall start timer T3247 (see 3GPP TS 24.008 [13]) with a random value uniformly drawn from the range between 30 minutes and 60 minutes, if the timer is not running (see subclause 5.3.7b). Additionally, the UE shall:

   - if the UE maintains a counter for "SIM/USIM considered invalid for GPRS services" events and the counter has a value less than a UE implementation-specific maximum value, proceed as specified in subclause 5.3.7b, list item 1a for the case that the EMM cause value received is #3; and

   - otherwise proceed as specified under list item a above for the case that the message has been successfully integrity checked.

If the AUTHENTICATION REJECT message is received by the UE, the UE shall abort any EMM signalling procedure, stop any of the timers T3410, T3417, T3430, T3418 or T3420 (if they were running) and enter state EMM-DEREGISTERED.

Depending on local requirements or operator preference for emergency bearer services, if the UE has a PDN connection for emergency bearer services established or is establishing a PDN connection for emergency bearer services, the MME need not follow the procedures specified for the authentication failure in the present subclause. The MME may continue a current EMM specific procedure or PDN connectivity request procedure. Upon completion of the authentication procedure, if not initiated as part of another procedure, or upon completion of the EMM procedure or PDN connectivity request procedure, the MME shall deactivate all non-emergency EPS bearers, if any, by initiating an EPS bearer context deactivation procedure. The network shall consider the UE to be attached for emergency bearer services only.

5.4.2.6 Authentication not accepted by the UE

In an EPS authentication challenge, the UE shall check the authenticity of the core network by means of the AUTN parameter received in the AUTHENTICATION REQUEST message. This enables the UE to detect a false network.

During an EPS authentication procedure, the UE may reject the core network due to an incorrect AUTN parameter (see 3GPP TS 33.401 [19]). This parameter contains three possible causes for authentication failure:

a) MAC code failure:

   If the UE finds the MAC code (supplied by the core network in the AUTN parameter) to be invalid, the UE shall send an AUTHENTICATION FAILURE message to the network, with the EMM cause #20 "MAC failure". The UE shall then follow the procedure described in subclause 5.4.2.7, item c.

b) Non-EPS authentication unacceptable:

If the UE finds that the "separation bit" in the AMF field of AUTN supplied by the core network is 0, the UE shall send an AUTHENTICATION FAILURE message to the network, with the EMM cause #26 "non-EPS authentication unacceptable" (see subclause 6.1.1 in 3GPP TS 33.401 [19]). The UE shall then follow the procedure described in subclause 5.4.2.7, item d.

c) SQN failure:

If the UE finds the SQN (supplied by the core network in the AUTN parameter) to be out of range, the UE shall send an AUTHENTICATION FAILURE message to the network, with the EMM cause #21 "synch failure" and a re-synchronization token AUTS provided by the USIM (see 3GPP TS 33.102 [18]). The UE shall then follow the procedure described in subclause 5.4.2.7, item e.

If the UE returns an AUTHENTICATION FAILURE message to the network, the UE shall delete any previously stored RAND and RES and shall stop timer T3416, if running.

If the UE has a PDN connection for emergency bearer services established or is establishing such a PDN connection, additional UE requirements are specified in subclause 5.4.2.7, under "for items c, d, e".

5.4.2.7 Abnormal cases

a) Lower layer failure:

Upon detection of lower layer failure before the AUTHENTICATION RESPONSE message is received, the network shall abort the procedure.

b) Expiry of timer T3460:

The network shall, on the first expiry of the timer T3460, retransmit the AUTHENTICATION REQUEST message and shall reset and start timer T3460. This retransmission is repeated four times, i.e. on the fifth expiry of timer T3460, the network shall abort the authentication procedure and any ongoing EMM specific procedure and release the NAS signalling connection.

c) Authentication failure (EMM cause #20 "MAC failure"):

The UE shall send an AUTHENTICATION FAILURE message, with EMM cause #20 "MAC failure" according to subclause 5.4.2.6, to the network and start timer T3418 (see example in figure 5.4.2.7.1). Furthermore, the UE shall stop any of the retransmission timers that are running (e.g. T3410, T3417, T3421 or T3430). Upon the first receipt of an AUTHENTICATION FAILURE message from the UE with EMM cause #20 "MAC failure", the network may initiate the identification procedure described in subclause 5.4.4. This is to allow the network to obtain the IMSI from the UE. The network may then check that the GUTI originally used in the authentication challenge corresponded to the correct IMSI. Upon receipt of the IDENTITY REQUEST message from the network, the UE shall send the IDENTITY RESPONSE message.

NOTE 1: Upon receipt of an AUTHENTICATION FAILURE message from the UE with EMM cause #20 "MAC failure", the network may also terminate the authentication procedure (see subclause 5.4.2.5).

If the GUTI/IMSI mapping in the network was incorrect, the network should respond by sending a new AUTHENTICATION REQUEST message to the UE. Upon receiving the new AUTHENTICATION REQUEST message from the network, the UE shall stop the timer T3418, if running, and then process the challenge information as normal. If the GUTI/IMSI mapping in the network was correct, the network should terminate the authentication procedure by sending an AUTHENTICATION REJECT message (see subclause 5.4.2.5).

If the network is validated successfully (an AUTHENTICATION REQUEST message that contains a valid SQN and MAC is received), the UE shall send the AUTHENTICATION RESPONSE message to the network and shall start any retransmission timers (e.g. T3410, T3417, T3421 or T3430) if they were running and stopped when the UE received the first failed AUTHENTICATION REQUEST message.

If the UE receives the second AUTHENTICATION REQUEST message while T3418 is running, and the MAC value cannot be resolved, the UE shall follow the procedure specified in this subclause, item c, starting again from the beginning, or if the message contains a UMTS authentication challenge, the UE shall follow the procedure specified in item d. If the SQN is invalid, the UE shall proceed as specified in item e.

It can be assumed that the source of the authentication challenge is not genuine (authentication not accepted by the UE) if any of the following occur:

- the timer T3418 expires;
- the UE detects any combination of the authentication failures: EMM causes #20 "MAC failure", #21 "synch failure" or #26 "non-EPS authentication unacceptable", during three consecutive authentication challenges. The authentication challenges shall be considered as consecutive only, if the authentication challenges causing the second and third authentication failure are received by the UE, while the timer T3418 or T3420 started after the previous authentication failure is running.

The UE shall stop timer T3418, if the timer is running and the UE enters EMM-IDLE mode, e.g. upon detection of a lower layer failure, release of the NAS signalling connection, or as the result of an inter-system handover to A/Gb mode or Iu mode.

When it has been deemed by the UE that the source of the authentication challenge is not genuine (i.e. authentication not accepted by the UE), the UE shall proceed as described in item f.

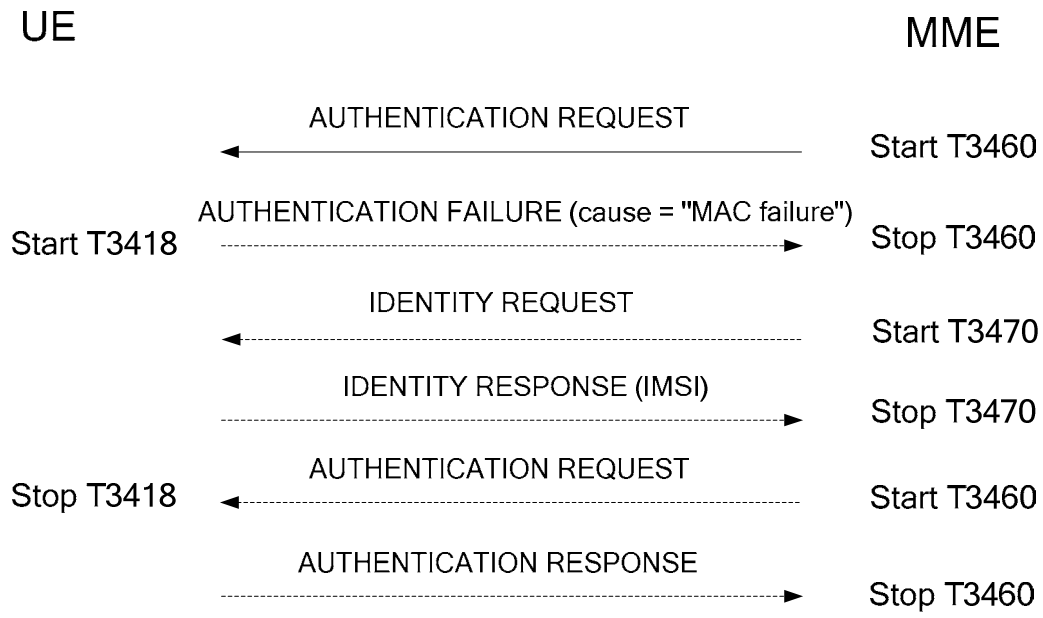


Figure 5.4.2.7.1: Authentication failure procedure (EMM cause #20 "MAC failure" or #26 "non-EPS authentication unacceptable")

d) Authentication failure (EMM cause #26 "non-EPS authentication unacceptable"):

The UE shall send an AUTHENTICATION FAILURE message, with EMM cause #26 "non-EPS authentication unacceptable", to the network and start the timer T3418 (see example in figure 5.4.2.7.1). Furthermore, the UE shall stop any of the retransmission timers that are running (e.g. T3410, T3417, T3421 or T3430). Upon the first receipt of an AUTHENTICATION FAILURE message from the UE with EMM cause #26 "non-EPS authentication unacceptable", the network may initiate the identification procedure described in subclause 5.4.4. This is to allow the network to obtain the IMSI from the UE. The network may then check that the GUTI originally used in the authentication challenge corresponded to the correct IMSI. Upon receipt of the IDENTITY REQUEST message from the network, the UE shall send the IDENTITY RESPONSE message.

NOTE 2: Upon receipt of an AUTHENTICATION FAILURE message from the UE with EMM cause #26 "non-EPS authentication unacceptable", the network may also terminate the authentication procedure (see subclause 5.4.2.5).

If the GUTI/IMSI mapping in the network was incorrect, the network should respond by sending a new AUTHENTICATION REQUEST message to the UE. Upon receiving the new AUTHENTICATION REQUEST message from the network, the UE shall stop the timer T3418, if running, and then process the challenge information as normal. If the GUTI/IMSI mapping in the network was correct, the network should terminate the authentication procedure by sending an AUTHENTICATION REJECT message (see subclause 5.4.2.5).

It can be assumed that the source of the authentication challenge is not genuine (authentication not accepted by the UE) if any of the following occur:

- the timer T3418 expires;

- the UE detects any combination of the authentication failures: EMM causes #20 "MAC failure", #21 "synch failure" or #26 "non-EPS authentication unacceptable", during three consecutive authentication challenges. The authentication challenges shall be considered as consecutive only, if the authentication challenges causing the second and third authentication failure are received by the UE, while the timer T3418 or T3420 started after the previous authentication failure is running.

The UE shall stop timer T3420, if the timer is running and the UE enters EMM-IDLE mode, e.g. upon detection of a lower layer failure, release of the NAS signalling connection, or as the result of an inter-system handover to A/Gb mode or Iu mode.

When it has been deemed by the UE that the source of the authentication challenge is not genuine (i.e. authentication not accepted by the UE), the UE shall proceed as described in item f.

e) Authentication failure (EMM cause #21 "synch failure"):

The UE shall send an AUTHENTICATION FAILURE message, with EMM cause #21 "synch failure", to the network and start the timer T3420 (see example in figure 5.4.2.7.2). Furthermore, the UE shall stop any of the retransmission timers that are running (e.g. T3410, T3417, T3421 or T3430). Upon the first receipt of an AUTHENTICATION FAILURE message from the UE with the EMM cause #21 "synch failure", the network shall use the returned AUTS parameter from the authentication failure parameter IE in the AUTHENTICATION FAILURE message, to re-synchronise. The re-synchronisation procedure requires the MME to delete all unused authentication vectors for that IMSI and obtain new vectors from the HSS. When re-synchronisation is complete, the network shall initiate the authentication procedure. Upon receipt of the AUTHENTICATION REQUEST message, the UE shall stop the timer T3420, if running.

NOTE 3: Upon receipt of two consecutive AUTHENTICATION FAILURE messages from the UE with EMM cause #21 "synch failure", the network may terminate the authentication procedure by sending an AUTHENTICATION REJECT message.

If the network is validated successfully (a new AUTHENTICATION REQUEST message is received which contains a valid SQN and MAC) while T3420 is running, the UE shall send the AUTHENTICATION RESPONSE message to the network and shall start any retransmission timers (e.g. T3410, T3417, T3421 or T3430), if they were running and stopped when the UE received the first failed AUTHENTICATION REQUEST message.

If the UE receives the second AUTHENTICATION REQUEST message while T3420 is running, and the MAC value cannot be resolved, the UE shall follow the procedure specified in item c or if the message contains a UMTS authentication challenge, the UE shall proceed as specified in item d; if the SQN is invalid, the UE shall follow the procedure specified in this subclause, item e, starting again from the beginning.

The UE shall deem that the network has failed the authentication check and proceed as described in item f if any of the following occurs:

- the timer T3420 expires;

- the UE detects any combination of the authentication failures: EMM cause #20 "MAC failure", #21 "synch failure", or #26 "non-EPS authentication unacceptable", during three consecutive authentication challenges. The authentication challenges shall be considered as consecutive only if the authentication challenges causing the second and third authentication failure are received by the UE while the timer T3418 or T3420 started after the previous authentication failure is running.

When it has been deemed by the UE that the source of the authentication challenge is not genuine (i.e. authentication not accepted by the UE), the UE shall proceed as described in item f.

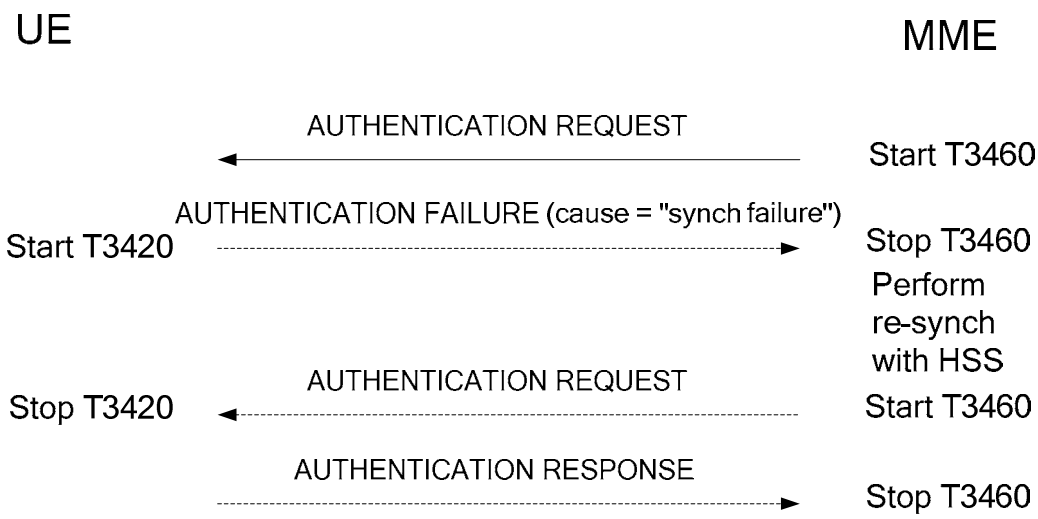


Figure 5.4.2.7.2: Authentication failure procedure (EMM cause #21 "synch failure")

Upon receipt of an AUTHENTICATION REJECT message, the UE shall perform the actions as specified in subclause 5.4.2.5.

f) Network failing the authentication check:

If the UE deems that the network has failed the authentication check, then it shall request RRC to locally release the RRC connection and treat the active cell as barred (see 3GPP TS 36.304 [21]). The UE shall start any retransmission timers (e.g. T3410, T3417, T3421 or T3430), if they were running and stopped when the UE received the first AUTHENTICATION REQUEST message containing an invalid MAC or SQN.

g) Transmission failure of AUTHENTICATION RESPONSE message or AUTHENTICATION FAILURE message indication from lower layers (if the authentication procedure is triggered by a tracking area updating procedure)

The UE shall stop any of the timers T3418 and T3420, if running, and re-initiate the tracking area updating procedure.

h) Transmission failure of AUTHENTICATION RESPONSE message or AUTHENTICATION FAILURE message indication with TAI change from lower layers (if the authentication procedure is triggered by a service request procedure)

The UE shall stop any of the timers T3418 and T3420, if running.

If the current TAI is not in the TAI list, the authentication procedure shall be aborted and a tracking area updating procedure shall be initiated.

If the current TAI is still part of the TAI list, it is up to the UE implementation how to re-run the ongoing procedure that triggered the authentication procedure.

i) Transmission failure of AUTHENTICATION RESPONSE message or AUTHENTICATION FAILURE message indication without TAI change from lower layers (if the authentication procedure is triggered by a service request procedure)

The UE shall stop any of the timers T3418 and T3420, if running. It is up to the UE implementation how to re-run the ongoing procedure that triggered the authentication procedure.

j) Lower layers indication of non-delivered NAS PDU due to handover

If the AUTHENTICATION REQUEST message could not be delivered due to an intra MME handover and the target TA is included in the TAI list, then upon successful completion of the intra MME handover the MME shall retransmit the AUTHENTICATION REQUEST message. If a failure of handover procedure is reported by the lower layer and the S1 signalling connection exists, the MME shall retransmit the AUTHENTICATION REQUEST message.

For items c, d, and e:

Depending on local requirements or operator preference for emergency bearer services, if the UE has a PDN connection for emergency bearer services established or is establishing a PDN connection for emergency bearer services, the MME need not follow the procedures specified for the authentication failure specified in the present subclause. The MME may respond to the AUTHENTICATION FAILURE message by initiating the security mode control procedure selecting the "null integrity protection algorithm" EIA0, null ciphering algorithm or may abort the authentication procedure and continue using the current security context, if any. The MME shall deactivate all non-emergency EPS bearer contexts, if any, by initiating an EPS bearer context deactivation procedure. If there is an ongoing PDN connectivity procedure, the MME shall deactivate all non-emergency EPS bearer contexts upon completion of the PDN connectivity procedure. The network shall consider the UE to be attached for emergency bearer services only.

If a UE has a PDN connection for emergency bearer services established or is establishing a PDN connection for emergency bearer services and sends an AUTHENTICATION FAILURE message to the MME with the EMM cause appropriate for these cases (#20, #21, or #26, respectively) and receives the SECURITY MODE COMMAND message before the timeout of timer T3418 or T3420, the UE shall deem that the network has passed the authentication check successfully, stop timer T3418 or T3420, respectively, and execute the security mode control procedure.

If a UE has a PDN connection for emergency bearer services established or is establishing a PDN connection for emergency bearer services when timer T3418 or T3420 expires, the UE shall not deem that the network has failed the authentication check and not behave as described in item f. Instead the UE shall continue using the current security context, if any, deactivate all non-emergency EPS bearer contexts, if any, by initiating UE requested PDN disconnect procedure. If there is an ongoing PDN connectivity procedure, the UE shall deactivate all non-emergency EPS bearer contexts upon completion of the PDN connectivity procedure. The UE shall start any retransmission timers (e.g. T3410, T3417, T3421 or T3430) if:

- they were running and stopped when the UE received the AUTHENTICATION REQUEST message and detected an authentication failure;

- the procedures associated with these timers have not yet been completed.

The UE shall consider itself to be attached for emergency bearer services only.

5.4.3 Security mode control procedure

5.4.3.1 General

The purpose of the NAS security mode control procedure is to take an EPS security context into use, and initialise and start NAS signalling security between the UE and the MME with the corresponding EPS NAS keys and EPS security algorithms.

Furthermore, the network may also initiate the security mode control procedure in the following cases:

- in order to change the NAS security algorithms for a current EPS security context already in use; and

- in order to change the value of uplink NAS COUNT used in the latest SECURITY MODE COMPLETE message as described in 3GPP TS 33.401 [19], subclause 7.2.9.2.

For restrictions concerning the concurrent running of a security mode control procedure with other security related procedures in the AS or inside the core network see 3GPP TS 33.401 [19], subclause 7.2.10.

5.4.3.2 NAS security mode control initiation by the network

The MME initiates the NAS security mode control procedure by sending a SECURITY MODE COMMAND message to the UE and starting timer T3460 (see example in figure 5.4.3.2.1).

The MME shall reset the downlink NAS COUNT counter and use it to integrity protect the initial SECURITY MODE COMMAND message if the security mode control procedure is initiated:

- to take into use the EPS security context created after a successful execution of the EPS authentication procedure;

- upon receipt of TRACKING AREA UPDATE REQUEST message including a GPRS ciphering key sequence number IE, if the MME wishes to create a mapped EPS security context (i.e. the type of security context flag is set to "mapped security context" in the NAS key set identifier IE included in the SECURITY MODE COMMAND message).

The MME shall send the SECURITY MODE COMMAND message unciphered, but shall integrity protect the message with the NAS integrity key based on K_{ASME} or mapped K'_{ASME} indicated by the eKSI included in the message. The MME shall set the security header type of the message to "integrity protected with new EPS security context".

The MME shall create a locally generated K_{ASME} and send the SECURITY MODE COMMAND message including a KSI value in the NAS key set identifier IE set to "000" and EIA0 and EEA0 as the selected NAS security algorithms only when the security mode control procedure is initiated:

- during an attach procedure for emergency bearer services if no shared EPS security context is available;
- during a tracking area updating procedure for a UE that has a PDN connection for emergency bearer services if no shared EPS security context is available;
- during a service request procedure for a UE that has a PDN connection for emergency bearer services if no shared EPS security context is available; or
- after a failed authentication procedure for a UE that has a PDN connection for emergency bearer services or that is establishing a PDN connection for emergency bearer services, if continued usage of a shared security context is not possible.

The UE shall process a SECURITY MODE COMMAND message including a KSI value in the NAS key set identifier IE set to "000" and EIA0 and EEA0 as the selected NAS security algorithms and, if accepted, create a locally generated K_{ASME} when the security mode control procedure is initiated:

- during an attach procedure for emergency bearer services;
- during a tracking area updating procedure when the UE has a PDN connection for emergency bearer services;
- during a service request procedure when the UE has a PDN connection for emergency bearer services; or
- after an authentication procedure when the UE has a PDN connection for emergency bearer services or is establishing a PDN connection for emergency bearer services.

NOTE 1: The process for creation of the locally generated K_{ASME} by the MME and the UE is implementation dependent.

Upon receipt of a TRACKING AREA UPDATE REQUEST message including a GPRS ciphering key sequence number IE, if the MME does not have the valid current EPS security context indicated by the UE, the MME shall either:

- indicate the use of the new mapped EPS security context to the UE by setting the type of security context flag in the NAS key set identifier IE to "mapped security context" and the KSI value related to the security context of the source system; or
- set the KSI value "000" in the NAS key set identifier IE if the MME sets EIA0 and EEA0 as the selected NAS security algorithms for a UE that has a PDN connection for emergency bearer services.

While having a current mapped EPS security context with the UE, if the MME wants to take the native EPS security context into use, the MME shall include the eKSI that indicates the native EPS security context in the SECURITY MODE COMMAND message.

The MME shall include the replayed security capabilities of the UE (including the security capabilities with regard to NAS, RRC and UP (user plane) ciphering as well as NAS and RRC integrity, and other possible target network security capabilities, i.e. UTRAN/GERAN if the UE included them in the message to network), the replayed $nonce_{UE}$ when creating a mapped EPS security context and if the UE included it in the message to the network, the selected NAS ciphering and integrity algorithms and the Key Set Identifier (eKSI). If the MME supports handling of UE additional security capabilities and the UE included a UE additional security capability IE in the message to the network, the MME shall include the replayed additional security capabilities of the UE.

The MME shall include both the $nonce_{MME}$ and the $nonce_{UE}$ when creating a mapped EPS security context during inter-system change from A/Gb mode to S1 mode or Iu mode to S1 mode in EMM-IDLE mode.

The MME may initiate a SECURITY MODE COMMAND in order to change the NAS security algorithms for a current EPS security context already in use. The MME re-derives the NAS keys from K_{ASME} with the new NAS algorithm identities as input and provides the new NAS algorithm identities within the SECURITY MODE COMMAND message. The MME shall set the security header type of the message to "integrity protected with new EPS security context".

If, during an ongoing attach or tracking area updating procedure, the MME is initiating a SECURITY MODE COMMAND (i.e. after receiving the ATTACH REQUEST or TRACKING AREA UPDATE REQUEST message, but before sending a response to that message) and the ATTACH REQUEST or TRACKING AREA UPDATE REQUEST message is received without integrity protection or does not successfully pass the integrity check at the MME, the MME shall calculate the $HASH_{MME}$ of the entire plain ATTACH REQUEST or TRACKING AREA UPDATE REQUEST message as described in 3GPP TS 33.401 [19] and shall include the $HASH_{MME}$ in the SECURITY MODE COMMAND message.

Additionally, the MME may request the UE to include its IMEISV in the SECURITY MODE COMPLETE message.

NOTE 2: The AS and NAS security capabilities will be the same, i.e. if the UE supports one algorithm for NAS, the same algorithm is also supported for AS.

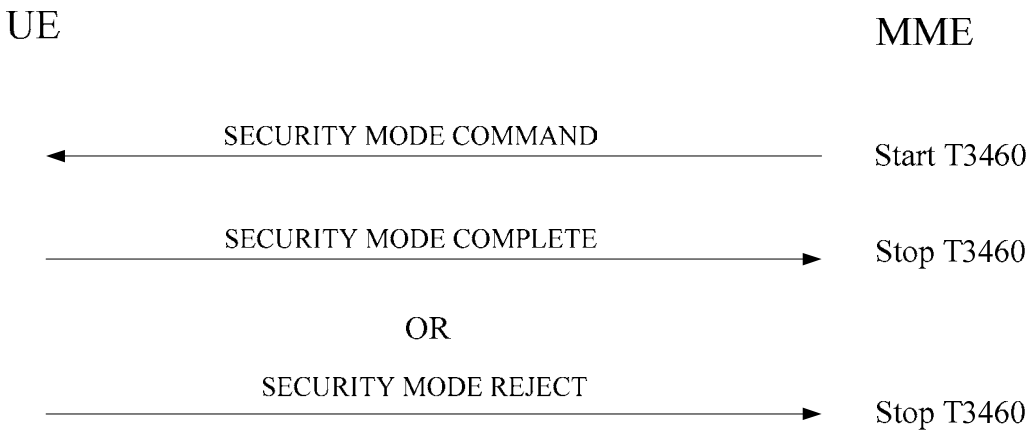


Figure 5.4.3.2.1: Security mode control procedure

5.4.3.3 NAS security mode command accepted by the UE

Upon receipt of the SECURITY MODE COMMAND message, the UE shall check whether the security mode command can be accepted or not. This is done by performing the integrity check of the message and by checking that the received replayed UE security capabilities, the received replayed UE additional security capabilities, if included in the SECURITY MODE COMMAND message, and the received $nonce_{UE}$ have not been altered compared to the latest values that the UE sent to the network. However, the UE is not required to perform the checking of the received $nonce_{UE}$ if the UE does not want to re-generate the K'_{ASME} (i.e. the SECURITY MODE COMMAND message is to derive and take into use a mapped EPS security context and the eKSI matches the current EPS security context, if it is a mapped EPS security context). When the UE has a PDN connection for emergency bearer services established or the UE is establishing a PDN connection for emergency bearer services, the UE is not required to locally re-generate the K_{ASME} (i.e. the SECURITY MODE COMMAND message is used to derive and take into use a native EPS security context where the KSI value "000" is included in the NAS key set identifier IE and the EIA0 and EEA0 are included as the selected NAS security algorithms).

The UE shall accept a SECURITY MODE COMMAND message indicating the "null integrity protection algorithm" EIA0 as the selected NAS integrity algorithm only if the message is received for a UE that has a PDN connection for emergency bearer services established or a UE that is establishing a PDN connection for emergency bearer services.

If the type of security context flag included in the SECURITY MODE COMMAND message is set to "native security context" and if the KSI matches a valid non-current native EPS security context held in the UE while the UE has a mapped EPS security context as the current EPS security context, the UE shall take the non-current native EPS security context into use which then becomes the current native EPS security context and delete the mapped EPS security context.

If the SECURITY MODE COMMAND message can be accepted, the UE shall take the EPS security context indicated in the message into use. The UE shall in addition reset the uplink NAS COUNT counter if:

- the SECURITY MODE COMMAND message is received in order to take an EPS security context into use created after a successful execution of the EPS authentication procedure;

- the SECURITY MODE COMMAND message received includes the type of security context flag set to "mapped security context" in the NAS key set identifier IE the eKSI does not match the current EPS security context, if it is a mapped EPS security context.

If the SECURITY MODE COMMAND message can be accepted and a new EPS security context is taken into use and SECURITY MODE COMMAND message does not indicate the "null integrity protection algorithm" EIA0 as the selected NAS integrity algorithm, the UE shall:

- if the SECURITY MODE COMMAND message has been successfully integrity checked using an estimated downlink NAS COUNT equal 0, then the UE shall set the downlink NAS COUNT of this new EPS security context to 0;

- otherwise the UE shall set the downlink NAS COUNT of this new EPS security context to the downlink NAS COUNT that has been used for the successful integrity checking of the SECURITY MODE COMMAND message.

If the SECURITY MODE COMMAND message can be accepted, the UE shall send a SECURITY MODE COMPLETE message integrity protected with the selected NAS integrity algorithm and the EPS NAS integrity key based on the K_{ASME} or mapped K'_{ASME} if the type of security context flag is set to "mapped security context" indicated by the eKSI. When the SECURITY MODE COMMAND message includes the type of security context flag set to "mapped security context" in the NAS key set identifier IE, the $nonce_{MME}$ and the $nonce_{UE}$, then the UE shall either:

- generate K'_{ASME} from both the $nonce_{MME}$ and the $nonce_{UE}$ as indicated in 3GPP TS 33.401 [19];or

- check whether the SECURITY MODE COMMAND message indicates the eKSI of the current EPS security context, if it is a mapped EPS security context, in order not to re-generate the K'_{ASME}.

Furthermore, if the SECURITY MODE COMMAND message can be accepted, the UE shall cipher the SECURITY MODE COMPLETE message with the selected NAS ciphering algorithm and the EPS NAS ciphering key based on the K_{ASME} or mapped K'_{ASME} indicated by the eKSI. The UE shall set the security header type of the message to "integrity protected and ciphered with new EPS security context".

From this time onward the UE shall cipher and integrity protect all NAS signalling messages with the selected NAS ciphering and NAS integrity algorithms.

If the MME indicated in the SECURITY MODE COMMAND message that the IMEISV is requested, the UE shall include its IMEISV in the SECURITY MODE COMPLETE message.

If, during an ongoing attach or tracking area updating procedure, the SECURITY MODE COMMAND message includes a $HASH_{MME}$, the UE shall compare $HASH_{MME}$ with a hash value locally calculated as described in 3GPP TS 33.401 [19] from the entire plain ATTACH REQUEST or TRACKING AREA UPDATE REQUEST message that the UE had sent to initiate the procedure. If $HASH_{MME}$ and the locally calculated hash value are different, the UE shall include the complete ATTACH REQUEST or TRACKING AREA UPDATE REQUEST message which the UE had previously sent in the Replayed NAS message container IE of the SECURITY MODE COMPLETE message.

5.4.3.4 NAS security mode control completion by the network

The MME shall, upon receipt of the SECURITY MODE COMPLETE message, stop timer T3460. From this time onward the MME shall integrity protect and encipher all signalling messages with the selected NAS integrity and ciphering algorithms.

If the SECURITY MODE COMPLETE message contains a Replayed NAS container message IE with an ATTACH REQUEST or TRACKING AREA UPDATE REQUEST message, the MME shall complete the ongoing attach or tracking area updating procedure by considering the ATTACH REQUEST or TRACKING AREA UPDATE REQUEST message contained in the Replayed NAS message container IE as the message that triggered the procedure.

5.4.3.5 NAS security mode command not accepted by the UE

If the security mode command cannot be accepted, the UE shall send a SECURITY MODE REJECT message. The SECURITY MODE REJECT message contains an EMM cause that typically indicates one of the following cause values:

#23: UE security capabilities mismatch;

#24: security mode rejected, unspecified.

Upon receipt of the SECURITY MODE REJECT message, the MME shall stop timer T3460. The MME shall also abort the ongoing procedure that triggered the initiation of the NAS security mode control procedure.

Both the UE and the MME shall apply the EPS security context in use before the initiation of the security mode control procedure, if any, to protect the SECURITY MODE REJECT message and any other subsequent messages according to the rules in subclauses 4.4.4 and 4.4.5.

5.4.3.6 Abnormal cases in the UE

The following abnormal cases can be identified:

a) Transmission failure of SECURITY MODE COMPLETE message or SECURITY MODE REJECT message indication from lower layers (if the security mode control procedure is triggered by a tracking area updating procedure)

The UE shall abort the security mode control procedure and re-initiate the tracking area updating procedure.

b) Transmission failure of SECURITY MODE COMPLETE message or SECURITY MODE REJECT message indication with TAI change from lower layers (if the security mode control procedure is triggered by a service request procedure)

If the current TAI is not in the TAI list, the security mode control procedure shall be aborted and a tracking area updating procedure shall be initiated.

If the current TAI is still part of the TAI list, the security mode control procedure shall be aborted and it is up to the UE implementation how to re-run the ongoing procedure that triggered the security mode control procedure.

c) Transmission failure of SECURITY MODE COMPLETE message or SECURITY MODE REJECT message indication without TAI change from lower layers (if the security mode control procedure is triggered by a service request procedure)

The security mode control procedure shall be aborted and it is up to the UE implementation how to re-run the ongoing procedure that triggered the security mode control procedure.

5.4.3.7 Abnormal cases on the network side

The following abnormal cases can be identified:

a) Lower layer failure before the SECURITY MODE COMPLETE or SECURITY MODE REJECT message is received

The network shall abort the security mode control procedure.

b) Expiry of timer T3460

The network shall, on the first expiry of the timer T3460, retransmit the SECURITY MODE COMMAND message and shall reset and start timer T3460. This retransmission is repeated four times, i.e. on the fifth expiry of timer T3460, the procedure shall be aborted.

NOTE: If the SECURITY MODE COMMAND message was sent to create a mapped EPS security context during inter-system change from A/Gb mode to S1 mode or Iu mode to S1 mode, then the network does not generate new values for the $nonce_{MME}$ and the $nonce_{UE}$, but includes the same values in the SECURITY MODE COMMAND message (see the subclause 7.2.4.4 in 3GPP TS 33.401 [19]).

c) Collision between security mode control procedure and attach, service request, tracking area updating procedure or detach procedure not indicating switch off

The network shall abort the security mode control procedure and proceed with the UE initiated procedure.

d) Collision between security mode control procedure and other EMM procedures than in item c

The network shall progress both procedures.

e) Lower layers indication of non-delivered NAS PDU due to handover

If the SECURITY MODE COMMAND message could not be delivered due to an intra MME handover and the target TA is included in the TAI list, then upon successful completion of the intra MME handover the MME shall retransmit the SECURITY MODE COMMAND message. If a failure of the handover procedure is reported by the lower layer and the S1 signalling connection exists, the MME shall retransmit the SECURITY MODE COMMAND message.

5.4.4 Identification procedure

5.4.4.1 General

The identification procedure is used by the network to request a particular UE to provide specific identification parameters, e.g. the International Mobile Subscriber Identity (IMSI) or the International Mobile Equipment Identity (IMEI). IMEI and IMSI definition and structure are specified in 3GPP TS 23.003 [2].

For mobile device supporting both 3GPP access and cdma2000® access a single IMEI is used to identify the device as specified in 3GPP TS 22.278 [1C].

5.4.4.2 Identification initiation by the network

The network initiates the identification procedure by sending an IDENTITY REQUEST message to the UE and starting the timer T3470 (see example in figure 5.4.4.2.1). The IDENTITY REQUEST message specifies the requested identification parameters in the Identity type information element.

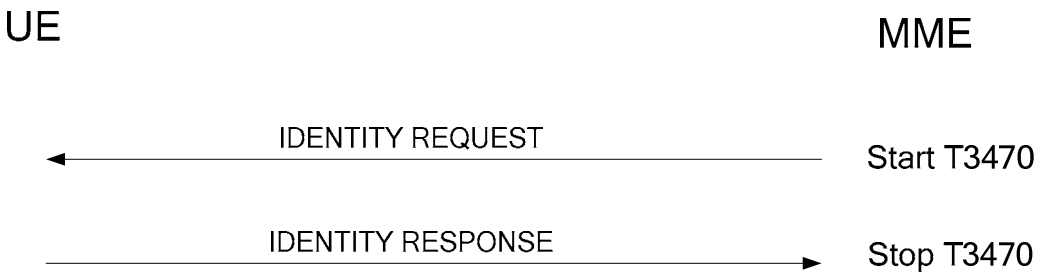


Figure 5.4.4.2.1: Identification procedure

5.4.4.3 Identification response by the UE

A UE shall be ready to respond to an IDENTITY REQUEST message at any time whilst in EMM-CONNECTED mode.

Upon receipt of the IDENTITY REQUEST message the UE shall send an IDENTITY RESPONSE message to the network. The IDENTITY RESPONSE message shall contain the identification parameters as requested by the network.

5.4.4.4 Identification completion by the network

Upon receipt of the IDENTITY RESPONSE the network shall stop the timer T3470.

5.4.4.5 Abnormal cases in the UE

The following abnormal cases can be identified:

a) Requested identity is not available

If the UE cannot encode the requested identity in the IDENTITY RESPONSE message, e.g. because no valid USIM is available, then it shall encode the identity type as "no identity".

b) Transmission failure of IDENTITY RESPONSE message indication from lower layers (if the identification procedure is triggered by a tracking area updating procedure)

The UE shall re-initiate the tracking area updating procedure.

5.4.4.6 Abnormal cases on the network side

The following abnormal cases can be identified:

a) Lower layer failure

Upon detection of a lower layer failure before the IDENTITY RESPONSE is received, the network shall abort any ongoing EMM procedure.

b) Expiry of timer T3470

The identification procedure is supervised by the network by the timer T3470. The network shall, on the first expiry of the timer T3470, retransmit the IDENTITY REQUEST message and reset and restart the timer T3470. This retransmission is repeated four times, i.e. on the fifth expiry of timer T3470, the network shall abort the identification procedure and any ongoing EMM procedure.

c) Collision of an identification procedure with an attach procedure

If the network receives an ATTACH REQUEST message before the ongoing identification procedure has been completed and no attach procedure is pending on the network (i.e. no ATTACH ACCEPT/REJECT message has still to be sent as an answer to an ATTACH REQUEST message), the network shall proceed with the attach procedure.

d) Collision of an identification procedure with an attach procedure when the identification procedure has been caused by an attach procedure

If the network receives an ATTACH REQUEST message before the ongoing identification procedure has been completed and an attach procedure is pending (i.e. an ATTACH ACCEPT/REJECT message has to be sent as an answer to an earlier ATTACH REQUEST message), then:

- If one or more of the information elements in the ATTACH REQUEST message differ from the ones received within the previous ATTACH REQUEST message, the network shall proceed with the new attach procedure; or
- If the information elements do not differ, then the network shall not treat any further this new ATTACH REQUEST.

e) Collision of an identification procedure with a UE initiated detach procedure

Detach containing cause "switch off" within the Detach type IE:

If the network receives a DETACH REQUEST message before the ongoing identification procedure has been completed, the network shall abort the identification procedure and shall progress the detach procedure.

Detach containing other causes than "switch off" within the Detach type IE:

If the network receives a DETACH REQUEST message before the ongoing identification procedure has been completed, the network shall complete the identification procedure and shall respond to the detach procedure as described in subclause 5.5.2.

f) Collision of an identification procedure with a tracking area updating procedure

If the network receives a TRACKING AREA UPDATE REQUEST message before the ongoing identification procedure has been completed, the network shall progress both procedures.

g) Collision of an identification procedure with a service request procedure

If the network receives an EXTENDED SERVICE REQUEST message for CS fallback or 1xCS fallback before the ongoing identification procedure has been completed, the network shall progress both procedures.

h) Lower layers indication of non-delivered NAS PDU due to handover

If the IDENTITY REQUEST message could not be delivered due to an intra MME handover and the target TA is included in the TAI list, then upon successful completion of the intra MME handover the MME shall retransmit the IDENTITY REQUEST message. If a failure of the handover procedure is reported by the lower layer and the S1 signalling connection exists, the MME shall retransmit the IDENTITY REQUEST message.

5.4.5 EMM information procedure

5.4.5.1 General

The purpose of sending the EMM INFORMATION message is to allow the network to provide information to the UE. The message implementation is optional in the network. The UE may use the received information if the UE supports implementing this message.

The EMM information procedure may be invoked by the network at any time during an established EMM context.

5.4.5.2 EMM information procedure initiation by the network

The EMM information procedure consists only of the EMM INFORMATION message sent from the network to the UE (see example in figure 5.4.5.2.1). During an established EMM context, the network may send none, one, or more EMM INFORMATION messages to the UE. If more than one EMM INFORMATION message is sent, the messages need not have the same content.

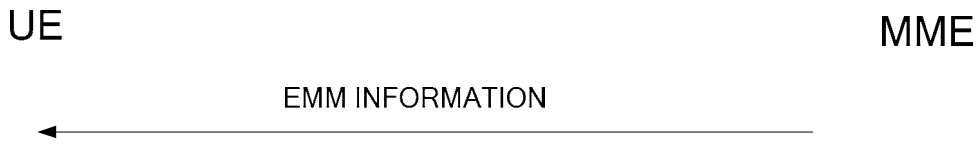


Figure 5.4.5.2.1: EMM information procedure

5.4.5.3 EMM information procedure in the UE

When the UE (supporting the EMM information message) receives an EMM INFORMATION message, it shall accept the message and optionally use the contents to update appropriate information stored within the UE.

If the UE does not support the EMM information message the UE shall ignore the contents of the message and return an EMM STATUS message with EMM cause #97 "message type non-existent or not implemented".

5.4.5.4 Abnormal cases on the network side

The following abnormal case can be identified:

a) Lower layers indication of non-delivered NAS PDU due to handover

If the EMM INFORMATION message could not be delivered due to an intra MME handover and the target TA is included in the TAI list, then upon successful completion of the intra MME handover the MME shall retransmit the EMM INFORMATION message. If a failure of the handover procedure is reported by the lower layer and the S1 signalling connection exists, the MME shall retransmit the EMM INFORMATION message.

5.5 EMM specific procedures

5.5.1 Attach procedure

5.5.1.1 General

The attach procedure is used to attach to an EPC for packet services in EPS.

The attach procedure is used for three purposes:

- by a UE in PS mode of operation to attach for EPS services only;
- by a UE in CS/PS mode 1 or CS/PS mode 2 of operation to attach for both EPS and non-EPS services;

- by a UE supporting NB-S1 mode only in PS mode of operation to attach for EPS services and "SMS only"; or
- to attach for emergency bearer services.

The lower layers indicate to NAS that the network does not support emergency bearer services for the UE in limited service state (3GPP TS 36.331 [22]). This information is taken into account when deciding whether to initiate attach for emergency bearer services in WB-S1 mode.

If the MME does not support an attach for emergency bearer services, the MME shall reject any request to attach with an attach type set to "EPS emergency attach".

With a successful attach procedure, a context is established for the UE in the MME. Furthermore, if the UE requested PDN connectivity, a default bearer is established between the UE and the PDN GW, thus enabling always-on IP connectivity to the UE. In WB-S1 mode, the network may also initiate the activation of dedicated bearers as part of the attach procedure. In NB-S1 mode the network shall not initiate the activation of dedicated bearers.

With a successful attach procedure in NB-S1 mode, a context is established for the UE in the MME. If the attach request included information to request PDN connectivity, a default bearer is also established between the UE and the PDN.

If EMM-REGISTERED without PDN connection is supported by the UE and the MME, a default bearer need not be requested by the UE during the attach procedure. If EMM-REGISTERED without PDN connection is not supported by the UE or the MME, then the UE shall request establishment of a default bearer.

During the attach procedure with default bearer establishment, the UE may also obtain the home agent IPv4 or IPv6 address or both.

In a shared network, the UE shall choose one of the PLMN identities as specified in 3GPP TS 23.122 [6]. The UE shall construct the TAI of the cell from this chosen PLMN identity and the TAC received for this PLMN identity as part of the broadcast system information. The chosen PLMN identity shall be indicated to the E-UTRAN (see 3GPP TS 36.331 [22]). Whenever an ATTACH REJECT message with the EMM cause #11 "PLMN not allowed" is received by the UE, the chosen PLMN identity shall be stored in the "forbidden PLMN list" and if the UE is configured to use timer T3245 (see 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17]) then the UE shall start timer T3245 and proceed as described in subclause 5.3.7a. Whenever an ATTACH REJECT message with the EMM cause #14 "EPS services not allowed in this PLMN" is received by the UE, the chosen PLMN identity shall be stored in the "forbidden PLMNs for GPRS service" and if the UE is configured to use timer T3245 (see 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17]) then the UE shall start timer T3245 and proceed as described in subclause 5.3.7a. Whenever an ATTACH REJECT message is received by the UE with the EMM cause #12 "tracking area not allowed", #13 "roaming not allowed in this tracking area", or #15 "no suitable cells in tracking area", the constructed TAI shall be stored in the suitable list.

An attach attempt counter is used to limit the number of subsequently rejected attach attempts. The attach attempt counter shall be incremented as specified in subclause 5.5.1.2.6. Depending on the value of the attach attempt counter, specific actions shall be performed. The attach attempt counter shall be reset when:

- the UE is powered on;
- a USIM is inserted;
- an attach or combined attach procedure is successfully completed;

NOTE: The attach procedure can be initiated in S1 or S101 mode as described in subclause 5.5.1.

- a GPRS attach or combined GPRS attach procedure is successfully completed in A/Gb or Iu mode;
- a combined attach procedure is completed for EPS services only with cause #2, #16, #17, #18 or #22;
- an attach or combined attach procedure is rejected with cause #11, #12, #13, #14, #15, #25 or #35:
- a network initiated detach procedure is completed with cause #11, #12, #13, #14, #15 or #25; or
- a new PLMN is selected.

Additionally the attach attempt counter shall be reset when the UE is in substate EMM-DEREGISTERED.ATTEMPTING-TO-ATTACH and:

- a new tracking area is entered;
- timer T3402 expires; or
- timer T3346 is started.

5.5.1.2 Attach procedure for EPS services

5.5.1.2.1 General

This procedure can be used by a UE to attach for:

- EPS services only; or
- EPS services and "SMS only" if the UE supports NB-S1 mode only.

When the UE initiates the attach procedure for normal service, the UE shall indicate "EPS attach" in the EPS attach type IE.

When the UE initiates the attach procedure for emergency bearer services, the UE shall indicate "EPS emergency attach" in the EPS attach type IE. The attach procedure for emergency bearer services is not applicable for NB-S1 mode (see 3GPP TS 23.401 [10]).

5.5.1.2.2 Attach procedure initiation

In state EMM-DEREGISTERED, the UE initiates the attach procedure by sending an ATTACH REQUEST message to the MME, starting timer T3410 and entering state EMM-REGISTERED-INITIATED (see example in figure 5.5.1.2.2.1). If timer T3402 is currently running, the UE shall stop timer T3402. If timer T3411 is currently running, the UE shall stop timer T3411.

The UE shall include the IMSI in the EPS mobile identity IE in the ATTACH REQUEST message if the selected PLMN is neither the registered PLMN nor in the list of equivalent PLMNs and:

a) the UE is configured for "AttachWithIMSI" as specified in 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17]; or

b) the UE is in NB-S1 mode.

For all other cases, the UE shall handle the EPS mobile identity IE in the ATTACH REQUEST message as follows:

If the UE supports neither A/Gb mode nor Iu mode:

a) the UE shall include in the ATTACH REQUEST message a valid GUTI together with the last visited registered TAI, if available. In addition, the UE shall include Old GUTI type IE with GUTI type set to "native GUTI". If there is no valid GUTI available, the UE shall include the IMSI in the ATTACH REQUEST message.

If the UE supports A/Gb mode or Iu mode or both:

a) if the TIN indicates "P-TMSI" and the UE holds a valid P-TMSI and RAI, the UE shall map the P-TMSI and RAI into the EPS mobile identity IE, and include Old GUTI type IE with GUTI type set to "mapped GUTI". If a P-TMSI signature is associated with the P-TMSI, the UE shall include it in the Old P-TMSI signature IE. Additionally, if the UE holds a valid GUTI, the UE shall indicate the GUTI in the Additional GUTI IE.

NOTE 1: The mapping of the P-TMSI and the RAI to the GUTI is specified in 3GPP TS 23.003 [2].

b) If the TIN indicates "GUTI" or "RAT-related TMSI" and the UE holds a valid GUTI, the UE shall indicate the GUTI in the EPS mobile identity IE, and include Old GUTI type IE with GUTI type set to "native GUTI".

c) If the TIN is deleted and

1) the UE holds a valid GUTI, the UE shall indicate the GUTI in the EPS mobile identity IE, and include Old GUTI type IE with GUTI type set to "native GUTI";

2) the UE does not hold a valid GUTI but holds a valid P-TMSI and RAI, the UE shall map the P-TMSI and RAI into the EPS mobile identity IE, and include Old GUTI type IE with GUTI type set to "mapped GUTI". If a P-TMSI signature is associated with the P-TMSI, the UE shall include it in the Old P-TMSI signature IE; or

3) the UE does not hold a valid GUTI, P-TMSI or RAI, the UE shall include the IMSI in the EPS mobile identity IE.

d) Otherwise the UE shall include the IMSI in the EPS mobile identity IE.

If the UE supports N1 mode:

a) if the UE is operating in the single-registration mode after an inter-system change in idle mode from N1 mode to S1 mode:

1) the UE shall map a valid 5G-GUTI into the EPS mobile identity IE, and include Old GUTI type IE with GUTI type set to "native GUTI" and UE status IE with a 5GMM registration status set to "UE is in 5GMM-REGISTERED state" if the UE holds a valid 5G-GUTI; or

2) the UE shall include the IMSI in the EPS mobile identity IE if the UE does not hold a valid 5G-GUTI;

b) if the UE is operating in the dual-registration mode:

1) the UE shall indicate the GUTI in the EPS mobile identity IE, and include Old GUTI type IE with GUTI type set to "native GUTI" if the UE holds a valid GUTI; or

2) the UE shall include the IMSI in the EPS mobility identity IE if the UE does not hold a valid GUTI; or

c) otherwise:

1) the UE shall indicate the GUTI in the EPS mobile identity IE and include Old GUTI type IE with GUTI type set to "native GUTI" if the UE holds a valid GUTI;

2) the UE shall map the 5G-GUTI into the EPS mobile identity IE, and include Old GUTI type IE with GUTI type set to "native GUTI" and UE status IE with a 5GMM registration status set to "UE is in 5GMM-DEREGISTERED state" if the UE does not hold a valid GUTI but holds a valid 5G-GUTI; or

3) the UE shall include the IMSI in the EPS mobile identity IE if the UE holds neither a valid GUTI nor a valid 5G-GUTI.

If the UE is operating in the dual-registration mode and it is in 5GMM state 5GMM-REGISTERED, the UE shall include the UE status IE with the 5GMM registration status set to "UE is in 5GMM-REGISTERED state".

If the UE is attaching for emergency bearer services and does not hold a valid GUTI, P-TMSI or IMSI as described above, the IMEI shall be included in the EPS mobile identity IE.

If the UE supports A/Gb mode or Iu mode or if the UE needs to indicate its UE specific DRX parameter to the network, the UE shall include the UE specific DRX parameter in the DRX parameter IE in the ATTACH REQUEST message.

NOTE 2: The UE specific DRX parameter is not used by the E-UTRAN for paging from NB-IoT cells (see 3GPP TS 23.401 [10] and 3GPP TS 36.304 [21]).

If the UE supports eDRX and requests the use of eDRX, the UE shall include the extended DRX parameters IE in the ATTACH REQUEST message.

If the UE supports SRVCC to GERAN/UTRAN, the UE shall set the SRVCC to GERAN/UTRAN capability bit to "SRVCC from UTRAN HSPA or E-UTRAN to GERAN/UTRAN supported".

If the UE supports vSRVCC from S1 mode to Iu mode, then the UE shall set the H.245 after handover capability bit to "H.245 after SRVCC handover capability supported" and additionally set the SRVCC to GERAN/UTRAN capability bit to "SRVCC from UTRAN HSPA or E-UTRAN to GERAN/UTRAN supported" in the ATTACH REQUEST message.

If the UE supports PSM and requests the use of PSM, then the UE shall include the T3324 value IE with a requested timer value in the ATTACH REQUEST message. When the UE includes the T3324 value IE and the UE indicates support for extended periodic timer value in the MS network feature support IE, it may also include the T3412 extended value IE to request a particular T3412 value to be allocated.

If the UE supports ProSe direct discovery, then the UE shall set the ProSe bit to "ProSe supported" and set the ProSe direct discovery bit to "ProSe direct discovery supported" in the UE network capability IE of the ATTACH REQUEST message.

If the UE supports ProSe direct communication, then the UE shall set the ProSe bit to "ProSe supported" and set the ProSe direct communication bit to "ProSe direct communication supported" in the UE network capability IE of the ATTACH REQUEST message.

If the UE supports acting as a ProSe UE-to-network relay, then the UE shall set the ProSe bit to "ProSe supported" and set the ProSe UE-to-network relay bit to "acting as a ProSe UE-to-network relay supported" in the UE network capability IE of the ATTACH REQUEST message.

If the UE supports NB-S1 mode, Non-IP PDN type, or N1 mode, then the UE shall support the extended protocol configuration options IE.

If the UE supports the extended protocol configuration options IE, then the UE shall set the ePCO bit to "extended protocol configuration options supported" in the UE network capability IE of the ATTACH REQUEST message.

If the UE supports the restriction on use of enhanced coverage, then the UE shall set the RestrictEC bit to "Restriction on use of enhanced coverage supported" in the UE network capability IE of the ATTACH REQUEST message.

If the UE supports the control plane data back-off timer T3448, the UE shall set the CP backoff bit to "back-off timer for transport of user data via the control plane supported" in the UE network capability IE of the ATTACH REQUEST message.

If the UE is in NB-S1 mode, then the UE shall set the control plane CIoT EPS optimization bit to "control plane CIoT EPS optimization supported" in the UE network capability IE of the ATTACH REQUEST message.

If the UE is in NB-S1 mode, supports NB-S1 mode only, and requests to attach for EPS services and "SMS only", the UE shall indicate the SMS only requested bit to "SMS only" in the additional update type IE and shall set the EPS attach type IE to "EPS attach" in the ATTACH REQUEST message.

If the UE supports CIoT EPS optimizations, it shall indicate in the UE network capability IE of the ATTACH REQUEST message whether it supports EMM-REGISTERED without PDN connection.

If the UE supports S1-U data transfer and multiple user plane radio bearers (see 3GPP TS 36.306 [44], 3GPP TS 36.331 [22]) in NB-S1 mode, then the UE shall set the Multiple DRB support bit to "Multiple DRB supported" in the UE network capability IE of the ATTACH REQUEST message.

If the UE supports V2X communication over PC5, then the UE shall set the V2X PC5 bit to "V2X communication over PC5 supported" in the UE network capability IE of the ATTACH REQUEST message.

If the UE supports service gap control, then the UE shall set the SGC bit to "service gap control supported" in the UE network capability IE of the ATTACH REQUEST message.

If the UE supports dual connectivity with New Radio (NR), then the UE shall set the DCNR bit to "dual connectivity with NR supported" in the UE network capability IE of the ATTACH REQUEST message and shall include the UE additional security capability IE in the ATTACH REQUEST message.

If the UE supports N1 mode, the UE shall set the N1mode bit to "N1 mode supported" in the UE network capability IE of the ATTACH REQUEST message.

If the UE supports signalling for a maximum number of 15 EPS bearer contexts, then the UE shall set the 15 bearers bit to "Signalling for a maximum number of 15 EPS bearer contexts supported" in the UE network capability IE of the ATTACH REQUEST message.

If the UE supports ciphered broadcast assistance data and needs to obtain new ciphering keys, the UE shall include the Additional information requested IE with the CipherKey bit set to "ciphering keys for ciphered broadcast assistance data requested" in the ATTACH REQUEST message.

If EMM-REGISTERED without PDN connection is not supported by the UE or the MME, or if the UE wants to request PDN connection with the attach procedure, the UE shall send the ATTACH REQUEST message together with a PDN CONNECTIVITY REQUEST message contained in the ESM message container IE.

If EMM-REGISTERED without PDN connection is supported by the UE and the MME, and the UE does not want to request PDN connection with the attach procedure, the UE shall send the ATTACH REQUEST message together with an ESM DUMMY MESSAGE contained in the ESM message container information element.

If a valid EPS security context exists, the UE shall integrity protect the ATTACH REQUEST message combined with the message included in the ESM message container IE. When the UE does not have a valid EPS security context, the

ATTACH REQUEST message combined with the message included in the ESM message container IE is not integrity protected.

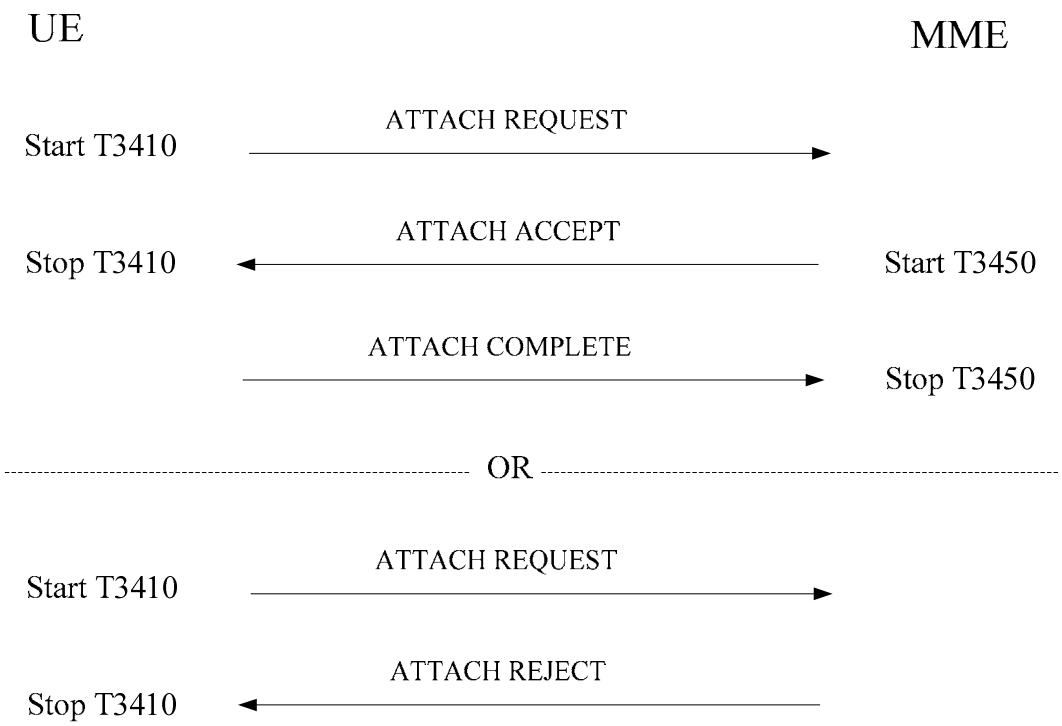


Figure 5.5.1.2.2.1: Attach procedure and combined attach procedure

5.5.1.2.3 EMM common procedure initiation

The network may initiate EMM common procedures, e.g. the identification, authentication and security mode control procedures during the attach procedure, depending on the information received in the ATTACH REQUEST message (e.g. IMSI, GUTI and KSI).

If the network receives an ATTACH REQUEST message containing the Old GUTI type IE and the EPS mobile identity IE with type of identity indicating "GUTI", and the network does not follow the use of the most significant bit of the <MME group id> as specified in 3GPP TS 23.003 [2], subclause 2.8.2.2.2, the network shall use the Old GUTI type IE to determine whether the mobile identity included in the EPS mobile identity IE is a native GUTI or a mapped GUTI.

During an attach for emergency bearer services, the MME may choose to skip the authentication procedure even if no EPS security context is available and proceed directly to the execution of the security mode control procedure as specified in subclause 5.4.3.

5.5.1.2.4 Attach accepted by the network

During an attach for emergency bearer services, if not restricted by local regulations, the MME shall not check for mobility and access restrictions, regional restrictions, subscription restrictions, or perform CSG access control when processing the ATTACH REQUEST message. The network shall not apply subscribed APN based congestion control during an attach procedure for emergency bearer services.

If the attach request is accepted by the network, the MME shall send an ATTACH ACCEPT message to the UE and start timer T3450.

If the attach request included the PDN CONNECTIVITY REQUEST message in the ESM message container information element to request PDN connectivity, the MME when accepting the attach request shall:

- send the ATTACH ACCEPT message together with an ESM DUMMY MESSAGE contained in the ESM message container information element and discard the ESM message container information element included in the attach request if:

- the UE indicated support of EMM-REGISTERED without PDN connection in the UE network capability IE of the ATTACH REQUEST message;
- the MME supports EMM-REGISTERED without PDN connection and PDN connection is restricted according to the user's subscription data;
- the attach type is not set to "EPS emergency attach"; and
- the request type of the UE requested PDN connection is not set to "emergency";

- otherwise, send the ATTACH ACCEPT message together with an ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message contained in the ESM message container information element to activate the default bearer (see subclause 6.4.1). In WB-S1 mode, the network may also initiate the activation of dedicated bearers towards the UE by invoking the dedicated EPS bearer context activation procedure (see subclause 6.4.2). In NB-S1 mode the network shall not initiate the activation of dedicated bearers.

If EMM-REGISTERED without PDN connection is supported by the UE and the MME, and the UE included an ESM DUMMY MESSAGE in the ESM message container information element of the ATTACH REQUEST message, the MME shall send the ATTACH ACCEPT message together with an ESM DUMMY MESSAGE contained in the ESM message container information element.

If the attach request is accepted by the network, the MME shall delete the stored UE radio capability information, if any.

In NB-S1 mode, if the attach request is accepted by the network, the MME shall set the EMC BS bit to zero in the EPS network feature support IE included in the ATTACH ACCEPT message to indicate that support of emergency bearer services in NB-S1 mode is not available.

If the UE has included the UE network capability IE or the MS network capability IE or both in the ATTACH REQUEST message, the MME shall store all octets received from the UE, up to the maximum length defined for the respective information element.

NOTE 1: This information is forwarded to the new MME during inter-MME handover or to the new SGSN during inter-system handover to A/Gb mode or Iu mode.

NOTE 2: For further details concerning the handling of the MS network capability and UE network capability in the MME see also 3GPP TS 23.401 [10].

If the UE specific DRX parameter was included in the DRX Parameter IE in the ATTACH REQUEST message, the MME shall replace any stored UE specific DRX parameter with the received parameter and use it for the downlink transfer of signalling and user data.

In NB-S1 mode, if the UE requested "SMS only" in the Additional update type IE, supports NB-S1 mode only and the MME decides to accept the attach request for EPS services and "SMS only", the MME shall indicate "SMS only" in the Additional update result IE and shall set the EPS attach result IE to "EPS only" in the ATTACH ACCEPT message.

The MME shall include the extended DRX parameters IE in the ATTACH ACCEPT message only if the extended DRX parameters IE was included in the ATTACH REQUEST message, and the MME supports and accepts the use of eDRX.

The MME shall assign and include the TAI list the UE is registered to in the ATTACH ACCEPT message. The MME shall not assign a TAI list containing both tracking areas in NB-S1 mode and tracking areas in WB-S1 mode. The UE, upon receiving an ATTACH ACCEPT message, shall delete its old TAI list and store the received TAI list.

NOTE 3: When assigning the TAI list, the MME can take into account the eNodeB's capability of support ofCIoT EPS optimiz ation.

The MME may include T3412 extended value IE in the ATTACH ACCEPT message only if the UE indicates support of the extended periodic timer T3412 in the MS network feature support IE in the ATTACH REQUEST message.

The MME shall include the T3324 value IE in the ATTACH ACCEPT message only if the T3324 value IE was included in the ATTACH REQUEST message, and the MME supports and accepts the use of PSM.

If the MME supports and accepts the use of PSM, and the UE included the T3412 extended value IE in the ATTACH REQUEST message, then the MME shall take into account the T3412 value requested when providing the T3412 value IE and the T3412 extended value IE in the ATTACH ACCEPT message.

NOTE 4: Besides the value requested by the UE, the MME can take local configuration or subscription data provided by the HSS into account when selecting a value for T3412 (3GPP TS 23.401 [10] subclause 4.3.17.3).

If the UE indicates support for EMM-REGISTERED without PDN connection in the ATTACH REQUEST message and the MME supports EMM-REGISTERED without PDN connection, the MME shall indicate support for EMM-REGISTERED without PDN connection in the EPS network feature support IE of the ATTACH ACCEPT message. The UE and the MME shall use the information whether the peer entity supports EMM-REGISTERED without PDN connection as specified in the present clause 5 and in clause 6.

If the UE requests "control plane CIoT EPS optimization" in the Additional update type IE, indicates support of control plane CIoT EPS optimization in the UE network capability IE and the MME decides to accept the requested CIoT EPS optimization and the attach request, the MME shall indicate "control plane CIoT EPS optimization supported" in the EPS network feature support IE.

If the MME supports NB-S1 mode, Non-IP PDN type, or inter-system change with 5GS, then the MME shall support the extended protocol configuration options IE.

If the MME supports the extended protocol configuration options IE and the UE indicated support of the extended protocol configuration options IE, then the MME shall set the ePCO bit to "extended protocol configuration options supported" in the EPS network feature support IE of the ATTACH ACCEPT message.

If the UE indicates support for restriction on use of enhanced coverage in the ATTACH REQUEST message, and the network decides to restrict the use of enhanced coverage for the UE, then the MME shall set the RestrictEC bit to "Use of enhanced coverage is restricted" in the EPS network feature support IE of the ATTACH ACCEPT message.

If the UE has indicated support for the control plane data back-off timer, and the MME decides to activate the congestion control for transport of user data via the control plane, then the MME shall include the T3448 value IE in the ATTACH ACCEPT message.

If the UE indicates support for dual connectivity with NR in the ATTACH REQUEST message, and the MME decides to restrict the use of dual connectivity with NR for the UE, then the MME shall set the RestrictDCNR bit to "Use of dual connectivity with NR is restricted" in the EPS network feature support IE of the ATTACH ACCEPT message.

If the UE indicates support for N1 mode in the ATTACH REQUEST message and the MME supports inter-system interworking with 5GS, the MME may set the IWK N26 bit to either:

- "interworking without N26 not supported" if the MME does not support interworking procedures without N26 interface; or
- "interworking without N26 supported" if the MME supports interworking procedures without N26 interface

in the EPS network feature support IE in the ATTACH ACCEPT message.

If the UE requests ciphering keys for ciphered broadcast assistance data in the ATTACH REQUEST message and the MME has valid ciphering key data applicable to the UE's subscription, then the MME shall include the ciphering key data in the Ciphering key data IE of the ATTACH ACCEPT message.

If due to operator policies unsecured redirection to a GERAN cell is not allowed in the current PLMN, the MME shall set the redir-policy bit to "Unsecured redirection to GERAN not allowed" in the Network policy IE of the ATTACH ACCEPT message.

The MME may include the T3447 value IE set to the service gap time value in the ATTACH ACCEPT message if:

- the UE has indicated support for service gap control; and
- a service gap time value is available in the EMM context.

If the network supports signalling for a maximum number of 15 EPS bearer contexts and the UE indicated support of signalling for a maximum number of 15 EPS bearer contexts in the ATTACH REQUEST message, then the MME shall set the 15 bearers bit to "Signalling for a maximum number of 15 EPS bearer contexts supported" in the EPS network feature support IE of the ATTACH ACCEPT message.

Upon receiving the ATTACH ACCEPT message, the UE shall stop timer T3410.

The GUTI reallocation may be part of the attach procedure. When the ATTACH REQUEST message includes the IMSI or IMEI, or the MME considers the GUTI provided by the UE is invalid, or the GUTI provided by the UE was assigned by another MME, the MME shall allocate a new GUTI to the UE. The MME shall include in the ATTACH ACCEPT message the new assigned GUTI together with the assigned TAI list. In this case the MME shall enter state EMM-COMMON-PROCEDURE-INITIATED as described in subclause 5.4.1.

For a shared network, the TAIs included in the TAI list can contain different PLMN identities. The MME indicates the selected core network operator PLMN identity to the UE in the GUTI (see 3GPP TS 23.251 [8B]).

If the ATTACH ACCEPT message contains a GUTI, the UE shall use this GUTI as the new temporary identity. The UE shall delete its old GUTI and store the new assigned GUTI. If no GUTI has been included by the MME in the ATTACH ACCEPT message, the old GUTI, if any available, shall be kept.

If A/Gb mode or Iu mode is supported in the UE, the UE shall set its TIN to "GUTI" when receiving the ATTACH ACCEPT message.

If the ATTACH ACCEPT message contains the T3412 extended value IE, then the UE shall use the value in T3412 extended value IE as periodic tracking area update timer (T3412). If the ATTACH ACCEPT message does not contain T3412 extended value IE, then the UE shall use the value in T3412 value IE as periodic tracking area update timer (T3412).

If the ATTACH ACCEPT message contains the T3324 value IE, then the UE shall use the included timer value for T3324 as specified in 3GPP TS 24.008 [13], subclause 4.7.2.8.

If the ATTACH ACCEPT message contains the DCN-ID IE, then the UE shall store the included DCN-ID value together with the PLMN code of the registered PLMN in a DCN-ID list in a non-volatile memory in the ME as specified in annex C.

The MME may also include a list of equivalent PLMNs in the ATTACH ACCEPT message. Each entry in the list contains a PLMN code (MCC+MNC). The UE shall store the list as provided by the network, and if the attach procedure is not for emergency bearer services, the UE shall remove from the list any PLMN code that is already in the list of "forbidden PLMNs" or in the list of "forbidden PLMNs for GPRS service". In addition, the UE shall add to the stored list the PLMN code of the registered PLMN that sent the list. The UE shall replace the stored list on each receipt of the ATTACH ACCEPT message. If the ATTACH ACCEPT message does not contain a list, then the UE shall delete the stored list.

If the attach procedure is not for emergency bearer services, and if the PLMN identity of the registered PLMN is a member of the list of "forbidden PLMNs" or the list of "forbidden PLMNs for GPRS service", any such PLMN identity shall be deleted from the corresponding list(s).

The network informs the UE about the support of specific features, such as IMS voice over PS session, location services (EPC-LCS, CS-LCS), emergency bearer services, or CIoT EPS optimizations, in the EPS network feature support information element. In a UE with IMS voice over PS capability, the IMS voice over PS session indicator and the emergency bearer services indicator shall be provided to the upper layers. The upper layers take the IMS voice over PS session indicator into account as specified in 3GPP TS 23.221 [8A], subclause 7.2a and subclause 7.2b, when selecting the access domain for voice sessions or calls. When initiating an emergency call, the upper layers also take both the IMS voice over PS session indicator and the emergency bearer services indicator into account for the access domain selection. In a UE with LCS capability, location services indicators (EPC-LCS, CS-LCS) shall be provided to the upper layers. When MO-LR procedure is triggered by the UE's application, those indicators are taken into account as specified in 3GPP TS 24.171 [13C].

If the RestrictDCNR bit is set to "Use of dual connectivity with NR is restricted" in the EPS network feature support IE of the ATTACH ACCEPT message, the UE shall provide the indication that dual connectivity with NR is restricted to the upper layers.

The UE supporting N1 mode shall operate in the mode for inter-system interworking with 5GS as follows:

- if the IWK N26 bit in the EPS network feature support IE is set to "interworking without N26 not supported", the UE shall operate in single-registration mode;

- if the IWK N26 bit in the EPS network feature support IE is set to "interworking without N26 supported" and the UE supports dual-registration mode, the UE may operate in dual-registration mode; or

NOTE: The registration mode used by the UE is implementation dependent.

- if the IWK N26 bit in the EPS network feature support IE is set to "interworking without N26 supported" and the UE only supports single-registration mode, the UE shall operate in single-registration mode.

The UE shall treat the indication on the support of interworking without N26 as valid in the entire PLMN and equivalent PLMNs. The interworking procedures required for coordination between 5GMM and EMM without N26 are specified in 3GPP TS 24.501 [54].

If the redir-policy bit is set to "Unsecured redirection to GERAN not allowed" in the Network policy IE of the ATTACH ACCEPT message, the UE shall set the network policy on unsecured redirection to GERAN for the current PLMN to "Unsecured redirection to GERAN not allowed" and indicate to the lower layers that unsecured redirection to a GERAN cell is not allowed. If the redir-policy bit is set to "Unsecured redirection to GERAN allowed" or if the Network policy IE is not included in the ATTACH ACCEPT message, the UE shall set the network policy for the current PLMN to "Unsecured redirection to GERAN allowed" and indicate to the lower layers that unsecured redirection to a GERAN cell is allowed. The UE shall set the network policy on unsecured redirection to GERAN to "Unsecured redirection to GERAN not allowed" and indicate this to the lower layers when any of the following events occurs:

- the UE initiates an EPS attach or tracking area updating procedure in a PLMN different from the PLMN where the UE performed the last successful EPS attach or tracking area updating procedure;

- the UE is switched on; or

- the UICC containing the USIM is removed.

If the UE has initiated the attach procedure due to manual CSG selection and receives an ATTACH ACCEPT message; and the UE sent the ATTACH REQUEST message in a CSG cell, the UE shall check if the CSG ID and associated PLMN identity of the cell are contained in the Allowed CSG list. If not, the UE shall add that CSG ID and associated PLMN identity to the Allowed CSG list and the UE may add the HNB Name (if provided by lower layers) to the Allowed CSG list if the HNB Name is present in neither the Operator CSG list nor the Allowed CSG list.

When the UE receives the ATTACH ACCEPT message combined with the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message, and if the UE has requested PDN connectivity the UE shall forward the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message to the ESM sublayer. Upon receipt of an indication from the ESM sublayer that the default EPS bearer context has been activated, the UE shall send an ATTACH COMPLETE message together with an ACTIVATE DEFAULT EPS BEARER CONTEXT ACCEPT message contained in the ESM message container information element to the network.

Additionally, the UE shall reset the attach attempt counter, service request attempt counter and tracking area updating attempt counter, enter state EMM-REGISTERED and set the EPS update status to EU1 UPDATED.

If EMM-REGISTERED without PDN connection is supported by the UE and the MME, and the UE receives the ATTACH ACCEPT message combined with an ESM DUMMY MESSAGE, the UE shall send an ATTACH COMPLETE message together with an ESM DUMMY MESSAGE contained in the ESM message container information element to the network.

If the UE receives the ATTACH ACCEPT message from a PLMN for which a PLMN-specific attempt counter or PLMN-specific PS-attempt counter is maintained (see subclause 5.3.7b), then the UE shall reset these counters. If the UE maintains a counter for "SIM/USIM considered invalid for GPRS services", then the UE shall reset this counter.

When the UE receives any ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST messages during the attach procedure, and if the UE has requested PDN connectivity the UE shall forward the ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST message(s) to the ESM sublayer. The UE shall send a response to the ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST message(s) after successful completion of the attach procedure.

If the attach procedure was initiated in S101 mode, the lower layers are informed about the successful completion of the procedure.

Upon receiving an ATTACH COMPLETE message, the MME shall stop timer T3450, enter state EMM-REGISTERED and consider the GUTI sent in the ATTACH ACCEPT message as valid.

If the T3448 value IE is present in the received ATTACH ACCEPT message, the UE shall:

- stop timer T3448 if it is running; and

- start timer T3448 with the value provided in the T3448 value IE.

If the UE is using EPS services with control plane CIoT EPS optimization, the T3448 value IE is present in the ATTACH ACCEPT message and the value indicates that this timer is either zero or deactivated, the UE shall consider this case as an abnormal case and proceed as if the T3448 value IE is not present.

If the UE has indicated "service gap control supported" in the ATTACH REQUEST message and:

- the ATTACH ACCEPT message contains the T3447 value IE, then the UE shall store the new T3447 value, erase any previous stored T3447 value if exists and use the the new T3447 value with the T3447 timer next time it is started; or

- the ATTACH ACCEPT message does not contain the T3447 value IE, then the UE shall erase any previous stored T3447 value if exists and stop the T3447 timer if running.

5.5.1.2.4A Attach successful for EPS services and not accepted for SMS services

Apart from the actions on the tracking area updating attempt counter, the description for attach for EPS services as specified in subclause 5.5.1.2.4 shall be followed. In addition, the following description for attach for SMS services applies.

In NB-S1 mode, if the UE requested "SMS only" in the Additional update type IE and supports NB-S1 mode only, the MME decides to accept the attach request for EPS services only and:

- the location update for non-EPS services is not accepted by the VLR as specified in 3GPP TS 29.118 [16A]; or

- the MME decides to not accept the attach request for "SMS only",

the MME shall set the EPS attach result IE to "EPS only", shall not indicate "SMS only" in the Additional update result IE in the ATTACH ACCEPT message and shall include an appropriate SMS services status value.

The UE receiving the ATTACH ACCEPT message takes one of the following actions depending on the value included in the SMS services status IE:

"SMS services not available"

The UE shall stop timer T3410 if still running, shall reset the tracking area updating attempt counter, shall set the EPS update status to EU1 UPDATED and shall enter state EMM-REGISTERED.NORMAL-SERVICE. The USIM shall be considered as invalid for SMS services until switching off or the UICC containing the USIM is removed or the timer T3245 expires as described in subclause 5.3.7a.

"SMS services not available in this PLMN"

The UE shall stop timer T3410 if still running, shall reset the tracking area updating attempt counter, shall set the EPS update status to EU1 UPDATED and shall enter state EMM-REGISTERED.NORMAL-SERVICE.

The UE may provide a notification to the user or the upper layers that the SMS services are not available.

The UE shall not attempt normal attach or tracking area update procedure indicating "SMS only" with current PLMN until switching off the UE or the UICC containing the USIM is removed. Additionally, the UE may perform a PLMN selection according to 3GPP TS 23.122 [6].

"Network failure"

The UE shall stop timer T3410 if still running. The tracking area updating attempt counter shall be incremented, unless it was already set to 5.

If the tracking area updating attempt counter is less than 5:

- the UE shall start timer T3411, shall set the EPS update status to EU1 UPDATED and shall enter state EMM-REGISTERED.NORMAL-SERVICE. When timer T3411 expires the normal tracking area updating procedure for EPS services and "SMS only" or the combined tracking area updating procedure for EPS services and "SMS only" is triggered.

If the tracking area updating attempt counter is equal to 5:

- the UE shall start timer T3402, shall set the EPS update status to EU1 UPDATED and shall enter state EMM-REGISTERED.NORMAL-SERVICE. When timer T3402 expires the normal tracking area updating procedure for EPS services and "SMS only" or the combined tracking area updating procedure for EPS services and "SMS only" is triggered.

"Congestion"

The UE shall stop the timer T3410 if still running. The tracking area updating attempt counter shall be set to 5. The UE shall start the timer T3402, shall set the EPS update status to EU1 UPDATED, and shall enter state EMM-REGISTERED.NORMAL-SERVICE. When timer T3402 expires the normal tracking area updating procedure for EPS services and "SMS only" or the combined tracking area updating procedure for EPS services and "SMS only" is triggered.

Other values and the case that no SMS services status IE was received are considered as abnormal cases. The attach procedure shall be considered as failed for SMS services. The behaviour of the UE in those cases is specified in subclause 5.5.1.2.6A.

5.5.1.2.5 Attach not accepted by the network

If the attach request cannot be accepted by the network, the MME shall send an ATTACH REJECT message to the UE including an appropriate EMM cause value.

If EMM-REGISTERED without PDN connection is not supported by the UE or the MME, the attach request included a PDN CONNECTIVITY REQUEST message, the attach procedure fails due to:

- a default EPS bearer setup failure;
- an ESM procedure failure; or
- operator determined barring is applied on default EPS bearer context activation during attach procedure,

the MME shall:

- combine the ATTACH REJECT message with a PDN CONNECTIVITY REJECT message contained in the ESM message container information element. In this case the EMM cause value in the ATTACH REJECT message shall be set to #19 "ESM failure"; or
- send the ATTACH REJECT message with the EMM cause set to #15 "No suitable cells in tracking area", if the PDN connectivity reject is due to ESM cause #29 subject to operator policies (see 3GPP TS 29.274 [16D] for further details). In this case, the network may additionally include the Extended EMM cause IE with value "E-UTRAN not allowed".

If the attach request is rejected due to NAS level mobility management congestion control, the network shall set the EMM cause value to #22 "congestion" and assign a back-off timer T3346.

If the attach request is rejected due to service gap control as specified in subclause 5.3.17 i.e. the T3447 timer is running, the network shall set the EMM cause value to #22 "congestion" and may assign a back-off timer T3346 with the remaining time of the running T3447 timer.

If the attach request is rejected due to incompatibility between the CIoT EPS optimizations supported by the UE and what the network supports and the network sets the EMM cause value to #15 "no suitable cells in tracking area", the network may additionally include the Extended EMM cause IE with value "requested EPS optimization not supported".

NOTE 1: How the UE uses the Extended EMM cause IE with value "requested EPS optimization not supported" is implementation specific. The UE still behaves according to the EMM cause value #15.

Upon receiving the ATTACH REJECT message, if the message is integrity protected or contains a reject cause other than EMM cause value #25, the UE shall stop timer T3410.

If the ATTACH REJECT message with EMM cause #25 was received without integrity protection, then the UE shall discard the message.

The UE shall take the following actions depending on the EMM cause value received in the ATTACH REJECT message.

#3 (Illegal UE);

#6 (Illegal ME); or

#8 (EPS services and non-EPS services not allowed);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and eKSI. The UE shall consider the USIM as invalid for EPS services and non-EPS services until switching off or the UICC containing the USIM is removed or the timer T3245 expires as described in subclause 5.3.7a. Additionally, the UE shall delete the list of equivalent PLMNs and enter state EMM-DEREGISTERED. If the message has been successfully integrity checked by the NAS and the UE maintains a counter for "SIM/USIM considered invalid for GPRS services", then the UE shall set this counter to UE implementation-specific maximum value. If the message has been successfully integrity checked by the NAS and the UE maintains a counter for "SIM/USIM considered invalid for non-GPRS services", then the UE shall set this counter to UE implementation-specific maximum value.

If A/Gb mode or Iu mode is supported by the UE, the UE shall in addition handle the MM parameters update status, TMSI, LAI and ciphering key sequence number, and the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI and GPRS ciphering key sequence number as specified in 3GPP TS 24.008 [13] for the case when the normal attach procedure is rejected with the GMM cause with the same value.

NOTE 2: The possibility to configure a UE so that the radio transceiver for a specific RAT is not active, although it is implemented in the UE, is out of scope of the present specification.

#7 (EPS services not allowed);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and eKSI. The UE shall consider the USIM as invalid for EPS services until switching off or the UICC containing the USIM is removed or the timer T3245 expires as described in subclause 5.3.7a. Additionally, the UE shall delete the list of equivalent PLMNs and enter state EMM-DEREGISTERED. If the message has been successfully integrity checked by the NAS and the UE maintains a counter for "SIM/USIM considered invalid for GPRS services", then the UE shall set this counter to UE implementation-specific maximum value.

If A/Gb mode or Iu mode is supported by the UE, the UE shall in addition handle the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI and GPRS ciphering key sequence number as specified in 3GPP TS 24.008 [13] for the case when the normal attach procedure is rejected with the GMM cause with the same value.

#11 (PLMN not allowed); or

#35 (Requested service option not authorized in this PLMN);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and eKSI. Additionally, the UE shall delete the list of equivalent PLMNs and reset the attach attempt counter.

In S1 mode, the UE shall store the PLMN identity in the "forbidden PLMN list" and enter state EMM-DEREGISTERED.PLMN-SEARCH and if the UE is configured to use timer T3245 (see 3GPP TS 24.368 [15] or 3GPP TS 31.102 [17]) then the UE shall start timer T3245 and proceed as described in subclause 5.3.7a. The UE shall perform a PLMN selection according to 3GPP TS 23.122 [6]. If the message has been successfully integrity checked by the NAS and the UE maintains a PLMN-specific attempt counter for that PLMN, then the UE shall set this counter to the UE implementation-specific maximum value.

In S101 mode, the UE shall store the PLMN identity provided with the indication from the lower layers to prepare for an S101 mode to S1 mode handover in the list of "forbidden PLMNs for attach in S101 mode" and enter the state EMM-DEREGISTERED.NO-CELL-AVAILABLE and if the UE is configured to use timer T3245 (see 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17]) then the UE shall start timer T3245 and proceed as described in subclause 5.3.7a.

If A/Gb mode or Iu mode is supported by the UE, the UE shall in addition handle the MM parameters update status, TMSI, LAI, ciphering key sequence number and location update attempt counter, and the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI, GPRS ciphering key sequence

number and GPRS attach attempt counter as specified in 3GPP TS 24.008 [13] for the case when the normal attach procedure is rejected with the GMM cause with the same value and no RR connection exists.

#12 (Tracking area not allowed);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and eKSI. Additionally, the UE shall reset the attach attempt counter.

In S1 mode, the UE shall store the current TAI in the list of "forbidden tracking areas for regional provision of service" and enter the state EMM-DEREGISTERED.LIMITED-SERVICE.

In S101 mode, the UE shall store the PLMN identity provided with the indication from the lower layers to prepare for an S101 mode to S1 mode handover in the list of "forbidden PLMNs for attach in S101 mode" and enter the state EMM-DEREGISTERED.NO-CELL-AVAILABLE and if the UE is configured to use timer T3245 (see 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17]) then the UE shall start timer T3245 and proceed as described in subclause 5.3.7a.

If A/Gb mode or Iu mode is supported by the UE, the UE shall in addition handle the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI, GPRS ciphering key sequence number and GPRS attach attempt counter as specified in 3GPP TS 24.008 [13] for the case when the normal attach procedure is rejected with the GMM cause with the same value.

#13 (Roaming not allowed in this tracking area);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and eKSI. The UE shall delete the list of equivalent PLMNs and reset the attach attempt counter.

In S1 mode, the UE shall store the current TAI in the list of "forbidden tracking areas for roaming". Additionally, the UE shall enter the state EMM-DEREGISTERED.LIMITED-SERVICE or optionally EMM-DEREGISTERED.PLMN-SEARCH. The UE shall perform a PLMN selection according to 3GPP TS 23.122 [6].

In S101 mode, the UE shall store the PLMN identity provided with the indication from the lower layers to prepare for an S101 mode to S1 mode handover in the list of "forbidden PLMNs for attach in S101 mode" and enter the state EMM-DEREGISTERED.NO-CELL-AVAILABLE and if the UE is configured to use timer T3245 (see 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17]) then the UE shall start timer T3245 and proceed as described in subclause 5.3.7a.

If A/Gb mode or Iu mode is supported by the UE, the UE shall in addition handle the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI, GPRS ciphering key sequence number and GPRS attach attempt counter as specified in 3GPP TS 24.008 [13] for the case when the normal attach procedure is rejected with the GMM cause with the same value.

#14 (EPS services not allowed in this PLMN);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and eKSI. Additionally, the UE shall delete the list of equivalent PLMNs and reset the attach attempt counter.

In S1 mode, the UE shall store the PLMN identity in the "forbidden PLMNs for GPRS service" list. Additionally, the UE shall enter state EMM-DEREGISTERED.PLMN-SEARCH and if the UE is configured to use timer T3245 (see 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17]) then the UE shall start timer T3245 and proceed as described in subclause 5.3.7a. The UE shall perform a PLMN selection according to 3GPP TS 23.122 [6]. If the message has been successfully integrity checked by the NAS and the UE maintains a PLMN-specific PS-attempt counter for that PLMN, then the UE shall set this counter to the UE implementation-specific maximum value.

In S101 mode, the UE shall store the PLMN identity provided with the indication from the lower layers to prepare for an S101 mode to S1 mode handover in the list of "forbidden PLMNs for attach in S101 mode" and enter the state EMM-DEREGISTERED.NO-CELL-AVAILABLE and if the UE is configured to use timer T3245 (see 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17]) then the UE shall start timer T3245 and proceed as described in subclause 5.3.7a.

If A/Gb mode or Iu mode is supported by the UE, the UE shall in addition handle the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI, GPRS ciphering key sequence number and GPRS attach attempt counter as specified in 3GPP TS 24.008 [13] for the case when the normal attach procedure is rejected with the GMM cause with the same value.

#15 (No suitable cells in tracking area);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and eKSI. Additionally, the UE shall reset the attach attempt counter.

The UE shall store the current TAI in the list of "forbidden tracking areas for roaming" and enter the state EMM-DEREGISTERED.LIMITED-SERVICE and:

- if the UE is in S1 mode and the Extended EMM cause IE with value "E-UTRAN not allowed" is included in the ATTACH REJECT message, the UE supports "E-UTRA Disabling for EMM cause #15", and the "E-UTRA Disabling Allowed for EMM cause #15" parameter as specified in 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17] is present and set to enabled; then the UE shall disable the E-UTRA capability as specified in subclause 4.5 and search for a suitable cell in GERAN or UTRAN radio access technology;

- if the UE is in NB-S1 mode and the Extended EMM cause IE with value "NB-IoT not allowed" is included in the ATTACH REJECT message, then the UE may disable the NB-IoT capability as specified in subclause 4.X and search for a suitable cell in E-UTRAN radio access technology;

- otherwise, the UE shall search for a suitable cell in another tracking area or in another location area according to 3GPP TS 36.304 [21].

In S101 mode, the UE shall store the PLMN identity provided with the indication from the lower layers to prepare for an S101 mode to S1 mode handover in the list of "forbidden PLMNs for attach in S101 mode" and enter the state EMM-DEREGISTERED.NO-CELL-AVAILABLE and if the UE is configured to use timer T3245 (see 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17]) then the UE shall start timer T3245 and proceed as described in subclause 5.3.7a.

If A/Gb mode or Iu mode is supported by the UE, the UE shall in addition handle the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI, GPRS ciphering key sequence number and GPRS attach attempt counter as specified in 3GPP TS 24.008 [13] for the case when the normal attach procedure is rejected with the GMM cause with the same value.

#22 (Congestion);

If the T3346 value IE is present in the ATTACH REJECT message and the value indicates that this timer is neither zero nor deactivated, the UE shall proceed as described below; otherwise it shall be considered as an abnormal case and the behaviour of the UE for this case is specified in subclause 5.5.1.2.6.

The UE shall abort the attach procedure, reset the attach attempt counter, set the EPS update status to EU2 NOT UPDATED and enter state EMM-DEREGISTERED.ATTEMPTING-TO-ATTACH.

The UE shall stop timer T3346 if it is running.

If the ATTACH REJECT message is integrity protected, the UE shall start timer T3346 with the value provided in the T3346 value IE.

If the ATTACH REJECT message is not integrity protected, the UE shall start timer T3346 with a random value from the default range specified in 3GPP TS 24.008 [13].

The UE stays in the current serving cell and applies the normal cell reselection process. The attach procedure is started if still needed when timer T3346 expires or is stopped.

If A/Gb mode or Iu mode is supported by the UE, the UE shall in addition handle the GMM parameters GMM state, GPRS update status and GPRS attach attempt counter as specified in 3GPP TS 24.008 [13] for the case when the normal attach procedure is rejected with the GMM cause with the same value.

#25 (Not authorized for this CSG);

EMM cause #25 is only applicable when received from a CSG cell. EMM cause #25 received from a non-CSG cell is considered as an abnormal case and the behaviour of the UE is specified in subclause 5.5.1.2.6.

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and store it according to subclause 5.1.3.3). Additionally, the UE shall reset the attach attempt counter and shall enter the state EMM-DEREGISTERED.LIMITED-SERVICE.

If the CSG ID and associated PLMN identity of the cell where the UE has sent the ATTACH REQUEST message are contained in the Allowed CSG list, the UE shall remove the entry corresponding to this CSG ID and associated PLMN identity from the Allowed CSG list.

If the CSG ID and associated PLMN identity of the cell where the UE has sent the ATTACH REQUEST message are contained in the Operator CSG list, the UE shall apply the procedures defined in 3GPP TS 23.122 [6] subclause 3.1A.

The UE shall search for a suitable cell according to 3GPP TS 36.304 [21].

If A/Gb mode or Iu mode is supported by the UE, the UE shall in addition handle the GMM parameters GMM state, GPRS update status and GPRS attach attempt counter as specified in 3GPP TS 24.008 [13] for the case when the normal attach procedure is rejected with the GMM cause with the same value.

#42 (Severe network failure);

The UE shall set the EPS update status to EU2 NOT UPDATED, and shall delete any GUTI, last visited registered TAI, TAI list, eKSI, and list of equivalent PLMNs, and set the attach attempt counter to 5. The UE shall start an implementation specific timer setting its value to 2 times the value of T as defined in 3GPP TS 23.122 [6]. While this timer is running, the UE shall not consider the PLMN + RAT combination that provided this reject cause a candidate for PLMN selection. The UE then enters state EMM-DEREGISTERED.PLMN-SEARCH in order to perform a PLMN selection according to 3GPP TS 23.122 [6].

If A/Gb mode or Iu mode is supported by the UE, the UE shall in addition set the GMM state to GMM-DEREGISTERED, GPRS update status to GU2 NOT UPDATED, and shall delete the P-TMSI, P-TMSI signature, RAI and GPRS ciphering key sequence number.

Other values are considered as abnormal cases. The behaviour of the UE in those cases is specified in subclause 5.5.1.2.6.

5.5.1.2.5A Attach for emergency bearer services not accepted by the network

If the attach request for emergency bearer services cannot be accepted by the network, the MME shall send an ATTACH REJECT message to the UE including EMM cause #5 "IMEI not accepted" or one of the EMM cause values as described in subclause 5.5.1.2.5.

NOTE 1: If EMM cause #11 is sent to a UE of a roaming subscriber attaching for emergency bearer services and the UE is in automatic network selection mode, it cannot obtain normal service provided by this PLMN.

Upon receiving the ATTACH REJECT message including EMM cause #5, the UE shall enter the state EMM-DEREGISTERED.NO-IMSI.

Upon receiving the ATTACH REJECT message including one of the other EMM cause values, the UE shall perform the actions as described in subclause 5.5.1.2.5 with the following addition: the UE shall inform the upper layers of the failure of the procedure.

NOTE 2: This can result in the upper layers requesting establishment of a CS emergency call (if not already attempted in the CS domain), or other implementation specific mechanisms, e.g. procedures specified in 3GPP TS 24.229 [13D] can result in the emergency call being attempted to another IP-CAN.

If the attach request for emergency bearer services fails due to abnormal case a) in subclause 5.5.1.2.6, the UE shall perform the actions as described in subclause 5.5.1.2.6 and inform the upper layers of the failure to access the network.

NOTE 3: This can result in the upper layers requesting establishment of a CS emergency call (if not already attempted in the CS domain), or other implementation specific mechanisms, e.g. procedures specified in 3GPP TS 24.229 [13D] can result in the emergency call being attempted to another IP-CAN .

If the attach request for emergency bearer services fails due to abnormal cases b), c) or d) in subclause 5.5.1.2.6, the UE shall perform the actions as described in subclause 5.5.1.2.6 with the following addition: the UE shall inform the upper layers of the failure of the procedure.

NOTE 4: This can result in the upper layers requesting establishment of a CS emergency call (if not already attempted in the CS domain), or other implementation specific mechanisms, e.g. procedures specified in 3GPP TS 24.229 [13D] can result in the emergency call being attempted to another IP-CAN .

In a shared network, upon receiving the ATTACH REJECT message, the UE shall perform the actions as described in subclause 5.5.1.2.5, and shall:

a) inform the upper layers of the failure of the procedure; or

NOTE 5: This can result in the upper layers requesting establishment of a CS emergency call (if not already attempted in the CS domain), or other implementation specific mechanisms, e.g. procedures specified in 3GPP TS 24.229 [13D] can result in the emergency call being attempted to another IP-CAN .

b) attempt the attach for emergency bearer services to another PLMN in the shared network.

In a shared network, if the attach request for emergency bearer services fails due to abnormal case a) in subclause 5.5.1.2.6, the UE shall perform the actions as described in subclause 5.5.1.2.6 and shall:

a) inform the upper layers of the failure to access the network; or

NOTE 6: This can result in the upper layers requesting establishment of a CS emergency call (if not already attempted in the CS domain), or other implementation specific mechanisms, e.g. procedures specified in 3GPP TS 24.229 [13D] can result in the emergency call being attempted to another IP-CAN .

b) attempt the attach for emergency bearer services to another PLMN in the shared network.

In a shared network, if the attach request for emergency bearer services fails due to abnormal cases b), c) or d) in subclause 5.5.1.2.6, the UE shall perform the actions as described in subclause 5.5.1.2.6, and shall:

a) inform the upper layers of the failure of the procedure; or

NOTE 7: This can result in the upper layers requesting establishment of a CS emergency call (if not already attempted in the CS domain), or other implementation specific mechanisms, e.g. procedures specified in 3GPP TS 24.229 [13D] can result in the emergency call being attempted to another IP-CAN .

b) attempt the attach for emergency bearer services to another PLMN in the shared network.

5.5.1.2.5B Attach for initiating a PDN connection for emergency bearer services not accepted by the network

If the network cannot accept attach request for initiating a PDN connection for emergency bearer services with attach type not set to "EPS emergency attach", the UE shall perform the procedures as described in subclause 5.5.1.2.5. Then if the UE is in the same selected PLMN where the last attach request was attempted, the UE shall:

a) inform the upper layers of the failure of the procedure; or

NOTE 1: This can result in the upper layers requesting establishment of a CS emergency call (if not already attempted in the CS domain) or other implementation specific mechanisms, e.g. procedures specified in 3GPP TS 24.229 [13D] can result in the emergency call being attempted to another IP-CAN.

b) attempt EPS attach for emergency bearer services.

If the attach request for initiating a PDN connection for emergency bearer services with attach type not set to "EPS emergency attach" fails due to abnormal case a) in subclause 5.5.1.2.6, the UE shall perform the actions as described in subclause 5.5.1.2.6 and inform the upper layers of the failure to access the network.

NOTE 2: This can result in the upper layers requesting establishment of a CS emergency call (if not already attempted in the CS domain) or other implementation specific mechanisms, e.g. procedures specified in 3GPP TS 24.229 [13D] can result in the emergency call being attempted to another IP-CAN.

If the attach request for initiating a PDN connection for emergency bearer services with attach type not set to "EPS emergency attach" fails due to abnormal cases b), c) or d) in subclause 5.5.1.2.6, the UE shall perform the procedures as described in subclause 5.5.1.2.6. Then if the UE is in the same selected PLMN where the last attach request was attempted, the UE shall:

a) inform the upper layers of the failure of the procedure; or

NOTE 3: This can result in the upper layers requesting establishment of a CS emergency call (if not already attempted in the CS domain) or other implementation specific mechanisms, e.g. procedures specified in 3GPP TS 24.229 [13D] can result in the emergency call being attempted to another IP-CAN.

b) attempt EPS attach for emergency bearer services.

5.5.1.2.6 Abnormal cases in the UE

The following abnormal cases can be identified:

a) Access barred because of access class barring, EAB, ACDC or NAS signalling connection establishment rejected by the network without "Extended wait time" received from lower layers

In WB-S1 mode, if access is barred for "originating signalling" (see 3GPP TS 36.331 [22]), the attach procedure shall not be started. The UE stays in the current serving cell and applies the normal cell reselection process. The attach procedure is started as soon as possible, i.e. when access for "originating signalling" is granted on the current cell or when the UE moves to a cell where access for "originating signalling" is granted.

In NB-S1 mode, if access is barred for "originating signalling" (see 3GPP TS 36.331 [22]), the attach procedure shall not be started. The UE stays in the current serving cell and applies the normal cell reselection process. Further UE behaviour is implementation specific, e.g. the attach procedure is started again after an implementation dependent time.

In NB-S1 mode, if access is barred for "originating signalling" (see 3GPP TS 36.331 [22]), a request for an exceptional event is received from the upper layers, then the attach procedure shall be started.

NOTE 1: In NB-S1 mode, the EMM layer cannot receive the access barring alleviation indication from the lower layers (see 3GPP TS 36.331 [22]).

If access is barred because of access class barring for "originating signalling" (see 3GPP TS 36.331 [22]), ACDC is applicable to the request from the upper layers and the UE supports ACDC, then the attach procedure shall be started.

If access is barred for a certain ACDC category (see 3GPP TS 36.331 [22]), a request with a higher ACDC category is received from the upper layers and the UE supports ACDC, then the attach procedure shall be started.

If an access request for an uncategorized application is barred due to ACDC (see 3GPP TS 36.331 [22]), a request with a certain ACDC category is received from the upper layers and the UE supports ACDC, then the attach procedure shall be started.

b) Lower layer failure or release of the NAS signalling connection without "Extended wait time" and without "Extended wait time CP data" received from lower layers before the ATTACH ACCEPT or ATTACH REJECT message is received

The attach procedure shall be aborted, and the UE shall proceed as described below.

c) T3410 timeout

The UE shall abort the attach procedure and proceed as described below. The NAS signalling connection, if any, shall be released locally.

NOTE 2: The NAS signalling connection can also be released if the UE deems that the network has failed the authentication check as specified in subclause 5.4.2.7.

d) ATTACH REJECT, other EMM cause values than those treated in subclause 5.5.1.2.5, and cases of EMM cause values #22 and #25, if considered as abnormal cases according to subclause 5.5.1.2.5

Upon reception of the EMM cause #19 "ESM failure", if the UE is not configured for NAS signalling low priority and the ESM cause value received in the PDN CONNECTIVITY REJECT message is not #54 "PDN connection does not exist", the UE may set the attach attempt counter to 5. Subsequently, if the UE needs to retransmit the ATTACH REQUEST message to request PDN connectivity towards a different APN, the UE may stop T3411 or T3402, if running, and send the ATTACH REQUEST message.

NOTE 3: When receiving EMM cause #19 "ESM failure", coordination is required between the EMM and ESM sublayers in the UE to determine whether to set the attach attempt counter to 5.

If the attach request is neither for emergency bearer services nor for initiating a PDN connection for emergency bearer services with attach type not set to "EPS emergency attach", upon reception of the EMM causes #95, #96, #97, #99 and #111 the UE should set the attach attempt counter to 5.

The UE shall proceed as described below.

e) Change of cell into a new tracking area

If a cell change into a new tracking area occurs before the attach procedure is completed, the attach procedure shall be aborted and re-initiated immediately. If a tracking area border is crossed when the ATTACH ACCEPT message has been received but before an ATTACH COMPLETE message is sent, the attach procedure shall be re-initiated. If a GUTI was allocated during the attach procedure, this GUTI shall be used in the attach procedure.

f) Mobile originated detach required

The attach procedure shall be aborted, and the UE initiated detach procedure shall be performed.

g) Detach procedure collision

If the UE receives a DETACH REQUEST message from the network in state EMM-REGISTERED-INITIATED and the detach type indicates "re-attach not required" and no EMM cause IE, or "re-attach not required" and the EMM cause value is not #2 "IMSI unknown in HSS", the detach procedure shall be progressed and the attach procedure shall be aborted. If the UE receives a DETACH REQUEST message from the network in state EMM-REGISTERED-INITIATED and the detach type indicates "re-attach required", the detach procedure shall be progressed and the UE shall locally release the NAS signalling connection, before re-initiating the attach procedure. Otherwise the attach procedure shall be progressed and the DETACH REQUEST message shall be ignored.

h) Transmission failure of ATTACH REQUEST message indication from lower layers

The UE shall restart the attach procedure immediately.

i) Transmission failure of ATTACH COMPLETE message indication from lower layers

If the current TAI is not in the TAI list, the UE shall restart the attach procedure.

If the current TAI is still in the TAI list, it is up to the UE implementation how to re-run the ongoing procedure. The EMM sublayer notifies the ESM sublayer that the ESM message in the ESM message container IE of the ATTACH COMPLETE has failed to be transmitted.

j) If EMM-REGISTERED without PDN connection is not supported by the UE or the MME, and the ACTIVATE DEFAULT BEARER CONTEXT REQUEST message combined with the ATTACH ACCEPT is not accepted by the UE due to failure in the UE ESM sublayer, then the UE shall initiate the detach procedure by sending a DETACH REQUEST message to the network. Further UE behaviour is implementation specific.

If EMM-REGISTERED without PDN connection is supported by the UE and the MME, and the ACTIVATE DEFAULT BEARER CONTEXT REQUEST message combined with the ATTACH ACCEPT is not accepted by the UE due to failure in the UE ESM sublayer, then the UE shall either send an ATTACH COMPLETE message together with an ACTIVATE DEFAULT EPS BEARER CONTEXT REJECT contained in the ESM message container information element to the network or initiate the detach procedure by sending a DETACH REQUEST message. Further UE behaviour is implementation specific.

k) Indication from the lower layers that an S101 mode to S1 mode handover has been cancelled (S101 mode only)

The UE shall abort the attach procedure and enter state EMM-DEREGISTERED.NO-CELL-AVAILABLE.

l) "Extended wait time" from the lower layers

If the ATTACH REQUEST message contained the low priority indicator set to "MS is configured for NAS signalling low priority", the UE shall start timer T3346 with the "Extended wait time" value and reset the attach attempt counter.

If the ATTACH REQUEST message did not contain the low priority indicator set to "MS is configured for NAS signalling low priority", the UE is operating in NB-S1 mode and the UE is not a UE configured to use AC11 –

15 in selected PLMN, then the UE shall start timer T3346 with the "Extended wait time" value and reset the attach attempt counter.

In other cases the UE shall ignore the "Extended wait time".

The UE shall abort the attach procedure, stay in the current serving cell, change the state to EMM-DEREGISTERED.ATTEMPTING-TO-ATTACH and apply the normal cell reselection process.

The UE shall proceed as described below.

la) "Extended wait time CP data" from the lower layers

If the UE is operating in NB-S1 mode, the UE shall start the timer T3346 with the "Extended wait time CP data" value and reset the attach attempt counter.

In other cases the UE shall ignore the "Extended wait time CP data".

The UE shall abort the attach procedure, stay in the current serving cell, change the state to EMM-DEREGISTERED.ATTEMPTING-TO-ATTACH and apply the normal cell reselection process.

The UE shall proceed as described below.

m) Timer T3346 is running

The UE shall not start the attach procedure unless:

- the UE is a UE configured to use AC11 – 15 in selected PLMN;
- the UE needs to attach for emergency bearer services;
- the UE in NB-S1 mode is requested by the upper layer to transmit user data related to an exceptional event and
  - i) the UE is allowed to use exception data reporting (see the ExceptionDataReportingAllowed leaf of the NAS configuration MO in 3GPP TS 24.368 [15A] or the USIM file $EF_{NASCONFIG}$ in 3GPP TS 31.102 [17]); and
  - ii) timer T3346 was not started when NAS signaling connection was established with RRC establishment cause set to "MO exception data"; or
- the UE needs to attach without the NAS signalling low priority indication and if the timer T3346 was started due to rejection of a NAS request message (e.g. ATTACH REQUEST, TRACKING AREA UPDATE REQUEST or EXTENDED SERVICE REQUEST) which contained the low priority indicator set to "MS is configured for NAS signalling low priority".

The UE stays in the current serving cell and applies the normal cell reselection process.

NOTE 4: It is considered an abnormal case if the UE needs to initiate an attach procedure while timer T3346 is running independent on whether timer T3346 was started due to an abnormal case or a non successful case.

The UE shall proceed as described below.

n) If EMM-REGISTERED without PDN connection is supported by the UE and the MME, an ESM DUMMY MESSAGE is included in the ESM message container information element of the ATTACH REQUEST message and the UE receives the ATTACH ACCEPT message combined with a PDN CONNECTIVITY REJECT message, the UE shall send an ATTACH COMPLETE message together with an ESM DUMMY MESSAGE contained in the ESM message container information element to the network. Further UE behaviour is implementation specific.

o) Timer T3447 is running

The UE shall not start the attach procedure unless:

- the UE is a UE configured to use AC11 – 15 in selected PLMN;
- the UE attempts to attach for emergency bearer services; or

- the UE attempts to attach without PDN connection request.

The UE stays in the current serving cell and applies the normal cell reselection process. The attach request procedure is started, if still necessary, when timer T3447 expires.

For the cases b, c, d, l, la and m:

- Timer T3410 shall be stopped if still running.
- For the cases b, c, d, l when the "Extended wait time" is ignored, and la when the "Extended wait time CP data" is ignore, if the attach request is neither for emergency bearer services nor for initiating a PDN connection for emergency bearer services with attach type not set to "EPS emergency attach", the attach attempt counter shall be incremented, unless it was already set to 5.
- If the attach attempt counter is less than 5:
  - for the cases l, la and m, the attach procedure is started, if still necessary, when timer T3346 expires or is stopped;
  - for the cases b, c, d, l when the "Extended wait time" is ignored, and la when the "Extended wait time CP data" is ignore, if the attach request is neither for emergency bearer services nor for initiating a PDN connection for emergency bearer services with attach type not set to "EPS emergency attach", timer T3411 is started and the state is changed to EMM-DEREGISTERED.ATTEMPTING-TO-ATTACH. When timer T3411 expires the attach procedure shall be restarted, if still required by ESM sublayer.
- If the attach attempt counter is equal to 5:
  - the UE shall delete any GUTI, TAI list, last visited registered TAI, list of equivalent PLMNs and KSI, shall set the update status to EU2 NOT UPDATED, and shall start timer T3402. The state is changed to EMM-DEREGISTERED.ATTEMPTING-TO-ATTACH or optionally to EMM-DEREGISTERED.PLMN-SEARCH in order to perform a PLMN selection according to 3GPP TS 23.122 [6]; and
  - if A/Gb mode or Iu mode is supported by the UE:
    - the UE shall in addition handle the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI and GPRS ciphering key sequence number as specified in 3GPP TS 24.008 [13] for the abnormal case when a normal attach procedure fails and the attach attempt counter is equal to 5; and
    - the UE shall attempt to select GERAN or UTRAN radio access technology and proceed with appropriate GMM specific procedures. Additionally, the UE may disable the E-UTRA capability as specified in subclause 4.5.

5.5.1.2.6A Abnormal cases in the UE, SMS services not accepted

The UE shall proceed as follows:

1) if the attach was successful for EPS services only and the ATTACH ACCEPT message contained a value included in the SMS services status IE not treated in subclause 5.5.1.2.4A or the SMS services status IE is not included in the message, the UE shall proceed as follows:

   a) The UE shall stop timer T3410 if still running. The tracking area updating attempt counter shall be incremented, unless it was already set to 5;

   b) If the tracking area updating attempt counter is less than 5:

      - the UE shall start timer T3411, shall set the EPS update status to EU1 UPDATED and shall enter state EMM-REGISTERED.NORMAL-SERVICE. When timer T3411 expires the normal tracking area updating procedure for EPS services and "SMS only" or the combined tracking area updating procedure for EPS services and "SMS only" is triggered;

   c) If the tracking area updating attempt counter is equal to 5:

      - the UE shall start timer T3402, shall set the EPS update status to EU1 UPDATED and shall enter state EMM-REGISTERED.NORMAL-SERVICE. When timer T3402 expires the normal tracking area updating procedure for EPS services and "SMS only" or the combined tracking area updating procedure for EPS services and "SMS only" is triggered; and

2) otherwise, the abnormal cases specified in subclause 5.5.1.2.6 apply.

5.5.1.2.7 Abnormal cases on the network side

The following abnormal cases can be identified:

a) Lower layer failure

If a lower layer failure occurs before the message ATTACH COMPLETE has been received from the UE, the network shall locally abort the attach procedure, enter state EMM-DEREGISTERED and shall not resend the message ATTACH ACCEPT. If a new GUTI was assigned to the UE in the attach procedure, the MME shall consider both the old and the new GUTI as valid until the old GUTI can be considered as invalid by the network or the EMM context which has been marked as detached in the network is released.

If the old GUTI was allocated by an MME other than the current MME, the current MME does not need to retain the old GUTI. If the old GUTI is used by the UE in a subsequent attach message, the network may use the identification procedure to request the UE's IMSI.

b) Protocol error

If the ATTACH REQUEST message is received with a protocol error, the network shall return an ATTACH REJECT message with one of the following EMM cause values:

#96: invalid mandatory information;

#99: information element non-existent or not implemented;

#100: conditional IE error; or

#111: protocol error, unspecified.

c) T3450 time-out

On the first expiry of the timer, the network shall retransmit the ATTACH ACCEPT message and shall reset and restart timer T3450.

This retransmission is repeated four times, i.e. on the fifth expiry of timer T3450, the attach procedure shall be aborted and the MME enters state EMM-DEREGISTERED. If a new GUTI was allocated in the ATTACH ACCEPT message, the network shall consider both the old and the new GUTI as valid until the old GUTI can be considered as invalid by the network or the EMM context which has been marked as detached in the network is released. If the old GUTI was allocated by an MME other than the current MME, the current MME does not need to retain the old GUTI.

If the old GUTI is used by the UE in a subsequent attach message, the network acts as specified for case a above.

d) ATTACH REQUEST received after the ATTACH ACCEPT message has been sent and before the ATTACH COMPLETE message is received

- If one or more of the information elements in the ATTACH REQUEST message differ from the ones received within the previous ATTACH REQUEST message, the previously initiated attach procedure shall be aborted if the ATTACH COMPLETE message has not been received and the new attach procedure shall be progressed; or

- if the information elements do not differ, then the ATTACH ACCEPT message shall be resent and the timer T3450 shall be restarted if an ATTACH COMPLETE message is expected. In that case, the retransmission counter related to T3450 is not incremented.

e) More than one ATTACH REQUEST received and no ATTACH ACCEPT or ATTACH REJECT message has been sent

- If one or more of the information elements in the ATTACH REQUEST message differs from the ones received within the previous ATTACH REQUEST message, the previously initiated attach procedure shall be aborted and the new attach procedure shall be executed;

- if the information elements do not differ, then the network shall continue with the previous attach procedure and shall ignore the second ATTACH REQUEST message.

f) ATTACH REQUEST received in state EMM-REGISTERED

If an ATTACH REQUEST message is received in state EMM-REGISTERED the network may initiate the EMM common procedures; if it turned out that the ATTACH REQUEST message was sent by a UE that has already been attached, the EMM context, EPS bearer contexts, if any, are deleted and the new ATTACH REQUEST is progressed.

g) TRACKING AREA UPDATE REQUEST message received before ATTACH COMPLETE message.

Timer T3450 shall be stopped. The allocated GUTI in the attach procedure shall be considered as valid and the tracking area updating procedure shall be rejected with the EMM cause #10 "implicitly detached" as described in subclause 5.5.3.2.5.

h) DETACH REQUEST message received before ATTACH COMPLETE message.

The network shall abort the attach procedure and shall progress the detach procedure as described in subclause 5.5.2.2.

i) If EMM-REGISTERED without PDN connection is supported by the UE and the MME, the MME receives an ATTACH REQUEST message with an ESM message included in the ESM message container information element, and the ESM sublayer in the MME detects a message error according to clause 7, the MME may decide to proceed with the attach procedure or to reject it. When sending the ATTACH ACCEPT or ATTACH REJECT message to the UE, the MME shall include the ESM message provide by the ESM layer in the ESM message container information element.

5.5.1.3 Combined attach procedure for EPS services and non-EPS services (S1 mode only)

5.5.1.3.1 General

The combined attach procedure is used by a UE in CS/PS mode 1 or CS/PS mode 2 of operation to attach for both EPS and non-EPS services, or both EPS services and "SMS only".

The combined attach procedure is also used by a UE in CS/PS mode 1 or CS/PS mode 2 of operation to attach for EPS services if it is already IMSI attached for non-EPS services.

When the UE initiates a combined attach procedure, the UE shall indicate "combined EPS/IMSI attach" in the EPS attach type IE.

The combined attach procedure follows the attach procedure for EPS described in subclause 5.5.1.2 with exception of subclause 5.5.1.2.4A and subclause 5.5.1.2.6A.

5.5.1.3.2 Combined attach procedure initiation

If the UE is in EMM state EMM-DEREGISTERED, the UE initiates the combined attach procedure by sending an ATTACH REQUEST message to the network, starting timer T3410 and entering state EMM-REGISTERED-INITIATED (see example in figure 5.5.1.2.2.1).

The UE shall include the TMSI status IE if no valid TMSI is available. Furthermore, if the UE has stored a valid location area identification, the UE shall include it in the Old location area identification IE in the ATTACH REQUEST message.

If the UE has stored a valid TMSI, the UE shall include the TMSI based NRI container IE in the ATTACH REQUEST message.

If the UE initiates a combined attach procedure for EPS services and "SMS only", the UE shall indicate "SMS only" in the Additional update type IE.

5.5.1.3.3 EMM common procedure initiation

The network may initiate EMM common procedures, e.g. the identification, authentication and security mode control procedures, depending on the received information such as IMSI, GUTI and KSI.

5.5.1.3.4 Combined attach accepted by the network

5.5.1.3.4.1 General

Depending on the value of the EPS attach result IE received in the ATTACH ACCEPT message, the following different cases can be distinguished:

1) The EPS attach result IE value indicates "combined EPS/IMSI attach": attach for EPS and non-EPS services, or for EPS services and "SMS only" have been successful.

2) The EPS attach result IE value indicates "EPS only": attach for EPS services has been successful but attach for non-EPS services or "SMS only" has failed.

5.5.1.3.4.2 Combined attach successful

The description for attach for EPS services as specified in subclause 5.5.1.2.4 shall be followed. In addition, the following description for attach for non-EPS services or "SMS only" applies.

The TMSI reallocation may be part of the combined attach procedure. The TMSI allocated is then included in the ATTACH ACCEPT message, together with the location area identification (LAI). In this case the MME shall start timer T3450 as described in subclause 5.4.1.4, and enter state EMM-COMMON-PROCEDURE-INITIATED. If the MME does not indicate "SMS only" in the ATTACH ACCEPT message, subject to operator policies the MME should allocate a TAI list that does not span more than one location area.

For a shared network in CS domain, the MME indicates the selected PLMN for CS domain in the LAI to the UE as specified in 3GPP TS 23.272 [9].

The UE, receiving an ATTACH ACCEPT message, stores the received location area identification, stops timer T3410, resets the location update attempt counter and sets the update status to U1 UPDATED. If the message contains an IMSI, the UE is not allocated any TMSI, and shall delete any TMSI accordingly. If the message contains a TMSI, the UE shall use this TMSI as the new temporary identity. The UE shall delete its old TMSI and shall store the new TMSI. If neither a TMSI nor an IMSI has been included by the network in the ATTACH ACCEPT message, the old TMSI, if any available, shall be kept.

If the UE maintains a counter for "SIM/USIM considered invalid for non-GPRS services" events (see subclause 5.3.7b), then the UE shall reset this counter.

If the UE requested "SMS only" in the Additional update type IE, or if the UE requested a combined attach for EPS and non-EPS services, but the network decides to accept the attach request for EPS services and "SMS only", the network shall indicate "SMS only" in the Additional update result IE. In addition, if the SMS services are provided via SMS in MME, the network shall provide a non-broadcast LAI in the ATTACH ACCEPT message. If a TMSI has to be allocated, then the network shall also provide a TMSI value which cannot cause any ambiguity with assigned TMSI values.

If the ATTACH ACCEPT message includes the Additional update result IE with value "SMS only", a UE operating in CS/PS mode 2 and a UE operating in CS/PS mode 1 with "IMS voice available" shall not attempt to use CS fallback for mobile originating services.

As an implementation option, if the ATTACH ACCEPT message does not include the Additional update result IE with value "SMS only" and the UE is not configured for NAS signaling low priority then the UE may stop timer T3246 if running.

If the ATTACH ACCEPT message includes the Additional update result IE with value "CS Fallback not preferred", this indicates to a UE operating in CS/PS mode 2 and a UE operating in CS/PS mode 1 with "IMS voice available" that it is attached for EPS and non-EPS services and that it can use CS fallback.

If the LAI contained in the ATTACH ACCEPT message is a member of the list of "forbidden location areas for regional provision of service" or the list of "forbidden location areas for roaming" then such entry shall be deleted.

If the PLMN identity for the CS domain which is provided as part of the LAI contained in the ATTACH ACCEPT message differs from the PLMN identity provided as part of the GUTI, the MME shall include the PLMN identity for the CS domain in the list of equivalent PLMNs in the ATTACH ACCEPT message.

The UE, when having requested PDN connectivity as contained in the ATTACH REQUEST and on receiving the ATTACH ACCEPT message combined with the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST

message, shall send an ATTACH COMPLETE message combined with an ACTIVATE DEFAULT EPS BEARER CONTEXT ACCEPT message to the network.

Upon transmission of the ATTACH COMPLETE message the UE shall enter state EMM-REGISTERED and MM state MM-IDLE and set the EPS update status to EU1 UPDATED.

If the ATTACH ACCEPT message includes the Additional update result IE with value "SMS only" or "CS Fallback not preferred", a UE operating in CS/PS mode 1 with "IMS voice not available" shall attempt to select GERAN or UTRAN radio access technology and disable the E-UTRA capability (see subclause 4.5).

Upon receiving an ATTACH COMPLETE message, the MME shall stop timer T3450, enter state EMM-REGISTERED.

NOTE: Upon receiving an ATTACH COMPLETE message, the MME sends an SGsAP-TMSI-REALLOCATION-COMPLETE message as specified in 3GPP TS 29.118 [16A].

5.5.1.3.4.3 Combined attach successful for EPS services only

Apart from the actions on the tracking area updating attempt counter, the description for attach for EPS services as specified in subclause 5.5.1.2.4 shall be followed. In addition, the following description for attach for non-EPS services applies.

The UE receiving the ATTACH ACCEPT message takes one of the following actions depending on the EMM cause value:

#2 (IMSI unknown in HSS)

The UE shall stop T3410 if still running and shall reset the tracking area updating attempt counter. The UE shall set the update status to U3 ROAMING NOT ALLOWED and shall delete any TMSI, LAI and ciphering key sequence number. The UE shall enter state EMM-REGISTERED.NORMAL-SERVICE. The new MM state is MM IDLE. The USIM shall be considered as invalid for non-EPS services until switching off or the UICC containing the USIM is removed.or the timer T3245 expires as described in subclause 5.3.7a. If the UE maintains a counter for "SIM/USIM considered invalid for non-GPRS services", then the UE shall set this counter to UE implementation-specific maximum value.

#16 (MSC temporarily not reachable); or

#17 (Network failure)

The UE shall stop timer T3410 if still running, and shall enter state MM IDLE. The tracking area updating attempt counter shall be incremented, unless it was already set to 5.

If the tracking area updating attempt counter is less than 5:

- the UE shall start timer T3411, shall set the EPS update status to EU1 UPDATED and shall enter state EMM-REGISTERED.ATTEMPTING-TO-UPDATE-MM. When timer T3411 expires the combined tracking area updating procedure indicating "combined TA/LA updating with IMSI attach" is triggered.

If the tracking area updating attempt counter is equal to 5:

- a UE operating in CS/PS mode 2 of operation and a UE operating in CS/PS mode 1 of operation with "IMS voice available" shall start timer T3402, shall set the EPS update status to EU1 UPDATED and shall enter state EMM-REGISTERED.ATTEMPTING-TO-UPDATE-MM. When timer T3402 expires the combined tracking area updating procedure indicating "combined TA/LA updating with IMSI attach" is triggered;

- a UE operating in CS/PS mode 1 of operation with "IMS voice not available" shall attempt to select GERAN or UTRAN radio access technology and proceed with appropriate MM or GMM specific procedures and disable the E-UTRA capability (see subclause 4.5).

#18 (CS domain not available)

The UE shall stop timer T3410 if still running, shall reset the tracking area updating attempt counter, shall set the EPS update status to EU1 UPDATED and shall enter state EMM-REGISTERED.NORMAL-SERVICE.

The UE shall enter state MM IDLE and shall set the update status to U2 NOT UPDATED.

A UE in CS/PS mode 1 of operation with "IMS voice not available" shall attempt to select GERAN or UTRAN radio access technology and disable the E-UTRA capability (see subclause 4.5).

A UE in CS/PS mode 2 of operation and a UE operating in CS/PS mode 1 of operation with "IMS voice available" may provide a notification to the user or the upper layers that the CS domain is not available.

The UE shall not attempt combined attach or combined tracking area update procedure with current PLMN until switching off the UE or the UICC containing the USIM is removed.

#22 (Congestion)

The UE shall stop the timer T3410 if still running. The tracking area updating attempt counter shall be set to 5. The UE shall start the timer T3402, shall set the EPS update status to EU1 UPDATED, shall enter state EMM-REGISTERED.ATTEMPTING-TO-UPDATE-MM, and shall enter state MM IDLE.

Other EMM cause values and the case that no EMM cause IE was received are considered as abnormal cases. The combined attach procedure shall be considered as failed for non-EPS services. The behaviour of the UE in those cases is specified in subclause 5.5.1.3.6.

5.5.1.3.5 Combined attach not accepted by the network

If the attach request can neither be accepted by the network for EPS nor for non-EPS services, the MME shall send an ATTACH REJECT message to the UE including an appropriate EMM cause value. If EMM-REGISTERED without PDN connection is not supported by the UE or the MME, the attach request included a PDN CONNECTIVITY REQUEST message, and the attach procedure fails due to a default EPS bearer setup failure, an ESM procedure failure or operator determined barring, the MME shall:

- combine the ATTACH REJECT message with a PDN CONNECTIVITY REJECT message contained in the ESM message container information element. In this case the EMM cause value in the ATTACH REJECT message shall be set to #19, "ESM failure"; or

- send the ATTACH REJECT message with the EMM cause set to #15 "No suitable cells in tracking area" ,if the PDN connectivity reject is due to ESM cause #29 subject to operator policies (see 3GPP TS 29.274 [16D] for further details). In this case, the network may additionally include the Extended EMM cause IE with value "E-UTRAN not allowed".

If the attach request is rejected due to NAS level mobility management congestion control, the network shall set the EMM cause value to #22 "congestion" and assign a back-off timer T3346.

If the attach request is rejected due to service gap control as specified in subclause 5.3.17 i.e. the T3447 timer is running, the network shall set the EMM cause value to #22 "congestion" and may assign a back-off timer T3346 with the remaining time of the running T3447 timer.

Upon receiving the ATTACH REJECT message, if the message is integrity protected or contains a reject cause other than EMM cause value #25, the UE shall stop timer T3410 and enter MM state MM IDLE.

If the ATTACH REJECT message with EMM cause #25 was received without integrity protection, then the UE shall discard the message.

The UE shall take the following actions depending on the EMM cause value received in the ATTACH REJECT message.

#3 (Illegal UE);

#6 (Illegal ME); or

#8 (EPS services and non-EPS services not allowed);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and eKSI.

The UE shall consider the USIM as invalid for EPS and non-EPS services until switching off or the UICC containing the USIM is removed or the timer T3245 expires as described in subclause 5.3.7a. Additionally, the UE shall delete the list of equivalent PLMNs and shall enter the state EMM-DEREGISTERED. If the message has been successfully integrity checked by the NAS and the UE maintains a counter for "SIM/USIM considered invalid for GPRS services", then the UE shall set this counter to UE implementation-specific maximum value. If

the message has been successfully integrity checked by the NAS and the UE maintains a counter for "SIM/USIM considered invalid for non-GPRS services", then the UE shall set this counter to UE implementation-specific maximum value.

If A/Gb mode or Iu mode is supported by the UE, the UE shall in addition handle the MM parameters update status, TMSI, LAI and ciphering key sequence number, and the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI and GPRS ciphering key sequence number as specified in 3GPP TS 24.008 [13] for the case when the combined attach procedure is rejected with the GMM cause with the same value.

#7 (EPS services not allowed);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and eKSI. The UE shall consider the USIM as invalid for EPS services until switching off or the UICC containing the USIM is removed or the timer T3245 expires as described in subclause 5.3.7a. Additionally, the UE shall delete the list of equivalent PLMNs and shall enter the state EMM-DEREGISTERED. If the message has been successfully integrity checked by the NAS and the UE maintains a counter for "SIM/USIM considered invalid for GPRS services", then the UE shall set this counter to UE implementation-specific maximum value.

A UE which is already IMSI attached for non-EPS services is still IMSI attached for non-EPS services and shall set the update status to U2 NOT UPDATED.

The UE shall attempt to select GERAN or UTRAN radio access technology and shall proceed with the appropriate MM specific procedure according to the MM service state. The UE shall not reselect E-UTRAN radio access technology until switching off or the UICC containing the USIM is removed.

If A/Gb mode or Iu mode is supported by the UE, the UE shall in addition handle the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI and GPRS ciphering key sequence number as specified in 3GPP TS 24.008 [13] for the case when the combined attach procedure is rejected with the GMM cause with the same value.

#11 (PLMN not allowed); or

#35 (Requested service option not authorized in this PLMN);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and eKSI, and reset the attach attempt counter. The UE shall delete the list of equivalent PLMNs and enter the state EMM-DEREGISTERED.PLMN-SEARCH.

The UE shall store the PLMN identity in the "forbidden PLMN list" and if the UE is configured to use timer T3245 (see 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17]) then the UE shall start timer T3245 and proceed as described in subclause 5.3.7a. If the message has been successfully integrity checked by the NAS and the UE maintains a PLMN-specific attempt counter for that PLMN, then the UE shall set this counter to the UE implementation-specific maximum value.

The UE shall perform a PLMN selection according to 3GPP TS 23.122 [6].

If A/Gb mode or Iu mode is supported by the UE, the UE shall in addition handle the MM parameters update status, TMSI, LAI, ciphering key sequence number and location update attempt counter, and the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI, GPRS ciphering key sequence number and GPRS attach attempt counter as specified in 3GPP TS 24.008 [13] for the case when the combined attach procedure is rejected with the GMM cause with the same value and no RR connection exists.

#12 (Tracking area not allowed);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and eKSI. The UE shall reset the attach attempt counter and enter the state EMM-DEREGISTERED.LIMITED-SERVICE.

The UE shall store the current TAI in the list of "forbidden tracking areas for regional provision of service".

If A/Gb mode or Iu mode is supported by the UE, the UE shall in addition handle the MM parameters update status, TMSI, LAI, ciphering key sequence number and location update attempt counter, and the GMM

parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI, GPRS ciphering key sequence number and GPRS attach attempt counter as specified in 3GPP TS 24.008 [13] for the case when the combined attach procedure is rejected with the GMM cause with the same value.

#13 (Roaming not allowed in this tracking area);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and eKSI. The UE shall delete the list of equivalent PLMNs and reset the attach attempt counter. Additionally the UE enter the state EMM-DEREGISTERED.LIMITED-SERVICE or optionally EMM-DEREGISTERED.PLMN-SEARCH.

The UE shall store the current TAI in the list of "forbidden tracking areas for roaming".

The UE shall perform a PLMN selection according to 3GPP TS 23.122 [6].

If A/Gb mode or Iu mode is supported by the UE, the UE shall in addition handle the MM parameters update status, TMSI, LAI, ciphering key sequence number and location update attempt counter, and the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI, GPRS ciphering key sequence number and GPRS attach attempt counter as specified in 3GPP TS 24.008 [13] for the case when the combined attach procedure is rejected with the GMM cause with the same value.

#14 (EPS services not allowed in this PLMN);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and eKSI. Additionally the UE shall reset the attach attempt counter and enter the state EMM-DEREGISTERED.PLMN-SEARCH.

The UE shall store the PLMN identity in the "forbidden PLMNs for GPRS service" list and if the UE is configured to use timer T3245 (see 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17]) then the UE shall start timer T3245 and proceed as described in subclause 5.3.7a. If the message has been successfully integrity checked by the NAS and the UE maintains a PLMN-specific PS-attempt counter for that PLMN, then the UE shall set this counter to the UE implementation-specific maximum value.

A UE operating in CS/PS mode 1 or CS/PS mode 2 of operation which is already IMSI attached for non-EPS services is still IMSI attached for non-EPS services and shall set the update status to U2 NOT UPDATED.

A UE operating in CS/PS mode 1 of operation and supporting A/Gb or Iu mode may select GERAN or UTRAN radio access technology and proceed with the appropriate MM specific procedure according to the MM service state. In this case, the UE shall disable the E-UTRA capability (see subclause 4.5).

A UE operating in CS/PS mode 1 of operation and supporting A/Gb or Iu mode may perform a PLMN selection according to 3GPP TS 23.122 [6].

A UE operating in CS/PS mode 1 of operation and supporting S1 mode only, or operating in CS/PS mode 2 of operation shall delete the list of equivalent PLMNs and shall perform a PLMN selection according to 3GPP TS 23.122 [6].

If A/Gb mode or Iu mode is supported by the UE, the UE shall in addition handle the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI, GPRS ciphering key sequence number and GPRS attach attempt counter as specified in 3GPP TS 24.008 [13] for the case when the combined attach procedure is rejected with the GMM cause with the same value.

#15 (No suitable cells in tracking area);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and eKSI. Additionally the UE shall reset the attach attempt counter and enter the state EMM-DEREGISTERED.LIMITED-SERVICE.

The UE shall store the current TAI in the list of "forbidden tracking areas for roaming" and:

- if the UE is in S1 mode and the Extended EMM cause IE with value "E-UTRAN not allowed" is included in the ATTACH REJECT message, the UE supports "E-UTRA Disabling for EMM cause #15", and the "E-UTRA Disabling Allowed for EMM cause #15" parameter as specified in 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17] is present and set to enabled, then the UE shall disable the E-UTRA capability as specified in subclause 4.5 and search for a suitable cell in another location area;

- if the UE is in NB-S1 mode and the Extended EMM cause IE with value "NB-IoT not allowed" is included in the ATTACH REJECT message, then the UE may disable the NB-IoT capability as specified in subclause 4.X and search for a suitable cell in E-UTRAN radio access technology;

- otherwise, the UE shall search for a suitable cell in another tracking area or in another location area according to 3GPP TS 36.304 [21].

If A/Gb mode or Iu mode is supported by the UE, the UE shall in addition handle the MM parameters update status, TMSI, LAI, ciphering key sequence number and location update attempt counter, and the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI, GPRS ciphering key sequence number and GPRS attach attempt counter as specified in 3GPP TS 24.008 [13] for the case when the combined attach procedure is rejected with the GMM cause with the same value.

#22 (Congestion);

If the T3346 value IE is present in the ATTACH REJECT message and the value indicates that this timer is neither zero nor deactivated, the UE shall proceed as described below; otherwise it shall be considered as an abnormal case and the behaviour of the UE for this case is specified in subclause 5.5.1.3.6.

The UE shall abort the attach procedure, reset the attach attempt counter, set the EPS update status to EU2 NOT UPDATED and enter state EMM-DEREGISTERED.ATTEMPTING-TO-ATTACH.

The UE shall stop timer T3346 if it is running.

If the ATTACH REJECT message is integrity protected, the UE shall start timer T3346 with the value provided in the T3346 value IE.

If the ATTACH REJECT message is not integrity protected, the UE shall start timer T3346 with a random value from the default range specified in 3GPP TS 24.008 [13].

The UE stays in the current serving cell and applies the normal cell reselection process. The attach procedure is started if still needed when timer T3346 expires or is stopped.

If A/Gb mode or Iu mode is supported by the UE, the UE shall in addition handle the GMM parameters GMM state, GPRS update status and GPRS attach attempt counter as specified in 3GPP TS 24.008 [13] for the case when the combined attach procedure is rejected with the GMM cause with the same value.

#25 (Not authorized for this CSG);

EMM cause #25 is only applicable when received from a CSG cell. EMM cause #25 received from a non-CSG cell is considered as an abnormal case and the behaviour of the UE is specified in subclause 5.5.1.3.6.

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and store it according to subclause 5.1.3.3). Additionally, the UE shall reset the attach attempt counter and shall enter the state EMM-DEREGISTERED.LIMITED-SERVICE.

If the CSG ID and associated PLMN identity of the cell where the UE has sent the ATTACH REQUEST message are contained in the Allowed CSG list, the UE shall remove the entry corresponding to this CSG ID and associated PLMN identity from the Allowed CSG list.

If the CSG ID and associated PLMN identity of the cell where the UE has sent the ATTACH REQUEST message are contained in the Operator CSG list, the UE shall apply the procedures defined in 3GPP TS 23.122 [6] subclause 3.1A.

The UE shall search for a suitable cell according to 3GPP TS 36.304 [21].

If A/Gb mode or Iu mode is supported by the UE, the UE shall in addition handle the MM parameters update status and location update attempt counter, and GMM parameters GMM state, GPRS update status and GPRS attach attempt counter as specified in 3GPP TS 24.008 [13] for the case when the combined attach procedure is rejected with the GMM cause with the same value.

#42 (Severe network failure);

The UE shall set the EPS update status to EU2 NOT UPDATED, and shall delete any GUTI, last visited registered TAI, TAI list, eKSI, and list of equivalent PLMNs, and set the attach attempt counter to 5. The UE shall start an implementation specific timer, setting its value to 2 times the value of T as defined in

3GPP TS 23.122 [6]. While this timer is running, the UE shall not consider the PLMN + RAT combination that provided this reject cause as a candidate for PLMN selection. The UE then enters state EMM-DEREGISTERED.PLMN-SEARCH in order to perform a PLMN selection according to 3GPP TS 23.122 [6].

If A/Gb mode or Iu mode is supported by the UE, the UE shall in addition set the GMM state to GMM-DEREGISTERED, GPRS update status to GU2 NOT UPDATED, and shall delete the P-TMSI, P-TMSI signature, RAI and GPRS ciphering key sequence number.

Other values are considered as abnormal cases. The behaviour of the UE in those cases is specified in subclause 5.5.1.3.6.

5.5.1.3.6 Abnormal cases in the UE

The UE shall proceed as follows:

1) if the UE requested the combined attach for EPS services and "SMS only" and the ATTACH ACCEPT message indicates a combined attach successful for EPS and non-EPS services, the UE shall behave as if the combined attach was successful for EPS services and "SMS only";

NOTE: In this case the UE can ignore the CS SERVICE NOTIFICATION message or the Paging with CN domain indicator set to "CS", as specified in subclause 5.6.2.3.2.

2) if the combined attach was successful for EPS services only and the ATTACH ACCEPT message contained an EMM cause value not treated in subclause 5.5.1.3.4.3 or the EMM cause IE is not included in the message, the UE shall proceed as follows:

   a) The UE shall stop timer T3410 if still running, and shall enter state MM IDLE. The tracking area updating attempt counter shall be incremented, unless it was already set to 5;

   b) If the tracking area updating attempt counter is less than 5:

      - the UE shall start timer T3411, shall set the EPS update status to EU1 UPDATED and shall enter state EMM-REGISTERED.ATTEMPTING-TO-UPDATE-MM. When timer T3411 expires the combined tracking area updating procedure indicating "combined TA/LA updating with IMSI attach" is triggered;

   c) If the tracking area updating attempt counter is equal to 5:

      - a UE operating in CS/PS mode 2 of operation and a UE operating in CS/PS mode 1 of operation with "IMS voice available" shall start timer T3402, shall set the EPS update status to EU1 UPDATED and shall enter state EMM-REGISTERED.ATTEMPTING-TO-UPDATE-MM. When timer T3402 expires the combined tracking area updating procedure indicating "combined TA/LA updating with IMSI attach" is triggered; and

      - a UE operating in CS/PS mode 1 of operation with "IMS voice not available" shall attempt to select GERAN or UTRAN radio access technology and proceed with appropriate MM or GMM specific procedures and disable the E-UTRA capability (see subclause 4.5); and

   d) If there is a CS fallback emergency call pending or CS fallback call pending, the UE shall attempt to select GERAN or UTRAN radio access technology. If the UE finds a suitable GERAN or UTRAN cell, it then proceeds with the appropriate MM and CC specific procedures; otherwise the EMM sublayer shall indicate the abort of the EMM procedure to the MM sublayer; and

3) otherwise, the abnormal cases specified in subclause 5.5.1.2.6 apply with the following modification.

   If the attach attempt counter is incremented according to subclause 5.5.1.2.6 the next actions depend on the value of the attach attempt counter:

   - if the attach attempt counter is less than 5, the UE shall set the update status to U2 NOT UPDATED but shall not delete any LAI, TMSI, ciphering key sequence number and list of equivalent PLMNs; or

   - if the attach attempt counter is equal to 5, then the UE shall delete any LAI, TMSI, ciphering key sequence number and list of equivalent PLMNs and set the update status to U2 NOT UPDATED. The UE shall attempt to select GERAN or UTRAN radio access technology and proceed with appropriate MM or GMM specific procedures. Additionally, the UE may disable the E-UTRA capability as specified in subclause 4.5.

If there is a CS fallback emergency call pending or CS fallback call pending, the UE shall attempt to select GERAN or UTRAN radio access technology. If the UE finds a suitable GERAN or UTRAN cell, it then proceeds with the appropriate MM and CC specific procedures; otherwise the EMM sublayer shall indicate the abort of the EMM procedure to the MM sublayer.

5.5.1.3.7 Abnormal cases on the network side

The abnormal cases specified in subclause 5.5.1.2.7 apply.

5.5.2 Detach procedure

5.5.2.1 General

The detach procedure is used:

- by the UE to detach for EPS services only;
- by the UE to disconnect from the last remaining PDN it is connected to if EMM-REGISTERED without PDN connection is not supported by the UE or the MME;
- by the UE in CS/PS mode 1 or CS/PS mode 2 of operation to detach for both EPS services and non-EPS services or for non-EPS services only via a combined detach procedure;
- by the network to inform the UE that it is detached for EPS services or non-EPS services or both;
- by the network to disconnect the UE from the last remaining PDN to which it is connected if EMM-REGISTERED without PDN connection is not supported by the UE or the MME; and
- by the network to inform the UE to re-attach to the network and re-establish all PDN connections.

NOTE 1: After a successful completion of an inter-system change of the UE from S1 mode to non-3GPP access, if the non-3GPP network provides PDN connectivity to the same EPC and EMM-REGISTERED without PDN connection is not supported by the UE or the MME, the MME performs a local detach of the UE.

NOTE 2: If EMM-REGISTERED without PDN connection is supported by the UE and the MME, the detach procedure is not triggered when disconnecting the UE from the last remaining PDN to which it is connected.

The detach procedure also applies to the UE which is IMSI attached for "SMS only".

The detach procedure with appropriate detach type shall be invoked by the UE if the UE is switched off, the USIM card is removed from the UE, the UE wishes to detach for EPS services, the UE wishes to detach for non-EPS services or as part of the eCall inactivity procedure defined in subclause 5.5.4.

If the detach procedure is triggered due to USIM removal, the UE shall indicate "switch off" in the detach type IE.

When upper layers indicates that emergency bearer services are no longer required, the UE if still attached for emergency bearer services, may perform a detach followed by a re-attach to regain normal services, if the UE is in or moves to a suitable cell.

If a detach is requested by the HSS for a UE that has bearers for emergency services, the MME shall not send a DETACH REQUEST message to the UE, and shall follow the procedures in subclause 6.4.4.1 for a UE that has bearers for emergency services.

If the detach procedure for EPS services is performed, the EPS bearer context(s), if any, for this particular UE are deactivated locally without peer-to-peer signalling between the UE and the MME.

If the UE supports A/Gb mode or Iu mode or both, the UE shall store the TIN in the non-volatile memory in the ME, as described in annex C, for a subsequent attach procedure.

The UE is allowed to initiate the detach procedure even if the timer T3346 is running.

The network proceeds with the detach procedure even if NAS level mobility management congestion control is active.

5.5.2.2 UE initiated detach procedure

5.5.2.2.1 UE initiated detach procedure initiation

The detach procedure is initiated by the UE by sending a DETACH REQUEST message (see example in figure 5.5.2.2.1.1). The Detach type IE included in the message indicates whether detach is due to a "switch off" or not. The Detach type IE also indicates whether the detach is for EPS services only, for non-EPS services only, or for both. If the UE has a mapped EPS security context as the current EPS security context, the UE shall set the type of security context flag to "mapped security context". Otherwise, the UE shall set the type of security context flag to "native security context".

If the UE has a valid GUTI, the UE shall populate the EPS mobile identity IE with the valid GUTI. If the UE does not have a valid GUTI, the UE shall populate the EPS mobile identity IE with its IMSI.

If the UE does not have a valid GUTI and it does not have a valid IMSI, then the UE shall populate the EPS mobile identity IE with its IMEI.

NOTE: During the attach for emergency service when the UE (with no USIM or invalid USIM) is in EMM-REGISTERED-INITIATED STATE, the UE has neither a valid GUTI nor a valid IMSI.

If the detach is not due to switch off and the UE is in the state EMM-REGISTERED or EMM-REGISTERED-INITIATED, timer T3421 shall be started in the UE after the DETACH REQUEST message has been sent. If the detach type indicates that the detach is for non-EPS services only the UE shall enter the state EMM-REGISTERED.IMSI-DETACH-INITIATED, otherwise the UE shall enter the state EMM-DEREGISTERED-INITIATED. If the detach type indicates that the detach is for non-EPS services or both EPS and non-EPS services, the UE shall enter the state MM IMSI DETACH PENDING.

If the UE to be switched off is not operating in NB-S1 mode and not operating in WB-S1 mode in any enhanced coverage CE mode, the UE shall try for a period of 5 seconds to send the DETACH REQUEST message. If the UE to be switched off:-

- is operating in NB-S1 mode, then the UE should try for at least a period of 85 seconds to send the DETACH REQUEST; or
- is operating in WB-S1 mode in any enhanced coverage CE mode, then the UE should try for at least a period of 14 seconds to send the DETACH REQUEST.

During this period, the UE may be switched off as soon as the DETACH REQUEST message has been sent.

After the last DETACH REQUEST message is sent, the UE shall proceed as follows:

- if the current EPS security context is a native EPS security context, then the UE shall store the current EPS security context as specified in annex C and mark it as valid;
- else if the current EPS security context is a mapped EPS security context and a non-current full native EPS security context exists, then the UE shall store the non-current EPS security context as specified in annex C and mark it as valid, and finally the UE shall delete any mapped EPS security context or partial native EPS security context.

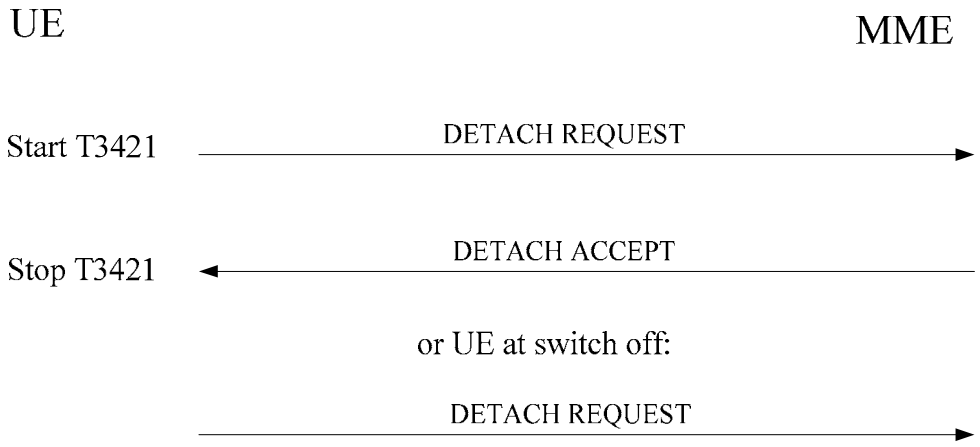


Figure 5.5.2.2.1.1: UE initiated detach procedure

5.5.2.2.2 UE initiated detach procedure completion for EPS services only

When the DETACH REQUEST message is received by the network, the network shall send a DETACH ACCEPT message to the UE, if the Detach type IE does not indicate "switch off". Otherwise, the procedure is completed when the network receives the DETACH REQUEST message.

The network and the UE shall deactivate the EPS bearer context(s), if any, for this UE locally without peer-to-peer signalling between the UE and the MME.

The UE is marked as inactive in the network for EPS services. The network shall enter the state EMM-DEREGISTERED.

The UE, when receiving the DETACH ACCEPT message, shall stop timer T3421. Furthermore, if the UE is operating in PS mode of operation, or is operating in CS/PS mode of operation and supports S1 mode only then:

- If the detach procedure was performed due to disabling of EPS services, then the UE shall enter the EMM-NULL state.
- Otherwise, the UE shall enter the EMM-DEREGISTERED state.

The UE operating in CS/PS mode 1 or CS/PS mode 2 of operation, and supporting A/Gb mode or Iu mode, shall further set the update status to U2 NOT UPDATED, disable the E-UTRA capability (see subclause 4.5) and attempt to select GERAN or UTRAN access technology.

5.5.2.2.3 UE initiated combined detach procedure completion

When the DETACH REQUEST message is received by the network, a DETACH ACCEPT message shall be sent to the UE, if the Detach type IE does not indicate "switch off". Otherwise, the procedure is completed when the network receives the DETACH REQUEST message.

Depending on the value of the Detach type IE the following applies:

- combined EPS/IMSI detach:

  The network and the UE shall deactivate the EPS bearer context(s) for this UE locally without peer-to-peer signalling between the UE and the MME. The UE is marked as inactive in the network for EPS and for non-EPS services. The states EMM-DEREGISTERED and MM-NULL are entered in both the UE and the network.

- IMSI detach:

  The UE is marked as inactive in the network for non-EPS services. The states MM-NULL and EMM-REGISTERED are entered in both the UE and the network.

The UE, when receiving the DETACH ACCEPT message, shall stop timer T3421.

5.5.2.2.4 Abnormal cases in the UE

The following abnormal cases can be identified:

a) Access barred because of access class barring, EAB or NAS signalling connection establishment rejected by the network

In WB-S1 mode, if access is barred for "originating signalling" (see 3GPP TS 36.331 [22]), the detach signalling procedure shall not be started. The UE stays in the current serving cell and applies the normal cell reselection process. The detach signalling procedure is started as soon as possible and if still necessary, i.e. when access for "originating signalling" is granted on the current cell or when the UE moves to a cell where access for "originating signalling" is granted. The UE may perform a local detach either immediately or after an implementation dependent time.

In NB-S1 mode, if access is barred for "originating signalling" (see 3GPP TS 36.331 [22]), the detach signalling procedure shall not be started. The UE stays in the current serving cell and applies the normal cell reselection process. Further UE behaviour is implementation specific, e.g. the detach signalling procedure is started again after an implementation dependent time.

NOTE 1: In NB-S1 mode, the EMM layer cannot receive the access barring alleviation indication from the lower layers (see 3GPP TS 36.331 [22]).

b) Lower layer failure or release of the NAS signalling connection before reception of DETACH ACCEPT message

The detach procedure shall be aborted and the UE proceeds as follows:

- if the detach procedure was performed due to disabling of EPS services, the UE shall enter the EMM-NULL state;
- if "EPS detach" was requested for reasons other than disabling of EPS services, the UE shall enter the EMM-DEREGISTERED state;
- if "IMSI detach" was requested, the UE shall enter the EMM-REGISTERED.NORMAL-SERVICE state and the MM-NULL state; or
- if "combined EPS/IMSI detach" was requested, the UE shall enter the EMM-DEREGISTERED state and the MM-NULL state.

c) T3421 timeout

On the first four expiries of the timer, the UE shall retransmit the DETACH REQUEST message and shall reset and restart timer T3421. On the fifth expiry of timer T3421, the detach procedure shall be aborted and the UE proceeds as follows:

- if the detach procedure was performed due to disabling of EPS services, the UE shall enter the EMM-NULL state;
- if "EPS detach" was requested for reasons other than disabling of EPS services, the UE shall enter the EMM-DEREGISTERED state;
- if "IMSI detach" was requested, the UE shall enter the EMM-REGISTERED.NORMAL-SERVICE state and the MM-NULL state; or
- if "combined EPS/IMSI detach" was requested, the UE shall enter the EMM-DEREGISTERED state and the MM-NULL state.

d) Detach procedure collision

Detach containing cause "switch off" within the Detach type IE:

- If the UE receives a DETACH REQUEST message before the UE initiated detach procedure has been completed, this message shall be ignored and the UE initiated detach procedure shall continue.

Detach containing other causes than "switch off" within the Detach type IE:

- If the UE receives a DETACH REQUEST message before the UE initiated detach procedure has been completed, it shall treat the message as specified in subclause 5.5.2.3.2 with the following modifications:

  - If the DETACH REQUEST message received by the UE contains detach type "re-attach required", and the UE initiated detach procedure is with detach type "EPS detach" or "combined EPS/IMSI detach", the UE need not initiate the attach or combined attach procedure.

  - If the DETACH REQUEST message received by the UE contains detach type "IMSI detach", and the UE initiated detach procedure is with detach type "IMSI detach", the UE need not re-attach to non-EPS services.

  - If the DETACH REQUEST message received by the UE contains detach type "IMSI detach", and the UE initiated detach procedure is with detach type "EPS detach" or "combined EPS/IMSI detach", the UE shall progress both procedures. The UE need not re-attach to non-EPS services.

e) Detach and EMM common procedure collision

Detach containing cause "switch off":

- If the UE receives a message used in an EMM common procedure before the detach procedure has been completed, this message shall be ignored and the detach procedure shall continue.

Detach containing other causes than "switch off" and containing detach type "IMSI detach":

- If the UE receives a message used in an EMM common procedure before the detach procedure has been completed, both the EMM common procedure and the detach procedure shall continue.

Detach containing other causes than "switch off" and containing other detach types than "IMSI detach":

- If the UE receives a GUTI REALLOCATION COMMAND, an EMM STATUS or an EMM INFORMATION message before the detach procedure is completed, this message shall be ignored and the detach procedure shall continue.

- If the UE receives an AUTHENTICATION REQUEST, SECURITY MODE COMMAND or IDENTITY REQUEST message before the detach procedure has been completed, the UE shall respond to it as described in subclause 5.4.2, 5.4.3 and 5.4.4 respectively and the detach procedure shall continue.

f) Change of cell into a new tracking area

If a cell change into a new tracking area that is not in the stored TAI list occurs before the UE initiated detach procedure is completed, the detach procedure shall be aborted and re-initiated after successfully performing a tracking area updating procedure. If the detach procedure was initiated due to removal of the USIM or the UE is to be switched off, the UE shall abort the detach procedure and enter the state EMM-DEREGISTERED.

g) Transmission failure of DETACH REQUEST message indication with TAI change from lower layers

If the current TAI is not in the TAI list, the detach procedure shall be aborted and re-initiated after successfully performing a tracking area updating procedure. If the detach procedure was initiated due to removal of the USIM or the UE is to be switched off, the UE shall abort the detach procedure and enter the state EMM-DEREGISTERED.

If the current TAI is still part of the TAI list, the UE shall restart the detach procedure.

h) Transmission failure of DETACH REQUEST message indication without TAI change from lower layers

The UE shall restart the detach procedure.

5.5.2.2.5 Abnormal cases on the network side

The following abnormal cases can be identified:

a) Detach request received in a CSG cell for which the UE has no valid CSG subscription

If the UE initiates a detach procedure in a CSG cell the CSG ID of which is not valid for the UE, and the detach procedure is not due to "switch off", the network shall proceed as follows:

- if the detach type is "IMSI detach" and the UE has a PDN connection for emergency bearer services active, the MME shall send a DETACH ACCEPT message and deactivate all non-emergency EPS bearers, if any, by initiating an EPS bearer context deactivation procedure;

- otherwise, the network shall initiate the detach procedure. The MME shall send a DETACH REQUEST message including the EMM cause #25,"not authorized for this CSG".

b) Lower layers indication of non-delivered NAS PDU due to handover

If the DETACH ACCEPT message could not be delivered due to an intra MME handover and the target TA is included in the TAI list, then upon successful completion of the intra MME handover the MME shall retransmit the DETACH ACCEPT message. If a failure of the handover procedure is reported by the lower layer and the S1 signalling connection exists, the MME shall retransmit the DETACH ACCEPT message.

5.5.2.3 Network initiated detach procedure

5.5.2.3.1 Network initiated detach procedure initiation

The network initiates the detach procedure by sending a DETACH REQUEST message to the UE (see example in figure 5.5.2.3.1).

NOTE: If the MME performs a local detach, it will inform the UE with an EMM messages (e.g. SERVICE REJECT or TRACKING AREA UPDATE reject) with EMM cause #10 "implicitly detached" only when the UE initiates an EMM procedure.

The network may include an EMM cause IE to specify the reason for the detach request. The network shall start timer T3422. If the Detach type IE indicates "re-attach required" or "re-attach not required" and the EMM cause value is not #2 "IMSI unknown in HSS", or if the MME performs a local detach, the MME shall either store the current EPS security context if it is a native EPS security context, or the MME shall delete the current EPS security context if it is a mapped EPS security context. If the detach type IE indicates "re-attach required" or "re-attach not required" and the EMM cause value is not #2 "IMSI unknown in HSS", the network shall deactivate the EPS bearer context(s), if any, for the UE locally and enter state EMM-DEREGISTERED-INITIATED.

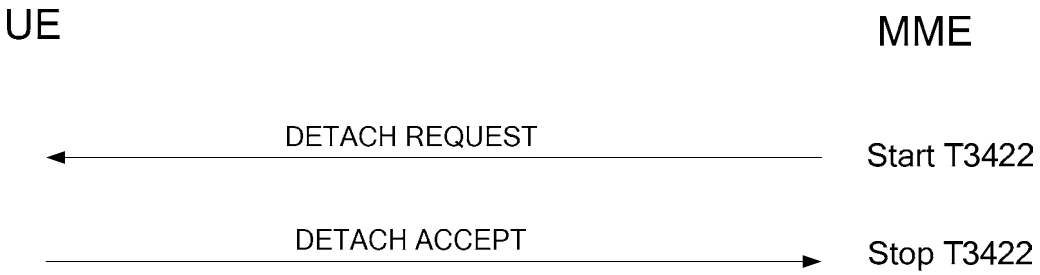


Figure 5.5.2.3.1: Network initiated detach procedure

5.5.2.3.2 Network initiated detach procedure completion by the UE

When receiving the DETACH REQUEST message and the detach type indicates "re-attach required", the UE shall deactivate the EPS bearer context(s), if any, including the default EPS bearer context locally without peer-to-peer signalling between the UE and the MME. The UE shall stop the timer T3346, if it is running. The UE shall also stop timer(s) T3396, if it is running. The UE shall send a DETACH ACCEPT message to the network and enter the state EMM-DEREGISTERED. Furthermore, the UE shall, after the completion of the detach procedure, and the release of the existing NAS signalling connection, initiate an attach or combined attach procedure. The UE should also re-establish any previously established PDN connection(s).

NOTE 1: When the detach type indicates "re-attach required", user interaction is necessary in some cases when the UE cannot re-activate the EPS bearer(s), if any, automatically.

A UE which receives a DETACH REQUEST message with detach type indicating "re-attach required" or "re-attach not required" and no EMM cause IE, is detached only for EPS services.

When receiving the DETACH REQUEST message and the detach type indicates "IMSI detach", the UE shall not deactivate the EPS bearer context(s) including the default EPS bearer context. The UE shall set the MM update status to

U2 NOT UPDATED. A UE may send a DETACH ACCEPT message to the network, and shall re-attach to non-EPS services by performing the combined tracking area updating procedure according to subclause 5.5.3.3, sending a TRACKING AREA UPDATE REQUEST message with EPS update type IE indicating "combined TA/LA updating with IMSI attach".

If the UE is attached for EPS and non-EPS services, then the UE shall set the update status to U2 NOT UPDATED if:

- the Detach type IE indicates "re-attach required"; or
- the Detach type IE indicates "re-attach not required" and no EMM cause IE is included.

When receiving the DETACH REQUEST message and the detach type indicates "re-attach not required" and no EMM cause IE, or "re-attach not required" and the EMM cause value is not #2 "IMSI unknown in HSS", the UE shall deactivate the EPS bearer context(s), if any, including the default EPS bearer context locally without peer-to-peer signalling between the UE and the MME. The UE shall then send a DETACH ACCEPT message to the network and enter state EMM-DEREGISTERED.

If the detach type indicates "IMSI detach" or "re-attach required", then the UE shall ignore the EMM cause IE if received.

If the detach type indicates "re-attach not required", the UE shall take the following actions depending on the received EMM cause value:

#2 (IMSI unknown in HSS);

The UE shall handle the MM parameters update status, TMSI, LAI and ciphering key sequence number as specified in 3GPP TS 24.008 [13] for the case when a DETACH REQUEST is received with the GMM cause with the same value and with detach type set to "re-attach not required". The USIM shall be considered as invalid for non-EPS services until switching off or the UICC containing the USIM is removed or the timer T3245 expires as described in subclause 5.3.7a. If the UE maintains a counter for "SIM/USIM considered invalid for non-GPRS services", then the UE shall set this counter to UE implementation-specific maximum value.

The UE is still attached for EPS services in the network.

#3 (Illegal UE);

#6 (Illegal ME); or

#8 (EPS services and non-EPS services not allowed);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and KSI. The UE shall consider the USIM as invalid for EPS services until switching off or the UICC containing the USIM is removed or the timer T3245 expires as described in subclause 5.3.7a. The UE shall delete the list of equivalent PLMNs and shall enter the state EMM-DEREGISTERED. If the UE maintains a counter for "SIM/USIM considered invalid for GPRS services", then the UE shall set this counter to UE implementation-specific maximum value. If the UE maintains a counter for "SIM/USIM considered invalid for non-GPRS services", then the UE shall set this counter to UE implementation-specific maximum value.

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the MM parameters update status, TMSI, LAI and ciphering key sequence number and the GMM parameters GMM state, RAI, P-TMSI, P-TMSI signature, GPRS ciphering key sequence number and GPRS update status as specified in 3GPP TS 24.008 [13] for the case when a DETACH REQUEST is received with the GMM cause with the same value and with detach type set to "re-attach not required". The USIM shall also be considered as invalid for non-EPS services until switching off or the UICC containing the USIM is removed or the timer T3245 expires as described in subclause 5.3.7a.

NOTE 2: The possibility to configure a UE so that the radio transceiver for a specific radio access technology is not active, although it is implemented in the UE, is out of scope of the present specification.

#7 (EPS services not allowed);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and KSI. The UE shall consider the USIM as invalid for EPS services until switching off or the UICC containing the USIM is removed

or the timer T3245 expires as described in subclause 5.3.7a. The UE shall delete the list of equivalent PLMNs and shall enter the state EMM-DEREGISTERED. If the UE maintains a counter for "SIM/USIM considered invalid for GPRS services", then the UE shall set this counter to UE implementation-specific maximum value.

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM parameters GMM state, RAI, P-TMSI, P-TMSI signature, GPRS ciphering key sequence number and GPRS update status as specified in 3GPP TS 24.008 [13] for the case when a DETACH REQUEST is received with the GMM cause with the same value and with detach type set to "re-attach not required".

A UE operating in CS/PS mode 1 or CS/PS mode 2 of operation which is IMSI attached for non-EPS services is still IMSI attached for non-EPS services in the network. The UE operating in CS/PS mode 1 or CS/PS mode 2 of operation shall set the update status to U2 NOT UPDATED, shall attempt to select GERAN or UTRAN access technology and shall proceed with the appropriate MM specific procedure according to the MM service state. The UE shall not reselect E-UTRAN radio access technology until switching off or the UICC containing the USIM is removed.

#11 (PLMN not allowed);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and KSI. The UE shall delete the list of equivalent PLMNs, shall reset the attach attempt counter and enter the state EMM-DEREGISTERED.PLMN-SEARCH.

The UE shall store the PLMN identity in the "forbidden PLMN list" and if the UE is configured to use timer T3245 (see 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17]) then the UE shall start timer T3245 and proceed as described in subclause 5.3.7a. If the message has been successfully integrity checked by the NAS and the UE maintains a PLMN-specific attempt counter for that PLMN, then the UE shall set this counter to the UE implementation-specific maximum value.

The UE shall perform a PLMN selection according to 3GPP TS 23.122 [6].

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the MM parameters update status, TMSI, LAI and ciphering key sequence number and the GMM parameters GMM state, RAI, P-TMSI, P-TMSI signature, GPRS ciphering key sequence number, GPRS update status and GPRS attach attempt counter as specified in 3GPP TS 24.008 [13] for the case when a DETACH REQUEST is received with the GMM cause with the same value and with detach type set to "re-attach not required".

#12 (Tracking area not allowed);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and KSI. The UE shall reset the attach attempt counter and shall enter the state EMM-DEREGISTERED.LIMITED-SERVICE.

The UE shall store the current TAI in the list of "forbidden tracking areas for regional provision of service".

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM parameters GMM state, RAI, P-TMSI, P-TMSI signature, GPRS ciphering key sequence number, GPRS update status and GPRS attach attempt counter as specified in 3GPP TS 24.008 [13] for the case when a DETACH REQUEST is received with the GMM cause with the same value and with detach type set to "re-attach not required". If the UE is IMSI attached for non-EPS services, the UE shall in addition handle the MM parameters update status, TMSI, LAI, ciphering key sequence number and location update attempt counter as specified in 3GPP TS 24.008 [13] for the case when a DETACH REQUEST is received with the GMM cause with the same value and with detach type set to "re-attach not required".

#13 (Roaming not allowed in this tracking area);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and KSI. The UE shall delete the list of equivalent PLMNs, reset the attach attempt counter and shall change to state EMM-DEREGISTERED.PLMN-SEARCH.

The UE shall store the current TAI in the list of "forbidden tracking areas for roaming".

The UE shall perform a PLMN selection according to 3GPP TS 23.122 [6]

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM parameters GMM state, RAI, P-TMSI, P-TMSI signature, GPRS ciphering key sequence number, GPRS update status and GPRS attach attempt counter as specified in 3GPP TS 24.008 [13] for the case when a DETACH REQUEST is received with the GMM cause with the same value and with detach type set to "re-attach not required". If the UE is IMSI attached for non-EPS services, the UE shall in addition handle the MM parameters update status, TMSI, LAI, ciphering key sequence number and location update attempt counter and as specified in 3GPP TS 24.008 [13] for the case when a DETACH REQUEST is received with the GMM cause with the same value and with detach type set to "re-attach not required".

#14 (EPS services not allowed in this PLMN);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3). Furthermore the UE shall delete any GUTI, last visited registered TAI, TAI list and KSI. The UE shall reset the attach attempt counter and shall enter the state EMM-DEREGISTERED.PLMN-SEARCH.

The UE shall store the PLMN identity in the "forbidden PLMNs for GPRS service" list and if the UE is configured to use timer T3245 (see 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17]) then the UE shall start timer T3245 and proceed as described in subclause 5.3.7a. If the message has been successfully integrity checked by the NAS and the UE maintains a PLMN-specific PS-attempt counter for that PLMN, then the UE shall set this counter to the UE implementation-specific maximum value.

A UE in PS mode 1 or PS mode 2 of operation shall delete the list of equivalent PLMNs and perform a PLMN selection according to 3GPP TS 23.122 [6].

A UE operating in CS/PS mode 1 or CS/PS mode 2 of operation which is IMSI attached for non-EPS services is still IMSI attached for non-EPS services and shall set the update status to U2 NOT UPDATED.

A UE operating in CS/PS mode 1 of operation and supporting A/Gb mode or Iu mode may select GERAN or UTRAN radio access technology and proceed with the appropriate MM specific procedure according to the MM service state. In this case, the UE shall disable the E-UTRA capability (see subclause 4.5).

A UE operating in CS/PS mode 1 of operation and supporting A/Gb mode or Iu mode may perform a PLMN selection according to 3GPP TS 23.122 [6].

A UE operating in CS/PS mode 1 of operation and supporting S1 mode only or operating in CS/PS mode 2 of operation shall delete the list of equivalent PLMNs and shall perform a PLMN selection according to 3GPP TS 23.122 [6].

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM parameters GMM state, GPRS update status, RAI, P-TMSI, P-TMSI signature, GPRS ciphering key sequence number and GPRS attach attempt counter as specified in 3GPP TS 24.008 [13] for the case when a DETACH REQUEST is received with the GMM cause with the same value and with detach type set to "re-attach not required".

#15 (No suitable cells in tracking area);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3). and shall delete any GUTI, last visited registered TAI, TAI list and KSI. The UE shall reset the attach attempt counter and shall enter the state EMM-DEREGISTERED.LIMITED-SERVICE.

The UE shall store the current TAI in the list of "forbidden tracking areas for roaming".

The UE shall search for a suitable cell in another tracking area or in another location area according to 3GPP TS 36.304 [21].

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM parameters GMM state, RAI, P-TMSI, P-TMSI signature, GPRS ciphering key sequence number, GPRS update status and GPRS attach attempt counter as specified in 3GPP TS 24.008 [13] for the case when a DETACH REQUEST is received with the GMM cause with the same value and with detach type set to "re-attach not required". If the UE is IMSI attached for non-EPS services, the UE shall in addition handle the MM parameters update status, TMSI, LAI, ciphering key sequence number and location update attempt counter as specified in 3GPP TS 24.008 [13] for the case when a DETACH REQUEST is received with the GMM cause with the same value and with detach type set to "re-attach not required".

#25 (Not authorized for this CSG);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3). The UE shall reset the attach attempt counter and shall enter the state EMM-DEREGISTERED.LIMITED-SERVICE.

If the cell where the UE has received the DETACH REQUEST message is a CSG cell and the CSG ID and associated PLMN identity of the cell are contained in the Allowed CSG list, the UE shall remove the entry corresponding to this CSG ID and associated PLMN identity from the Allowed CSG list.

If the cell where the UE has received the DETACH REQUEST message is a CSG cell and the CSG ID and associated PLMN identity of the cell are contained in the Operator CSG list, the UE shall apply the procedures defined in 3GPP TS 23.122 [6] subclause 3.1A.

The UE shall search for a suitable cell according to 3GPP TS 36.304 [21].

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM parameters GMM state, GPRS update status and GPRS attach attempt counter as specified in 3GPP TS 24.008 [13] for the case when a DETACH REQUEST is received with GMM cause with the same value and with detach type set to "re-attach not required". If the UE is IMSI attached for non-EPS services, the UE shall in addition handle the MM parameters update status and location update attempt counter as specified in 3GPP TS 24.008 [13] for the case when a DETACH REQUEST is received with the GMM cause with the same value and with detach type set to "re-attach not required".

Other EMM cause values or if no EMM cause IE is included is considered as abnormal cases. The behaviour of the UE in those cases is described in subclause 5.5.2.3.4.

5.5.2.3.3 Network initiated detach procedure completion by the network

The network shall stop timer T3422 upon receipt of the DETACH ACCEPT message. If the Detach type IE indicates "IMSI detach", or "re-attach not required" and the EMM cause value is #2 "IMSI unknown in HSS", the network shall not change the current EMM state; otherwise the network shall enter state EMM-DEREGISTERED.

5.5.2.3.4 Abnormal cases in the UE

The following abnormal cases can be identified:

a) Transmission failure of DETACH ACCEPT message indication from lower layers

The detach procedure shall be progressed and the UE shall send the DETACH ACCEPT message.

b) DETACH REQUEST, other EMM cause values than those treated in subclause 5.5.2.3.2 or no EMM cause IE is included, and the Detach type IE indicates "re-attach not required"

The UE shall delete any GUTI, TAI list, last visited registered TAI, list of equivalent PLMNs, KSI, shall set the update status to EU2 NOT UPDATED and shall start timer T3402.

A UE operating in CS/PS mode 1 or CS/PS mode 2 of operation which is IMSI attached for non-EPS services is still IMSI attached for non-EPS services and shall set the update status to U2 NOT UPDATED.

- A UE not supporting A/Gb mode or Iu mode, or operating in PS mode of operation may enter the state EMM-DEREGISTERED.PLMN-SEARCH in order to perform a PLMN selection according to 3GPP TS 23.122 [6]; otherwise the UE shall enter the state EMM-DEREGISTERED.ATTEMPTING-TO-ATTACH.

  A UE supporting A/Gb mode or Iu mode and operating in CS/PS mode 1 of operation or CS/PS mode 2 of operation shall

  - enter the state EMM-DEREGISTERED and attempt to select GERAN or UTRAN radio access technology and proceed with the appropriate MM or GMM specific procedures. In this case, the UE may disable the E-UTRA capability (see subclause 4.5); or

  - enter the state EMM-DEREGISTERED.PLMN-SEARCH in order to perform a PLMN selection according to 3GPP TS 23.122 [6].

  If A/Gb mode or Iu mode is supported by the UE, the UE shall set the GPRS update status to GU2 NOT UPDATED and shall delete the GMM parameters P-TMSI, P-TMSI signature, RAI, GPRS ciphering key sequence number and shall enter the state GMM-DEREGISTERED.

5.5.2.3.5 Abnormal cases on the network side

The following abnormal cases can be identified:

a) T3422 time-out

On the first expiry of the timer, the network shall retransmit the DETACH REQUEST message and shall start timer T3422. This retransmission is repeated four times, i.e. on the fifth expiry of timer T3422, the detach procedure shall be aborted. If the detach type is "IMSI detach", or "re-attach not required" and the EMM cause value is #2 "IMSI unknown in HSS", the network shall not change the current EMM state; otherwise the network shall change to state EMM-DEREGISTERED.

b) Lower layer failure

The detach procedure is aborted. If the detach type indicates "IMSI detach", or "re-attach not required" and the EMM cause value is #2 "IMSI unknown in HSS", the network shall not change the current EMM state; otherwise the network shall change to state EMM-DEREGISTERED.

c) Detach procedure collision

If the network receives a DETACH REQUEST message with "switch off" indication, before the network initiated detach procedure has been completed, both procedures shall be considered completed.

If the network receives a DETACH REQUEST message without "switch off" indication, before the network initiated detach procedure has been completed, the network shall send a DETACH ACCEPT message to the UE.

d) Detach and attach procedure collision

If the network receives an ATTACH REQUEST message before the network initiated detach procedure with detach type "re-attach not required" and the EMM cause value not #2 "IMSI unknown in HSS", has been completed, the network shall ignore the ATTACH REQUEST message. If the Detach type IE, sent in the DETACH REQUEST message, indicates "re-attach required" the detach procedure is aborted and the attach procedure shall be progressed after the EPS bearer context(s) have been deleted. If the Detach type IE, sent in DETACH REQUEST message, indicates "IMSI detach", or "re-attach not required" and the EMM cause value is #2 "IMSI unknown in HSS", the detach procedure is aborted and the attach procedure shall be progressed.

e) Detach and tracking area updating procedure collision

If the Detach type IE, sent in DETACH REQUEST message, indicates "re-attach not required" with EMM cause other than #2 "IMSI unknown in HSS" or indicates "re-attach required", and the network receives a TRACKING AREA UPDATE REQUEST message before the network initiated detach procedure has been completed, the detach procedure shall be progressed, i.e. the TRACKING AREA UPDATE REQUEST message shall be ignored.

If the Detach type IE, sent in DETACH REQUEST message, indicates "re-attach not required" with EMM cause #2 "IMSI unknown in HSS" or indicates "IMSI detach" and the network receives a TRACKING AREA UPDATE REQUEST message before the network initiated detach procedure has been completed, the network shall abort the detach procedure, shall stop T3422 and shall progress the tracking area updating procedure.

f) Detach and service request procedure collision

If the network receives a SERVICE REQUEST message or an EXTENDED SERVICE REQUEST message for packet services before the network initiated detach procedure has been completed (e.g. the DETACH REQUEST message is pending to be sent to the UE) and the DETACH REQUEST contains detach type "re-attach not required" with EMM cause #2 "IMSI unknown in HSS" or detach type "IMSI detach", the network shall progress both procedures. If the DETACH REQUEST message contains detach type "re-attach not required" with EMM cause other than #2 "IMSI unknown in HSS" or detach type "re-attach required", the network shall progress the detach procedure.

If the network receives an EXTENDED SERVICE REQUEST message for CS fallback, but not for CS fallback for emergency call, before the network initiated detach procedure has been completed (e.g. the DETACH REQUEST message is pending to be sent to the UE) and the DETACH REQUEST contains detach type "re-attach not required" with EMM cause #2 "IMSI unknown in HSS" or detach type "IMSI detach", the network shall ignore the EXTENDED SERVICE REQUEST message and progress the detach procedure.

If the network receives an EXTENDED SERVICE REQUEST message for CS fallback for emergency call before the network initiated detach procedure has been completed (e.g. the DETACH REQUEST message is pending to be sent to the UE) and the DETACH REQUEST contains detach type "re-attach not required" with EMM cause #2 "IMSI unknown in HSS" or detach type "IMSI detach", the network shall progress both procedures.

g) Lower layers indication of non-delivered NAS PDU due to handover

If the DETACH REQUEST message could not be delivered due to an intra MME handover and the target TA is included in the TAI list, then upon successful completion of the intra MME handover the MME shall retransmit the DETACH REQUEST message. If a failure of the handover procedure is reported by the lower layer and the S1 signalling connection exists, the MME shall retransmit the DETACH REQUEST message.

5.5.3 Tracking area updating procedure (S1 mode only)

5.5.3.1 General

The tracking area updating procedure is always initiated by the UE and is used for the following purposes:

- normal tracking area updating to update the registration of the actual tracking area of a UE in the network;
- combined tracking area updating to update the registration of the actual tracking area for a UE in CS/PS mode 1 or CS/PS mode 2 of operation;
- periodic tracking area updating to periodically notify the availability of the UE to the network;
- IMSI attach for non-EPS services when the UE is attached for EPS services. This procedure is used by a UE in CS/PS mode 1 or CS/PS mode 2 of operation;
- in various cases of inter-system change from Iu mode to S1 mode or from A/Gb mode to S1 mode;
- in various cases of inter-system change from N1 mode to S1 mode if the UE operates in single-registration mode and as described in 3GPP TS 24.501 [54];

S101 mode to S1 mode inter-system change;

- MME load balancing;
- to update certain UE specific parameters in the network;
- recovery from certain error cases;
- to indicate that the UE enters S1 mode after CS fallback or 1xCS fallback;
- to indicate to the network that the UE has selected a CSG cell whose CSG identity and associated PLMN identity are not included in the UE's Allowed CSG list or in the UE's Operator CSG list;
- to indicate the current radio access technology to the network for the support of terminating access domain selection for voice calls or voice sessions; and
- to indicate to the network that the UE has locally released EPS bearer context(s).

Details on the conditions for the UE to initiate the tracking area updating procedure are specified in subclause 5.5.3.2.2 and subclause 5.5.3.3.2.

While a UE has a PDN connection for emergency bearer services, the UE shall not perform manual CSG selection.

If control plane CIoT EPS optimization is not used by the UE, a UE initiating the tracking area updating procedure in EMM-IDLE mode may request the network to re-establish the radio and S1 bearers for all active EPS bearer contexts during the procedure. If control plane CIoT EPS optimization is used by the UE, a UE initiating the tracking area updating procedure in EMM-IDLE mode may request the network to re-establish the radio and S1 bearers for all active EPS bearer contexts associated with PDN connections established without control plane only indication during the procedure.

In a shared network, the UE shall choose one of the PLMN identities as specified in 3GPP TS 23.122 [6]. The UE shall construct the TAI of the cell from this chosen PLMN identity and the TAC received for this PLMN identity on the

broadcast system information. The chosen PLMN identity shall be indicated to the E-UTRAN (see 3GPP TS 36.331 [22]). Whenever a TRACKING AREA UPDATE REJECT message with the EMM cause #11 "PLMN not allowed" is received by the UE, the chosen PLMN identity shall be stored in the "forbidden PLMN list" and if the UE is configured to use timer T3245 (see 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17]) then the UE shall start timer T3245 and proceed as described in subclause 5.3.7a. Whenever a TRACKING AREA UPDATE REJECT message with the EMM cause #14 "EPS services not allowed in this PLMN" is received by the UE, the chosen PLMN identity shall be stored in the "forbidden PLMNs for GPRS service". Whenever a TRACKING AREA UPDATE REJECT message is received by the UE with the EMM cause #12 "tracking area not allowed", #13 "roaming not allowed in this tracking area", or #15 "no suitable cells in tracking Area", the constructed TAI shall be stored in the suitable list.

In a shared network, if TRACKING AREA UPDATE REJECT is received as a response to a tracking area update procedure initiated in EMM-CONNECTED mode, the UE need not update forbidden lists.

A tracking area updating attempt counter is used to limit the number of subsequently rejected tracking area update attempts. The tracking area updating attempt counter shall be incremented as specified in subclause 5.5.3.2.6. Depending on the value of the tracking area updating attempt counter, specific actions shall be performed. The tracking area updating attempt counter shall be reset when:

- an attach or combined attach procedure is successfully completed;
- a normal or periodic tracking area updating or a combined tracking area updating procedure is successfully completed;
- a normal or periodic tracking area updating or a combined tracking area updating procedure is rejected with EMM cause #11, #12, #13, #14, #15, #25 or #35:
- a combined attach procedure or a combined tracking area updating procedure is completed for EPS services only with cause #2 or #18;or
- a new PLMN is selected.

Additionally the tracking area updating attempt counter shall be reset when the UE is in substate EMM-REGISTERED.ATTEMPTING-TO-UPDATE or EMM-REGISTERED.ATTEMPTING-TO-UPDATE-MM, and:

- a new tracking area is entered;
- timer T3402 expires; or
- timer T3346 is started.

5.5.3.2 Normal and periodic tracking area updating procedure

5.5.3.2.1 General

The periodic tracking area updating procedure is controlled in the UE by timer T3412. When timer T3412 expires, the periodic tracking area updating procedure is started. Start and reset of timer T3412 is described in subclause 5.3.5.

5.5.3.2.2 Normal and periodic tracking area updating procedure initiation

The UE in state EMM-REGISTERED shall initiate the tracking area updating procedure by sending a TRACKING AREA UPDATE REQUEST message to the MME,

a) when the UE detects entering a tracking area that is not in the list of tracking areas that the UE previously registered in the MME, unless the UE is configured for "AttachWithIMSI" as specified in 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17] and is entering a tracking area in a new PLMN that is neither the registered PLMN nor in the list of equivalent PLMNs;

b) when the periodic tracking area updating timer T3412 expires;

c) when the UE enters EMM-REGISTERED.NORMAL-SERVICE and the UE's TIN indicates "P-TMSI";

d) when the UE performs an inter-system change from S101 mode to S1 mode and has no user data pending;

e) when the UE receives an indication from the lower layers that the RRC connection was released with cause "load balancing TAU required";

f) when the UE deactivated EPS bearer context(s) locally while in EMM-REGISTERED, because it could not establish a NAS signalling connection, and then returns to EMM-REGISTERED.NORMAL-SERVICE and no EXTENDED SERVICE REQUEST message, CONTROL PLANE SERVICE REQUEST message or DETACH REQUEST message with detach type is "EPS detach" or "combined EPS/IMSI detach" is pending to be sent by the UE;

g) when the UE changes the UE network capability information or the MS network capability information or both;

h) when the UE changes the UE specific DRX parameter;

i) when the UE receives an indication of "RRC Connection failure" from the lower layers and has no signalling or user uplink data pending (i.e when the lower layer requests NAS signalling connection recovery);

j) when the UE enters S1 mode after 1xCS fallback or 1xSRVCC;

k) when due to manual CSG selection the UE has selected a CSG cell whose CSG identity and associated PLMN identity are not included in the UE's Allowed CSG list or in the UE's Operator CSG list;

l) when the UE reselects an E-UTRAN cell while it was in GPRS READY state or PMM-CONNECTED mode;

m) when the UE supports SRVCC to GERAN or UTRAN or supports vSRVCC to UTRAN and changes the mobile station classmark 2 or the supported codecs, or the UE supports SRVCC to GERAN and changes the mobile station classmark 3;

n) when the UE changes the radio capability for GERAN, or cdma2000® or both;

o) when the UE's usage setting or the voice domain preference for E-UTRAN change in the UE;

p) when the UE activates mobility management for IMS voice termination as specified in 3GPP TS 24.008 [13], annex P.2, and the TIN indicates "RAT-related TMSI";

q) when the UE performs an inter-system change from A/Gb mode to S1 mode and the TIN indicates "RAT-related TMSI", but the UE is required to perform tracking area updating for IMS voice termination as specified in 3GPP TS 24.008 [13], annex P.4;

r) upon reception of a paging indication using S-TMSI and the UE is in state EMM-REGISTERED.ATTEMPTING-TO-UPDATE;

s) when the UE needs to update the network with EPS bearer context status due to local de-activation of EPS bearer context(s) as specified in subclause 6.5.1.4A;

t) when the UE needs to request the use of PSM or needs to stop the use of PSM;

u) when the UE needs to request the use of eDRX or needs to stop the use of eDRX;

v) when a change in the eDRX usage conditions at the UE requires different extended DRX parameters;

w) when a change in the PSM usage conditions at the UE requires a different timer T3412 value or different timer T3324 value;

NOTE 2: A change in the PSM or eDRX usage conditions at the UE can include e.g. a change in the UE configuration, a change in requirements from upper layers or the battery running low at the UE.

x) when the CIoT EPS optimizations the UE needs to use, change in the UE;

y) when the Default_DCN_ID value changes, as specified in 3GPP TS 24.368 [15A] or in USIM file NAS_{CONFIG} as specified in 3GPP TS 31.102 [17];

NOTE 3: The tracking area updating procedure is initiated after deleting the DCN-ID list as specified in annex C.

z) when the UE performs inter-system change from N1 mode to S1 mode in EMM-IDLE mode, and the UE operates in single-registration mode (see 3GPP TS 24.501 [54]), and the following conditions apply;

- if both the UE and the MME support EMM-REGISTERED without PDN connection, or

- if the UE has at least one PDU session context for which interworking to EPS is supported as described in 3GPP TS 24.501 [54] subclause 4.8.3; or

za) when the UE in EMM-IDLE mode changes the radio capability for E-UTRAN; or

zb) when the UE needs to request new ciphering keys for ciphered broadcast assistance data.

For all cases except case b, the UE shall set the EPS update type IE in the TRACKING AREA UPDATE REQUEST message to "TA updating". For case b, the UE shall set the EPS update type IE to "periodic updating".

For cases n and za, the UE shall include a UE radio capability information update needed IE in the TRACKING AREA UPDATE REQUEST message.

For case l, if the TIN indicates "RAT-related TMSI", the UE shall set the TIN to "P-TMSI" before initiating the tracking area updating procedure.

For case r, the "active" flag in the EPS update type IE shall be set to 1. If a UE is only using EPS services with control plane CIoT EPS optimization, the "signalling active" flag in the Additional update type IE shall be set to 1.

If the UE is using only control plane CIoT EPS optimization, the case i only applies to the case that the UE has indicated to the network that subsequent to the uplink data transmission a downlink data transmission is expected during the transport of uplink user data via the control plane procedure (see subclause 6.6.4).

If the UE has to request resources for ProSe direct discovery or Prose direct communication (see 3GPP TS 36.331 [22]), then the UE shall set the "active" flag to 1 in the TRACKING AREA UPDATE REQUEST message.

If the UE does not have any established PDN connection, the "active" flag in the EPS update type IE shall be set to 0.

When the UE has user data pending and performs an inter-system change from S101 mode to S1 mode to a tracking area included in the TAI list stored in the UE, the UE shall perform a service request procedure instead of a tracking area updating procedure.

When initiating a tracking area updating procedure while in S1 mode, the UE shall use the current EPS NAS integrity key to integrity protect the TRACKING AREA UPDATE REQUEST message, unless the UE is performing inter-system change from N1 mode to S1 mode.

In order to indicate its UE specific DRX parameter while in E-UTRAN coverage, the UE shall send the TRACKING AREA UPDATE REQUEST message containing the UE specific DRX parameter in the DRX parameter IE to the network, with the exception of the case if the UE had indicated its DRX parameter (3GPP TS 24.008 [13]) to the network while in GERAN or UTRAN coverage. In this case, when the UE enters E-UTRAN coverage and initiates a tracking area updating procedure, the UE shall not include the UE specific DRX parameter in the DRX parameter IE in the TRACKING AREA UPDATE REQUEST message.

NOTE 4: The UE specific DRX parameter is not used by the E-UTRAN for paging from NB-IoT cells (see 3GPP TS 23.401 [10] and 3GPP TS 36.304 [21]).

If the UE supports eDRX and requests the use of eDRX, the UE shall include the extended DRX parameters IE in the TRACKING AREA UPDATE REQUEST message.

If the UE supports PSM and requests the use of PSM, the UE shall include the T3324 value IE with a requested timer value in the TRACKING AREA UPDATE REQUEST message. When the UE includes the T3324 value IE and the UE indicates support for extended periodic timer value in the MS network feature support IE, it may also include the T3412 extended value IE to request a particular T3412 value to be allocated.

If a UE supporting CIoT EPS optimizations in NB-S1 mode initiates the tracking area updating procedure for EPS services and "SMS only", the UE shall indicate "SMS only" in the Additional update type IE and shall set the EPS update type IE to "TA updating".

If the UE supports S1-U data transfer and multiple user plane radio bearers (see 3GPP TS 36.306 [44], 3GPP TS 36.331 [22]) in NB-S1 mode, then the UE shall set the Multiple DRB support bit to "Multiple DRB supported" in the UE network capability IE of the TRACKING AREA UPDATE REQUEST message.

If the UE has to request resources for V2X communication over PC5 (see 3GPP TS 23.285 [47]), then the UE shall set the "active" flag to 1 in the TRACKING AREA UPDATE REQUEST message.

After sending the TRACKING AREA UPDATE REQUEST message to the MME, the UE shall start timer T3430 and enter state EMM-TRACKING-AREA-UPDATING-INITIATED (see example in figure 5.5.3.2.2.1). If timer T3402 is currently running, the UE shall stop timer T3402. If timer T3411 is currently running, the UE shall stop timer T3411. If timer T3442 is currently running, the UE shall stop timer T3442.

If the UE supports neither A/Gb mode nor Iu mode, the UE shall include a valid GUTI in the Old GUTI IE in the TRACKING AREA UPDATE REQUEST message. In addition, the UE shall include Old GUTI type IE with GUTI type set to "native GUTI".

If the UE supports A/Gb mode or Iu mode or both, the UE shall handle the Old GUTI IE as follows:

- If the TIN indicates "P-TMSI" and the UE holds a valid P-TMSI and RAI, the UE shall map the P-TMSI and RAI into the Old GUTI IE, and include Old GUTI type IE with GUTI type set to "mapped GUTI". If a P-TMSI signature is associated with the P-TMSI, the UE shall include it in the Old P-TMSI signature IE. Additionally, if the UE holds a valid GUTI, the UE shall indicate the GUTI in the Additional GUTI IE.

NOTE 5: The mapping of the P-TMSI and RAI to the GUTI is specified in 3GPP TS 23.003 [2].

- If the TIN indicates "GUTI" or "RAT-related TMSI" and the UE holds a valid GUTI, the UE shall indicate the GUTI in the Old GUTI IE, and include Old GUTI type IE with GUTI type set to "native GUTI".

If a UE has established PDN connection(s) and uplink user data pending to be sent via user plane when it initiates the tracking area updating procedure, or uplink signalling not related to the tracking area updating procedure when the UE does not support control plane CIoT EPS optimization, it may also set an "active" flag in the TRACKING AREA UPDATE REQUEST message to indicate the request to establish the user plane to the network and to keep the NAS signalling connection after the completion of the tracking area updating procedure.

If a UE is using EPS services with control plane CIoT EPS optimization and has user data pending to be sent via control plane over MME but no user data pending to be sent via user plane, or uplink signalling not related to the tracking area updating procedure, the UE may set a "signalling active" flag in the TRACKING AREA UPDATE REQUEST message to indicate the request to keep the NAS signalling connection after the completion of the tracking area updating procedure.

If the UE has a current EPS security context, the UE shall include the eKSI (either KSI_{ASME} or KSI_{SGSN}) in the NAS Key Set Identifier IE in the TRACKING AREA UPDATE REQUEST message. Otherwise, the UE shall set the NAS Key Set Identifier IE to the value "no key is available". If the UE has a current EPS security context, the UE shall integrity protect the TRACKING AREA UPDATE REQUEST message with the current EPS security context. Otherwise the UE shall not integrity protect the TRACKING AREA UPDATE REQUEST message.

When the tracking area updating procedure is initiated in EMM-IDLE mode to perform an inter-system change from A/Gb mode or Iu mode to S1 mode and the TIN is set to "P-TMSI", the UE shall include the GPRS ciphering key sequence number applicable for A/Gb mode or Iu mode and a $nonce_{UE}$ in the TRACKING AREA UPDATE REQUEST message.

When the tracking area updating procedure is initiated in EMM-CONNECTED mode to perform an inter-system change from A/Gb mode or Iu mode to S1 mode, the UE shall derive the EPS NAS keys from the mapped K'_{ASME} using the selected NAS algorithms, $nonce_{MME}$ and KSI_{SGSN} (to be associated with the mapped K'_{ASME}) provided by lower layers as indicated in 3GPP TS 33.401 [19]. The UE shall reset both the uplink and downlink NAS COUNT counters of the mapped EPS security context which shall be taken into use. If the UE has a non-current native EPS security context, the UE shall include the KSI_{ASME} in the Non-current native NAS key set identifier IE and its associated GUTI, as specified above, either in the Old GUTI IE or in the Additional GUTI IE of the TRACKING AREA UPDATE REQUEST message. The UE shall set the TSC flag in the Non-current native NAS key set identifier IE to "native security context".

For the case z, the TRACKING AREA UPDATE REQUEST message shall be integrity protected using the 5GS security context available in the UE. The UE shall include a GUTI, mapped from 5G-GUTI (see 3GPP TS 23.501 [54] and 3GPP TS 23.003 [2]), in the Old GUTI IE in the TRACKING AREA UPDATE REQUEST message. In addition, the UE shall include Old GUTI type IE with GUTI set to "Native GUTI", and the UE shall include a UE status IE with a 5GMM registration status set to "UE is in 5GMM-REGISTERED state".

When the tracking area updating procedure is initiated in EMM-IDLE mode, the UE may also include an EPS bearer context status IE in the TRACKING AREA UPDATE REQUEST message, indicating which EPS bearer contexts are active in the UE. The UE shall include the EPS bearer context status IE in TRACKING AREA UPDATE REQUEST message:

- for the case f;
- for the case s;
- for the case z; and

- if the UE has established PDN connection(s) of "non IP" PDN type.

If the UE initiates the first tracking area updating procedure following an attach in A/Gb mode or Iu mode, the UE shall include a UE radio capability information update needed IE in the TRACKING AREA UPDATE REQUEST message.

For all cases except case b, if the UE supports SRVCC to GERAN/UTRAN, the UE shall set the SRVCC to GERAN/UTRAN capability bit in the MS network capability IE to "SRVCC from UTRAN HSPA or E-UTRAN to GERAN/UTRAN supported".

For all cases except case b, if the UE supports vSRVCC from S1 mode to Iu mode, then the UE shall set the H.245 after handover capability bit in the UE network capability IE to "H.245 after SRVCC handover capability supported" and additionally set the SRVCC to GERAN/UTRAN capability bit in the MS network capability IE to "SRVCC from UTRAN HSPA or E-UTRAN to GERAN/UTRAN supported" in the TRACKING AREA UPDATE REQUEST message.

For all cases except case b, if the UE supports ProSe direct discovery, then the UE shall set the ProSe bit to "ProSe supported" and set the ProSe direct discovery bit to "ProSe direct discovery supported" in the UE network capability IE of the TRACKING AREA UPDATE REQUEST message.

For all cases except case b, if the UE supports ProSe direct communication, then the UE shall set the ProSe bit to "ProSe supported" and set the ProSe direct communication bit to "ProSe direct communication supported" in the UE network capability IE of the TRACKING AREA UPDATE REQUEST message.

For all cases except case b, if the UE supports acting as a ProSe UE-to-network relay, then the UE shall set the ProSe bit to "ProSe supported" and set the ProSe UE-to-network relay bit to "acting as a ProSe UE-to-network relay supported" in the UE network capability IE of the TRACKING AREA UPDATE REQUEST message.

If the UE supports NB-S1 mode, Non-IP PDN type, or N1 mode, then the UE shall support the extended protocol configuration options IE.

For all cases except case b, if the UE supports the extended protocol configuration options IE, then the UE shall set the ePCO bit to "extended protocol configuration options supported" in the UE network capability IE of the TRACKING AREA UPDATE REQUEST message.

For all cases except case b, if the UE supports V2X communication over PC5, then the UE shall set the V2X PC5 bit to "V2X communication over PC5 supported" in the UE network capability IE of the TRACKING AREA UPDATE REQUEST message.

For all cases except case b, if the UE supports the restriction on use of enhanced coverage, then the UE shall set the RestrictEC bit to "Restriction on use of enhanced coverage supported" in the UE network capability IE of the TRACKING AREA UPDATE REQUEST message.

For all cases except case b, if the UE supports the control plane data back-off timer T3448, the UE shall set the CP backoff bit to "backoff timer for transport of user data via the control plane supported" in the UE network capability IE of the TRACKING AREA UPDATE REQUEST message.

For all cases except case b, if the UE supports dual connectivity with NR, then the UE shall set the DCNR bit to "dual connectivity with NR supported" in the UE network capability IE of the TRACKING AREA UPDATE REQUEST message and shall include the UE additional security capability IE in the TRACKING AREA UPDATE REQUEST message.

For all cases except case b, if the UE supports SGC, then the UE shall set the SGC bit to "service gap control supported" in the UE network capability IE of the TRACKING AREA UPDATE REQUEST message.

For all cases except case b, if the UE supports signalling for a maximum number of 15 EPS bearer contexts, then the UE shall set the 15 bearers bit to "Signalling for a maximum number of 15 EPS bearer contexts supported" in the UE network capability IE of the TRACKING AREA UPDATE REQUEST message.

For all cases except cases b and zb, if the UE supports ciphered broadcast assistance data and the UE needs to obtain new ciphering keys, the UE shall include the Additional information requested IE with the CipherKey bit set to "ciphering keys for ciphered broadcast assistance data requested" in the TRACKING AREA UPDATE REQUEST message.

For case ee, the UE shall include the Additional information requested IE with the CipherKey bit set to "ciphering keys for ciphered broadcast assistance data requested" in the TRACKING AREA UPDATE REQUEST message.

For case a, if the UE supports ciphered broadcast assistance data and the UE detects entering a tracking area for which one or more ciphering keys stored at the UE is not applicable, the UE should include the Additional information requested IE with the CipherKey bit set to "ciphering keys for ciphered broadcast assistance data requested" in the TRACKING AREA UPDATE REQUEST message.

For case b, if the UE supports ciphered broadcast assistance data and the remaining validity time for one or more ciphering keys stored at the UE is less than timer T3412, the UE should include the Additional information requested IE with the CipherKey bit set to "ciphering keys for ciphered broadcast assistance data requested" in the TRACKING AREA UPDATE REQUEST message.

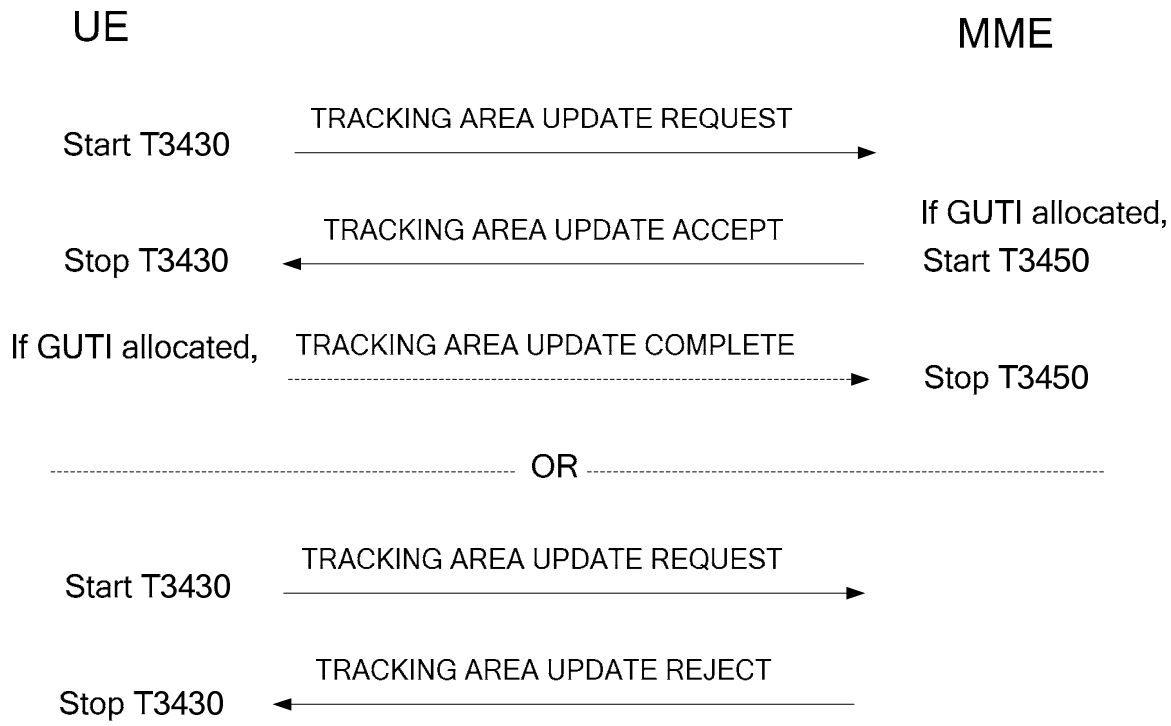


Figure 5.5.3.2.2.1: Tracking area updating procedure

5.5.3.2.3 EMM common procedure initiation

If the network receives a TRACKING AREA UPDATE REQUEST message containing the Old GUTI type IE, and the network does not follow the use of the most significant bit of the <MME group id> to distinguish the node type as specified in 3GPP TS 23.003 [2], subclause 2.8.2.2.2, the network shall use the Old GUTI type IE to determine whether the mobile identity included in the Old GUTI IE is a native GUTI or a mapped GUTI.

During the tracking area updating procedure, the MME may initiate EMM common procedures, e.g. the EMM authentication and security mode control procedures.

The MME may be configured to skip the authentication procedure even if no EPS security context is available and proceed directly to the execution of the security mode control procedure as specified in subclause 5.4.3, during a tracking area updating procedure for a UE that has only a PDN connection for emergency bearer services.

The MME shall not initiate an EMM authentication procedure before completion of the tracking area updating procedure, if the following conditions apply:

a) the UE initiated the tracking area updating procedure after handover or inter-system handover to S1 mode;

b) the target cell is a shared network cell; and

- the UE has provided its GUTI in the Old GUTI IE or the Additional GUTI IE in the TRACKING AREA UPDATE REQUEST message, and the PLMN identity included in the GUTI is different from the selected PLMN identity of the target cell; or

- the UE has mapped the P-TMSI and RAI into the Old GUTI IE and not included an Additional GUTI IE in the TRACKING AREA UPDATE REQUEST message, and the PLMN identity included in the RAI is different from the selected PLMN identity of the target cell.

5.5.3.2.4 Normal and periodic tracking area updating procedure accepted by the network

If the tracking area update request has been accepted by the network, the MME shall send a TRACKING AREA UPDATE ACCEPT message to the UE. If the MME assigns a new GUTI for the UE, a GUTI shall be included in the TRACKING AREA UPDATE ACCEPT message. In this case, the MME shall start timer T3450 and enter state EMM-COMMON-PROCEDURE-INITIATED as described in subclause 5.4.1. The MME may include a new TAI list for the UE in the TRACKING AREA UPDATE ACCEPT message. The MME shall not assign a TAI list containing both tracking areas in NB-S1 mode and tracking areas in WB-S1 mode.

NOTE 1: When assigning the TAI list, the MME can take into account the eNodeB's capability of support of CIoT EPS optimization.

If the UE has included the UE network capability IE or the MS network capability IE or both in the TRACKING AREA UPDATE REQUEST message, the MME shall store all octets received from the UE, up to the maximum length defined for the respective information element.

NOTE 2: This information is forwarded to the new MME during inter-MME handover or to the new SGSN during inter-system handover to A/Gb mode or Iu mode.

NOTE 3: For further details concerning the handling of the MS network capability and UE network capability in the MME see also 3GPP TS 23.401 [10].

In NB-S1 mode, if the tracking area update request is accepted by the network, the MME shall set the EMC BS bit to zero in the EPS network feature support IE included in the TRACKING AREA UPDATE ACCEPT message to indicate that support of emergency bearer services in NB-S1 mode is not available.

If a UE radio capability information update needed IE is included in the TRACKING AREA UPDATE REQUEST message, the MME shall delete the stored UE radio capability information, if any.

If the UE specific DRX parameter was included in the DRX Parameter IE in the TRACKING AREA UPDATE REQUEST message, the network shall replace any stored UE specific DRX parameter with the received parameter and use it for the downlink transfer of signalling and user data.

If the UE requests "control plane CIoT EPS optimization" in the Additional update type IE, indicates support of control plane CIoT EPS optimization in the UE network capability IE and the MME decides to accept the requested CIoT EPS optimization and the tracking area update request, the MME shall indicate "control plane CIoT EPS optimization supported" in the EPS network feature support IE.

In NB-S1 mode, if the UE requested "SMS only" in the Additional update type IE, supports NB-S1 mode only and the MME decides to accept the tracking area update request for EPS services and "SMS only", the MME shall indicate "SMS only" in the Additional update result IE and shall set the EPS update type IE to "TA updating" in the TRACKING AREA UPDATE ACCEPT message.

The MME shall include the extended DRX parameters IE in the TRACKING AREA UPDATE ACCEPT message only if the extended DRX parameters IE was included in the TRACKING AREA UPDATE REQUEST message, and the MME supports and accepts the use of eDRX.

If the UE indicates support for EMM-REGISTERED without PDN connection in the TRACKING AREA UPDATE REQUEST message and the MME supports EMM-REGISTERED without PDN connection, the MME shall indicate this in the EPS network feature support IE of the TRACKING AREA UPDATE ACCEPT message. The UE and the MME shall use the information whether the peer entity supports EMM-REGISTERED without PDN connection as specified in the present clause 5 and in clause 6.

If an EPS bearer context status IE is included in the TRACKING AREA UPDATE REQUEST message, the MME shall deactivate all those EPS bearer contexts locally (without peer-to-peer signalling between the MME and the UE) which are in ESM state BEARER CONTEXT ACTIVE or BEARER CONTEXT MODIFY PENDING on the network side, but are indicated by the UE as being in ESM state BEARER CONTEXT INACTIVE. If a default EPS bearer context is marked as inactive in the EPS bearer context status IE included in the TRACKING AREA UPDATE REQUEST message, and this default bearer is not associated with the last remaining PDN connection of the UE in the MME, the MME shall locally deactivate all EPS bearer contexts associated to the PDN connection with the default EPS bearer context without peer-to-peer ESM signalling to the UE. If the default bearer is associated with the last remaining PDN

connection of the UE in the MME, and EMM-REGISTERED without PDN connection is supported by the UE and the MME, the MME shall locally deactivate all EPS bearer contexts associated to the PDN connection with the default EPS bearer context without peer-to-peer ESM signalling to the UE.

If the EPS bearer context status IE is included in the TRACKING AREA UPDATE REQUEST, the MME shall include an EPS bearer context status IE in the TRACKING AREA UPDATE ACCEPT message, indicating which EPS bearer contexts are active in the MME except for the case no EPS bearer context exists on the network side.

If the EPS update type IE included in the TRACKING AREA UPDATE REQUEST message indicates "periodic updating", and the UE was previously successfully attached for EPS and non-EPS services, subject to operator policies the MME should allocate a TAI list that does not span more than one location area.

The MME shall indicate "combined TA/LA updated" or "combined TA/LA updated and ISR activated" in the EPS update result IE in the TRACKING AREA UPDATE ACCEPT message, if the following conditions apply:

- the EPS update type IE included in the TRACKING AREA UPDATE REQUEST message indicates "periodic updating" and the UE was previously successfully attached for EPS and non-EPS services; and

- location area updating for non-EPS services as specified in 3GPP TS 29.118 [16A] is successful.

The MME may include T3412 extended value IE in the TRACKING AREA UPDATE ACCEPT message only if the UE indicates support of the extended periodic timer T3412 in the MS network feature support IE in the TRACKING AREA UPDATE REQUEST message.

The MME shall include the T3324 value IE in the TRACKING AREA UPDATE ACCEPT message only if the T3324 value IE was included in the TRACKING AREA UPDATE REQUEST message, and the MME supports and accepts the use of PSM.

If the MME supports and accepts the use of PSM, and the UE included the T3412extended value IE in the TRACKING AREA UPDATE REQUEST message, then the MME shall take into account the T3412 value requested when providing the T3412 value IE and the T3412 extended value IE in the TRACKING AREA UPDATE ACCEPT message.

NOTE 4: Besides the value requested by the MS, the MME can take local configuration or subscription data provided by the HSS into account when selecting a value for T3412 (see 3GPP TS 23.401 [10] subclause 4.3.17.3).

If the MME includes the T3324 value IE indicating a value other than deactivated in the TRACKING AREA UPDATE ACCEPT message, then the MME shall indicate in the EPS update result IE in the TRACKING AREA UPDATE ACCEPT message that ISR is not activated.

Also during the tracking area updating procedure without "active" flag, if the MME has deactivated EPS bearer context(s) locally for any reason, the MME shall inform the UE of the deactivated EPS bearer context(s) by including the EPS bearer context status IE in the TRACKING AREA UPDATE ACCEPT message.

Also during the tracking area updating procedure with "active" flag, if the MME has deactivated EPS bearer context(s) associated with control plane only indication locally for any reason, the MME shall inform the UE of the deactivated EPS bearer context(s) by including the EPS bearer context status IE in the TRACKING AREA UPDATE ACCEPT message.

If the TRACKING AREA UPDATE ACCEPT message contains the DCN-ID IE, then the UE shall store the included DCN-ID value together with the PLMN code of the registered PLMN in a DCN-ID list in a non-volatile memory in the ME as specified in annex C.

If due to regional subscription restrictions or access restrictions the UE is not allowed to access the TA, but it has a PDN connection for emergency bearer services established, the MME may accept the TRACKING AREA UPDATE REQUEST message and deactivate all non-emergency EPS bearer contexts by initiating an EPS bearer context deactivation procedure when the tracking area updating procedure is initiated in EMM-CONNECTED mode. When the tracking area updating procedure is initiated in EMM-IDLE mode, the MME locally deactivates all non-emergency EPS bearer contexts and informs the UE via the EPS bearer context status IE in the TRACKING AREA UPDATE ACCEPT message. The MME shall not deactivate the emergency EPS bearer contexts. The network shall consider the UE to be attached for emergency bearer services only and shall indicate in the EPS update result IE in the TRACKING AREA UPDATE ACCEPT message that ISR is not activated.

If a TRACKING AREA UPDATE REQUEST message is received from a UE with a LIPA PDN connection, and if:

- a GW Transport Layer Address IE value identifying a L-GW is provided by the lower layer together with the TRACKING AREA UPDATE REQUEST message, and the P-GW address included in the EPS bearer context of the LIPA PDN Connection is different from the provided GW Transport Layer Address IE value (see 3GPP TS 36.413 [23]); or

- no GW Transport Layer Address is provided together with the TRACKING AREA UPDATE REQUEST message by the lower layer,

then the MME locally deactivates all EPS bearer contexts associated with the LIPA PDN connection. Furthermore, the MME takes one of the following actions:

- if no active EPS bearer contexts remain for the UE, the MME shall not accept the tracking area update request as specified in subclause 5.5.3.2.5;

- if active EPS bearer contexts remain for the UE and the TRACKING AREA UPDATE REQUEST message is accepted, the MME informs the UE via the EPS bearer context status IE in the TRACKING AREA UPDATE ACCEPT message that EPS bearer contexts were locally deactivated.

If a TRACKING AREA UPDATE REQUEST message is received from a UE with a SIPTO at the local network PDN connection, is accepted by the network, the following different cases can be distinguished:

1) If the PDN connection is a SIPTO at the local network PDN connection with collocated L-GW and if:

   - a SIPTO L-GW Transport Layer Address IE value identifying a L-GW is provided by the lower layer together with the TRACKING AREA UPDATE REQUEST message, and the P-GW address included in the EPS bearer context of the SIPTO at the local network PDN connection is different from the provided SIPTO L-GW Transport Layer Address IE value (see 3GPP TS 36.413 [23]); or

   - no SIPTO L-GW Transport Layer Address is provided together with the TRACKING AREA UPDATE REQUEST message by the lower layer,

2) If the PDN connection is a SIPTO at the local network PDN connection with stand-alone GW and if:

   - a LHN-ID value is provided by the lower layer together with the TRACKING AREA UPDATE REQUEST message, and the LHN-ID stored in the EPS bearer context of the SIPTO at the local network PDN connection is different from the provided LHN-ID value (see 3GPP TS 36.413 [23]); or

   - no LHN-ID value is provided together with the TRACKING AREA UPDATE REQUEST message by the lower layer,

then the MME takes one of the following actions:

- if the SIPTO at the local network PDN connection is the last remaining PDN connection for the UE, and EMM-REGISTERED without PDN connection is not supported by the UE or the MME, then the MME shall upon completion of the tracking area updating procedure detach the UE by using detach type "re-attach required" (see subclause 5.5.2.3.1);

- if the SIPTO at the local network PDN connection is the last remaining PDN connection for the UE, and EMM-REGISTERED without PDN connection is supported by the UE and the MME, then the MME shall upon completion of the tracking area updating procedure initiate an EPS bearer context deactivation procedure with ESM cause #39 "reactivation requested"for the default EPS bearer context of the SIPTO at the local network PDN connection (see subclause 6.4.4.2); and

- if a PDN connection remains that is not SIPTO at the local network PDN connection, the MME shall upon completion of the tracking area updating procedure initiate an EPS bearer context deactivation procedure with ESM cause #39 "reactivation requested"for the default EPS bearer context of each SIPTO at the local network PDN connection (see subclause 6.4.4.2);

For a SIPTO at the local network PDN connection with stand-alone GW, the conditions to deactivate ISR are specified in 3GPP TS 23.401 [10], subclause 4.3.5.6.

For a shared network, the TAIs included in the TAI list can contain different PLMN identities. The MME indicates the selected core network operator PLMN identity to the UE in the GUTI (see 3GPP TS 23.251 [8B]).

If the "active" flag is included in the TRACKING AREA UPDATE REQUEST message and control plane CIoT EPS optimization is not used by the MME, the MME shall re-establish the radio and S1 bearers for all active EPS bearer

contexts. If the "active" flag is included in the TRACKING AREA UPDATE REQUEST message and control plane CIoT EPS optimization is used by the MME, the MME shall re-establish the radio and S1 bearers for all active EPS bearer contexts associated with PDN connections established without Control plane only indication.

If the "signalling active" flag is included in the TRACKING AREA UPDATE REQUEST message and control plane CIoT EPS optimization is used by the MME, the MME shall not immediately release the NAS signalling connection after the completion of the tracking area updating procedure.

If the "active" flag is not included in the TRACKING AREA UPDATE REQUEST message and control plane CIoT EPS optimization is not used by the MME, the MME may also re-establish the radio and S1 bearers for all active EPS bearer contexts due to downlink pending data or downlink pending signalling. If the "active" flag is not included in the TRACKING AREA UPDATE REQUEST message and control plane CIoT EPS optimization is used by the MME, the MME may also re-establish the radio and S1 bearers for all active EPS bearer contexts associated with PDN connections established without Control plane only indication due to downlink pending data or downlink pending signalling.

If the MME supports NB-S1 mode, Non-IP PDN type, or inter-system change with 5GS, then the MME shall support the extended protocol configuration options IE.

If the MME supports the extended protocol configuration options IE and the UE indicated support of the extended protocol configuration options IE, then the MME shall set the ePCO bit to "extended protocol configuration options supported" in the EPS network feature support IE of the TRACKING AREA UPDATE ACCEPT message.

If the UE indicates support for restriction on use of enhanced coverage in the TRACKING AREA UPDATE REQUEST message, and the network decides to restrict the use of enhanced coverage for the UE, then the MME shall set the RestrictEC bit to "Use of enhanced coverage is restricted" in the EPS network feature support IE of the TRACKING AREA UPDATE ACCEPT message.

The MME may indicate the header compression configuration status IE in the TRACKING AREA UPDATE ACCEPT message for each established EPS bearer context using control plane CIoT EPS optimisation.

If the UE has indicated support for the control plane data back-off timer, and the MME decides to activate the congestion control for transport of user data via the control plane, then the MME shall include the T3448 value IE in the TRACKING AREA UPDATE ACCEPT message.

If the UE indicates support for dual connectivity with NR in the TRACKING AREA UPDATE REQUEST message, and the MME decides to restrict the use of dual connectivity with NR for the UE, then the MME shall set the RestrictDCNR bit to "Use of dual connectivity with NR is restricted" in the EPS network feature support IE of the TRACKING AREA UPDATE ACCEPT message.

If due to operator policies unsecured redirection to a GERAN cell is not allowed in the current PLMN, the MME shall set the redir-policy bit to "Unsecured redirection to GERAN not allowed" in the Network policy IE of the TRACKING AREA UPDATE ACCEPT message.

If the UE has indicated support for service gap control, a service gap time value is available in the EMM context, the MME may include the T3447 value IE set to the service gap time value in the TRACKING AREA UPDATE ACCEPT message.

If the network supports signalling for a maximum number of 15 EPS bearer contexts and the UE indicated support of signalling for a maximum number of 15 EPS bearer contexts in the TRACKING AREA UPDATE REQUEST message, then the MME shall set the 15 bearers bit to "Signalling for a maximum number of 15 EPS bearer contexts supported" in the EPS network feature support IE of the TRACKING AREA UPDATE ACCEPT message.

If the UE requests ciphering keys for ciphered broadcast assistance data in the TRACKING AREA UPDATE REQUEST message and the MME has valid ciphering key data applicable to the UE's subscription, then the MME shall include the ciphering key data in the Ciphering key data IE of the TRACKING AREA UPDATE ACCEPT message.

Upon receiving a TRACKING AREA UPDATE ACCEPT message, the UE shall stop timer T3430, reset the service request attempt counter, tracking area updating attempt counter, enter state EMM-REGISTERED and set the EPS update status to EU1 UPDATED. If the message contains a GUTI, the UE shall use this GUTI as new temporary identity for EPS services and shall store the new GUTI. If no GUTI was included by the MME in the TRACKING AREA UPDATE ACCEPT message, the old GUTI shall be used. If the UE receives a new TAI list in the TRACKING AREA UPDATE ACCEPT message, the UE shall consider the new TAI list as valid and the old TAI list as invalid; otherwise, the UE shall consider the old TAI list as valid.

If the UE receives the TRACKING AREA UPDATE ACCEPT message from a PLMN for which a PLMN-specific attempt counter or PLMN-specific PS-attempt counter is maintained (see subclause 5.3.7b), then the UE shall reset these counters. If the UE maintains a counter for "SIM/USIM considered invalid for GPRS services", then the UE shall reset this counter.

If the TRACKING AREA UPDATE ACCEPT message contains the T3412 extended value IE, then the UE shall use the T3412 extended value IE as periodic tracking area update timer (T3412). If the TRACKING AREA UPDATE ACCEPT contains T3412 value IE, but not T3412 extended value IE, then the UE shall use value in T3412 value IE as periodic tracking area update timer (T3412). If neither T3412 value IE nor T3412 extended value IE is included, the UE shall use the value currently stored, e.g. from a prior ATTACH ACCEPT or TRACKING AREA UPDATE ACCEPT message.

If the TRACKING AREA UPDATE ACCEPT message contains the T3324 value IE, then the UE shall use the timer value for T3324 as specified in 3GPP TS 24.008 [13], subclause 4.7.2.8.

If the UE had initiated the tracking area updating procedure in EMM-IDLE mode to perform an inter-system change from A/Gb mode or Iu mode to S1 mode and the $nonce_{UE}$ was included in the TRACKING AREA UPDATE REQUEST message, the UE shall delete the $nonce_{UE}$ upon receipt of the TRACKING AREA UPDATE ACCEPT message.

If an EPS bearer context status IE is included in the TRACKING AREA UPDATE ACCEPT message, the UE shall deactivate all those EPS bearers contexts locally (without peer-to-peer signalling between the UE and the MME) which are active in the UE, but are indicated by the MME as being inactive. If a default EPS bearer context is marked as inactive in the EPS bearer context status IE included in the TRACKING AREA UPDATE ACCEPT message, and this default bearer is not associated with the last remaining PDN connection in the UE, the UE shall locally deactivate all EPS bearer contexts associated to the PDN connection with the default EPS bearer context without peer-to-peer ESM signalling to the MME. If only the PDN connection for emergency bearer services remains established, the UE shall consider itself attached for emergency bearer services only. If the default bearer is associated with the last remaining PDN connection of the UE in the MME, and EMM-REGISTERED without PDN connection is supported by the UE and the MME, the UE shall locally deactivate all EPS bearer contexts associated to the PDN connection with the default EPS bearer context without peer-to-peer ESM signalling to the UE.

If an EPS bearer context status IE is included in the TRACKING AREA UPDATE ACCEPT message, the UE may choose to ignore all those EPS bearers which are indicated by the MME as being active but are inactive at the UE.

The MME may also include a list of equivalent PLMNs in the TRACKING AREA UPDATE ACCEPT message. Each entry in the list contains a PLMN code (MCC+MNC). The UE shall store the list as provided by the network, and if there is no PDN connection for emergency bearer services established, the UE shall remove from the list any PLMN code that is already in the list of "forbidden PLMNs" or in the list of "forbidden PLMNs for GPRS service". If the UE is not attached for emergency bearer services and there is a PDN connection for emergency bearer services established, the UE shall remove from the list of equivalent PLMNs any PLMN code present in the list of forbidden PLMNs or in the list of "forbidden PLMNs for GPRS service" when the PDN connection for emergency bearer services is released. In addition, the UE shall add to the stored list the PLMN code of the registered PLMN that sent the list. The UE shall replace the stored list on each receipt of the TRACKING AREA UPDATE ACCEPT message. If the TRACKING AREA UPDATE ACCEPT message does not contain a list, then the UE shall delete the stored list.

If the UE is not attached for emergency bearer services and if the PLMN identity of the registered PLMN is a member of the list of "forbidden PLMNs" or the list of "forbidden PLMNs for GPRS service", any such PLMN identity shall be deleted from the corresponding list(s).

The network may also indicate in the EPS update result IE in the TRACKING AREA UPDATE ACCEPT message that ISR is active. If the UE is attached for emergency bearer services, the network shall indicate in the EPS update result IE in the TRACKING AREA UPDATE ACCEPT message that ISR is not activated. If the TRACKING AREA UPDATE ACCEPT message contains:

i) no indication that ISR is activated, the UE shall set the TIN to "GUTI" and shall stop the periodic routing area update timer T3312 or T3323, if running;

ii) an indication that ISR is activated, then:

- if the UE is required to perform routing area updating for IMS voice termination as specified in 3GPP TS 24.008 [13], annex P.5, the UE shall set the TIN to "GUTI" and shall stop the periodic routing area update timer T3312 or T3323, if running;

- if the UE had initiated the tracking area updating procedure due to a change in UE network capability or change in DRX parameters, the UE shall set the TIN to "GUTI" and shall stop the periodic routing area update timer T3312 or T3323, if running;

- if the UE had initiated the tracking area updating procedure due to a change in the UE's usage setting or the voice domain preference for E-UTRAN, the UE shall set the TIN to "GUTI" and shall stop the periodic routing area update timer T3312 or T3323, if running; or

- the UE shall regard a previously assigned P-TMSI and RAI as valid and registered with the network. If the TIN currently indicates "P-TMSI" and the periodic routing area update timer T3312 is running or is deactivated, the UE shall set the TIN to "RAT-related TMSI". If the TIN currently indicates "P-TMSI" and the periodic routing area update timer T3312 has already expired, the UE shall set the TIN to "GUTI".

The network informs the UE about the support of specific features, such as IMS voice over PS session, location services (EPC-LCS, CS-LCS), emergency bearer services, or CIoT EPS optimizations, in the EPS network feature support information element. In a UE with IMS voice over PS capability, the IMS voice over PS session indicator and the emergency bearer services indicator shall be provided to the upper layers. The upper layers take the IMS voice over PS session indicator into account as specified in 3GPP TS 23.221 [8A], subclause 7.2a and subclause 7.2b, when selecting the access domain for voice sessions or calls. When initiating an emergency call, the upper layers also take both the IMS voice over PS session indicator and the emergency bearer services indicator into account for the access domain selection. When the UE determines via the IMS voice over PS session indicator that the network does not support IMS voice over PS sessions in S1 mode, then the UE shall not locally release any persistent EPS bearer context. When the UE determines via the emergency bearer services indicator that the network does not support emergency bearer services in S1 mode, then the UE shall not locally release any emergency EPS bearer context if there is a radio bearer associated with that context. In a UE with LCS capability, location services indicators (EPC-LCS, CS-LCS) shall be provided to the upper layers. When MO-LR procedure is triggered by the UE's application, those indicators are taken into account as specified in 3GPP TS 24.171 [13C].

If the RestrictDCNR bit is set to "Use of dual connectivity with NR is restricted" in the EPS network feature support IE of the TRACKING AREA UPDATE ACCEPT message, the UE shall provide the indication that dual connectivity with NR is restricted to the upper layers.

If the redir-policy bit is set to "Unsecured redirection to GERAN not allowed" in the Network policy IE of the TRACKING AREA UPDATE ACCEPT message, the UE shall set the network policy on unsecured redirection to GERAN for the current PLMN to "Unsecured redirection to GERAN not allowed" and indicate to the lower layers that unsecured redirection to a GERAN cell is not allowed. If the redir-policy bit is set to "Unsecured redirection to GERAN allowed" or if the Network policy IE is not included in the TRACKING AREA UPDATE ACCEPT message, the UE shall set the network policy on unsecured redirection to GERAN for the current PLMN to "Unsecured redirection to GERAN allowed" and indicate to the lower layers that unsecured redirection to a GERAN cell is allowed. The UE shall set the network policy on unsecured redirection to GERAN to "Unsecured redirection to GERAN not allowed" and indicate this to the lower layers when any of the following events occurs:

- the UE initiates an EPS attach or tracking area updating procedure in a PLMN different from the PLMN where the UE performed the last successful EPS attach or tracking area updating procedure;

- the UE is switched on; or

- the UICC containing the USIM is removed.

If the UE has initiated the tracking area updating procedure due to manual CSG selection and receives a TRACKING AREA UPDATE ACCEPT message, and the UE sent the TRACKING AREA UPDATE REQUEST message in a CSG cell, the UE shall check if the CSG ID and associated PLMN identity of the cell where the UE has sent the TRACKING AREA UPDATE REQUEST message are contained in the Allowed CSG list. If not, the UE shall add that CSG ID and associated PLMN identity to the Allowed CSG list and the UE may add the HNB Name (if provided by lower layers) to the Allowed CSG list if the HNB Name is present in neither the Operator CSG list nor the Allowed CSG list.

If the TRACKING AREA UPDATE ACCEPT message contained a GUTI, the UE shall return a TRACKING AREA UPDATE COMPLETE message to the MME to acknowledge the received GUTI.

If the UE which was previously successfully attached for EPS and non-EPS services receives the TRACKING AREA UPDATE ACCEPT message with EPS update result IE indicating "combined TA/LA updated" or "combined TA/LA updated and ISR activated" as the response of the TRACKING AREA UPDATE REQUEST message with EPS update type IE indicating "periodic updating", the UE shall behave as follows:

- If the TRACKING AREA UPDATE ACCEPT message contains an IMSI, the UE is not allocated any TMSI, and shall delete any old TMSI accordingly.

- If the TRACKING AREA UPDATE ACCEPT message contains a TMSI, the UE shall use this TMSI as new temporary identity. The UE shall delete its old TMSI and shall store the new TMSI. In this case, a TRACKING AREA UPDATE COMPLETE message is returned to the network to confirm the received TMSI.

- If neither a TMSI nor an IMSI has been included by the network in the TRACKING AREA UPDATE ACCEPT message, the old TMSI, if any is available, shall be kept.

If the header compression configuration status is included in the TRACKING AREA UPDATE ACCEPT message, the UE shall stop using header compression and decompression for those EPS bearers using Control plane CIoT EPS optimisation for which the MME indicated that the header compression configuration is not used.

If the T3448 value IE is present in the received TRACKING AREA UPDATE ACCEPT message, the UE shall:

- stop timer T3448 if it is running; and

- start timer T3448 with the value provided in the T3448 value IE.

If the UE is using EPS services with control plane CIoT EPS optimization, the T3448 value IE is present in the TRACKING AREA UPDATE ACCEPT message and the value indicates that this timer is either zero or deactivated, the UE shall consider this case as an abnormal case and proceed as if the T3448 value IE is not present.

If the UE in EMM-IDLE mode initiated the tracking area update procedure and the TRACKING AREA UPDATE ACCEPT message does not include the T3448 value IE and if timer T3448 is running, then the UE shall stop timer T3448.

If the UE has indicated "service gap control supported" in the TRACKING AREA UPDATE REQUEST message and:

- the TRACKING AREA UPDATE ACCEPT message contains the T3447 value IE, then the UE shall store the new T3447 value, erase any previous stored T3447 value if exists and use the the new T3447 value with the T3447 timer next time it is started; or

- the TRACKING AREA UPDATE ACCEPT message does not contain the T3447 value IE, then the UE shall erase any previous stored T3447 value if exists and stop the T3447 timer if running.

Upon receiving a TRACKING AREA UPDATE COMPLETE message, the MME shall stop timer T3450 and change to state EMM-REGISTERED. The GUTI, if sent in the TRACKING AREA UPDATE ACCEPT message, shall be considered as valid.

NOTE 5: Upon receiving a TRACKING AREA UPDATE COMPLETE message, if a new TMSI was included in the TRACKING AREA UPDATE ACCEPT message, the MME sends an SGsAP-TMSI-REALLOCATION-COMPLETE message as specified in 3GPP TS 29.118 [16A].

For inter-system change from A/Gb mode to S1 mode or Iu mode to S1 mode in EMM-IDLE mode, if the UE has included an eKSI in the NAS Key Set Identifier IE indicating a current EPS security context in the TRACKING AREA UPDATE REQUEST message by which the TRACKING AREA UPDATE REQUEST message is integrity protected, the MME shall take one of the following actions:

- if the MME retrieves the current EPS security context as indicated by the eKSI and GUTI sent by the UE, the MME shall integrity check the TRACKING AREA UPDATE REQUEST message using the current EPS security context and integrity protect the TRACKING AREA UPDATE ACCEPT message using the current EPS security context;

- if the MME cannot retrieve the current EPS security context as indicated by the eKSI and GUTI sent by the UE, and if the UE has included a valid GPRS ciphering key sequence number, the MME shall create a new mapped EPS security context as specified in 3GPP TS 33.401 [19], and then perform a security mode control procedure to indicate the use of the new mapped EPS security context to the UE (see subclause 5.4.3.2); or

- if the UE has not included an Additional GUTI IE, the MME may treat the TRACKING AREA UPDATE REQUEST message as in the previous item, i.e. as if it cannot retrieve the current EPS security context.

NOTE 6: The handling described above at failure to retrieve the current EPS security context or if no Additional GUTI IE was provided does not preclude the option for the MME to perform an EPS authentication procedure and create a new native EPS security context.

For inter-system change from A/Gb mode to S1 mode or Iu mode to S1 mode in EMM-IDLE mode, if the UE has not included a valid eKSI in the NAS Key Set Identifier IE and has included a valid GPRS ciphering key sequence number in the TRACKING AREA UPDATE REQUEST message, the MME shall create a new mapped EPS security context as specified in 3GPP TS 33.401 [19], and then perform a security mode control procedure to indicate the use of the new mapped EPS security context to the UE (see subclause 5.4.3.2).

NOTE 7: This does not preclude the option for the MME to perform an EPS authentication procedure and create a new native EPS security context.

For inter-system change from A/Gb mode to S1 mode or Iu mode to S1 mode in EMM-CONNECTED mode, the MME shall integrity check TRACKING AREA UPDATE REQUEST message using the current K'_{ASME} as derived when triggering the handover to E-UTRAN (see subclause 4.4.2.2). The MME shall verify the received UE security capabilities in the TRACKING AREA UPDATE REQUEST message. The MME shall then take one of the following actions:

- if the TRACKING AREA UPDATE REQUEST does not contain a valid KSI_{ASME} in the Non-current native NAS key set identifier IE, the MME shall remove the non-current native EPS security context, if any, for any GUTI for this UE. The MME shall then integrity protect and cipher the TRACKING AREA UPDATE ACCEPT message using the security context based on K'_{ASME} and take the mapped EPS security context into use; or

- if the TRACKING AREA UPDATE REQUEST contains a valid KSI_{ASME} in the Non-current native NAS key set identifier IE, the MME may initiate a security mode control procedure to take the corresponding native EPS security context into use.

5.5.3.2.4A Tracking area updating successful for EPS services and not accepted for SMS services

Apart from the actions on the tracking area updating attempt counter, the description for tracking area update for EPS services as specified in subclause 5.5.3.2.4 shall be followed. In addition, the following description for tracking area updating for SMS services applies.

In NB-S1 mode, if the UE requested "SMS only" in the Additional update type IE and supports NB-S1 mode only, the MME decides to accept the tracking area update request for EPS services only and:

- the location update for non-EPS services is not accepted by the VLR as specified in 3GPP TS 29.118 [16A]; or

- the MME decides to not accept the tracking area update request for "SMS only",

the MME shall set the EPS update result IE to "EPS only", shall not indicate "SMS only" in the Additional update result IE in the TRACKING AREA UPDATE ACCEPT message and shall include an appropriate SMS services status value.

The UE receiving the TRACKING AREA UPDATE ACCEPT message takes one of the following actions depending on the value included in the SMS services status IE:

"SMS services not available"

The UE shall stop timer T3430 if still running, shall reset the tracking area updating attempt counter, shall set the EPS update status to EU1 UPDATED and shall enter state EMM-REGISTERED.NORMAL-SERVICE. The USIM shall be considered as invalid for SMS services until switching off or the UICC containing the USIM is removed or the timer T3245 expires as described in subclause 5.3.7a.

"SMS services not available in this PLMN"

The UE shall stop timer T3430 if still running, shall reset the tracking area updating attempt counter, shall set the EPS update status to EU1 UPDATED and shall enter state EMM-REGISTERED.NORMAL-SERVICE.

The UE may provide a notification to the user or the upper layers that the SMS services are not available.

The UE shall not attempt normal attach or tracking area update procedure indicating "SMS only" with current PLMN until switching off the UE or the UICC containing the USIM is removed. Additionally, the UE may perform a PLMN selection according to 3GPP TS 23.122 [6].

"Network failure"

The UE shall stop timer T3430 if still running. The tracking area updating attempt counter shall be incremented, unless it was already set to 5.

If the tracking area updating attempt counter is less than 5:

- the UE shall start timer T3411, shall set the EPS update status to EU1 UPDATED and shall enter state EMM-REGISTERED.NORMAL-SERVICE. When timer T3411 expires the normal tracking area updating procedure for EPS services and "SMS only" or the combined tracking area updating procedure for EPS services and "SMS only" is triggered.

If the tracking area updating attempt counter is equal to 5:

- the UE shall start timer T3402, shall set the EPS update status to EU1 UPDATED and shall enter state EMM-REGISTERED.NORMAL-SERVICE. When timer T3402 expires the normal tracking area updating procedure for EPS services and "SMS only" or the combined tracking area updating procedure for EPS services and "SMS only" is triggered.

"Congestion"

The UE shall stop the timer T3430 if still running. The tracking area updating attempt counter shall be set to 5. The UE shall start the timer T3402, shall set the EPS update status to EU1 UPDATED, and shall enter state EMM-REGISTERED.NORMAL-SERVICE. When timer T3402 expires the normal tracking area updating procedure for EPS services and "SMS only" or the combined tracking area updating procedure for EPS services and "SMS only" is triggered.

Other values and the case that no SMS services status IE was received are considered as abnormal cases. The tracking area update procedure shall be considered as failed for SMS services. The behaviour of the UE in those cases is specified in subclause 5.5.3.2.6A.

5.5.3.2.5 Normal and periodic tracking area updating procedure not accepted by the network

If the tracking area updating cannot be accepted by the network, the MME sends a TRACKING AREA UPDATE REJECT message to the UE including an appropriate EMM cause value.

If a tracking area update request from a UE with a LIPA PDN connection is not accepted due to the reasons specified in subclause 5.5.3.2.4, the MME shall send the TRACKING AREA UPDATE REJECT message with EMM cause value #10 "Implicitly detached".

If the tracking area update request is rejected due to general NAS level mobility management congestion control, the network shall set the EMM cause value to #22 "congestion" and assign a back-off timer T3346.

If the tracking area request is rejected due to service gap control as specified in subclause 5.3.17 i.e. the T3447 timer is running, the network shall set the EMM cause value to #22 "congestion" and may assign a back-off timer T3346 with the remaining time of the running T3447 timer.

If the tracking area update request is rejected due to incompatibility between the CIoT EPS optimizations supported by the UE and what the network supports and the network sets the EMM cause value to #15 "no suitable cells in tracking area", the network may additionally include the Extended EMM cause IE with value "requested EPS optimization not supported".

NOTE: How the UE uses the Extended EMM cause IE with value "requested EPS optimization not supported" is implementation specific. The UE still behaves according to the EMM cause value #15.

If the UE initiated the tracking area updating procedure due to inter-system change from N1 mode to S1 mode, and the MME is only supporting interworking procedures without N26 interface, the MME shall send a TRACKING AREA UPDATE REJECT message with EMM cause value #9 "UE identity cannot be derived by the network".

Upon receiving the TRACKING AREA UPDATE REJECT message, if the message is integrity protected or contains a reject cause other than EMM cause value #25, the UE shall stop timer T3430 and stop any transmission of user data.

If the TRACKING AREA UPDATE REJECT message with EMM cause #25 was received without integrity protection, then the UE shall discard the message.

The UE shall take the following actions depending on the EMM cause value received in the TRACKING AREA UPDATE REJECT message.

#3 (Illegal UE);

#6 (Illegal ME); or

#8 (EPS services and non-EPS services not allowed);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and eKSI. The UE shall consider the USIM as invalid for EPS services until switching off or the UICC containing the USIM is removed or the timer T3245 expires as described in subclause 5.3.7a. The UE shall delete the list of equivalent PLMNs and shall enter the state EMM-DEREGISTERED. If the message has been successfully integrity checked by the NAS and the UE maintains a counter for "SIM/USIM considered invalid for GPRS services", then the UE shall set this counter to UE implementation-specific maximum value.

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI and GPRS ciphering key sequence number and the MM parameters update status, TMSI, LAI and ciphering key sequence number as specified in 3GPP TS 24.008 [13] for the case when the normal routing area updating procedure is rejected with the GMM cause with the same value. The USIM shall be considered as invalid also for non-EPS services until switching off or the UICC containing the USIM is removed or the timer T3245 expires as described in subclause 5.3.7a. If the message has been successfully integrity checked by the NAS and the UE maintains a counter for "SIM/USIM considered invalid for non-GPRS services", then the UE shall set this counter to UE implementation-specific maximum value.

NOTE 3: The possibility to configure a UE so that the radio transceiver for a specific radio access technology is not active, although it is implemented in the UE, is out of scope of the present specification.

#7 (EPS services not allowed);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and eKSI. The UE shall consider the USIM as invalid for EPS services until switching off or the UICC containing the USIM is removed or the timer T3245 expires as described in subclause 5.3.7a. The UE shall delete the list of equivalent PLMNs and shall enter the state EMM-DEREGISTERED. If the message has been successfully integrity checked by the NAS and the UE maintains a counter for "SIM/USIM considered invalid for GPRS services", then the UE shall set this counter to UE implementation-specific maximum value.

If the EPS update type is "periodic updating", a UE operating in CS/PS mode 1 or CS/PS mode 2 of operation, which is IMSI attached for non-EPS services, is still IMSI attached for non-EPS services. The UE operating in CS/PS mode 1 or CS/PS mode 2 of operation shall set the update status to U2 NOT UPDATED, shall attempt to select GERAN or UTRAN radio access technology and shall proceed with appropriate MM specific procedure according to the MM service state. The UE shall not reselect E-UTRAN radio access technology until switching off or the UICC containing the USIM is removed.

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI and GPRS ciphering key sequence number as specified in 3GPP TS 24.008 [13] for the case when the normal routing area updating procedure is rejected with the GMM cause with the same value.

#9 (UE identity cannot be derived by the network);

The UE shall set the EPS update status to EU2 NOT UPDATED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and eKSI. The UE shall enter the state EMM-DEREGISTERED.

If the rejected request was not for initiating a PDN connection for emergency bearer services, the UE shall subsequently, automatically initiate the attach procedure.

NOTE 4: User interaction is necessary in some cases when the UE cannot re-activate the EPS bearer(s) automatically.

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI and GPRS ciphering key sequence number as specified in 3GPP TS 24.008 [13] for the case when the normal routing area updating procedure is rejected with the GMM cause with the same value.

If the UE is operating in the single-registration mode, the UE shall handle the 5GMM parameters as specified in 3GPP TS 24.501 [54] for the case when the registration procedure for mobility and periodic registration update indicating "mobility registration updating" in the 5GS registration type IE of the REGISTRATION REQUEST message is rejected with the 5GMM cause with the same value.

#10 (Implicitly detached);

If the EPS update type is "periodic updating", a UE in CS/PS mode 1 or CS/PS mode 2 of operation is IMSI detached for both EPS services and non-EPS services.

The UE shall enter the state EMM-DEREGISTERED.NORMAL-SERVICE. The UE shall delete any mapped EPS security context or partial native EPS security context. If the rejected request was not for initiating a PDN connection for emergency bearer services, the UE shall then perform a new attach procedure.

NOTE 5: User interaction is necessary in some cases when the UE cannot re-activate the EPS bearer(s) automatically.

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM state as specified in 3GPP TS 24.008 [13] for the case when the normal routing area updating procedure is rejected with the GMM cause with the same value.

#11 (PLMN not allowed); or

#35 (Requested service option not authorized in this PLMN);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and eKSI. The UE shall reset the tracking area updating attempt counter, delete the list of equivalent PLMNs and enter the state EMM-DEREGISTERED.PLMN-SEARCH.

The UE shall store the PLMN identity in the "forbidden PLMN list" and if the UE is configured to use timer T3245 (see 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17]) then the UE shall start timer T3245 and proceed as described in subclause 5.3.7a. If the message has been successfully integrity checked by the NAS and the UE maintains a PLMN-specific attempt counter for that PLMN, then the UE shall set this counter to the UE implementation-specific maximum value.

The UE shall perform a PLMN selection according to 3GPP TS 23.122 [6].

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI, GPRS ciphering key sequence number and routing area updating attempt counter and the MM parameters update status, TMSI, LAI, ciphering key sequence number and the location update attempt counter as specified in 3GPP TS 24.008 [13] for the case when the normal routing area updating procedure is rejected with the GMM cause with the same value and no RR connection exists.

#12 (Tracking area not allowed);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and eKSI. The UE shall reset the tracking area updating attempt counter and shall enter the state EMM-DEREGISTERED.LIMITED-SERVICE.

The UE shall store the current TAI in the list of "forbidden tracking areas for regional provision of service".

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI, GPRS ciphering key sequence number and routing area updating attempt counter as specified in 3GPP TS 24.008 [13] for the case when the normal routing area updating procedure is rejected with the GMM cause with the same value.

#13 (Roaming not allowed in this tracking area);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete the list of equivalent PLMNs. The UE shall reset the tracking area updating attempt counter and shall change to state EMM-REGISTERED.PLMN-SEARCH.

The UE shall store the current TAI in the list of "forbidden tracking areas for roaming" and shall remove the current TAI from the stored TAI list if present.

The UE shall perform a PLMN selection according to 3GPP TS 23.122 [6].

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM parameters GMM state, GPRS update status and routing area updating attempt counter as specified in 3GPP TS 24.008 [13] for the case when the normal routing area updating procedure is rejected with the GMM cause with the same value.

#14 (EPS services not allowed in this PLMN);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3). Furthermore, the UE shall delete any GUTI, last visited registered TAI, TAI list and eKSI. The UE shall reset the tracking area updating attempt counter and shall enter the state EMM-DEREGISTERED.PLMN-SEARCH.

The UE shall store the PLMN identity in the "forbidden PLMNs for GPRS service" list and if the UE is configured to use timer T3245 (see 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17]) then the UE shall start timer T3245 and proceed as described in subclause 5.3.7a. If the message has been successfully integrity checked by the NAS and the UE maintains a PLMN-specific PS-attempt counter for that PLMN, then the UE shall set this counter to the UE implementation-specific maximum value.

If the EPS update type is "TA updating", or the EPS update type is "periodic updating" and the UE is in PS mode 1 or PS mode 2 of operation, the UE shall perform a PLMN selection according to 3GPP TS 23.122 [6]. In this case, the UE supporting S1 mode only shall delete the list of equivalent PLMNs before performing the procedure.

If the EPS update type is "periodic updating", a UE operating in CS/PS mode 1 or CS/PS mode 2 of operation, which is IMSI attached for non-EPS services, is still IMSI attached for non-EPS services and shall proceed as follows:

- a UE operating in CS/PS mode 1 or CS/PS mode 2 of operation shall set the update status to U2 NOT UPDATED;

- a UE operating in CS/PS mode 1 of operation and supporting A/Gb mode or Iu mode may select GERAN or UTRAN radio access technology and proceed with the appropriate MM specific procedure according to the MM service state. In this case, the UE shall disable the E-UTRA capability (see subclause 4.5);

- a UE operating in CS/PS mode 1 of operation and supporting A/Gb mode or Iu mode may perform a PLMN selection according to 3GPP TS 23.122 [6];

- a UE operating in CS/PS mode 1 of operation and supporting S1 mode only, or operating in CS/PS mode 2 of operation shall delete the list of equivalent PLMNs and shall perform a PLMN selection according to 3GPP TS 23.122 [6].

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI, GPRS ciphering key sequence number and routing area updating attempt counter as specified in 3GPP TS 24.008 [13] for the case when the normal routing area updating procedure is rejected with the GMM cause with the same value.

#15 (No suitable cells in tracking area);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3). The UE shall reset the tracking area updating attempt counter and shall enter the state EMM-REGISTERED.LIMITED-SERVICE.

The UE shall store the current TAI in the list of "forbidden tracking areas for roaming" and shall remove the current TAI from the stored TAI list if present and:

- if the UE is in S1 mode and the Extended EMM cause IE with value "E-UTRAN not allowed" is included in the TRACKING AREA UPDATE REJECT message, the UE supports "E-UTRA Disabling for EMM cause #15", and the "E-UTRA Disabling Allowed for EMM cause #15" parameter as specified in 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17] is present and set to enabled; then the UE shall disable the E-UTRA capability as specified in subclause 4.5 and search for a suitable cell in another location area;

- if the UE is in NB-S1 mode and the Extended EMM cause IE with value "NB-IoT not allowed" is included in the TRACKING AREA UPDATE REJECT message, then the UE may disable the NB-IoT capability as specified in subclause 4.X and search for a suitable cell in E-UTRAN radio access technology;

- otherwise, the UE shall search for a suitable cell in another tracking area or in another location area according to 3GPP TS 36.304 [21].

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM parameters GMM state, GPRS update status and routing area updating attempt counter as specified in 3GPP TS 24.008 [13] for the case when the normal routing area updating procedure is rejected with the GMM cause with the same value.

#22 (Congestion);

If the T3346 value IE is present in the TRACKING AREA UPDATE REJECT message and the value indicates that this timer is neither zero nor deactivated, the UE shall proceed as described below, otherwise it shall be considered as an abnormal case and the behaviour of the UE for this case is specified in subclause 5.5.3.2.6.

The UE shall abort the tracking area updating procedure, reset the tracking area updating attempt counter and set the EPS update status to EU2 NOT UPDATED. If the rejected request was not for initiating a PDN connection for emergency bearer services, the UE shall change to state EMM-REGISTERED.ATTEMPTING-TO-UPDATE.

The UE shall stop timer T3346 if it is running.

If the TRACKING AREA UPDATE REJECT message is integrity protected, the UE shall start timer with the value provided in the T3346 value IE.

If the TRACKING AREA UPDATE REJECT message is not integrity protected, the UE shall start timer T3346 with a random value from the default range specified in 3GPP TS 24.008 [13].

The UE stays in the current serving cell and applies the normal cell reselection process. The tracking area updating procedure is started, if still necessary, when timer T3346 expires or is stopped.

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM parameters GMM state, GPRS update status and routing area updating attempt counter as specified in 3GPP TS 24.008 [13] for the case when the normal routing area updating procedure is rejected with the GMM cause with the same value.

#25 (Not authorized for this CSG);

EMM cause #25 is only applicable when received from a CSG cell. EMM cause #25 received from a non-CSG cell is considered as an abnormal case and the behaviour of the UE is specified in subclause 5.5.3.2.6.

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and store it according to subclause 5.1.3.3). The UE shall reset the tracking area updating attempt counter and shall enter the state EMM-REGISTERED.LIMITED-SERVICE.

If the CSG ID and associated PLMN identity of the cell where the UE has sent the TRACKING AREA UPDATE REQUEST message are contained in the Allowed CSG list, the UE shall remove the entry corresponding to this CSG ID and associated PLMN identity from the Allowed CSG list.

If the CSG ID and associated PLMN identity of the cell where the UE has sent the TRACKING AREA UPDATE REQUEST message are contained in the Operator CSG list, the UE shall apply the procedures defined in 3GPP TS 23.122 [6] subclause 3.1A.

The UE shall search for a suitable cell according to 3GPP TS 36.304 [21].

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM parameters GMM state, GPRS update status and routing area updating attempt counter as specified in 3GPP TS 24.008 [13] for the case when the normal routing area updating procedure is rejected with the GMM cause with the same value.

#40 (No EPS bearer context activated);

The UE shall deactivate all the EPS bearer contexts locally, if any, and shall enter the state EMM-DEREGISTERED.NORMAL-SERVICE. The UE shall perform a new attach procedure.

NOTE 6: User interaction is necessary in some cases when the UE cannot re-activate the EPS bearer(s) automatically.

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM state as specified in 3GPP TS 24.008 [13] for the case when the normal routing area updating procedure is rejected with the GMM cause value #10 "Implicitly detached".

#42 (Severe network failure);

The UE shall set the EPS update status to EU2 NOT UPDATED, and shall delete any GUTI, last visited registered TAI, eKSI, and list of equivalent PLMNs, and set the tracking area update counter to 5. The UE shall start an implementation specific timer, setting its value to 2 times the value of T as defined in 3GPP TS 23.122 [6]. While this timer is running, the UE shall not consider the PLMN + RAT combination that provided this reject cause as a candidate for PLMN selection. The UE then enters state EMM-DEREGISTERED.PLMN-SEARCH in order to perform a PLMN selection according to 3GPP TS 23.122 [6].

If A/Gb mode or Iu mode is supported by the UE, the UE shall in addition set the GMM state to GMM-DEREGISTERED, GPRS update status to GU2 NOT UPDATED, and shall delete the P-TMSI, P-TMSI signature, RAI and GPRS ciphering key sequence number.

Other values are considered as abnormal cases. The specification of the UE behaviour in those cases is described in subclause 5.5.3.2.6.

5.5.3.2.5A Tracking area updating procedure for initiating a PDN connection for emergency bearer services not accepted by the network

If the tracking area updating request for initiating a PDN connection for emergency bearer services cannot be accepted by the network, the UE shall perform the procedures as described in subclause 5.5.3.2.5. Then if the UE is in the same selected PLMN where the last tracking area updating request was attempted, the UE shall:

a) inform the upper layers of the failure of the procedure; or

NOTE 1: This can result in the upper layers establishment of a CS emergency call (if not already attempted in the CS domain) or other implementation specific mechanisms, e.g. procedures specified in 3GPP TS 24.229 [13D] can result in the emergency call being attempted to another IP-CAN.

b) detach locally, if not detached already, attempt EPS attach for emergency bearer services.

If the tracking area updating request for initiating a PDN connection for emergency bearer services fails due to abnormal case a) in subclause 5.5.3.2.6, the UE shall perform the actions as described in subclause 5.5.3.2.6 and inform the upper layers of the failure to access the network.

NOTE 2: This can result in the upper layers establishment of a CS emergency call (if not already attempted in the CS domain) or other implementation specific mechanisms, e.g. procedures specified in 3GPP TS 24.229 [13D] can result in the emergency call being attempted to another IP-CAN.

If the tracking area updating request for initiating a PDN connection for emergency bearer services fails due to abnormal cases b), c) or d) in subclause 5.5.3.2.6, the UE shall perform the procedures as described in subclause 5.5.3.2.6. Then if the UE is in the same selected PLMN where the last tracking area updating request was attempted, the UE shall:

a) inform the upper layers of the failure of the procedure; or

NOTE 3: This can result in the upper layers establishment of a CS emergency call (if not already attempted in the CS domain) or other implementation specific mechanisms, e.g. procedures specified in 3GPP TS 24.229 [13D] can result in the emergency call being attempted to another IP-CAN.

b) detach locally, if not detached already, attempt EPS attach for emergency bearer services.

5.5.3.2.6 Abnormal cases in the UE

The following abnormal cases can be identified:

a) Access barred because of access class barring, EAB, ACDC or NAS signalling connection establishment rejected by the network without "Extended wait time" received from lower layers

In WB-S1 mode, if the tracking area updating procedure is started in response to a paging request from the network, access class barring, EAB or ACDC is not applicable.

In NB-S1 mode, if the tracking area updating procedure is started in response to a paging request from the network, access barring is not applicable.

In WB-S1 mode, if access is barred for "originating signalling" (see 3GPP TS 36.331 [22]), the tracking area updating procedure shall not be started. The UE stays in the current serving cell and applies the normal cell reselection process. The tracking area updating procedure is started as soon as possible and if still necessary, e.g. when access for "originating signalling" is granted on the current cell or when the UE moves to a cell where access for "originating signalling" is granted.

In NB-S1 mode, if access is barred for "originating signalling" (see 3GPP TS 36.331 [22]), the tracking area updating procedure shall not be started. The UE stays in the current serving cell and applies the normal cell reselection process. Further UE behaviour is implementation specific, e.g. the tracking area updating procedure is started again after an implementation dependent time.

In NB-S1 mode, if access is barred for "originating signalling" (see 3GPP TS 36.331 [22]), a request for an exceptional event is received from the upper layers, then the tracking area updating procedure shall be started.

NOTE 1: In NB-S1 mode, the EMM layer cannot receive the access barring alleviation indication from the lower layers (see 3GPP TS 36.331 [22]).

If access is barred because of access class barring for "originating signalling" (see 3GPP TS 36.331 [22]) and if:

- one of the MO MMTEL voice call is started, MO MMTEL video call is started or MO SMSoIP is started conditions is satisfied;
- the upper layers request to send a mobile originated SMS over NAS or SMS over S102; or
- the upper layers request user plane radio resources, ACDC is applicable to the request and the UE supports ACDC.

then the tracking area updating procedure shall be started according to subclause 5.5.3.2.2. The call type used shall be per annex D of this document.

NOTE 2: If more than one of MO MMTEL voice call is started, MO MMTEL video call is started or MO SMSoIP is started conditions are satisfied, it is left to UE implementation to determine the call type based on Annex D of this document.

If access is barred for a certain ACDC category (see 3GPP TS 36.331 [22]), and if the upper layers request user plane radio resources for a higher ACDC category and the UE supports ACDC, then the tracking area updating procedure shall be started according to subclause 5.5.3.2.2.

If an access request for an uncategorized application is barred due to ACDC (see 3GPP TS 36.331 [22]), and if the upper layers request user plane radio resources for a certain ACDC category and the UE supports ACDC, then the tracking area updating procedure shall be started according to subclause 5.5.3.2.2.

If the trigger for the tracking area update procedure is the response to a paging request from the network and the NAS signalling connection establishment is rejected by the network, the tracking area update procedure shall not be started. The UE stays in the current serving cell and applies normal cell reselection process. The tracking area update procedure may be started if it is still necessary when access for "terminating calls" is granted or because of a cell change.

b) Lower layer failure or release of the NAS signalling connection without "Extended wait time" and without "Extended wait time CP data" received from lower layers before the TRACKING AREA UPDATE ACCEPT or TRACKING AREA UPDATE REJECT message is received

The tracking area updating procedure shall be aborted, and the UE shall proceed as described below.

c) T3430 timeout

The UE shall abort the procedure and proceed as described below. The NAS signalling connection, if any, shall be released locally.

NOTE 3: The NAS signalling connection can also be released if the UE deems that the network has failed the authentication check as specified in subclause 5.4.2.7.

d) TRACKING AREA UPDATE REJECT, other causes than those treated in subclause 5.5.3.2.5, and cases of EMM cause values #22 and #25, if considered as abnormal cases according to subclause 5.5.3.2.5

If the tracking area updating request is not for initiating a PDN connection for emergency bearer services, upon reception of the EMM causes #95, #96, #97, #99 and #111 the UE should set the tracking area updating attempt counter to 5.

The UE shall proceed as described below.

e) Change of cell into a new tracking area

If a cell change into a new tracking area occurs before the tracking area updating procedure is completed, the tracking area updating procedure shall be aborted and re-initiated immediately. The UE shall set the EPS update status to EU2 NOT UPDATED.

The UE shall proceed as described below.

f) Tracking area updating and detach procedure collision

EPS detach containing detach type "re-attach required" or "re-attach not required":

If the UE receives a DETACH REQUEST message before the tracking area updating procedure has been completed, the tracking area updating procedure shall be aborted and the detach procedure shall be progressed. If the DETACH REQUEST message contains detach type "re-attach not required" and EMM cause #2 "IMSI unknown in HSS", the UE will follow the procedure as described below for the detach type "IMSI detach".

EPS detach containing detach type "IMSI detach":

If the UE receives a DETACH REQUEST message before the tracking area updating procedure has been completed, the DETACH REQUEST message shall be ignored and tracking area updating procedure shall be progressed.

The UE shall proceed as described below.

g) Tracking area updating and GUTI reallocation procedure collision

If the UE receives a GUTI REALLOCATION COMMAND message before the tracking area updating procedure has been completed, this message shall be ignored and the tracking area updating procedure shall be progressed.

h) Transmission failure of TRACKING AREA UPDATE REQUEST message indication from lower layers

The tracking area updating procedure shall be aborted and re-initiated immediately. The UE shall set the EPS update status to EU2 NOT UPDATED.

i) Transmission failure of TRACKING AREA UPDATE COMPLETE message indication with TAI change from lower layers

If the current TAI is not in the TAI list, the tracking area updating procedure shall be aborted and re-initiated immediately. The UE shall set the EPS update status to EU2 NOT UPDATED.

If the current TAI is still part of the TAI list, it is up to the UE implementation how to re-run the ongoing procedure.

j) Transmission failure of TRACKING AREA UPDATE COMPLETE message indication without TAI change from lower layers

It is up to the UE implementation how to re-run the ongoing procedure.

k) "Extended wait time" from the lower layers

If the TRACKING AREA UPDATE REQUEST message contained the low priority indicator set to "MS is configured for NAS signalling low priority", the UE shall start timer T3346 with the "Extended wait time" value and reset the tracking area updating attempt counter.

If the TRACKING AREA UPDATE REQUEST message did not contain the low priority indicator set to "MS is configured for NAS signalling low priority", the UE is operating in NB-S1 mode and the UE is not a UE configured to use AC11 – 15 in selected PLMN, then the UE shall start timer T3346 with the "Extended wait time" value and reset the tracking area updating attempt counter.

In other cases the UE shall ignore the "Extended wait time".

The UE shall abort the tracking area updating procedure, stay in the current serving cell, set the EPS update status to EU2 NOT UPDATED, change the state to EMM-REGISTERED.ATTEMPTING-TO-UPDATE and apply the normal cell reselection process.

If the UE had used eDRX before initiating tracking area updating procedure, then the UE shall continue to use the eDRX with the extended DRX parameters IE received during the last attach or tracking area updating procedure.

The UE shall proceed as described below.

ka) "Extended wait time CP data" from the lower layers

If the UE is operating in NB-S1 mode and supports the timer T3448, the UE shall start the timer T3448 with the "Extended wait time CP data" value. If the UE is operating in NB-S1 mode and does not support the timer T3448, the UE shall start the timer T3346 with the "Extended wait time CP data" value and reset the tracking area updating attempt counter.

In other cases the UE shall ignore the "Extended wait time CP data".

The UE shall abort the tracking area updating procedure, stay in the current serving cell, set the EPS update status to EU2 NOT UPDATED, change the state to EMM-REGISTERED.ATTEMPTING-TO-UPDATE and apply the normal cell reselection process.

If the UE had used eDRX before initiating tracking area updating procedure, then the UE shall continue to use the eDRX with the extended DRX parameters IE received during the last attach or tracking area updating procedure.

The UE shall proceed as described below.

l) Timer T3346 is running

The UE shall not start the tracking area updating procedure unless:

- the UE is in EMM-CONNECTED mode;
- the UE received a paging;
- the UE is a UE configured to use AC11 – 15 in selected PLMN;
- the UE has a PDN connection for emergency bearer services established or is establishing a PDN connection for emergency bearer services;
- the UE is requested by the upper layer for a CS fallback for emergency call or a 1xCS fallback for emergency call;
- the UE in NB-S1 mode is requested by the upper layer to transmit user data related to an exceptional event and

  i) the UE is allowed to use exception data reporting (see the ExceptionDataReportingAllowed leaf of the NAS configuration MO in 3GPP TS 24.368 [15A] or the USIM file $EF_{NASCONFIG}$ in 3GPP TS 31.102 [17]); and

  ii) timer T3346 was not started when NAS signaling connection was established with RRC establishment cause set to "MO exception data"; or

- the UE has a PDN connection established without the NAS signalling low priority indication or is establishing a PDN connection without the NAS signalling low priority indication, the timer T3402 and the timer T3411 are not running and the timer T3346 was started due to rejection of a NAS request message (e.g.

ATTACH REQUEST, TRACKING AREA UPDATE REQUEST or EXTENDED SERVICE REQUEST) which contained the low priority indicator set to "MS is configured for NAS signalling low priority".

The UE stays in the current serving cell and applies the normal cell reselection process.

NOTE 4: It is considered an abnormal case if the UE needs to initiate a tracking area updating procedure while timer T3346 is running independent on whether timer T3346 was started due to an abnormal case or a non successful case.

If the TAI of the current serving cell is not included in the TAI list or the TIN indicates "P-TMSI", the UE shall set the EPS update status to EU2 NOT UPDATED and change to state EMM-REGISTERED.ATTEMPTING-TO-UPDATE.

The UE shall proceed as described below.

la) Timer T3448 is running

The UE shall not start the tracking area updating procedure with the "signalling active" flag unless:

- the UE is a UE configured to use AC11 – 15 in selected PLMN;
- the UE which is only using EPS services with control plane CIoT EPS optimization received a paging; or
- the UE in NB-S1 mode is requested by the upper layer to transmit user data related to an exceptional event and the UE is allowed to use exception data reporting (see the ExceptionDataReportingAllowed leaf of the NAS configuration MO in 3GPP TS 24.368 [15A] or the USIM file $EF_{NASCONFIG}$ in 3GPP TS 31.102 [17]).

The UE stays in the current serving cell and applies the normal cell reselection process.

The UE shall proceed as described below.

m) Mobile originated detach required

Detach due to removal of USIM or due to switch off:

The tracking area updating procedure shall be aborted, and the UE initiated detach procedure shall be performed.

Detach not due to removal of USIM and not due to switch off:

The UE initiated detach procedure shall be initiated after successful completion of the tracking area updating procedure.

o) Timer T3447 is running

The UE shall not start the tracking area updating procedure with the "signalling active" or "active" flag unless:

- the UE received a paging;
- the UE is a UE configured to use AC11 – 15 in selected PLMN;
- the UE has a PDN connection for emergency bearer services established or is establishing a PDN connection for emergency bearer services;

The UE stays in the current serving cell and applies the normal cell reselection process. The tracking area update request procedure is started, if still necessary, when timer T3447 expires.

For the cases b, c, d, e, f with detach type "re-attach required" or "re-attach not required" with EMM cause other than #2 "IMSI unknown in HSS", k and ka, the UE shall stop any ongoing transmission of user data.

For the cases b, c, d, k, ka, l and la, the UE shall proceed as follows:

Timer T3430 shall be stopped if still running.

For the cases b, c, d, la k when the "Extended wait time" is ignored, and ka when the "Extended wait time CP data" is ignored, if the tracking area updating request is not for initiating a PDN connection for emergency bearer services, the tracking area updating attempt counter shall be incremented, unless it was already set to 5.

If the tracking area updating attempt counter is less than 5, and the TAI of the current serving cell is included in the TAI list, and the EPS update status is equal to EU1 UPDATED and the TIN does not indicate "P-TMSI":

the UE shall keep the EPS update status to EU1 UPDATED and enter state EMM-REGISTERED.NORMAL-SERVICE. The UE shall start timer T3411.

If in addition the TRACKING AREA UPDATE REQUEST indicated "periodic updating" or if tracking area updating procedure was initiated to recover NAS signalling connection due to "RRC Connection failure" from the lower layers, none of the other reasons for initiating the tracking area updating procedure listed in subclause 5.5.3.2.2 was applicable, and the TRACKING AREA UPDATE REQUEST message did not include T3324 value IE, T3412 extended value IE or Extended DRX parameters IE, the timer T3411 may be stopped when the UE enters EMM-CONNECTED mode.

If timer T3411 expires the tracking area updating procedure is triggered again.

If the tracking area updating attempt counter is less than 5, and the TAI of the current serving cell is not included in the TAI list or the EPS update status is different to EU1 UPDATED or the TIN indicates "P-TMSI":

- for the cases k and l, the tracking area updating procedure is started, if still necessary, when timer T3346 expires or is stopped.

- for the case ka, if timer T3346 is started, the tracking area updating procedure is started, if still necessary, when timer T3346 expires or is stopped.

- for the case ka, if timer T3448 is started and the "signalling active" flag is set in the TRACKING AREA UPDATE REQUEST message, the tracking area updating procedure is started, if still necessary, when timer T3448 expires or is stopped.

- for the case la, if the "signalling active" flag is set in the TRACKING AREA UPDATE REQUEST message, the tracking area updating procedure is started, if still necessary, when timer T3448 expires or is stopped.

- for the cases b, c, d, k when the "Extended wait time" is ignored, and ka when the "Extended wait time CP data" is ignored, if the tracking area updating request is not for initiating a PDN connection for emergency bearer services, the UE shall start timer T3411, shall set the EPS update status to EU2 NOT UPDATED and change to state EMM-REGISTERED.ATTEMPTING-TO-UPDATE. When timer T3411 expires the tracking area updating procedure is triggered again.

  If A/Gb mode or Iu mode is supported by the UE, the UE shall in addition handle the GPRS update status as specified in 3GPP TS 24.008 [13] for the abnormal case when a normal or periodic routing area updating procedure fails and the routing area updating attempt counter is less than 5 and the GPRS update status is different from GU1 UPDATED.

If the tracking area updating attempt counter is equal to 5:

- the UE shall start timer T3402, shall set the EPS update status to EU2 NOT UPDATED;

- the UE shall delete the list of equivalent PLMNs and shall change to state EMM-REGISTERED.ATTEMPTING-TO-UPDATE or optionally to EMM-REGISTERED.PLMN-SEARCH in order to perform a PLMN selection according to 3GPP TS 23.122 [6]; and

- if A/Gb mode or Iu mode is supported by the UE:

  - the UE shall in addition handle the GPRS update status as specified in 3GPP TS 24.008 [13] for the abnormal case when a normal or periodic routing area updating procedure fails and the routing area updating attempt counter is equal to 5; and

  - if the UE does not change to state EMM-REGISTERED.PLMN-SEARCH, the UE shall attempt to select GERAN or UTRAN radio access technology. A UE in PS mode 1 or PS mode 2 of operation shall proceed with appropriate GMM specific procedures; a UE in CS/PS mode 1 or CS/PS mode 2 of operation shall proceed with appropriate MM or GMM specific procedures. Additionally, the UE may disable the E-UTRA capability as specified in subclause 4.5.

5.5.3.2.6A Abnormal cases in the UE, SMS services not accepted

The UE shall proceed as follows:

1) if the tracking area update was successful for EPS services only and the TRACKING AREA UPDATE ACCEPT message contained a value included in the SMS services status IE not treated in subclause 5.5.3.2.4A or the SMS services status IE is not included in the message, the UE shall proceed as follows:

   a) The UE shall stop timer T3430 if still running. The tracking area updating attempt counter shall be incremented, unless it was already set to 5;

   b) If the tracking area updating attempt counter is less than 5:

      - the UE shall start timer T3411, shall set the EPS update status to EU1 UPDATED and shall enter state EMM-REGISTERED.NORMAL-SERVICE. When timer T3411 expires the normal tracking area updating procedure for EPS services and "SMS only" or the combined tracking area updating procedure for EPS services and "SMS only" is triggered;

   c) If the tracking area updating attempt counter is equal to 5:

      - the UE shall start timer T3402, shall set the EPS update status to EU1 UPDATED and shall enter state EMM-REGISTERED.NORMAL-SERVICE. When timer T3402 expires the normal tracking area updating procedure for EPS services and "SMS only" or the combined tracking area updating procedure for EPS services and "SMS only" is triggered; and

2) otherwise, the abnormal cases specified in subclause 5.5.3.2.6 apply.

5.5.3.2.7 Abnormal cases on the network side

The following abnormal cases can be identified:

a) If a lower layer failure occurs before the message TRACKING AREA UPDATE COMPLETE has been received from the UE and a GUTI has been assigned, the network shall abort the procedure, enter EMM-IDLE mode and shall consider both, the old and new GUTI as valid until the old GUTI can be considered as invalid by the network (see subclause 5.4.1.4). During this period the network may use the identification procedure followed by a GUTI reallocation procedure if the old GUTI is used by the UE in a subsequent message.

   The network may page with IMSI if paging with old and new S-TMSI fails. Paging with IMSI causes the UE to re-attach as described in subclause 5.6.2.2.2.

b) Protocol error

   If the TRACKING AREA UPDATE REQUEST message has been received with a protocol error, the network shall return a TRACKING AREA UPDATE REJECT message with one of the following EMM cause values:

   #96: invalid mandatory information element error;

   #99: information element non-existent or not implemented;

   #100: conditional IE error; or

   #111: protocol error, unspecified.

c) T3450 time-out

   On the first expiry of the timer, the network shall retransmit the TRACKING AREA UPDATE ACCEPT message and shall reset and restart timer T3450. The retransmission is performed four times, i.e. on the fifth expiry of timer T3450, the tracking area updating procedure is aborted. Both, the old and the new GUTI shall be considered as valid until the old GUTI can be considered as invalid by the network (see subclause 5.4.1.4). During this period the network acts as described for case a above.

d) TRACKING AREA UPDATE REQUEST received after the TRACKING AREA UPDATE ACCEPT message has been sent and before the TRACKING AREA UPDATE COMPLETE message is received

   - If one or more of the information elements in the TRACKING AREA UPDATE REQUEST message differ from the ones received within the previous TRACKING AREA UPDATE REQUEST message, the previously initiated tracking area updating procedure shall be aborted if the TRACKING AREA UPDATE COMPLETE message has not been received and the new tracking area updating procedure shall be progressed; or

- if the information elements do not differ, then the TRACKING AREA UPDATE ACCEPT message shall be resent and the timer T3450 shall be restarted if an TRACKING AREA UPDATE COMPLETE message is expected. In that case, the retransmission counter related to T3450 is not incremented.

e) More than one TRACKING AREA UPDATE REQUEST received and no TRACKING AREA UPDATE ACCEPT or TRACKING AREA UPDATE REJECT message has been sent

- If one or more of the information elements in the TRACKING AREA UPDATE REQUEST message differs from the ones received within the previous TRACKING AREA UPDATE REQUEST message, the previously initiated tracking area updating procedure shall be aborted and the new tracking area updating procedure shall be progressed;

- if the information elements do not differ, then the network shall continue with the previous tracking area updating procedure and shall not treat any further this TRACKING AREA UPDATE REQUEST message.

f) Lower layers indication of non-delivered NAS PDU due to handover

If the TRACKING AREA UPDATE ACCEPT message or TRACKING AREA UPDATE REJECT message could not be delivered due to an intra MME handover and the target TA is included in the TAI list, then upon successful completion of the intra MME handover the MME shall retransmit the TRACKING AREA UPDATE ACCEPT message or TRACKING AREA UPDATE REJECT message. If a failure of the handover procedure is reported by the lower layer and the S1 signalling connection exists, the MME shall retransmit the TRACKING AREA UPDATE ACCEPT message or TRACKING AREA UPDATE REJECT message.

g) DETACH REQUEST message received before the TRACKING AREA UPDATE ACCEPT message is sent or before the TRACKING AREA UPDATE COMPLETE message (in case of GUTI and/or TMSI was allocated) is received.

Detach containing cause "switch off":

The network shall abort the signalling for the tracking area updating procedure towards the UE and shall progress the detach procedure as described in subclause 5.5.2.2.

NOTE: Internally in the network, before processing the detach request, the MME can perform the necessary signalling procedures for the tracking area updating procedure before progressing the detach procedure.

Detach containing other causes than "switch off":

The network shall proceed with the tracking area updating procedure and shall progress the detach procedure after successful completion of the tracking area updating procedure.

h) If the TRACKING AREA UPDATE REQUEST message with EPS update type IE indicating "periodic updating" is received by the new MME which does not have the EMM context data related to the subscription, the new MME may send the TRACKING AREA UPDATE REJECT message with EMM cause value #10 "Implicitly detached"

5.5.3.3 Combined tracking area updating procedure

5.5.3.3.1 General

Within a combined tracking area updating procedure the messages TRACKING AREA UPDATE ACCEPT and TRACKING AREA UPDATE COMPLETE carry information for the tracking area updating and the location area updating.

The combined tracking area updating procedure follows the normal tracking area updating procedure described in subclause 5.5.3.2 with exception of subclause 5.5.3.2.4A and subclause 5.5.3.2.6A.

5.5.3.3.2 Combined tracking area updating procedure initiation

The UE operating in CS/PS mode 1 or CS/PS mode 2, in state EMM-REGISTERED, shall initiate the combined tracking area updating procedure:

a) when the UE that is attached for both EPS and non-EPS services detects entering a tracking area that is not in the list of tracking areas that the UE previously registered in the MME, unless the UE is configured for

"AttachWithIMSI" as specified in 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17] and is entering a tracking area in a new PLMN that is neither the registered PLMN nor in the list of equivalent PLMNs;

b) when the UE that is attached for EPS services wants to perform an attach for non-EPS services. In this case the EPS update type IE shall be set to "combined TA/LA updating with IMSI attach";

c) when the UE performs an intersystem change from A/Gb mode to S1 mode and the EPS services were previously suspended in A/Gb mode;

d) when the UE performs an intersystem change from A/Gb or Iu mode to S1 mode, and the UE previously either performed a combined GPRS attach procedure, an IMSI attach procedure, a location area updating procedure or a combined routing area updating procedure, in A/Gb or Iu mode, or moved to A/Gb or Iu mode from S1 mode through an SRVCC handover or moved to Iu mode from S1 mode through an vSRVCC handover. In this case the EPS update type IE shall be set to "combined TA/LA updating with IMSI attach";

e) when the UE enters EMM-REGISTERED.NORMAL-SERVICE and the UE's TIN indicates "P-TMSI";

f) when the UE receives an indication from the lower layers that the RRC connection was released with cause "load balancing TAU required";

g) when the UE deactivated EPS bearer context(s) locally while in EMM-REGISTERED, because it was not able or not allowed to establish a NAS signalling connection, and then returns to EMM-REGISTERED.NORMAL-SERVICE and no EXTENDED SERVICE REQUEST message, CONTROL PLANE SERVICE REQUEST message or DETACH REQUEST message is pending to be sent by the UE;

h) when the UE changes the UE network capability information or the MS network capability information or both;

i) when the UE changes the UE specific DRX parameter;

j) when the UE receives an indication of "RRC Connection failure" from the lower layers and has no signalling or user uplink data pending (i.e when the lower layer requests NAS signalling connection recovery);

k) when due to manual CSG selection the UE has selected a CSG cell whose CSG identity and associated PLMN identity are not included in the UE's Allowed CSG list or in the UE's Operator CSG list;

l) when the UE reselects an E-UTRAN cell while it was in GPRS READY state or PMM-CONNECTED mode;

m) when the UE supports SRVCC to GERAN or UTRAN or supports vSRVCC to UTRAN, and changes the mobile station classmark 2 or the supported codecs, or the UE supports SRVCC to GERAN and changes the mobile station classmark 3;

n) when the UE changes the radio capability for GERAN or cdma2000® or both;

o) when the UE's usage setting or the voice domain preference for E-UTRAN change in the UE;

p) when the UE activates mobility management for IMS voice termination as specified in 3GPP TS 24.008 [13], annex P.2, and the TIN indicates "RAT-related TMSI";

q) when the UE performs an intersystem change from A/Gb mode to S1 mode and the TIN indicates "RAT-related TMSI", but the UE is required to perform tracking area updating for IMS voice termination as specified in 3GPP TS 24.008 [13], annex P.4;

r) upon reception of a paging indication, if the UE is in state EMM-REGISTERED.ATTEMPTING-TO-UPDATE and the paging indication uses S-TMSI or it uses IMSI with domain indicator set to ″CS″;

s) when the UE needs to update the network with EPS bearer context status due to local de-activation of EPS bearer context(s) as specified in subclause 6.5.1.4A;

t) when the UE performs an intersystem change from A/Gb or Iu mode to S1 mode, and the UE has previously performed the MM connection establishment for CS fallback emergency calls (see 3GPP TS 24.008 [13], subclause 4.5.1.5a) without performing a location area updating procedure or combined routing area updating procedure while camping on a location area which is different from the stored location area. In this case, the EPS update type IE shall be set to "combined TA/LA updating with IMSI attach";

u) when the UE performs an intersystem change from A/Gb or Iu mode to S1 mode, and the MM update status is U2 NOT UPDATED. In this case the EPS update type IE shall be set to "combined TA/LA updating with IMSI attach";

v) when the UE needs to request the use of PSM or needs to stop the use of PSM;

w) when the UE needs to request the use of eDRX or needs to stop the use of eDRX;

x) when a change in the eDRX usage conditions at the UE requires different extended DRX parameters;

y) when a change in the PSM usage conditions at the UE requires a different timer T3412 value or different timer T3324 value;

NOTE 1: A change in the PSM or eDRX usage conditions at the UE can include e.g. a change in the UE configuration, a change in requirements from upper layers or the battery running low at the UE.

z) when the CIoT EPS optimizations the UE needs to use, change in the UE;

za) when the Default_DCN_ID value changes, as specified in 3GPP TS 24.368 [15A] or in USIM file NAS_{CONFIG} as specified in 3GPP TS 31.102 [17];

NOTE 2: The tracking area updating procedure is initiated after deleting the DCN-ID list as specified in annex C.

zb) when the UE performs inter-system change from N1 mode to S1 mode in EMM-IDLE mode, and the UE operates in single-registration mode (see 3GPP TS 24.501 [54]), and the following conditions apply;

- if both the UE and the MME support EMM-REGISTERED without PDN connection, or
- if the UE has at least one PDU session context for which interworking to EPS is supported (see 3GPP TS 24.501 [54]); or

zc) when the UE in EMM-IDLE mode changes the radio capability for E-UTRAN.

For case c, if the TIN indicates "RAT-related TMSI" and the EPS services were not resumed before returning to S1 mode, the UE shall set the TIN to "P-TMSI" before initiating the combined tracking area updating procedure.

For cases n and zc, the UE shall include a UE radio capability information update needed IE in the TRACKING AREA UPDATE REQUEST message.

For case l, if the TIN indicates "RAT-related TMSI", the UE shall set the TIN to "P-TMSI" before initiating the combined tracking area updating procedure.

For case r, the "active" flag in the EPS update type IE shall be set to 1. If the paging is received for CS fallback, the UE shall send the EXTENDED SERVICE REQUEST message to the MME by using the existing NAS signalling connection after the completion of the tracking area updating procedure.

To initiate a combined tracking area updating procedure the UE sends the message TRACKING AREA UPDATE REQUEST to the network, starts timer T3430 and changes to state EMM-TRACKING-AREA-UPDATING-INITIATED. The value of the EPS update type IE in the message shall indicate "combined TA/LA updating" unless explicitly specified otherwise.

If the UE initiates the combined tracking area updating procedure for EPS services and "SMS only", the UE shall indicate "SMS only" in the additional update type IE.

The UE shall include the TMSI status IE if no valid TMSI is available. Furthermore, if the UE has stored a valid location area identification, the UE shall include it in the Old location area identification IE in the TRACKING AREA UPDATE REQUEST message.

If the UE has stored a valid TMSI, the UE shall include the TMSI based NRI container IE in the TRACKING AREA UPDATE REQUEST message.

For cases g, s and zb, the UE shall include EPS bearer context status IE in TRACKING AREA UPDATE REQUEST message.

5.5.3.3.3 EMM common procedure initiation

During the combined tracking area updating procedure, the MME may initiate EMM common procedures, e.g. the EMM authentication and security mode control procedures. For restrictions applicable after handover or inter-system handover to S1 mode see subclause 5.5.3.2.3.

5.5.3.3.4 Combined tracking area updating procedure accepted by the network

5.5.3.3.4.1 General

Depending on the value of the EPS update result IE received in the TRACKING AREA UPDATE ACCEPT message, the following different cases can be distinguished:

1) The EPS update result IE value indicates "combined TA/LA updated": Tracking and location area updating is successful for EPS and non-EPS services, or for EPS services and "SMS only";

2) The EPS update result IE value indicates "TA updated": Tracking area updating is successful, but location area updating for non-EPS services or "SMS only" is not successful.

A TRACKING AREA UPDATE COMPLETE message shall be returned to the network if the TRACKING AREA UPDATE ACCEPT message contains a GUTI or a TMSI or both.

5.5.3.3.4.2 Combined tracking area updating successful

The description for normal tracking area update as specified in subclause 5.5.3.2.4 shall be followed. In addition, the following description for location area updating applies.

The TMSI reallocation may be part of the combined tracking area updating procedure. The TMSI allocated is then included in the TRACKING AREA UPDATE ACCEPT message together with the location area identification (LAI). In this case the MME shall change to state EMM-COMMON-PROCEDURE-INITIATED and shall start the timer T3450 as described in subclause 5.4.1. The LAI may be included in the TRACKING AREA UPDATE ACCEPT message without TMSI. If the MME does not indicate "SMS only" in the TRACKING AREA UPDATE ACCEPT message, subject to operator policies the MME should allocate a TAI list that does not span more than one location area.

For a shared network in CS domain, the MME indicates the selected PLMN for CS domain in the LAI to the UE as specified in 3GPP TS 23.272 [9].

The UE, receiving a TRACKING AREA UPDATE ACCEPT message, stores the received location area identification, resets the location update attempt counter, sets the update status to U1 UPDATED and enters MM state MM IDLE.

If the UE maintains a counter for "SIM/USIM considered invalid for non-GPRS services" events (see subclause 5.3.7b), then the UE shall reset this counter.

If the LAI contained in the TRACKING AREA UPDATE ACCEPT message is a member of the list of "forbidden location areas for regional provision of service" or the list of "forbidden location areas for roaming" then such entry shall be deleted.

If the PLMN identity for the CS domain which is provided as part of the LAI contained in the TRACKING AREA UPDATE ACCEPT message differs from the PLMN identity provided as part of the GUTI, the MME shall include the PLMN identity for the CS domain in the list of equivalent PLMNs in the TRACKING AREA UPDATE ACCEPT message.

If the UE requested "SMS only" in the Additional update type IE, or if the UE requested a combined tracking area updating for EPS and non-EPS services, but the network decides to accept the tracking area update request for EPS services and "SMS only", the network shall indicate "SMS only" in the Additional update result IE. In addition, if the SMS services are provided via SMS in MME, the network shall, in the TRACKING AREA UPDATE ACCEPT message, provide a non-broadcast LAI and may indicate in the EPS update result IE that ISR is activated. If a TMSI has to be allocated, then the network shall also provide a TMSI which cannot cause any ambiguity with assigned TMSI values.

If the TRACKING AREA UPDATE ACCEPT message includes the Additional update result IE with value "SMS only", a UE operating in CS/PS mode 2 and a UE operating in CS/PS mode 1 with "IMS voice available" shall not attempt to use CS fallback for mobile originating services.

As an implementation option, if the TRACKING AREA UPDATE ACCEPT message does not include the Additional update result IE with value "SMS only" and the UE is not configured for NAS signaling low priority then the UE may stop timer T3246 if running.

If the TRACKING AREA UPDATE ACCEPT message includes the Additional update result IE with value "CS Fallback not preferred", this indicates to a UE operating in CS/PS mode 2 and a UE operating in CS/PS mode 1 with "IMS voice available" that it is attached for EPS and non-EPS services and that it can use CS fallback.

How to handle the old TMSI stored in the UE depends on the mobile identity included in the TRACKING AREA UPDATE ACCEPT message.

- If the TRACKING AREA UPDATE ACCEPT message contains an IMSI, the UE is not allocated any TMSI, and shall delete any old TMSI accordingly.

- If the TRACKING AREA UPDATE ACCEPT message contains a TMSI, the UE shall use this TMSI as new temporary identity. The UE shall delete its old TMSI and shall store the new TMSI. In this case, a TRACKING AREA UPDATE COMPLETE message is returned to the network to confirm the received TMSI.

- If neither a TMSI nor an IMSI has been included by the network in the TRACKING AREA UPDATE ACCEPT message, the old TMSI, if any is available, shall be kept.

NOTE 1: It is possible for UEs compliant with earlier versions of this specification to send a TRACKING AREA UPDATE COMPLETE message even if TMSI reallocation is not part of the combined tracking area update procedure.

If the TRACKING AREA UPDATE ACCEPT message includes the Additional update result IE with value "SMS only" or "CS Fallback not preferred", a UE operating in CS/PS mode 1 with "IMS voice not available" shall attempt to select GERAN or UTRAN radio access technology and disable the E-UTRA capability (see subclause 4.5).

The network receiving a TRACKING AREA UPDATE COMPLETE message stops timer T3450, changes to state EMM-REGISTERED.

NOTE 2: Upon receiving a TRACKING AREA UPDATE COMPLETE message, if a new TMSI was included in the TRACKING AREA UPDATE ACCEPT message, the MME sends an SGsAP-TMSI-REALLOCATION-COMPLETE message as specified in 3GPP TS 29.118 [16A].

5.5.3.3.4.3 Combined tracking area updating successful for EPS services only

Apart from the actions on the tracking area updating attempt counter, the description for tracking area for EPS services as specified in subclause 5.5.3.2.4 shall be followed. In addition, the following description for location updating for non-EPS services applies.

The UE receiving the TRACKING AREA UPDATE ACCEPT message takes one of the following actions depending on the EMM cause value:

#2 (IMSI unknown in HSS)

The UE shall stop T3430 if still running and shall reset the tracking area updating attempt counter. The UE shall set the update status to U3 ROAMING NOT ALLOWED and shall delete any TMSI, LAI and ciphering key sequence number. The UE shall enter state EMM-REGISTERED.NORMAL-SERVICE. The new MM state is MM IDLE. The USIM shall be considered as invalid for non-EPS services until switching off or the UICC containing the USIM is removed or the timer T3245 expires as described subclause 5.3.7a. If the UE maintains a counter for "SIM/USIM considered invalid for non-GPRS services", then the UE shall set this counter to UE implementation-specific maximum value.

#16 (MSC temporarily not reachable); or

#17 (Network failure)

The UE shall stop timer T3430 if still running, and shall enter state MM IDLE. The tracking area updating attempt counter shall be incremented, unless it was already set to 5.

If the tracking area updating attempt counter is less than 5:

- the UE shall start timer T3411, shall set the EPS update status to EU1 UPDATED and shall enter state EMM-REGISTERED.ATTEMPTING-TO-UPDATE-MM. When timer T3411 expires the combined

tracking area updating procedure indicating "combined TA/LA updating with IMSI attach" is triggered again.

If the tracking area updating attempt counter is equal to 5:

- a UE operating in CS/PS mode 2 of operation and a UE operating in CS/PS mode 1 of operation with "IMS voice available" shall start timer T3402, shall set the EPS update status to EU1 UPDATED and shall enter state EMM-REGISTERED.ATTEMPTING-TO-UPDATE-MM. When timer T3402 expires the combined tracking area updating procedure indicating "combined TA/LA updating with IMSI attach" is triggered again;

- a UE operating in CS/PS mode 1 of operation with "IMS voice not available" without a persistent EPS bearer context shall attempt to select GERAN or UTRAN radio access technology and proceed with appropriate MM or GMM specific procedures and disable the E-UTRA capability (see subclause 4.5);

- a UE operating in CS/PS mode 1 of operation with "IMS voice not available" and with a persistent EPS bearer context shall start timer T3402, shall set the EPS update status to EU1 UPDATED and shall enter state EMM-REGISTERED.ATTEMPTING-TO-UPDATE-MM. When timer T3402 expires the combined tracking area updating procedure indicating "combined TA/LA updating with IMSI attach" is triggered again. When the radio bearer associated with the persistent EPS bearer context has been released and the UE is registered for EPS services only, operating in CS/PS mode 1 of operation with "IMS voice not available", then the UE shall stop timer T3402, if already running, attempt to select GERAN or UTRAN radio access technology and proceed with appropriate MM or GMM specific procedures and disable the E-UTRA capability (see subclause 4.5).

#18 (CS domain not available)

The UE shall stop timer T3430 if still running, shall reset the tracking area updating attempt counter, shall set the EPS update status to EU1 UPDATED and shall enter state EMM-REGISTERED.NORMAL-SERVICE.

The UE shall enter state MM IDLE and shall set the update status to U2 NOT UPDATED.

A UE in CS/PS mode 1 of operation with "IMS voice not available" without a persistent EPS bearer context shall attempt to select GERAN or UTRAN radio access technology rather than E-UTRAN for the registered PLMN or equivalent PLMN and disable the E-UTRA capability (see subclause 4.5).

A UE in CS/PS mode 1 of operation with "IMS voice not available" and with a persistent EPS bearer context shall, after the radio bearer associated with the persistent EPS bearer context has been released, attempt to select GERAN or UTRAN radio access technology rather than E-UTRAN for the registered PLMN or equivalent PLMN and disable the E-UTRA capability (see subclause 4.5).

A UE in CS/PS mode 2 of operation and a UE operating in CS/PS mode 1 of operation with "IMS voice available" may provide a notification to the user or the upper layers that the CS domain is not available.

The UE shall not attempt combined attach or combined tracking area updating procedure with current PLMN until switching off the UE or the UICC containing the USIM is removed.

#22 (Congestion)

The UE shall stop timer T3430 if still running. The tracking area updating attempt counter shall be set to 5. The UE shall start timer T3402, shall set the EPS update status to EU1 UPDATED, shall enter state EMM-REGISTERED.ATTEMPTING-TO-UPDATE-MM, shall enter state MM IDLE.

Other EMM cause values and the case that no EMM cause IE was received are considered as abnormal cases. The combined tracking area updating procedure shall be considered as failed for non-EPS services. The behaviour of the UE in those cases is specified in subclause 5.5.3.3.6.

5.5.3.3.5 Combined tracking area updating procedure not accepted by the network

If the combined tracking area updating cannot be accepted by the network, the MME shall send a TRACKING AREA UPDATE REJECT message to the UE including an appropriate EMM cause value.

If the MME locally deactivates EPS bearer contexts for the UE (see subclause 5.5.3.2.4) and no active EPS bearer contexts remain for the UE, the MME shall send the TRACKING AREA UPDATE REJECT message including the EMM cause value #10 "implicitly detached".

If the tracking area update request is rejected due to general NAS level mobility management congestion control, the network shall set the EMM cause value to #22 "congestion" and assign a back-off timer T3346.

If the UE initiated the tracking area updating procedure due to inter-system change from N1 mode to S1 mode, and the MME is only supporting interworking procedures without N26 interface, the MME shall send a TRACKING AREA UPDATE REJECT message with EMM cause value #9 "UE identity cannot be derived by the network".

If the tracking area request is rejected due to service gap control as specified in subclause 5.3.17 i.e. the T3447 timer is running, the network shall set the EMM cause value to #22 "congestion" and may assign a back-off timer T3346 with the remaining time of the running T3447 timer.

Upon receiving the TRACKING AREA UPDATE REJECT message, if the message is integrity protected or contains a reject cause other than EMM cause value #25, the UE shall stop timer T3430, stop any transmission of user data and enter state MM IDLE.

If the TRACKING AREA UPDATE REJECT message with EMM cause #25 was received without integrity protection, then the UE shall discard the message.

The UE shall take the following actions depending on the EMM cause value received in the TRACKING AREA UPDATE REJECT message.

#3 (Illegal UE);

#6 (Illegal ME); or

#8 (EPS services and non-EPS services not allowed);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI List and eKSI.

The UE shall consider the USIM as invalid for EPS and non-EPS services until switching off or the UICC containing the USIM is removed or the timer T3245 expires as described in subclause 5.3.7a. Additionally, the UE shall delete the list of equivalent PLMNs and shall enter the state EMM-DEREGISTERED. If the message has been successfully integrity checked by the NAS and the UE maintains a counter for "SIM/USIM considered invalid for GPRS services", then the UE shall set this counter to UE implementation-specific maximum value. If the message has been successfully integrity checked by the NAS and the UE maintains a counter for "SIM/USIM considered invalid for non-GPRS services", then the UE shall set this counter to UE implementation-specific maximum value.

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the MM parameters update status, TMSI, LAI and ciphering key sequence number, and the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI and GPRS ciphering key sequence number as specified in 3GPP TS 24.008 [13] for the case when the combined routing area updating procedure is rejected with the GMM cause with the same value.

#7 (EPS services not allowed);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI List and eKSI. The UE shall consider then USIM as invalid for EPS services until switching off or the UICC containing the USIM is removed or the timer T3245 expires as described in subclause 5.3.7a. The UE shall delete the list of equivalent PLMNs and shall enter the state EMM-DEREGISTERED. If the message has been successfully integrity checked by the NAS and the UE maintains a counter for "SIM/USIM considered invalid for GPRS services", then the UE shall set this counter to UE implementation-specific maximum value.

A UE in CS/PS mode 1 or CS/PS mode 2 of operation which is already IMSI attached for non-EPS services is still IMSI attached for non-EPS services.

A UE in CS/PS mode 1 or CS/PS mode 2 of operation shall set the update status to U2 NOT UPDATED, shall attempt to select GERAN or UTRAN radio access technology and proceed with appropriate MM specific procedure according to the MM service state. The UE shall not reselect E-UTRAN radio access technology until switching off or the UICC containing the USIM is removed.

If A/Gb mode or Iu mode is supported by the UE, the UE shall in addition handle the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI and GPRS ciphering key sequence number as

specified in 3GPP TS 24.008 [13] for the case when the combined routing area updating procedure is rejected with the GMM cause with the same value.

#9 (UE identity cannot be derived by the network);

The UE shall set the EPS update status to EU2 NOT UPDATED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI List and eKSI. The UE shall enter the state EMM-DEREGISTERED.

If there is a CS fallback emergency call pending or CS fallback call pending, or a paging for CS fallback, the UE shall attempt to select GERAN or UTRAN radio access technology. If the UE finds a suitable GERAN or UTRAN cell, it then proceeds with the appropriate MM and CC specific procedures; otherwise, if there is a CS fallback emergency call or CS fallback call pending, the EMM sublayer shall indicate the abort of the EMM procedure to the MM sublayer.

If there is a 1xCS fallback emergency call pending or 1xCS fallback call pending, or a paging for 1xCS fallback, the UE shall select cdma2000® 1x radio access technology. The UE then proceeds with appropriate cdma2000® 1x CS procedures.

If there is a 1xCS fallback emergency call pending or 1xCS fallback call pending, or a paging for 1xCS fallback, and the UE has dual Rx/Tx configuration and supports enhanced 1xCS fallback, the UE shall perform a new attach procedure.

If there is no CS fallback emergency call pending, CS fallback call pending, 1xCS fallback emergency call pending, 1xCS fallback call pending, paging for CS fallback, or paging for 1xCS fallback and the rejected request was not for initiating a PDN connection for emergency bearer services, the UE shall subsequently, automatically initiate the attach procedure.

NOTE 1: User interaction is necessary in some cases when the UE cannot re-activate the EPS bearer(s) automatically.

If A/Gb mode or Iu mode is supported by the UE, the UE shall in addition handle the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI and GPRS ciphering key sequence number as specified in 3GPP TS 24.008 [13] for the case when the combined routing area updating procedure is rejected with the GMM cause with the same value.

A UE in CS/PS mode 1 or CS/PS mode 2 of operation which is already IMSI attached for non-EPS services is still IMSI attached for non-EPS services.

A UE in CS/PS mode 1 or CS/PS mode 2 of operation shall set the update status to U2 NOT UPDATED.

If the UE is operating in the single-registration mode, the UE shall handle the 5GMM parameters as specified in 3GPP TS 24.501 [54] for the case when the registration procedure for mobility and periodic registration update indicating "mobility registration updating" in the 5GS registration type IE of the REGISTRATION REQUEST message is rejected with the 5GMM cause with the same value.

#10 (Implicitly detached);

A UE in CS/PS mode 1 or CS/PS mode 2 of operation is IMSI detached for both EPS services and non-EPS services.

The UE shall enter the state EMM-DEREGISTERED.NORMAL-SERVICE. The UE shall delete any mapped EPS security context or partial native EPS security context.

If there is a CS fallback emergency call pending or CS fallback call pending, or a paging for CS fallback, the UE shall attempt to select GERAN or UTRAN radio access technology. If the UE finds a suitable GERAN or UTRAN cell, it then proceeds with the appropriate MM and CC specific procedures; otherwise, if there is a CS fallback emergency call or CS fallback call pending, the EMM sublayer shall indicate the abort of the EMM procedure to the MM sublayer.

If there is a 1xCS fallback emergency call pending or 1xCS fallback call pending, or a paging for 1xCS fallback, the UE shall select cdma2000® 1x radio access technology. The UE then proceeds with appropriate cdma2000® 1x CS procedures.

If there is a 1xCS fallback emergency call pending or 1xCS fallback call pending, or a paging for 1xCS fallback, and the UE has dual Rx/Tx configuration and supports enhanced 1xCS fallback, the UE shall perform a new attach procedure.

If there is no CS fallback emergency call pending, CS fallback call pending, 1xCS fallback emergency call pending, 1xCS fallback call pending, paging for CS fallback, or paging for 1xCS fallback and the rejected request was not for initiating a PDN connection for emergency bearer services, the UE shall then perform a new attach procedure.

NOTE 2: User interaction is necessary in some cases when the UE cannot re-activate the EPS bearer(s) automatically.

If A/Gb mode or Iu mode is supported by the UE, the UE shall in addition handle the GMM state as specified in 3GPP TS 24.008 [13] for the case when the combined routing area updating procedure is rejected with the GMM cause with the same value.

A UE in CS/PS mode 1 or CS/PS mode 2 of operation shall set the update status to U2 NOT UPDATED.

#11 (PLMN not allowed); or

#35 (Requested service option not authorized in this PLMN);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI List and eKSI, and reset the tracking area updating attempt counter. The UE shall delete the list of equivalent PLMNs and enter the state EMM-DEREGISTERED.PLMN-SEARCH.

The UE shall store the PLMN identity in the "forbidden PLMN list" and if the UE is configured to use timer T3245 (see 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17]) then the UE shall start timer T3245 and proceed as described in subclause 5.3.7a. If the message has been successfully integrity checked by the NAS and the UE maintains a PLMN-specific attempt counter for that PLMN, then the UE shall set this counter to the UE implementation-specific maximum value.

The UE shall then perform a PLMN selection according to 3GPP TS 23.122 [6].

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle and the MM parameters update status, TMSI, LAI, ciphering key sequence number and the location update attempt counter, and the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI, GPRS ciphering key sequence number and routing area updating attempt counter as specified in 3GPP TS 24.008 [13] for the case when the combined routing area updating procedure is rejected with the GMM cause with the same value and no RR connection exists.

#12 (Tracking area not allowed);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI List and eKSI. The UE shall reset the tracking area updating attempt counter and shall enter the state EMM-DEREGISTERED.LIMITED-SERVICE.

The UE shall store the current TAI in the list of "forbidden tracking areas for regional provision of service".

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the MM parameters update status, TMSI, LAI, ciphering key sequence number and the location update attempt counter, and the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI, GPRS ciphering key sequence number and routing area updating attempt counter as specified in 3GPP TS 24.008 [13] for the case when the combined routing area updating procedure is rejected with the GMM cause with the same value.

#13 (Roaming not allowed in this tracking area);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete the list of equivalent PLMNs. The UE shall reset the tracking area updating attempt counter and shall change to state EMM-REGISTERED.PLMN-SEARCH.

The UE shall store the current TAI in the list of "forbidden tracking areas for roaming" and shall remove the current TAI from the stored TAI list if present.

The UE shall perform a PLMN selection according to 3GPP TS 23.122 [6].

The UE shall indicate the Update type IE "combined TA/LA updating with IMSI attach" when performing the tracking area updating procedure following the PLMN selection.

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the MM parameters update status and the location update attempt counter, and the GMM parameters GMM state, GPRS update status and routing area updating attempt counter as specified in 3GPP TS 24.008 [13] for the case when the combined routing area updating procedure is rejected with the GMM cause with the same value.

#14 (EPS services not allowed in this PLMN);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3). Furthermore, the UE shall delete any GUTI, last visited registered TAI, TAI List and eKSI. The UE shall reset the tracking area updating attempt counter and shall enter the state EMM-DEREGISTERED.PLMN-SEARCH.

The UE shall store the PLMN identity in the "forbidden PLMNs for GPRS service" list and if the UE is configured to use timer T3245 (see 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17]) then the UE shall start timer T3245 and proceed as described in subclause 5.3.7a. If the message has been successfully integrity checked by the NAS and the UE maintains a PLMN-specific PS-attempt counter for that PLMN, then the UE shall set this counter to the UE implementation-specific maximum value.

The UE operating in CS/PS mode 1 or CS/PS mode 2 of operation which is already IMSI attached for non-EPS services is still IMSI attached for non-EPS services.

The UE operating in CS/PS mode 1 or CS/PS mode 2 of operation shall set the update status to U2 NOT UPDATED.

A UE operating in CS/PS mode 1 of operation and supporting A/Gb mode or Iu mode may select GERAN or UTRAN radio access technology and proceed with the appropriate MM specific procedure according to the MM service state. In this case, the UE shall disable the E-UTRA capability (see subclause 4.5).

A UE operating in CS/PS mode 1 of operation and supporting A/Gb mode or Iu mode may perform a PLMN selection according to 3GPP TS 23.122 [6].

A UE operating in CS/PS mode 1 of operation and supporting S1 mode only, or operating in CS/PS mode 2 of operation shall delete the list of equivalent PLMNs and shall perform a PLMN selection according to 3GPP TS 23.122 [6].

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI, GPRS ciphering key sequence number and routing area updating attempt counter as specified in 3GPP TS 24.008 [13] for the case when the combined routing area updating procedure is rejected with the GMM cause with the same value.

#15 (No suitable cells in tracking area);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3). The UE shall reset the tracking area updating attempt counter and shall enter the state EMM-REGISTERED.LIMITED-SERVICE.

The UE shall store the current TAI in the list of "forbidden tracking areas for roaming" and shall remove the current TAI from the stored TAI list if present and:

- if the UE is in S1 mode and the Extended EMM cause IE with value "E-UTRAN not allowed" is included in the TRACKING AREA UPDATE REJECT message, the UE supports "E-UTRA Disabling for EMM cause #15", and the "E-UTRA Disabling Allowed for EMM cause #15" parameter as specified in 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17] is present and set to enabled; then the UE shall disable the E-UTRA capability as specified in subclause 4.5 and search for a suitable cell in another location area;

  - if the UE is in NB-S1 mode and the Extended EMM cause IE with value "NB-IoT not allowed" is included in the TRACKING AREA UPDATE REJECT message, then the UE may disable the NB-IoT capability as specified in subclause 4.X and search for a suitable cell in E-UTRAN radio access technology;

- otherwise, the UE shall search for a suitable cell in another tracking area or in another location area according to 3GPP TS 36.304 [21].

The UE shall indicate the Update type IE "combined TA/LA updating with IMSI attach" when performing the tracking area updating procedure.

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the MM parameters update status and the location update attempt counter, and the GMM parameters GMM state, GPRS update status and routing area updating attempt counter as specified in 3GPP TS 24.008 [13] for the case when the combined routing area updating procedure is rejected with the GMM cause with the same value.

#22 (Congestion);

If the T3346 value IE is present in the TRACKING AREA UPDATE REJECT message and the value indicates that this timer is neither zero nor deactivated, the UE shall proceed as described below, otherwise it shall be considered as an abnormal case and the behaviour of the UE for this case is specified in subclause 5.5.3.3.6.

The UE shall abort the tracking area updating procedure, reset the tracking area updating attempt counter and set the EPS update status to EU2 NOT UPDATED. If the rejected request was not for initiating a PDN connection for emergency bearer services, the UE shall change to state EMM-REGISTERED.ATTEMPTING-TO-UPDATE.

The UE shall stop timer T3346 if it is running.

If the TRACKING AREA UPDATE REJECT message is integrity protected, the UE shall start timer with the value provided in the T3346 value IE.

If the TRACKING AREA UPDATE REJECT message is not integrity protected, the UE shall start timer T3346 with a random value from the default range specified in 3GPP TS 24.008 [13].

The UE stays in the current serving cell and applies the normal cell reselection process. The tracking area updating procedure is started, if still necessary, when timer T3346 expires or is stopped.

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM parameters GMM state, GPRS update status and routing area updating attempt counter as specified in 3GPP TS 24.008 [13] for the case when the combined routing area updating procedure is rejected with the GMM cause with the same value.

#25 (Not authorized for this CSG);

EMM cause #25 is only applicable when received from a CSG cell. EMM cause #25 received from a non-CSG cell is considered as an abnormal case and the behaviour of the UE is specified in subclause 5.5.3.3.6.

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and store it according to subclause 5.1.3.3). The UE shall reset the tracking area updating attempt counter and shall enter the state EMM-REGISTERED.LIMITED-SERVICE.

If the CSG ID and associated PLMN identity of the cell where the UE has sent the TRACKING AREA UPDATE REQUEST message are contained in the Allowed CSG list, the UE shall remove the entry corresponding to this CSG ID and associated PLMN identity from the Allowed CSG list.

If the CSG ID and associated PLMN identity of the cell where the UE has sent the TRACKING AREA UPDATE REQUEST message are contained in the Operator CSG list, the UE shall apply the procedures defined in 3GPP TS 23.122 [6] subclause 3.1A.

The UE shall search for a suitable cell according to 3GPP TS 36.304 [21].

The UE shall indicate the Update type IE "combined TA/LA updating with IMSI attach" when performing the tracking area updating procedure.

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the MM parameters update status and the location update attempt counter, and the GMM parameters GMM state, GPRS update status and routing area updating attempt counter as specified in 3GPP TS 24.008 [13] for the case when the combined routing area updating procedure is rejected with the GMM cause with the same value.

#40 (No EPS bearer context activated);

The UE shall deactivate all the EPS bearer contexts locally, if any, and shall enter the state EMM-DEREGISTERED.NORMAL-SERVICE.

If there is a CS fallback emergency call pending or CS fallback call pending, or a paging for CS fallback, the UE shall attempt to select GERAN or UTRAN radio access technology. If the UE finds a suitable GERAN or UTRAN cell, it then proceeds with the appropriate MM and CC specific procedures; otherwise, if there is a CS fallback emergency call or CS fallback call pending, the EMM sublayer shall indicate the abort of the EMM procedure to the MM sublayer.

If there is a 1xCS fallback emergency call pending or 1xCS fallback call pending, or a paging for 1xCS fallback, the UE shall select cdma2000® 1x radio access technology. The UE then proceeds with appropriate cdma2000® 1x CS procedures.

If there is a 1xCS fallback emergency call pending or 1xCS fallback call pending, or a paging for 1xCS fallback, and the UE has dual Rx/Tx configuration and supports enhanced 1xCS fallback, the UE shall perform a new attach procedure.

If there is no CS fallback emergency call pending, CS fallback call pending, 1xCS fallback emergency call pending, 1xCS fallback call pending, paging for CS fallback, or paging for 1xCS fallback, the UE shall perform a new attach procedure.

NOTE 3: User interaction is necessary in some cases when the UE cannot re-activate the EPS bearer(s) automatically.

If A/Gb mode or Iu mode is supported by the UE, the UE shall in addition handle the GMM state as specified in 3GPP TS 24.008 [13] for the case when the combined routing area updating procedure is rejected with the GMM cause value #10 "Implicitly detached".

A UE in CS/PS mode 1 or CS/PS mode 2 of operation which is already IMSI attached for non-EPS services is still IMSI attached for non-EPS services.

A UE in CS/PS mode 1 or CS/PS mode 2 of operation shall set the update status to U2 NOT UPDATED.

#42 (Severe network failure);

The UE shall set the EPS update status to EU2 NOT UPDATED, and shall delete any GUTI, last visited registered TAI, eKSI, and list of equivalent PLMNs, and set the tracking area update attempt counter to 5. The UE shall start an implementation specific timer, setting its value to 2 times the value of T as defined in 3GPP TS 23.122 [6]. While this timer is running, the UE shall not consider the PLMN + RAT combination that provided this reject cause as a candidate for PLMN selection. The UE then enters state EMM-DEREGISTERED.PLMN-SEARCH in order to perform a PLMN selection according to 3GPP TS 23.122 [6].

If A/Gb mode or Iu mode is supported by the UE, the UE shall in addition set the GMM state to GMM-DEREGISTERED, GPRS update status to GU2 NOT UPDATED, and shall delete the P-TMSI, P-TMSI signature, RAI and GPRS ciphering key sequence number.

Other values are considered as abnormal cases. The behaviour of the UE in those cases is specified in subclause 5.5.3.3.6.

5.5.3.3.6 Abnormal cases in the UE

The UE shall proceed as follows:

1) if the UE requested the combined tracking area update for EPS services and "SMS only" and the TRACKING AREA UPDATE ACCEPT message indicates a combined tracking area updating procedure successful for EPS and non-EPS services, the UE shall behave as if the combined tracking area updating procedure was successful for EPS services and "SMS only";

NOTE: In this case the UE can ignore the CS SERVICE NOTIFICATION message or the Paging with CN domain indicator set to "CS", as specified in subclause 5.6.2.3.2.

2) if the combined tracking area update was successful for EPS services only and the TRACKING AREA UPDATE ACCEPT message contained an EMM cause value not treated in subclause 5.5.3.3.4.3 or the EMM Cause IE is not included in the message, the UE shall proceed as follows:

a) The UE shall stop timer T3430 if still running, and shall enter state MM IDLE. The tracking area updating attempt counter shall be incremented, unless it was already set to 5;

b) If the tracking area updating attempt counter is less than 5:

- the UE shall start timer T3411, shall set the EPS update status to EU1 UPDATED and shall enter state EMM-REGISTERED.ATTEMPTING-TO-UPDATE-MM. When timer T3411 expires the combined tracking area updating procedure indicating "combined TA/LA updating with IMSI attach" is triggered again;

c) If the tracking area updating attempt counter is equal to 5:

- a UE operating in CS/PS mode 2 of operation and a UE operating in CS/PS mode 1 of operation with "IMS voice available" shall start timer T3402, shall set the EPS update status to EU1 UPDATED and shall enter state EMM-REGISTERED.ATTEMPTING-TO-UPDATE-MM. When timer T3402 expires the combined tracking area updating procedure indicating "combined TA/LA updating with IMSI attach" is triggered again; and

- a UE operating in CS/PS mode 1 of operation with "IMS voice not available" shall attempt to select GERAN or UTRAN radio access technology and proceed with appropriate MM or GMM specific procedures and disable the E-UTRA capability (see subclause 4.5); and

d) If there is a CS fallback emergency call or CS fallback call pending, or a paging for CS fallback, the UE shall attempt to select GERAN or UTRAN radio access technology. If the UE finds a suitable GERAN or UTRAN cell, it then proceeds with the appropriate MM and CC specific procedures; otherwise, if there is a CS fallback emergency call or CS fallback call pending, the EMM sublayer shall indicate the abort of the EMM procedure to the MM sublayer; and

3) otherwise, the abnormal cases specified in subclause 5.5.3.2.6 apply with the following modification.

If the tracking area updating attempt counter is incremented according to subclause 5.5.3.2.6 the next actions depend on the value of the tracking area updating attempt counter.

- If the tracking area updating attempt counter is less than 5, the UE shall set the update status to U2 NOT UPDATED, but shall not delete any LAI, TMSI, ciphering key sequence number and list of equivalent PLMNs; or

- if the tracking area updating attempt counter is equal to 5, the UE shall delete any LAI, TMSI and ciphering key sequence number and set the update status to U2 NOT UPDATED.

If there is a CS fallback emergency call pending or CS fallback call pending, or a paging for CS fallback, the UE shall attempt to select GERAN or UTRAN radio access technology. If the UE finds a suitable GERAN or UTRAN cell, it then proceeds with the appropriate MM and CC specific procedures; otherwise if there is a CS fallback emergency call or CS fallback call pending, the EMM sublayer shall indicate the abort of the EMM procedure to the MM sublayer.

5.5.3.3.7 Abnormal cases on the network side

The abnormal cases specified in subclause 5.5.3.2.7 apply.

5.5.4 eCall inactivity procedure

The eCall inactivity procedure is applicable only to a UE configured for eCall only mode as specified in 3GPP TS 31.102 [17]. The procedure shall be started when:

- the UE is in any EMM-REGISTERED substate except substates EMM-REGISTERED.PLMN-SEARCH or EMM-REGISTERED.NO-CELL-AVAILABLE;

- the UE is in EMM-IDLE mode, and

- one of the following conditions applies:

1) timer T3444 expires or is found to have already expired and timer T3445 is not running;

2) timer T3445 expires or is found to have already expired and timer T3444 is not running; or

3) timers T3444 and T3445 expire or are found to have already expired.

The UE shall then perform the following actions:

- stop other running timers (e.g. T3411, T3412);
- if the UE is currently registered to EPS services only, perform a detach procedure for EPS services only;
- if the UE is currently registered for both EPS services and non-EPS services, perform a combined detach procedure for EPS services and non-EPS services;
- delete any GUTI, TAI list, last visited registered TAI, list of equivalent PLMNs, and KSI; and
- enter EMM-DEREGISTERED.eCALL-INACTIVE state.

5.6 EMM connection management procedures (S1 mode only)

5.6.1 Service request procedure

5.6.1.1 General

The purpose of the service request procedure is to transfer the EMM mode from EMM-IDLE to EMM-CONNECTED mode. If the UE is not using EPS services with control plane CIoT EPS optimization, this procedure is used to establish the radio and S1 bearers when user data or signalling is to be sent. If the UE is using EPS services with control plane CIoT EPS optimization, this procedure can be used for UE initiated transfer of user data via the control plane. Another purpose of this procedure is to invoke MO/MT CS fallback or 1xCS fallback procedures.

This procedure is used when:

- the network has downlink signalling pending;
- the UE has uplink signalling pending;
- the UE or the network has user data pending and the UE is in EMM-IDLE mode;
- the UE is in EMM-CONNECTED mode and has a NAS signalling connection only; the UE is using EPS services with control plane CIoT EPS optimization, and it has user data pending which is to be transferred via user plane radio bearers;
- the UE in EMM-IDLE or EMM-CONNECTED mode has requested to perform mobile originating/terminating CS fallback or 1xCS fallback;
- the network has downlink cdma2000® signalling pending;
- the UE has uplink cdma2000® signalling pending;
- the UE has to request resources for ProSe direct discovery or Prose direct communication; or
- the UE has to request resources for V2X communication over PC5.

The service request procedure is initiated by the UE, however, for the downlink transfer of signalling, cdma2000® signalling or user data in EMM-IDLE mode, the trigger is given by the network by means of the paging procedure (see subclause 5.6.2).

The UE shall invoke the service request procedure when:

a) the UE in EMM-IDLE mode receives a paging request using S-TMSI with CN domain indicator set to "PS" from the network;

b) the UE, in EMM-IDLE mode, has pending user data to be sent;

c) the UE, in EMM-IDLE mode, has uplink signalling pending;

d) the UE in EMM-IDLE or EMM-CONNECTED mode is configured to use CS fallback and has a mobile originating CS fallback request from the upper layer;

e) the UE in EMM-IDLE mode is configured to use CS fallback and receives a paging request with CN domain indicator set to "CS", or the UE in EMM-CONNECTED mode is configured to use CS fallback and receives a CS SERVICE NOTIFICATION message;

f) the UE in EMM-IDLE or EMM-CONNECTED mode is configured to use 1xCS fallback and has a mobile originating 1xCS fallback request from the upper layer;

g) the UE in EMM-CONNECTED mode is configured to use 1xCS fallback and accepts cdma2000® signalling messages containing a 1xCS paging request received over E-UTRAN;

h) the UE, in EMM-IDLE mode, has uplink cdma2000® signalling pending to be transmitted over E-UTRAN;

i) the UE, in EMM-IDLE or EMM-CONNECTED mode, is configured to use 1xCS fallback, accepts cdma2000® signalling messages containing a 1xCS paging request received over cdma2000® 1xRTT, and the network supports dual Rx CSFB or provide CS fallback registration parameters (see 3GPP TS 36.331 [22]);

j) the UE, in EMM-IDLE or EMM-CONNECTED mode, has uplink cdma2000® signalling pending to be transmitted over cdma2000® 1xRTT, and the network supports dual Rx CSFB or provide CS fallback registration parameters (see 3GPP TS 36.331 [22]);

k) the UE performs an inter-system change from S101 mode to S1 mode and has user data pending;

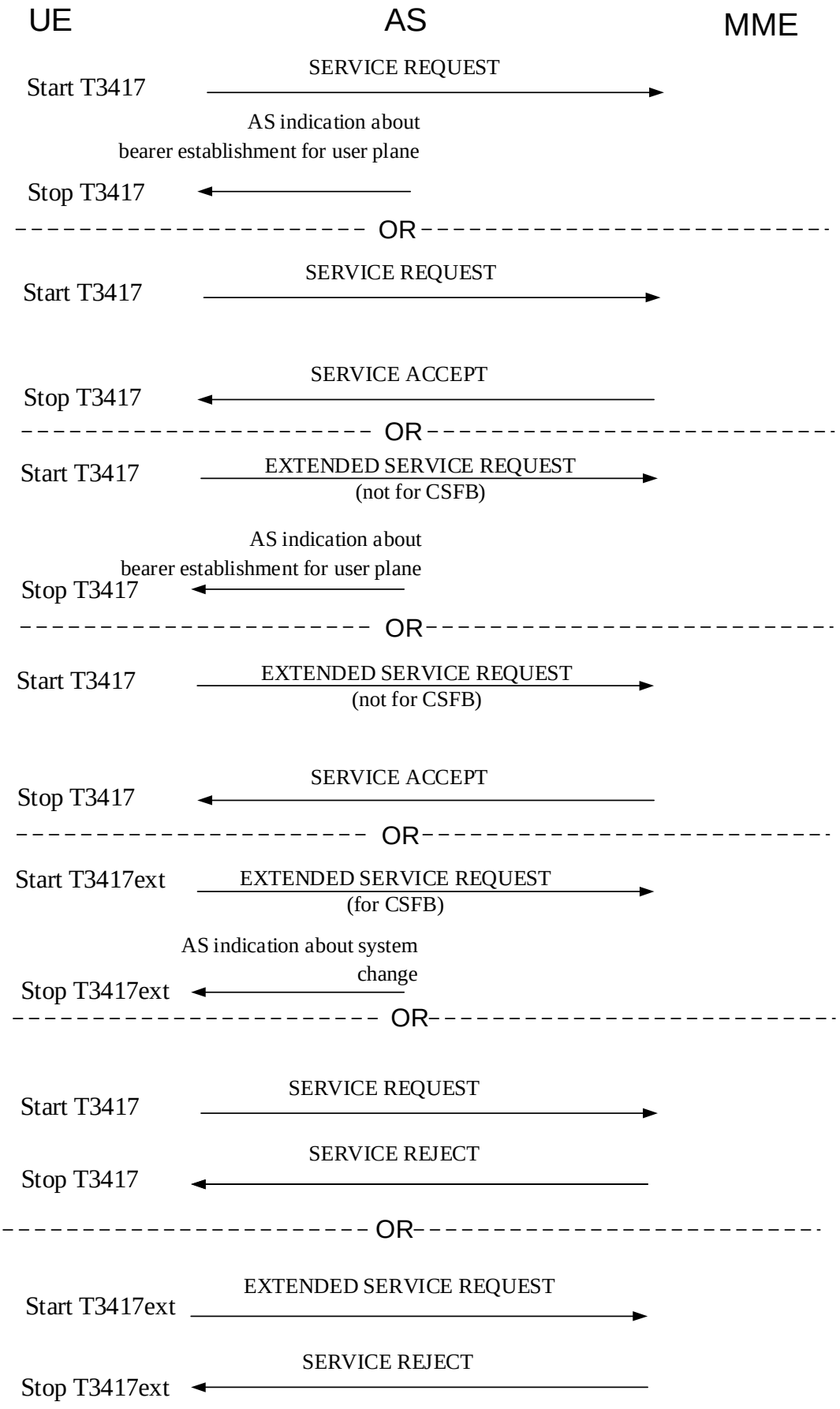
l) the UE in EMM-IDLE mode has to request resources for ProSe direct discovery or Prose direct communication (see 3GPP TS 36.331 [22]); or

m) the UE, in EMM-CONNECTED mode and has a NAS signalling connection only, is using EPS services with control plane CIoT EPS optimization and has pending user data to be sent via user plane radio bearers; or

n) the UE in EMM-IDLE mode has to request resources for V2X communication over PC5 (see 3GPP TS 23.285 [47]).

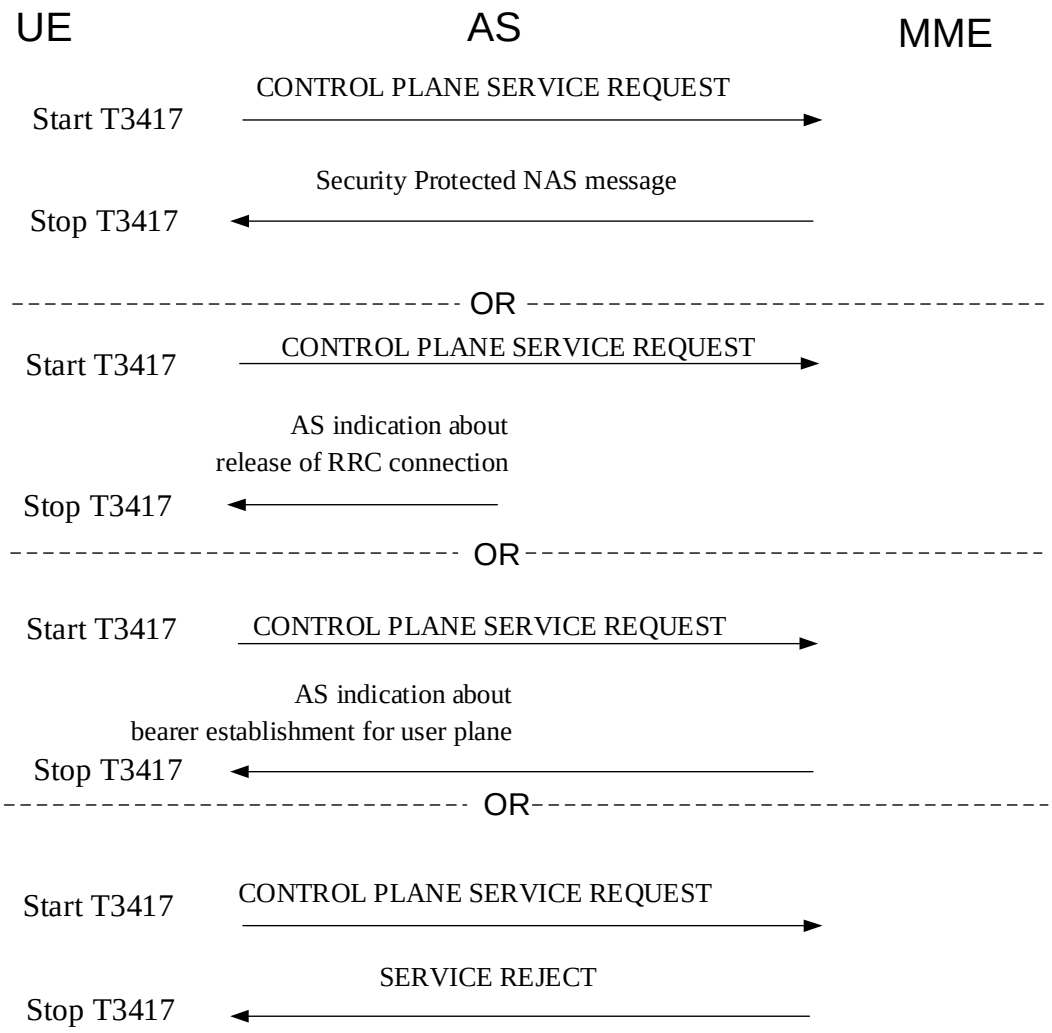
If one of the above criteria to invoke the service request procedure is fulfilled, then the service request procedure may only be initiated by the UE when the following conditions are fulfilled:

- its EPS update status is EU1 UPDATED, and the TAI of the current serving cell is included in the TAI list; and
- no EMM specific procedure is ongoing.


UE
AS
MME
SERVICE REQUEST
Start T3417
AS indication about
bearer establishment for user plane
Stop T3417
OR
SERVICE REQUEST
Start T3417
SERVICE ACCEPT
Stop T3417
OR
Start T3417
EXTENDED SERVICE REQUEST
(not for CSFB)
AS indication about
bearer establishment for user plane
Stop T3417
OR
Start T3417
EXTENDED SERVICE REQUEST
(not for CSFB)
SERVICE ACCEPT
Stop T3417
OR
Start T3417ext
EXTENDED SERVICE REQUEST
(for CSFB)
AS indication about system
change
Stop T3417ext
OR
SERVICE REQUEST
Start T3417
SERVICE REJECT
Stop T3417
OR
EXTENDED SERVICE REQUEST
Start T3417ext
SERVICE REJECT
Stop T3417ext

NOTE 1: AS indications (indications from lower layers) are results of procedures triggered by MME in service request procedure. Triggered procedures could be e.g. RRC connection reconfiguration procedure (see 3GPP TS 36.331 [22]) and inter system PS handover to GERAN or UTRAN procedure as a result of CSFB procedure (see 3GPP TS 23.272 [9]).
NOTE 2: For 1xCS fallback, the UE sends the EXTENDED SERVICE REQUEST message and starts timer T3417. The procedure is considered completed upon receiving indication of system change from AS.

Figure 5.6.1.1.1: Service request procedure (part 1)



NOTE 1: Security protected NAS message: this could be e.g. a SECURITY MODE COMMAND, SERVICE ACCEPT, or ESM DATA TRANSPORT message.
NOTE 2: AS indications (indications from lower layers) are results of procedures triggered by MME in service request procedure. Triggered procedures could be e.g. an RRC connection release procedure or RRC connection reconfiguration procedure (see 3GPP TS 36.331 [22]).

Figure 5.6.1.1.2: Service request procedure (part 2)

A service request attempt counter is used to limit the number of service request attempts and no response from the network. The service request attempt counter shall be incremented as specified in subclause 5.6.1.6.

The service request attempt counter shall be reset when:

- an attach or combined attach procedure is successfully completed;

- a normal or periodic tracking area updating or a combined tracking area updating procedure is successfully completed; or

- a service request procedure in order to obtain packet services is successfully completed.

5.6.1.2 Service request procedure initiation

5.6.1.2.1 UE is not using EPS services with control plane CIoT EPS optimization

For cases a, b, c, h, k and l in subclause 5.6.1.1:

- if the UE is not configured for NAS signalling low priority, the UE initiates the service request procedure by sending a SERVICE REQUEST message to the MME;

- if the UE is configured for NAS signalling low priority, and the last received ATTACH ACCEPT message or TRACKING AREA UPDATE ACCEPT message from the network indicated that the network supports use of EXTENDED SERVICE REQUEST for packet services, the UE shall send an EXTENDED SERVICE REQUEST message with service type set to "packet services via S1"; or

NOTE: A UE configured for dual priority is configured for NAS signalling low priority indicator.

- if the UE is configured for NAS signalling low priority and the last received ATTACH ACCEPT message or TRACKING AREA UPDATE ACCEPT message from the network did not indicate that the network supports use of EXTENDED SERVICE REQUEST for packet services, the UE shall instead send a SERVICE REQUEST message.

For cases a, b, c, h, k and l in subclause 5.6.1.1, after sending the SERVICE REQUEST message or the EXTENDED SERVICE REQUEST message with service type set to "packet services via S1", the UE shall start T3417 and enter the state EMM-SERVICE-REQUEST-INITIATED.

For case d in subclause 5.6.1.1, the UE shall send an EXTENDED SERVICE REQUEST message, start T3417ext and enter the state EMM-SERVICE-REQUEST-INITIATED.

For case e in subclause 5.6.1.1:

- if the UE is in EMM-IDLE mode, the UE shall send an EXTENDED SERVICE REQUEST message, start T3417ext-mt and enter the state EMM-SERVICE-REQUEST-INITIATED;

- if the UE is in EMM-CONNECTED mode and if the UE accepts the paging, the UE shall send an EXTENDED SERVICE REQUEST message with the CSFB response IE indicating "CS fallback accepted by the UE", start T3417ext-mt and enter the state EMM-SERVICE-REQUEST-INITIATED; or

- if the UE is in EMM-CONNECTED mode and if the UE rejects the paging, the UE shall send an EXTENDED SERVICE REQUEST message with the CSFB response IE indicating "CS fallback rejected by the UE" and enter the state EMM-REGISTERED.NORMAL-SERVICE. The network shall not initiate CS fallback procedures.

For cases f, g, i and j in subclause 5.6.1.1, the UE shall send an EXTENDED SERVICE REQUEST message, start T3417 and enter the state EMM-SERVICE-REQUEST-INITIATED.

5.6.1.2.2 UE is using EPS services with control plane CIoT EPS optimization

The UE shall send a CONTROL PLANE SERVICE REQUEST message, start T3417 and enter the state EMM-SERVICE-REQUEST-INITIATED.

For case a in subclause 5.6.1.1, the Control plane service type of the CONTROL PLANE SERVICE REQUEST message shall indicate "mobile terminating request". The UE may include the ESM DATA TRANSPORT message. The UE shall not include any ESM message other than ESM DATA TRANSPORT message.

For case b in subclause 5.6.1.1,

- if the UE has pending IP or non-IP user data that is to be sent via the control plane radio bearers, the Control plane service type of the CONTROL PLANE SERVICE REQUEST message shall indicate "mobile originating request". The UE shall include an ESM DATA TRANSPORT message in the ESM message container IE

For cases b and m in subclause 5.6.1.1,

- if the UE has pending IP or non-IP user data that is to be sent via the user plane radio bearers, the UE shall set the Control plane service type of the CONTROL PLANE SERVICE REQUEST message to "mobile originating request" and the "active" flag in the Control plane service type IE to 1. The UE shall not include any ESM message container or NAS message container IE in the CONTROL PLANE SERVICE REQUEST message.

For case c in subclause 5.6.1.1, the UE shall set the Control plane service type of the CONTROL PLANE SERVICE REQUEST message to "mobile originating request". If the CONTROL PLANE SERVICE REQUEST message is:

- for sending SMS , the UE shall include the SMS message in the NAS message container IE and shall not include any ESM message container IE in the CONTROL PLANE SERVICE REQUEST message ; and

- for sending signalling different from SMS, the UE shall not include any ESM message container or NAS message container IE in the CONTROL PLANE SERVICE REQUEST message.

5.6.1.3 EMM common procedure initiation

Upon receipt of the SERVICE REQUEST, EXTENDED SERVICE REQUEST or CONTROL PLANE SERVICE REQUEST message, the MME may initiate the EMM common procedures, e.g. the authentication procedure and security mode control procedure.

5.6.1.4 Service request procedure accepted by the network

5.6.1.4.1 UE is not using EPS services with control plane CIoT EPS optimization

If EMM-REGISTERED without PDN connection is supported by the UE and the MME and the MME has no active EPS bearer contexts for the UE, for cases a, b and c in subclause 5.6.1.1, upon receipt of the SERVICE REQUEST message or the EXTENDED SERVICE REQUEST message for packet services, after completion of the EMM common procedures according to subclause 5.6.1.3, if any, the MME shall send a SERVICE ACCEPT message.

If EMM-REGISTERED without PDN connection is supported by the UE and the MME and the UE has no active EPS bearer contexts, for cases a, b and c in subclause 5.6.1.1, the UE shall treat the receipt of a SERVICE ACCEPT message as successful completion of the procedure. Otherwise, for cases a, b, c, h, k and l in subclause 5.6.1.1, the UE shall treat the indication from the lower layers that the user plane radio bearer is set up as successful completion of the procedure. The UE shall reset the service request attempt counter, stop the timer T3417 and enter the state EMM-REGISTERED.

If the service type information element in the EXTENDED SERVICE REQUEST message indicates "mobile terminating CS fallback or 1xCS fallback" and the CSFB response IE, if included, indicates "CS fallback accepted by the UE", or if the service type information element in the EXTENDED SERVICE REQUEST message indicates "mobile originating CS fallback or 1xCS fallback" or "mobile originating CS fallback emergency call or 1xCS fallback emergency call", the network initiates CS fallback or 1xCS fallback procedures.

If the EPS bearer context status IE is included in the EXTENDED SERVICE REQUEST message, the network shall deactivate all those EPS bearer contexts locally (without peer-to-peer signalling between the network and the UE) which are active on the network side but are indicated by the UE as being inactive. If a default EPS bearer context is marked as inactive in the EPS bearer context status IE included in the EXTENDED SERVICE REQUEST message, and this default bearer is not associated with the last remaining PDN connection of the UE in the MME, the MME shall locally deactivate all EPS bearer contexts associated to the PDN connection with the default EPS bearer context without peer-to-peer ESM signalling to the UE. If the default bearer is associated with the last remaining PDN connection of the UE in the MME, and EMM-REGISTERED without PDN connection is supported by the UE and the MME, the MME shall locally deactivate all EPS bearer contexts associated to the PDN connection with the default EPS bearer context without peer-to-peer ESM signalling to the UE.

If the SERVICE REQUEST message or the EXTENDED SERVICE REQUEST message for packet services, was sent in a CSG cell and the CSG subscription has expired or was removed for a UE, but the UE has a PDN connection for emergency bearer services established, the network shall accept the SERVICE REQUEST message or the EXTENDED SERVICE REQUEST message for packet services and deactivate all non-emergency EPS bearers locally. The emergency EPS bearers shall not be deactivated.

For cases d in subclause 5.6.1.1, and for case e in subclause 5.6.1.1 when the CSFB response was set to "CS fallback accepted by the UE", the UE shall treat the indication from the lower layers that the inter-system change from S1 mode to A/Gb or Iu mode is completed as successful completion of the procedure. The EMM sublayer in the UE shall indicate to the MM sublayer that the CS fallback procedure has succeeded. The UE shall stop the timer T3417ext or T3417ext-mt, respectively, and enter the state EMM-REGISTERED.NO-CELL-AVAILABLE.

If the service request procedure was initiated in EMM-IDLE mode and an EXTENDED SERVICE REQUEST message was sent in a CSG cell and the CSG subscription has expired or was removed for the UE, the network need not perform CSG access control if the service type information element indicates "mobile originating CS fallback emergency call or 1xCS fallback emergency call".

For cases f and g in subclause 5.6.1.1:

- if the UE receives the indication from the lower layers that the signalling connection is released with the redirection indication to cdma2000® 1x access network or the indication from the lower layers that a change to cdma2000® 1x access network for 1xCS fallback has started (see 3GPP TS 36.331 [22]), the UE shall consider the service request procedure successfully completed, stop timer T3417 and enter the state EMM-REGISTERED.NO-CELL-AVAILABLE;

- if the UE receives the dual Rx/Tx redirection indication from the lower layers (see 3GPP TS 36.331 [22]), the UE shall select cdma2000® 1x access network for 1xCS fallback, consider the service request procedure successfully completed, stop timer T3417 and enter the state EMM-REGISTERED.NORMAL-SERVICE; and

- if the UE receives a cdma2000® signalling message indicating 1xCS fallback rejection by cdma2000® 1x access network, the UE shall abort the service request procedure, stop timer T3417 and enter the state EMM-REGISTERED.NORMAL-SERVICE.

For cases i and j in subclause 5.6.1.1, if the UE receives the indication from the lower layers that the signalling connection is released, the UE shall consider the service request procedure successfully completed, stop timer T3417 and enter the state EMM-REGISTERED.NO-CELL-AVAILABLE.

If the SERVICE REQUEST message or an EXTENDED SERVICE REQUEST message for packet services was used, the UE shall locally deactivate the EPS bearer contexts that do not have a user plane radio bearer established upon successful completion of the service request procedure.

If the EXTENDED SERVICE REQUEST message is for CS fallback or 1xCS fallback and radio bearer establishment takes place during the procedure, the UE shall locally deactivate the EPS bearer contexts that do not have a user plane radio bearer established upon receiving a lower layer indication of radio bearer establishment. The UE does not perform local deactivation of EPS bearer contexts upon receiving an indication of inter-system change from lower layers.

If the EXTENDED SERVICE REQUEST message is for CS fallback or 1xCS fallback and radio bearer establishment does not take place during the procedure, the UE does not perform local deactivation of the EPS bearer context. The UE does not perform local deactivation of EPS bearer contexts upon receiving an indication of inter-system change from lower layers.

If a service request is received from a UE with a LIPA PDN connection, and if:

- a GW Transport Layer Address IE value identifying a L-GW is provided by the lower layer together with the service request, and the P-GW address included in the EPS bearer context of the LIPA PDN connection is different from the provided GW Transport Layer Address IE value (see 3GPP TS 36.413 [23]); or

- no GW Transport Layer Address is provided together with the service request by the lower layer;

then the MME shall locally deactivate all EPS bearer contexts associated with any LIPA PDN connection. Furthermore, if no active EPS bearer contexts remain for the UE, the MME shall not accept the service request as specified in subclause 5.6.1.5.

If a service request is received from a UE with a SIPTO at the local network PDN connection, and if the PDN connection is a:

1) SIPTO at the local network PDN connection with stand-alone GW, and if:

- a LHN-ID value is provided by the lower layer together with the service request, and the LHN-ID value stored in the EPS bearer context of the SIPTO at the local network PDN connection is different from the provided LHN-ID value (see 3GPP TS 36.413 [23]); or

- no LHN-ID value is provided together with the service request by the lower layer; or

2) SIPTO at the local network PDN connection with collocated L-GW, and if:

- a SIPTO L-GW Transport Layer Address IE value identifying a L-GW is provided by the lower layer together with the service request, and the P-GW address included in the EPS bearer context of the SIPTO at

the local network PDN connection is different from the provided SIPTO L-GW Transport Layer Address IE value (see 3GPP TS 36.413 [23]); or

- no SIPTO L-GW Transport Layer Address is provided together with the service request by the lower layer;

then, the MME takes one of the following actions:

- if all the remaining PDN connections are SIPTO at the local network PDN connections, the MME shall not accept the service request as specified in subclause 5.6.1.5; and

- if a PDN connection remains that is not SIPTO at the local network PDN connection and the network decides to set up the S1 and radio bearers, the MME shall upon completion of the setup of the S1 bearers initiate an EPS bearer context deactivation procedure with ESM cause #39 "reactivation requested" for the default EPS bearer context of each SIPTO at the local network PDN connection (see subclause 6.4.4.2).

NOTE: For some cases of CS fallback or 1x CS fallback the network can decide not to set up any S1 and radio bearers.

When the E-UTRAN fails to establish radio bearers for one or more EPS bearer contexts, then the MME shall locally deactivate the EPS bearer contexts corresponding to the failed radio bearers based on the lower layer indication from the E-UTRAN, without notifying the UE.

If the UE is not using EPS services with control plane CIoT EPS optimization, the network shall consider the service request procedure successfully completed in the following cases:

- when it receives an indication from the lower layer that the user plane is setup, if radio bearer establishment is required;

- otherwise when it receives an indication from the lower layer that the UE has been redirected to the other RAT (GERAN or UTRAN in CS fallback, or cdma2000® 1x access network for 1xCS fallback).

5.6.1.4.2 UE is using EPS services with control plane CIoT EPS optimization

For case a in subclause 5.6.1.1, upon receipt of the CONTROL PLANE SERVICE REQUEST message with Control plane service type indicating "mobile terminating request", after completion of the EMM common procedures according to subclause 5.6.1.3:

1) if the MME needs to perform an EPS bearer context status synchronization

   - for an EPS bearer context associated with Control plane only indication; or

   - for an EPS bearer context not associated with Control plane only indication, there is no downlink user data pending to be delivered via the user plane, and the UE did not set the "active" flag in the Control plane service type IE to 1; or

2) if the control plane data back-off time for the UE is stored in MME and the MME decides to deactivate congestion control for transport of user data via the control plane,

then the MME shall send a SERVICE ACCEPT message.

Furthermore the MME may:

1) initiate the transport of user data via the control plane procedure or any other NAS signalling procedure;

2) if supported by the UE and required by the network, initiate the setup of the user plane radio bearer(s); or

3) send a NAS signalling message not related to an EMM common procedure to the UE if downlink signalling is pending.

For case b in subclause 5.6.1.1, upon receipt of the CONTROL PLANE SERVICE REQUEST message with Control plane service type indicating "mobile originating request", after completion of the EMM common procedures according to subclause 5.6.1.3, if any, if the MME needs to perform an EPS bearer context status synchronization

- for an EPS bearer context associated with Control plane only indication; or

- for an EPS bearer context not associated with Control plane only indication, there is no downlink user data pending to be delivered via the user plane, and the UE did not set the "active" flag in the Control plane service type IE to 1,

then the MME shall send a SERVICE ACCEPT message.

Furthermore, the MME may:

1) initiate release of the NAS signalling connection upon receipt of an indication from the ESM layer (see subclause 6.6.4.2), unless the MME has additional downlink user data or signalling pending;

2) initiate the setup of the user plane radio bearer(s), if downlink user data is pending to be delivered via the user plane or the UE has set the "active" flag in the Control plane service type IE to 1;

3) send an ESM DATA TRANSPORT message to the UE, if downlink user data is pending to be delivered via the control plane;

4) send a NAS signalling message not related to an EMM common procedure to the UE if downlink signalling is pending; or

5) send a SERVICE ACCEPT message to complete the service request procedure, if no NAS security mode control procedure was initiated, the MME did not send a SERVICE ACCEPT message as specified above to perform an EPS bearer context status synchronization, and the MME did not initiate any of the procedures specified in item 1 to 4 above.

NOTE 1: The MME can initiate the setup of the user plane radio bearer(s) if the MME decides to activate the congestion control for transport of user data via the control plane.

For case m in subclause 5.6.1.1, upon receipt of the CONTROL PLANE SERVICE REQUEST message with Control plane service type indicating "mobile originating request" and the "active" flag in the Control plane service type IE set to 1:

1) if the MME accepts the request, the MME shall initiate the setup of the user plane radio bearer(s) for all active EPS bearer contexts of SGi PDN connections that are established without control plane only indication.

2) if the MME does not accept the request, the MME shall send a SERVICE ACCEPT message to complete the service request procedure.

NOTE 2: The MME takes into account the maximum number of user plane radio bearers supported by the UE, in addition to local policies and the UE's preferred CIoT network behaviour when deciding whether to accept the request to establish user plane bearer(s) as described in subclause 5.3.15. If the MME accepts the request, all SGi PDN connections are considered as established without Control plane only indication.

NOTE 3: In this release of the specification, a UE in NB-S1 mode can support a maximum of 2 user plane radio bearers (see subclause 6.5.0).

For case c in subclause 5.6.1.1, upon receipt of the CONTROL PLANE SERVICE REQUEST message with Control plane service type indicating "mobile originating request" and without an ESM message container IE, after completion of the EMM common procedures according to subclause 5.6.1.3, if any, the MME proceeds as follows:

If the MME needs to perform an EPS bearer context status synchronization

- for an EPS bearer context associated with Control plane only indication; or

- for an EPS bearer context not associated with Control plane only indication, and there is no downlink user data pending to be delivered via the user plane,

then the MME shall send a SERVICE ACCEPT message.

Furthermore, the MME may:

1) initiate the setup of the user plane radio bearer(s), if downlink user data is pending to be delivered via the user plane;

2) send an ESM DATA TRANSPORT message to the UE, if downlink user data is pending to be delivered via the control plane;

3) send a NAS signalling message not related to an EMM common procedure to the UE, if downlink signalling is pending; or

4) send a SERVICE ACCEPT message to complete the service request procedure, if no NAS security mode control procedure was initiated, the MME did not send a SERVICE ACCEPT message as specified above to perform an EPS bearer context status synchronization, and the MME did not initiate any of the procedures specified in item 1 to 3 above.

In NB-S1 mode, for cases a, b, c and m in subclause 5.6.1.1, if the MME needs to initiate the setup of user plane radio bearer(s), the MME shall check if the UE can support the establishment of additional user plane radio bearer based on the multiple DRB support indicated by UE in the UE network capability IE.

For cases a, b and c in subclause 5.6.1.1, if the EPS bearer context status IE is included in the CONTROL PLANE SERVICE REQUEST message, the network shall deactivate all those EPS bearer contexts locally (without peer-to-peer signalling between the network and the UE) which are active on the network side but are indicated by the UE as being inactive. If a default EPS bearer context is marked as inactive in the EPS bearer context status IE included in the CONTROL PLANE SERVICE REQUEST message, and this default bearer is not associated with the last PDN connection of the UE in the MME, the MME shall locally deactivate all EPS bearer contexts associated to the PDN connection with the default EPS bearer context without peer-to-peer ESM signalling to the UE. If the default bearer is associated with the last remaining PDN connection of the UE in the MME, and EMM-REGISTERED without PDN connection is supported by the UE and the MME, the MME shall locally deactivate all EPS bearer contexts associated to the PDN connection with the default EPS bearer context without peer-to-peer ESM signalling to the UE.

If the EPS bearer context status IE is included in the CONTROL PLANE SERVICE REQUEST and the MME decides to respond with a SERVICE ACCEPT message, the MME shall include an EPS bearer context status IE, indicating which EPS bearer contexts are active in the MME, except for the case when no EPS bearer context exists on the network side.

If the MME needs to initiate an EPS bearer context status synchronization, the MME may include an EPS bearer context status IE in the SERVICE ACCEPT message also if no EPS bearer context status IE was included in the CONTROL PLANE SERVICE REQUEST message.

If the MME sends a SERVICE ACCEPT message upon receipt of the CONTROL PLANE SERVICE REQUEST message piggybacked with the ESM DATA TRANSPORT message:

- if the Release assistance indication IE is set to "No further uplink or downlink data transmission subsequent to the uplink data transmission is expected" in the message;

- if the UE has indicated support for the control plane data back-off timer; and

- if the MME decides to activate the congestion control for transport of user data via the control plane,

then the MME shall include the T3448 value IE in the SERVICE ACCEPT message.

If the MME sends a SERVICE ACCEPT message and decides to deactivate congestion control for transport of user data via the control plane then the MME shall delete the stored control plane data back-off time for the UE and the MME shall not include timer T3448 value IE in SERVICE ACCEPT message.

For cases a, b, c and m in subclause 5.6.1.1, if the EPS bearer context status IE is included in the CONTROL PLANE SERVICE REQUEST message or the MME needs to initiate an EPS bearer context status synchronization, the MME shall consider the service request procedure successfully completed when it sends the SERVICE ACCEPT message. If the EPS bearer context status IE is not included in the CONTROL PLANE SERVICE REQUEST message and the MME does not need to initiate an EPS bearer context status synchronization, the MME shall consider the service request procedure successfully completed in the following cases:

- when it successfully completes a NAS security mode control procedure;

- when it receives an indication from the lower layer that the user plane is setup, if radio bearer establishment is required;

- upon receipt of the CONTROL PLANE SERVICE REQUEST message and completion of the EMM common procedures, if any, if the CONTROL PLANE SERVICE REQUEST message was successfully integrity checked and the ESM message container or NAS message container in the CONTROL PLANE SERVICE REQUEST message, if applicable, was successfully deciphered, radio bearer establishment is not required, and the MME has downlink user data or signalling not related to an EMM common procedure pending; and

- with the transmission of a SERVICE ACCEPT message or with the decision to initiate release of the NAS signalling connection, if the CONTROL PLANE SERVICE REQUEST message was successfully integrity checked and the ESM message container or NAS message container in the CONTROL PLANE SERVICE REQUEST message, if applicable, was successfully deciphered, radio bearer establishment is not required, and the MME does not have any downlink user data or signalling pending.

If the MME considers the service request procedure successfully completed the MME shall:

1) forward the contents of the ESM message container IE, if any, to the ESM layer; and

2) forward the contents of the NAS message container IE, if any.

For cases a, b and c in subclause 5.6.1.1, the UE shall treat the receipt of any of the following as successful completion of the procedure:

- a SECURITY MODE COMMAND message;

- a security protected EMM message different from a SERVICE REJECT message and not related to an EMM common procedure;

- a security protected ESM message; and

- receipt of the indication from the lower layers that the user plane radio bearers are set up.

Upon successful completion of the procedure, the UE shall reset the service request attempt counter, stop the timer T3417 and enter the state EMM-REGISTERED.

NOTE 4: The security protected EMM message can be e.g. a SERVICE ACCEPT message and the ESM message an ESM DATA TRANSPORT message.

For case m in subclause 5.6.1.1, the UE shall treat the indication from the lower layers that the user plane radio bearers are set up as successful completion of the procedure. The UE shall treat the receipt of a SERVICE ACCEPT message as completion of the procedure without the establishment of the user plane radio bearers. For both cases, the UE shall reset the service request attempt counter, stop the timer T3417 and enter the state EMM-REGISTERED.

For case b in subclause 5.6.1.1, the UE shall also treat the indication from the lower layers that the RRC connection has been released as successful completion of the procedure. The UE shall reset the service request attempt counter, stop the timer T3417 and enter the state EMM-REGISTERED.

For cases a, c and m in subclause 5.6.1.1, the UE shall treat the indication from the lower layers that the RRC connection has been released as an abnormal case and shall follow the procedure described in subclause 5.6.1.6, item b.

For cases a, b and c in subclause 5.6.1.1,

- if the MME needs to initiate an EPS bearer context status synchronization, the UE can receive a SERVICE ACCEPT message even after it received a SECURITY MODE COMMAND message or an indication from the lower layers that the user plane radio bearers are set up and determined successful completion of the service request procedure. Upon receipt of the SECURITY MODE COMMAND message or an indication from the lower layers that the user plane radio bearers are set up, the UE shall start timer T3449. If the UE receives a security protected ESM message or a security protected EMM message not related to an EMM common procedure, the UE shall stop the timer T3449. If the UE receives a SERVICE ACCEPT message while the timer T3449 is running, the UE shall treat the SERVICE ACCEPT message and stop the timer T3449. If the UE is not in state EMM-SERVICE-REQUEST-INITIATED and timer T3449 is not running, the receipt of the SERVICE ACCEPT message is considered as protocol error and the UE shall return EMM STATUS message as specified in subclause 7.4; otherwise the UE shall treat the SERVICE ACCEPT message; and

- if the UE treats the SERVICE ACCEPT message and an EPS bearer context status IE is included in the message, the UE shall deactivate all those EPS bearers contexts locally (without peer-to-peer signalling between the UE and the MME) which are active in the UE, but are indicated by the MME as being inactive. If a default EPS bearer context is marked as inactive in the EPS bearer context status IE included in the SERVICE ACCEPT message, and this default bearer is not associated with the last remaining PDN connection in the UE, the UE shall locally deactivate all EPS bearer contexts associated to the PDN connection with the default EPS bearer context without peer-to-peer ESM signalling to the MME. If the default bearer is associated with the last remaining PDN connection of the UE in the MME, and EMM-REGISTERED without PDN connection is

supported by the UE and the MME, the UE shall locally deactivate all EPS bearer contexts associated to the PDN connection with the default EPS bearer context without peer-to-peer ESM signalling to the MME.

If the T3448 value IE is present in the received SERVICE ACCEPT message, the UE shall:

- stop timer T3448 if it is running;
- consider the transport of user data via the control plane as successful; and
- start timer T3448 with the value provided in the T3448 value IE.

If the UE is using EPS services with control plane CIoT EPS optimization, the T3448 value IE is present in the SERVICE ACCEPT message and the value indicates that this timer is either zero or deactivated, the UE shall consider this case as an abnormal case and proceed as if the T3448 value IE is not present.

If the UE in EMM-IDLE mode initiated the service request procedure by sending a CONTROL PLANE SERVICE REQUEST message and the SERVICE ACCEPT message does not include the T3448 value IE and if timer T3448 is running, then the UE shall stop timer T3448.

5.6.1.5 Service request procedure not accepted by the network

If the service request cannot be accepted, the network shall return a SERVICE REJECT message to the UE including an appropriate EMM cause value.

NOTE 1: A service request can only be rejected before the network has initiated any procedure which will be interpreted by the UE as successful completion of the service request procedure (see subclauses 5.6.1.4.1 and 5.6.1.4.2) and which will trigger a transition from state EMM-SERVICE-REQUEST-INITIATED to EMM-REGISTERED on the UE side.

Based on local policies or configurations in the MME, if the MME determines to change the periodic tracking area update timer (T3412), or if the MME determines to change the PSM usage or the value of timer T3324 in the UE for which PSM is allowed by the MME, the MME may return a SERVICE REJECT with the cause #10 "implicitly detached" to the UE.

The MME may be configured to perform MME-based access control for mobile originating CS fallback calls for a certain area A by rejecting related service request with EMM cause #39 "CS service temporarily not available".

NOTE 2: Dependent on implementation and operator configuration the area A can be configured with the granularity of an MME area, tracking area or eNodeB service area.

The MME may further be configured for a certain area A' to exempt service requests for mobile originating CS fallback calls from this MME-based access control, if:

- the service request is initiated in EMM-IDLE mode; and
- the UE indicated support of eNodeB-based access control for mobile originating CS fallback calls during an attach or tracking area updating procedure.

NOTE 3: The operator can use this second option when the eNodeBs in area A' are supporting the eNodeB-based access control for CS fallback calls. The area A' can be part of area A or the whole area A. It is the responsibility of the operator to coordinate the activation of MME-based access control and eNodeB-based access control for mobile originating CS fallback calls.

When the EMM cause value is #39 "CS service temporarily not available", the MME shall include a value for timer T3442 in the SERVICE REJECT message. If a mobile terminating CS fallback call is aborted by the network during call establishment as specified in 3GPP TS 29.118 [16A], the MME shall include the EMM cause value #39 "CS service temporarily not available" and set the value of timer T3442 to zero.

If a service request from a UE with only LIPA PDN connections is not accepted due to the reasons specified in subclause 5.6.1.4, depending on the service request received, the MME shall include the following EMM cause value in the SERVICE REJECT message:

- if the service request received is not due to CS fallback or 1xCS fallback, EMM cause value #10 "implicitly detached"; or

- if the service request received is due to CS fallback or 1xCS fallback, EMM cause value #40 "no EPS bearer context activated".

If a service request from a UE with only remaining SIPTO at the local network PDN connections is not accepted due to the reasons specified in subclause 5.6.1.4, depending on the service request received, the MME shall:

- if the service request received is due to CS fallback or 1xCS fallback, include the EMM cause value #40 "no EPS bearer context activated" in the SERVICE REJECT message; or

- if the service request received is not due to CS fallback or 1xCS fallback, abort the service request procedure and send a DETACH REQUEST message to the UE with detach type "re-attach required" (see subclause 5.5.2.3.1).

If the service request for mobile originated services is rejected due to general NAS level mobility management congestion control, the network shall set the EMM cause value to #22 "congestion" and assign a value for back-off timer T3346.

If the service request for mobile originated services is rejected due to service gap control as specified in subclause 5.3.17 i.e. the T3447 timer is running, the network shall set the EMM cause value to #22 "congestion" and may assign a back-off timer T3346 with the remaining time of the running T3447 timer.

If the MME sends a SERVICE REJECT message upon receipt of the CONTROL PLANE SERVICE REQUEST message piggybacked with the ESM DATA TRANSPORT message:

- if the Release assistance indication IE is not set to "No further uplink or downlink data transmission subsequent to the uplink data transmission is expected" in the message;

- if the UE has indicated a support for the control plane data back-off timer; and

- if the MME decides to activate the congestion control for transport of user data via the control plane,

then the MME shall set the EMM cause value to #22 "congestion" and assign a value for control plane data back-off timer T3448.

On receipt of the SERVICE REJECT message, if the UE is in state EMM-SERVICE-REQUEST-INITIATED and the message is integrity protected or contains a reject cause other than EMM cause value #25, the UE shall reset the service request attempt counter, stop timer T3417, T3417ext or T3417ext-mt, if running.

If the SERVICE REJECT message with EMM cause #25 was received without integrity protection, then the UE shall discard the message.

The UE shall take the following actions depending on the received EMM cause value in the SERVICE REJECT message.

#3 (Illegal UE);

#6 (Illegal ME); or

#8 (EPS services and non-EPS services not allowed);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and eKSI. The UE shall consider the USIM as invalid for EPS services until switching off or the UICC containing the USIM is removed or the timer T3245 expires as described in subclause 5.3.7a. The UE shall enter the state EMM-DEREGISTERED. If the message has been successfully integrity checked by the NAS and the UE maintains a counter for "SIM/USIM considered invalid for GPRS services", then the UE shall set this counter to UE implementation-specific maximum value.

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI and GPRS ciphering key sequence number and the MM parameters update status, TMSI, LAI and ciphering key sequence number as specified in 3GPP TS 24.008 [13] for the case when the service request procedure is rejected with the GMM cause with the same value. The USIM shall be considered as invalid also for non-EPS services until switching off or the UICC containing the USIM is removed or the timer T3245 expires as described in subclause 5.3.7a. If the message has been successfully integrity checked by the NAS and the UE maintains a counter for "SIM/USIM considered invalid for non-GPRS services", then the UE shall set this counter to UE implementation-specific maximum value.

NOTE 4: The possibility to configure a UE so that the radio transceiver for a specific radio access technology is not active, although it is implemented in the UE, is out of scope of the present specification.

#7 (EPS services not allowed);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and eKSI. The UE shall consider the USIM as invalid for EPS services until switching off or the UICC containing the USIM is removed or the timer T3245 expires as described in subclause 5.3.7a. The UE shall enter the state EMM-DEREGISTERED. If the message has been successfully integrity checked by the NAS and the UE maintains a counter for "SIM/USIM considered invalid for GPRS services", then the UE shall set this counter to UE implementation-specific maximum value.

A UE operating in CS/PS mode 1 or CS/PS mode 2 of operation which is already IMSI attached for non-EPS services is still IMSI attached for non-EPS services.

A UE operating in CS/PS mode 1 or CS/PS mode 2 of operation shall set the update status to U2 NOT UPDATED, shall attempt to select GERAN or UTRAN radio access technology and proceed with appropriate MM specific procedure according to the MM service state. The UE shall not reselect E-UTRAN radio access technology until switching off or the UICC containing the USIM is removed.

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI and GPRS ciphering key sequence number as specified in 3GPP TS 24.008 [13] for the case when the service request procedure is rejected with the GMM cause with the same value.

#9 (UE identity cannot be derived by the network);

The UE shall set the EPS update status to EU2 NOT UPDATED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and eKSI. The UE shall enter the state EMM-DEREGISTERED.

If the service request was initiated for CS fallback and a CS fallback cancellation request was not received, the UE shall attempt to select GERAN or UTRAN radio access technology. If the UE finds a suitable GERAN or UTRAN cell, it then proceeds with the appropriate MM and CC specific procedures and the EMM sublayer shall not indicate the abort of the service request procedure to the MM sublayer. Otherwise the EMM sublayer shall indicate the abort of the service request procedure to the MM sublayer.

If the service request was initiated for 1xCS fallback, the UE shall select cdma2000® 1x radio access technology. The UE then proceeds with appropriate cdma2000® 1x CS procedures.

If the service request was initiated for 1xCS fallback and the UE has dual Rx/Tx configuration and supports enhanced 1xCS fallback, the UE shall perform a new attach procedure.

If the service request was initiated for any reason other than CS fallback, 1x CS fallback or initiating a PDN connection for emergency bearer services, the UE shall perform a new attach procedure.

NOTE 5: User interaction is necessary in some cases when the UE cannot re-activate the EPS bearer(s) automatically.

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI and GPRS ciphering key sequence number as specified in 3GPP TS 24.008 [13] for the case when the service request procedure is rejected with the GMM cause with the same value.

A UE operating in CS/PS mode 1 or CS/PS mode 2 of operation which is already IMSI attached for non-EPS services is still IMSI attached for non-EPS services.

A UE operating in CS/PS mode 1 or CS/PS mode 2 of operation shall set the update status to U2 NOT UPDATED.

#10 (Implicitly detached);

A UE in CS/PS mode 1 or CS/PS mode 2 of operation is IMSI detached for both EPS services and non-EPS services.

The UE shall enter the state EMM-DEREGISTERED.NORMAL-SERVICE. The UE shall delete any mapped EPS security context or partial native EPS security context.

If the service request was initiated for CS fallback and a CS fallback cancellation request was not received, the UE shall attempt to select GERAN or UTRAN radio access technology. If the UE finds a suitable GERAN or UTRAN cell, it then proceeds with the appropriate MM and CC specific procedures and the EMM sublayer shall not indicate the abort of the service request procedure to the MM sublayer. Otherwise the EMM sublayer shall indicate the abort of the service request procedure to the MM sublayer.

If the service request was initiated for 1xCS fallback, the UE shall select cdma2000® 1x radio access technology. The UE then proceeds with appropriate cdma2000® 1x CS procedures.

If the service request was initiated for 1xCS fallback and the UE has dual Rx/Tx configuration and supports enhanced 1xCS fallback, the UE shall perform a new attach procedure.

If the service request was initiated for any reason other than CS fallback, 1x CS fallback or initiating a PDN connection for emergency bearer services, the UE shall perform a new attach procedure.

NOTE 6: User interaction is necessary in some cases when the UE cannot re-activate the EPS bearer(s) automatically.

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM state as specified in 3GPP TS 24.008 [13] for the case when the service request procedure is rejected with the GMM cause with the same value.

A UE operating in CS/PS mode 1 or CS/PS mode 2 of operation shall set the update status to U2 NOT UPDATED.

#11 (PLMN not allowed); or

#35 (Requested service option not authorized in this PLMN);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and eKSI. The UE shall enter the state EMM-DEREGISTERED.PLMN-SEARCH.

The UE shall store the PLMN identity in the "forbidden PLMN list" and if the UE is configured to use timer T3245 (see 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17]) then the UE shall start timer T3245 and proceed as described in subclause 5.3.7a. If the message has been successfully integrity checked by the NAS and the UE maintains a PLMN-specific attempt counter for that PLMN, then the UE shall set this counter to the UE implementation-specific maximum value.

The UE shall perform a PLMN selection according to 3GPP TS 23.122 [6].

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI and GPRS ciphering key sequence number and the MM parameters update status, TMSI, LAI, ciphering key sequence number and the location update attempt counter as specified in 3GPP TS 24.008 [13] for the case when the service request procedure is rejected with the GMM cause with the same value.

#12 (Tracking area not allowed);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3) and shall delete any GUTI, last visited registered TAI, TAI list and eKSI. The UE shall enter the state EMM-DEREGISTERED.LIMITED-SERVICE.

The UE shall store the current TAI in the list of "forbidden tracking areas for regional provision of service".

If the UE initiated service request for mobile originated CS fallback and a CS fallback cancellation request was not received, then the UE shall attempt to select GERAN or UTRAN radio access technology. If the UE finds a suitable GERAN or UTRAN cell, it then proceeds with the appropriate MM and CC specific procedures and the EMM sublayer shall not indicate the abort of the service request procedure to the MM sublayer. Otherwise the EMM sublayer shall indicate the abort of the service request procedure to the MM sublayer.

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI and GPRS ciphering key sequence number as specified in

3GPP TS 24.008 [13] for the case when the service request procedure is rejected with the GMM cause with the same value.

#13 (Roaming not allowed in this tracking area);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3). The UE shall enter the state EMM-REGISTERED.PLMN-SEARCH.

The UE shall store the current TAI in the list of "forbidden tracking areas for roaming" and remove the current TAI from the stored TAI list if present.

The UE shall perform a PLMN selection according to 3GPP TS 23.122 [6].

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM parameters GMM state and GPRS update status as specified in 3GPP TS 24.008 [13] for the case when the service request procedure is rejected with the GMM cause with the same value.

#15 (No suitable cells in tracking area);

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and shall store it according to subclause 5.1.3.3). The UE shall enter the state EMM-REGISTERED.LIMITED-SERVICE.

The UE shall store the current TAI in the list of "forbidden tracking areas for roaming" and remove the current TAI from the stored TAI list if present.

If the UE initiated service request for mobile originated CS fallback and a CS fallback cancellation request was not received, then the UE shall attempt to select GERAN or UTRAN radio access technology. If the UE finds a suitable GERAN or UTRAN cell, it then proceeds with the appropriate MM and CC specific procedures and the EMM sublayer shall not indicate the abort of the service request procedure to the MM sublayer. Otherwise the EMM sublayer shall indicate the abort of the service request procedure to the MM sublayer.

If the service request was not initiated for mobile originated CS fallback, the UE shall search for a suitable cell in another tracking area or in another location area according to 3GPP TS 36.304 [21].

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM parameters GMM state and GPRS update status as specified in 3GPP TS 24.008 [13] for the case when the service request procedure is rejected with the GMM cause with the same value.

#18 (CS domain not available);

If the request was related to CS fallback, the UE shall send an indication to the MM sublayer and shall not attempt CS fallback until combined tracking area updating procedure has been successfully completed. The UE shall enter the state EMM-REGISTERED.NORMAL-SERVICE.

The UE shall set the update status to U2 NOT UPDATED.

If the UE is in CS/PS mode 1 of operation with "IMS voice not available" and the request was related to CS fallback, the UE shall attempt to select GERAN or UTRAN radio access technology and disable the E-UTRA capability (see subclause 4.5).

If the UE is in CS/PS mode 1 or CS/PS mode 2 mode of operation, the UE may provide a notification to the user or the upper layers that the CS domain is not available.

If the request was related to 1xCS fallback, the UE shall cancel upper layer actions related to 1xCS fallback and enter the state EMM-REGISTERED.NORMAL-SERVICE.

#22 (Congestion);

If the T3346 value IE is present in the SERVICE REJECT message and the value indicates that this timer is neither zero nor deactivated, the UE shall proceed as described below, otherwise it shall be considered as an abnormal case and the behaviour of the UE for this case is specified in subclause 5.6.1.6.

If the rejected request was not for initiating a PDN connection for emergency bearer services, the UE shall abort the service request procedure and enter state EMM-REGISTERED, and stop timer T3417, T3417ext or T3417ext-mt if still running.

The UE shall stop timer T3346 if it is running.

If the SERVICE REJECT message is integrity protected, the UE shall start timer T3346 with the value provided in the T3346 value IE.

If the SERVICE REJECT message is not integrity protected, the UE shall start timer T3346 with a random value from the default range specified in 3GPP TS 24.008 [13].

If the service request was initiated for CS fallback and a CS fallback cancellation request was not received, the UE in CS/PS mode 1 of operation shall attempt to select GERAN or UTRAN radio access technology. If the UE finds a suitable GERAN or UTRAN cell, it then proceeds with the appropriate MM and CC specific procedures and the EMM sublayer shall not indicate the abort of the service request procedure to the MM sublayer. Otherwise the EMM sublayer shall indicate the abort of the service request procedure to the MM sublayer.

NOTE 7: If the UE disables the E-UTRA capability, then subsequent mobile terminating calls could fail.

If the service request was initiated for CS fallback for emergency call and a CS fallback cancellation request was not received, the UE may attempt to select GERAN or UTRAN radio access technology. It then proceeds with appropriate MM and CC specific procedures. The EMM sublayer shall not indicate the abort of the service request procedure to the MM sublayer.

If the service request was initiated for 1xCS fallback, the UE shall select cdma2000® 1x radio access technology. The UE then proceeds with appropriate cdma2000® 1x CS procedures.

If the service request was initiated for 1xCS fallback for emergency call, the UE may select cdma2000® 1x radio access technology. The UE then proceeds with appropriate cdma2000® 1x CS procedures.

If the service request was initiated in EMM-CONNECTED mode with Control plane service type "mobile originating request" and with the "active" flag set to 1, the UE shall abort the procedure.

If the service request was initiated for an "originating MMTEL voice" call type, a notification that the service request was not accepted due to congestion shall be provided to the upper layers.

NOTE 8: This can result in the upper layers requesting establishment of the originating voice call on an alternative radio access network, if available (see 3GPP TS 24.173 [13E]).

For all other cases the UE stays in the current serving cell and applies normal cell reselection process. The service request procedure is started, if still necessary, when timer T3346 expires or is stopped.

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM parameters GMM state and GPRS update status as specified in 3GPP TS 24.008 [13] for the case when the service request procedure is rejected with the GMM cause with the same value.

If the UE is using EPS services with control plane CIoT EPS optimization and if the T3448 value IE is present in the SERVICE REJECT message and the value indicates that this timer is neither zero nor deactivated, the UE shall:

- stop timer T3448 if it is running;
- consider the transport of user data via the control plane as unsuccessful; and
- start timer T3448:
  - with the value provided in the T3448 value IE if the SERVICE REJECT message is integrity protected; or
  - with a random value from the default range specified in table 10.2.1 if the SERVICE REJECT message is not integrity protected.

If the UE is using EPS services with control plane CIoT EPS optimization and if the T3448 value IE is present in the SERVICE REJECT message and the value indicates that this timer is either zero or deactivated, the UE shall consider this case as an abnormal case and follow the behaviour specified in subclause 5.6.1.6.

#25 (Not authorized for this CSG);

EMM cause #25 is only applicable when received from a CSG cell. EMM cause #25 received from a non-CSG cell is considered as an abnormal case and the behaviour of the UE is specified in subclause 5.6.1.6.

The UE shall set the EPS update status to EU3 ROAMING NOT ALLOWED (and store it according to subclause 5.1.3.3). The UE shall enter the state EMM-REGISTERED.LIMITED-SERVICE.

If the CSG ID and associated PLMN identity of the cell where the UE has initiated the service request procedure are contained in the Allowed CSG list, the UE shall remove the entry corresponding to this CSG ID and associated PLMN identity from the Allowed CSG list.

If the CSG ID and associated PLMN identity of the cell where the UE has initiated the service request procedure are contained in the Operator CSG list, the UE shall apply the procedures defined in 3GPP TS 23.122 [6] subclause 3.1A.

The UE shall search for a suitable cell according to 3GPP TS 36.304 [21].

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM parameters GMM state and GPRS update status as specified in 3GPP TS 24.008 [13] for the case when the service request procedure is rejected with the GMM cause with the same value.

#39 (CS service temporarily not available);

If the T3442 value received in the SERVICE REJECT message is not zero, the UE shall start timer T3442 and enter the state EMM-REGISTERED.NORMAL-SERVICE. If the T3442 value received in the SERVICE REJECT message is zero, the UE shall not start timer T3442.

The UE shall not try to send an EXTENDED SERVICE REQUEST message for mobile originating CS fallback to the network, except for mobile originating CS fallback for emergency calls, until timer T3442 expires or the UE sends a TRACKING AREA UPDATE REQUEST message.

#40 (No EPS bearer context activated);

The UE shall enter the state EMM-DEREGISTERED.NORMAL-SERVICE. The UE shall delete any mapped EPS security context or partial native EPS security context.

If the service request was initiated for CS fallback and a CS fallback cancellation request was not received, the UE shall attempt to select GERAN or UTRAN radio access technology. If the UE finds a suitable GERAN or UTRAN cell, it then proceeds with the appropriate MM and CC specific procedures and the EMM sublayer shall not indicate the abort of the service request procedure to the MM sublayer. Otherwise the EMM sublayer shall indicate the abort of the service request procedure to the MM sublayer.

If the service request was initiated for 1xCS fallback, the UE shall select cdma2000® 1x radio access technology. The UE then proceeds with appropriate cdma2000® 1x CS procedures.

If the service request was initiated for 1xCS fallback and the UE has dual Rx/Tx configuration and supports enhanced 1xCS fallback, the UE shall perform a new attach procedure.

If the service request was initiated for any reason other than CS fallback or 1x CS fallback, the UE shall perform a new attach procedure.

NOTE 9: User interaction is necessary in some cases when the UE cannot re-activate the EPS bearer(s) automatically.

If A/Gb mode or Iu mode is supported by the UE, the UE shall handle the GMM state as specified in 3GPP TS 24.008 [13] for the case when the service request procedure is rejected with the GMM cause value #10 "Implicitly detached".

A UE operating in CS/PS mode 1 or CS/PS mode 2 of operation which is already IMSI attached for non-EPS services is still IMSI attached for non-EPS services in the network.

A UE operating in CS/PS mode 1 or CS/PS mode 2 of operation shall set the update status to U2 NOT UPDATED.

#42 (Severe network failure);

The UE shall set the EPS update status to EU2 NOT UPDATED, and shall delete any GUTI, last visited registered TAI, eKSI, and list of equivalent PLMNs. The UE shall start an implementation specific timer, setting its value to 2 times the value of T as defined in 3GPP TS 23.122 [6]. While this timer is running, the UE shall not consider the PLMN + RAT combination that provided this reject cause as a candidate for PLMN selection.

The UE then enters state EMM-DEREGISTERED.PLMN-SEARCH in order to perform a PLMN selection according to 3GPP TS 23.122 [6].

If A/Gb mode or Iu mode is supported by the UE, the UE shall in addition set the GMM state to GMM-DEREGISTERED, GPRS update status to GU2 NOT UPDATED, and shall delete the P-TMSI, P-TMSI signature, RAI and GPRS ciphering key sequence number.

Other values are considered as abnormal cases. The specification of the UE behaviour in those cases is described in subclause 5.6.1.6.

5.6.1.5A Service request procedure for initiating a PDN connection for emergency bearer services not accepted by the network

If the service request for initiating a PDN connection for emergency bearer services cannot be accepted by the network, the UE shall perform the procedures as described in subclause 5.6.1.5. Then if the UE is in the same selected PLMN where the last service request was attempted, the UE shall:

a) inform the upper layers of the failure of the procedure; or

NOTE 1: This can result in the upper layers requesting establishment of a CS emergency call (if not already attempted in the CS domain) or other implementation specific mechanisms, e.g. procedures specified in 3GPP TS 24.229 [13D] can result in the emergency call being attempted to another IP-CAN.

b) detach locally, if not detached already, attempt EPS attach for emergency bearer services.

If the service request for initiating a PDN connection for emergency bearer services fails due to abnormal case a) in subclause 5.6.1.6, the UE shall perform the actions as described in subclause 5.6.1.6 and inform the upper layers of the failure to access the network.

NOTE 2: This can result in the upper layers requesting establishment of a CS emergency call (if not already attempted in the CS domain) or other implementation specific mechanisms, e.g. procedures specified in 3GPP TS 24.229 [13D] can result in the emergency call being attempted to another IP-CAN.

If the service request for initiating a PDN connection for emergency bearer services fails due to abnormal cases b), c) or e) in subclause 5.6.1.6, the UE shall perform the procedures as described in subclause 5.6.1.6. Then if the UE is in the same selected PLMN where the last service request was attempted, the UE shall:

a) inform the upper layers of the failure of the procedure; or

NOTE 3: This can result in the upper layers requesting establishment of a CS emergency call (if not already attempted in the CS domain) or other implementation specific mechanisms, e.g. procedures specified in 3GPP TS 24.229 [13D] can result in the emergency call being attempted to another IP-CAN.

b) detach locally, if not detached already, attempt EPS attach for emergency bearer services.

5.6.1.6 Abnormal cases in the UE

The following abnormal cases can be identified:

a) Access barred because of access class barring, EAB, ACDC or NAS signalling connection establishment rejected by the network without "Extended wait time" received from lower layers

In WB-S1 mode, if the service request procedure is started in response to a paging request from the network, access class barring, EAB or ACDC is not applicable.

In NB-S1 mode, if the service request procedure is started in response to a paging request from the network, access barring is not applicable.

If the trigger for the service request procedure is the response to a paging request from the network and the NAS signalling connection establishment is rejected by the network, the service request procedure shall not be started. The UE stays in the current serving cell and applies normal cell reselection process. During an implementation dependent time period, the service request procedure may be started when access for "terminating calls" is granted or upon a cell change.

If the service request was initiated for CS fallback and the access is barred for "mobile originating CS fallback" (see 3GPP TS 36.331 [22]) and the lower layer indicates "the barring is due to CSFB specific access barring information", the service request procedure shall not be started. The UE stays in the current serving cell and applies normal cell reselection process. The service request procedure may be started if it is still necessary, i.e. when access for "mobile originating CS fallback" is granted or because of a cell change.

If the service request was initiated for CS fallback and a CS fallback cancellation request was not received and the access is barred for "mobile originating CS fallback" (see 3GPP TS 36.331 [22]) and the lower layer does not indicate "the barring is due to CSFB specific access barring information", the UE shall attempt to select GERAN or UTRAN radio access technology. If the UE finds a suitable GERAN or UTRAN cell, it then proceeds with the appropriate MM and CC specific procedures and the EMM sublayer shall not indicate the abort of the service request procedure to the MM sublayer. Otherwise the EMM sublayer shall indicate the abort of the service request procedure to the MM sublayer.

If the service request was initiated for 1xCS fallback and the access is barred for "originating calls" (see 3GPP TS 36.331 [22]), the UE shall select cdma2000® 1x radio access technology. The UE then proceeds with appropriate cdma2000® 1x CS procedures.

If the lower layer indicated the access was barred because of access class barring for "originating calls" (see 3GPP TS 36.331 [22]) and if:

- the service request is initiated due to a request from upper layers for user plane radio resources, and the MO MMTEL voice call is started, the MO MMTEL video call is started or the MO SMSoIP is started;

- the service request is initiated due to a mobile originated SMS over NAS or SMS over S102; or

- the service request is initiated due to a request from upper layers for user plane radio resources, ACDC is applicable to the request and the UE supports ACDC.

then the service request procedure shall be started. The call type used shall be per annex D of this document.

NOTE 1: If more than one of MO MMTEL voice call is started, MO MMTEL video call is started or MO SMSoIP is started conditions are satisfied, it is left to UE implementation to determine the call type based on annex D of this document.

If access is barred for a certain ACDC category (see 3GPP TS 36.331 [22]), and if the upper layers request user plane radio resources for a higher ACDC category and the UE supports ACDC, then the service request procedure shall be started.

If an access request for an uncategorized application is barred due to ACDC (see 3GPP TS 36.331 [22]), and if the upper layers request user plane radio resources for a certain ACDC category and the UE supports ACDC, then the service request procedure shall be started.

Otherwise:

- In WB-S1 mode, if access is barred for "originating calls" (see 3GPP TS 36.331 [22]), the service request procedure shall not be started. The UE stays in the current serving cell and applies normal cell reselection process. The service request procedure may be started if it is still necessary when access for "originating calls" is granted or because of a cell change.

- In NB-S1 mode, if access is barred for "originating calls" (see 3GPP TS 36.331 [22]), the service request procedure shall not be started. The UE stays in the current serving cell and applies normal cell reselection process. Further UE behaviour is implementation specific, e.g. the service request procedure is started again after an implementation dependent time; or

  In NB-S1 mode, if access is barred for "originating calls" (see 3GPP TS 36.331 [22]), and a request for an exceptional event is received from the upper layers, then the service request procedure shall be started.

NOTE 2: In NB-S1 mode, the EMM layer cannot receive the access barring alleviation indication from the lower layers (see 3GPP TS 36.331 [22]).

b) Lower layer failure or release of the NAS signalling connection without "Extended wait time", without "Extended wait time CP data", and without redirection indication received from lower layers before the service request procedure is completed (see subclause 5.6.1.4) or before SERVICE REJECT message is received

If the service request was initiated for CS fallback and a CS fallback cancellation request was not received, the UE shall attempt to select GERAN or UTRAN radio access technology. If the UE finds a suitable GERAN or UTRAN cell, it then proceeds with the appropriate MM and CC specific procedures and the EMM sublayer shall not indicate the abort of the service request procedure to the MM sublayer. Otherwise the EMM sublayer shall indicate the abort of the service request procedure to the MM sublayer, and the UE shall also set the EPS update status to EU2 NOT UPDATED and enter the state EMM-REGISTERED.ATTEMPTING-TO-UPDATE.

If the service request was initiated for CS fallback and a CS fallback cancellation request was received, the UE shall set the EPS update status to EU2 NOT UPDATED and enter the state EMM-REGISTERED.ATTEMPTING-TO-UPDATE.

If the service request was initiated for 1xCS fallback, the UE shall either:

- attempt to select cdma2000® 1x radio access technology and proceed with appropriate cdma2000® 1x CS procedures. If the UE fails to select cdma2000® 1x radio access technology, the UE shall set the EPS update status to EU2 NOT UPDATED and enter the state EMM-REGISTERED.ATTEMPTING-TO-UPDATE; or

- set the EPS update status to EU2 NOT UPDATED and enter the state EMM-REGISTERED.ATTEMPTING-TO-UPDATE, and perform cell selection according to 3GPP TS 36.304 [21].

If the service request was not initiated for CS fallback or 1xCS fallback, the UE shall enter state EMM-REGISTERED.

The UE shall abort the service request procedure, stop timer T3417, T3417ext or T3417ext-mt and locally release any resources allocated for the service request procedure.

c) T3417 expired

The UE shall enter the state EMM-REGISTERED.

If the UE triggered the service request procedure in EMM-IDLE mode in order to obtain packet services, then the EMM sublayer shall increment the service request attempt counter, abort the procedure and release locally any resources allocated for the service request procedure. The service request counter shall not be incremented, if:

- the service request procedure is initiated to establish a PDN connection for emergency bearer services;

- the UE has a PDN connection for emergency bearer services established;

- the UE is a UE configured to use AC11 – 15 in selected PLMN;

- the service request is initiated in response to paging from the network; or

- the UE in NB-S1 mode is requested by the upper layer to transmit user data related to an exceptional event and the UE is allowed to use exception data reporting (see the ExceptionDataReportingAllowed leaf of the NAS configuration MO in 3GPP TS 24.368 [15A] or the USIM file $EF_{NASCONFIG}$ in 3GPP TS 31.102 [17]).

If the service request attempt counter is greater than or equal to 5, the UE shall start timer T3325 (see 3GPP TS 24.008 [13]). Additionally if the service request was initiated for an "originating MMTEL voice" call type, a notification that the service request was not accepted due to the UE having started timer T3325 shall be provided to the upper layers.

NOTE 3: This can result in the upper layers requesting establishment of a CS voice call (if not already attempted in the CS domain), or other implementation specific mechanisms (see 3GPP TS 24.173 [13E]).

The UE shall not attempt service request until expiry of timer T3325 unless:

- the service request is initiated in response to paging from the network;

- the UE is a UE configured to use AC11 – 15 in selected PLMN;

- the service request is initiated to establish a PDN connection for emergency bearer services;

- the UE has a PDN connection for emergency bearer services established;

- the UE is registered in a new PLMN; or

- the UE in NB-S1 mode is requested by the upper layer to transmit user data related to an exceptional event and the UE is allowed to use exception data reporting (see the ExceptionDataReportingAllowed leaf of the NAS configuration MO in 3GPP TS 24.368 [15A] or the USIM file $EF_{NASCONFIG}$ in 3GPP TS 31.102 [17]).

NOTE 4: The NAS signalling connection can also be released if the UE deems that the network has failed the authentication check as specified in subclause 5.4.2.7.

If the UE triggered the service request procedure in order to obtain services other than packet services from EMM-IDLE mode, then the EMM sublayer shall abort the procedure and release locally any resources allocated for the service request procedure.

If the UE triggered the service request procedure in EMM-CONNECTED mode, the EMM sublayer shall abort the procedure and consider the service request procedure with "active" flag or the 1xCS fallback procedure as failed. The UE shall stay in EMM-CONNECTED mode.

d) T3417ext or T3417ext-mt expired

If a CS fallback cancellation request was not received, the UE shall attempt to select GERAN or UTRAN radio access technology. If the UE finds a suitable GERAN or UTRAN cell, it then proceeds with the appropriate MM and CC specific procedures and the EMM sublayer shall not indicate the abort of the service request procedure to the MM sublayer. Otherwise the EMM sublayer shall indicate the abort of the service request procedure to the MM sublayer, and the UE shall also set the EPS update status to EU2 NOT UPDATED and enter the state EMM-REGISTERED.ATTEMPTING-TO-UPDATE.

If a CS fallback cancellation request was received the UE shall set the EPS update status to EU2 NOT UPDATED and enter the state EMM-REGISTERED.ATTEMPTING-TO-UPDATE.

e) SERVICE REJECT received, other EMM cause values than those treated in subclause 5.6.1.5, and cases of EMM cause values #22 and #25, if considered as abnormal cases according to subclause 5.6.1.5

If the service request was initiated for CS fallback and a CS fallback cancellation request was not received, the UE shall attempt to select GERAN or UTRAN radio access technology. If the UE finds a suitable GERAN or UTRAN cell, it then proceeds with the appropriate MM and CC specific procedures and the EMM sublayer shall not indicate the abort of the service request procedure to the MM sublayer. Otherwise the EMM sublayer shall indicate the abort of the service request procedure to the MM sublayer, and the UE shall also set the EPS update status to EU2 NOT UPDATED and enter the state EMM-REGISTERED.ATTEMPTING-TO-UPDATE.

If the service request was initiated for CS fallback and a CS fallback cancellation request was received, the UE shall set the EPS update status to EU2 NOT UPDATED and enter the state EMM-REGISTERED.ATTEMPTING-TO-UPDATE.

If the service request was initiated for 1xCS fallback, the UE shall select cdma2000® 1x radio access technology. The UE then proceeds with appropriate cdma2000® 1x CS procedures.

If the service request was initiated for 1xCS fallback and the UE has dual Rx/Tx configuration and supports enhanced 1xCS fallback, then upon entering EMM-IDLE mode the UE shall perform tracking area updating procedure.

If the service request was not initiated for CS fallback or 1xCS fallback, the UE shall enter state EMM-REGISTERED.

The UE shall abort the service request procedure, stop timer T3417, T3417ext or T3417ext-mt and locally release any resources allocated for the service request procedure.

f) Tracking area updating procedure is triggered

The UE shall abort the service request procedure, stop timer T3417, T3417ext or T3417ext-mt if running and perform the tracking area updating procedure. The "active" flag shall be set in the TRACKING AREA UPDATE REQUEST message. If the service request was initiated for CS fallback or 1xCS fallback, and the CS fallback cancellation request was not received, the UE shall send the EXTENDED SERVICE REQUEST message to the MME by using the existing NAS signalling connection after the completion of the tracking area updating procedure.

g) Switch off

If the UE is in state EMM-SERVICE-REQUEST-INITIATED at switch off, the detach procedure shall be performed.

h) Detach procedure collision

EPS detach containing detach type "re-attach required":

If the UE receives a DETACH REQUEST message from the network in state EMM-SERVICE-REQUEST-INITIATED, the UE shall take the following actions:

- If the service request was initiated for CS fallback, the UE shall attempt to select GERAN or UTRAN radio access technology. If the UE finds a suitable GERAN or UTRAN cell, it then proceeds with the appropriate MM, CC and GMM specific procedures and the EMM sublayer shall not indicate the abort of the service request procedure to the MM sublayer. Otherwise the EMM sublayer shall indicate the abort of the service request procedure to the MM sublayer;

- If the service request was initiated for 1xCS fallback, the UE shall attempt to select cdma2000® 1x radio access technology. The UE then proceeds with appropriate cdma2000® 1x CS procedures; or

- If the service request was not initiated for CS fallback or 1xCS fallback, the detach procedure shall be progressed and the service request procedure shall be aborted.

EPS detach containing detach type "re-attach not required":

If the UE receives a DETACH REQUEST message from the network in state EMM-SERVICE-REQUEST-INITIATED, the UE shall take the following actions:

- If the DETACH REQUEST message contains an EMM cause other than #2 "IMSI unknown in HSS" or no EMM cause IE, the detach procedure shall be progressed and the service request procedure shall be aborted. Additionally, if the service request was initiated for CS fallback or 1xCS fallback, but not for CS fallback for emergency call or 1xCS fallback for emergency call, the EMM sublayer shall indicate to the MM sublayer or the cdma2000® upper layers that the CS fallback or 1xCS fallback procedure has failed; or

If the DETACH REQUEST message contains EMM cause #2 "IMSI unknown in HSS", the UE will follow the procedure as described below for the detach type "IMSI detach".

EPS detach containing detach type "IMSI detach":

If the UE receives a DETACH REQUEST message from the network in state EMM-SERVICE-REQUEST-INITIATED, the UE shall take the following actions:

- if the service request was initiated for SMS over NAS or CS fallback, but not for CS fallback for emergency call, the UE shall abort the service request procedure and progress the detach procedure; or

- otherwise the UE shall progress both procedures.

i) Transmission failure of SERVICE REQUEST, CONTROL PLANE SERVICE REQUEST or EXTENDED SERVICE REQUEST message indication with TAI change from lower layers

If the current TAI is not in the TAI list, the service request procedure shall be aborted to perform the tracking area updating procedure. The "active" flag shall be set in the TRACKING AREA UPDATE REQUEST message. If the service request was initiated for CS fallback or 1xCS fallback, and the CS fallback cancellation request was not received, the UE shall send the EXTENDED SERVICE REQUEST message to the MME by using the existing NAS signalling connection after the completion of the tracking area updating procedure.

If the current TAI is still part of the TAI list, the UE shall restart the service request procedure.

j) Transmission failure of SERVICE REQUEST, CONTROL PLANE SERVICE REQUEST or EXTENDED SERVICE REQUEST message indication without TAI change from lower layers

The UE shall restart the service request procedure.

k) Default or dedicated bearer set up failure

If the lower layers indicate a failure to set up a radio bearer, the UE shall locally deactivate the EPS bearer as described in subclause 6.4.4.6.

l) "Extended wait time" from the lower layers

The UE shall abort the service request procedure, enter state EMM-REGISTERED, and stop timer T3417, T3417ext or T3417ext-mt if still running.

If the EXTENDED SERVICE REQUEST or CONTROL PLANE SERVICE REQUEST message contained the low priority indicator set to "MS is configured for NAS signalling low priority", the UE shall start timer T3346 with the "Extended wait time" value.

If the SERVICE REQUEST message was sent by a UE configured for NAS signalling low priority, the UE shall start timer T3346 with the "Extended wait time" value.

If the EXTENDED SERVICE REQUEST or CONTROL PLANE SERVICE REQUEST message did not contain the low priority indicator set to "MS is configured for NAS signalling low priority" or if the SERVICE REQUEST message was sent by a UE not configured for NAS signalling low priority, the UE is operating in NB-S1 mode and the UE is not a UE configured to use AC11 – 15 in selected PLMN, then the UE shall start timer T3346 with the "Extended wait time" value.

In other cases the UE shall ignore the "Extended wait time".

The UE stays in the current serving cell and applies normal cell reselection process. The service request procedure is started, if still necessary, when timer T3346 expires or is stopped.

If the service request was initiated for CS fallback and a CS fallback cancellation request was not received, the UE in CS/PS mode 1 of operation shall attempt to select GERAN or UTRAN radio access technology. If the UE finds a suitable GERAN or UTRAN cell, it then proceeds with the appropriate MM and CC specific procedures and the EMM sublayer shall not indicate the abort of the service request procedure to the MM sublayer. Otherwise the EMM sublayer shall indicate the abort of the service request procedure to the MM sublayer.

NOTE 5: If the UE disables the E-UTRA capability, then subsequent mobile terminating calls could fail.

If the service request was initiated for CS fallback for emergency call and a CS fallback cancellation request was not received, the UE may attempt to select GERAN or UTRAN radio access technology. It then proceeds with appropriate MM and CC specific procedures. The EMM sublayer shall not indicate the abort of the service request procedure to the MM sublayer.

If the service request was initiated for 1xCS fallback, the UE shall select cdma2000® 1x radio access technology. The UE then proceeds with appropriate cdma2000® 1x CS procedures.

If the service request was initiated for 1xCS fallback for emergency call, the UE may select cdma2000® 1x radio access technology. The UE then proceeds with appropriate cdma2000® 1x CS procedures.

If the service request was initiated due to a request from the SMS entity to send an SMS and timer T3246 is not running, the UE, if operating in CS/PS mode 1 of operation, may select GERAN or UTRAN radio access technology. It then proceeds with the appropriate MM procedure.

NOTE 6: If the UE disables the E-UTRA capability, then subsequent mobile terminating calls could fail.

la) "Extended wait time CP data" from the lower layers

The UE shall abort the service request procedure for transfer of user data via the control plane, enter state EMM-REGISTERED, and stop timer T3417 if still running.

If the UE is operating in NB-S1 mode and supports the timer T3448, the UE shall start the timer T3448 with the "Extended wait time CP data" value. If the UE is operating in NB-S1 mode and does not support the timer T3448, the UE shall start the timer T3346 with the "Extended wait time CP data" value.

In other cases the UE shall ignore the "Extended wait time CP data".

The UE stays in the current serving cell and applies normal cell reselection process. The service request procedure for transfer of user data via the control plane is started, if still necessary, when the timer T3448 expires or is stopped.

m) Timer T3346 is running

The UE shall not start the service request procedure unless:

- the UE receives a paging;
- the UE is a UE configured to use AC11 – 15 in selected PLMN;
- the UE has a PDN connection for emergency bearer services established or is establishing a PDN connection for emergency bearer services;
- the UE is requested by the upper layer for a CS fallback for emergency call or a 1xCS fallback for emergency call;
- the UE has a PDN connection established without the NAS signalling low priority indication or is establishing a PDN connection without the NAS signalling low priority indication and if the timer T3346 was started due to rejection of a NAS request message (e.g. ATTACH REQUEST, TRACKING AREA UPDATE REQUEST, EXTENDED SERVICE REQUEST or CONTROL PLANE SERVICE REQUEST) which contained the low priority indicator set to "MS is configured for NAS signalling low priority"; or
- the UE in NB-S1 mode is requested by the upper layer to transmit user data related to an exceptional event and:
  - the UE is allowed to use exception data reporting (see the ExceptionDataReportingAllowed leaf of the NAS configuration MO in 3GPP TS 24.368 [15A] or the USIM file $EF_{NASCONFIG}$ in 3GPP TS 31.102 [17]); and
  - timer T3346 was not started when NAS signaling connection was established with RRC establishment cause set to "MO exception data".

If the UE is in EMM-IDLE mode, the UE stays in the current serving cell and applies normal cell reselection process. The service request procedure is started, if still necessary, when timer T3346 expires or is stopped.

Upon upper layer's request for a mobile originated CS fallback which is not for emergency call, the UE in CS/PS mode 1 of operation shall attempt to select GERAN or UTRAN radio access technology. If the UE finds a suitable GERAN or UTRAN cell, it then proceeds with the appropriate MM and CC specific procedures and the EMM sublayer shall not indicate the abort of the service request procedure to the MM sublayer. Otherwise the EMM sublayer shall indicate the abort of the service request procedure to the MM sublayer.

NOTE 7: If the UE disables the E-UTRA capability, then subsequent mobile terminating calls could fail.

Upon upper layer's request for a CS fallback for emergency call, the UE may select GERAN or UTRAN radio access technology. It then proceeds with appropriate MM and CC specific procedures. The EMM sublayer shall not indicate the abort of the service request procedure to the MM sublayer.

Upon a request from the SMS entity to send an SMS and timer T3246 is not running, the UE, if operating in CS/PS mode 1 of operation, may select GERAN or UTRAN radio access technology. It then proceeds with the appropriate MM procedure.

NOTE 8: If the UE disables the E-UTRA capability, then subsequent mobile terminating calls could fail.

Upon upper layer's request for a mobile originated 1x CS fallback which is not for emergency call, the UE shall select cdma2000® 1x radio access technology. The UE then proceeds with appropriate cdma2000® 1x CS call procedures.

Upon upper layer's request for a 1xCS fallback for emergency call, the UE may select cdma2000® 1x radio access technology. The UE then proceeds with appropriate cdma2000® 1x CS call procedures.

n) Failure to find a suitable GERAN or UTRAN cell, after release of the NAS signalling connection without "Extended wait time" and with redirection indication received from lower layers when the service request was initiated for CS fallback

The EMM sublayer shall indicate the abort of the service request procedure to the MM sublayer, and the UE shall also set the EPS update status to EU2 NOT UPDATED and enter the state EMM-REGISTERED.ATTEMPTING-TO-UPDATE.

The UE shall abort the service request procedure, stop timer T3417ext or T3417ext-mt and locally release any resources allocated for the service request procedure.

o) Timer T3448 is running

The UE in EMM-IDLE mode shall not initiate the service request procedure for transport of user data via the control plane unless:

- the UE is a UE configured to use AC11 – 15 in selected PLMN;
- the UE which is only using EPS services with control plane CIoT EPS optimization received a paging; or
- the UE in NB-S1 mode is requested by the upper layer to transmit user data related to an exceptional event and the UE is allowed to use exception data reporting (see the ExceptionDataReportingAllowed leaf of the NAS configuration MO in 3GPP TS 24.368 [15A] or the USIM file $EF_{NASCONFIG}$ in 3GPP TS 31.102 [17]).

The UE stays in the current serving cell and applies the normal cell reselection process.

p) Timer T3447 is running

The UE shall not start any service request procedure unless:

- the UE receives a paging;
- the UE is a UE configured to use AC11 – 15 in selected PLMN;
- the UE has a PDN connection for emergency bearer services established or is establishing a PDN connection for emergency bearer services.

The UE stays in the current serving cell and applies the normal cell reselection process. The service request procedure is started, if still necessary, when timer T3447 expires.

5.6.1.7 Abnormal cases on the network side

The following abnormal cases can be identified:

a) Lower layer failure

If a lower layer failure occurs before a SERVICE REJECT message has been sent to the UE or the service request procedure has been completed by the network, the network enters/stays in EMM-IDLE.

b) Protocol error

If the SERVICE REQUEST, EXTENDED SERVICE REQUEST or the CONTROL PLANE SERVICE REQUEST message is received with a protocol error, the network shall return a SERVICE REJECT message with one of the following EMM cause values:

#96: invalid mandatory information;

#99: information element non-existent or not implemented;

#100: conditional IE error; or

#111: protocol error, unspecified.

The network stays in the current EMM mode.

c) More than one SERVICE REQUEST, EXTENDED SERVICE REQUEST or CONTROL PLANE SERVICE REQUEST received before the procedure has been completed (i.e., before SERVICE REJECT message has been sent or service request procedure has been completed)

- If one or more of the information elements in the SERVICE REQUEST message, CONTROL PLANE SERVICE REQUEST or EXTENDED SERVICE REQUEST for packet services differs from the ones received within the previous SERVICE REQUEST, CONTROL PLANE SERVICE REQUEST or EXTENDED SERVICE REQUEST message for packet services, the previously initiated service request procedure shall be aborted and the new service request procedure shall be progressed;

NOTE: The network actions are implementation dependent for the case that more than one EXTENDED SERVICE REQUEST messages for CS fallback or 1xCS fallback are received and their information elements differ.

- If the information elements do not differ, then the network shall continue with the previous service request procedure and shall not treat any further this SERVICE REQUEST, EXTENDED SERVICE REQUEST or CONTROL PLANE SERVICE REQUEST message.

d) ATTACH REQUEST received before a SERVICE REJECT message has been sent or the service request procedure has been completed

If an ATTACH REQUEST message is received and the service request procedure has not been completed or a SERVICE REJECT message has not been sent, the network may initiate the EMM common procedures, e.g. the EMM authentication procedure. The network may e.g. after a successful EMM authentication procedure execution, abort the service request procedure, delete the EMM context, EPS bearer contexts, if any, and progress the new ATTACH REQUEST.

e) TRACKING AREA UPDATE REQUEST message received before the service request procedure has been completed or a SERVICE REJECT message has been sent

If a TRACKING AREA UPDATE REQUEST message is received and the service request procedure has not been completed or a SERVICE REJECT message has not been sent, the network may initiate the EMM common procedures, e.g. the EMM authentication procedure. The network may e.g. after a successful EMM authentication procedure execution, abort the service request procedure and progress the tracking area updating procedure.

f) Default or dedicated bearer set up failure

If the lower layers indicate a failure to set up a radio or S1 bearer, the MME shall locally deactivate the EPS bearer as described in subclause 6.4.4.6.

5.6.2 Paging procedure

5.6.2.1 General

The paging procedure is used by the network to request the establishment or resumption of a NAS signalling connection to the UE. Another purpose of the paging procedure is to prompt the UE to reattach if necessary as a result of a network failure. If the UE is not attached when it receives a paging for EPS services, the UE shall ignore the paging.

Additionally, the network can use the paging procedure to initiate the mobile terminating CS fallback procedure or SMS or user data transfer via the MME.

5.6.2.2 Paging for EPS services

5.6.2.2.1 Paging for EPS services through E-UTRAN using S-TMSI

5.6.2.2.1.1 General

The network shall initiate the paging procedure for EPS services using S-TMSI with CN domain indicator set to "PS" when NAS signalling messages, cdma2000® signalling messages or user data is pending to be sent to the UE when no NAS signalling connection exists (see example in figure 5.6.2.2.1.1).

For the UE using eDRX, the network initiates the paging procedure when NAS signalling messages, cdma2000® signalling messages or user data is pending to be sent to the UE within the paging time window. If NAS signalling messages, cdma2000® signalling messages or user data is pending to be sent to the UE outside the paging time window and the eDRX value that the network provides to the UE in the Extended DRX parameters IE during the last attach procedure or the last tracking area updating procedure is not all zeros (i.e. the E-UTRAN eDRX cycle length duration is higher than 5.12 seconds), the network initiates the paging procedure at T time ahead of the beginning of the next paging time window.

NOTE 1: T time is a short time period based on implementation. The operator can take possible imperfections in the synchronization between the CN and the UE into account when choosing T time.

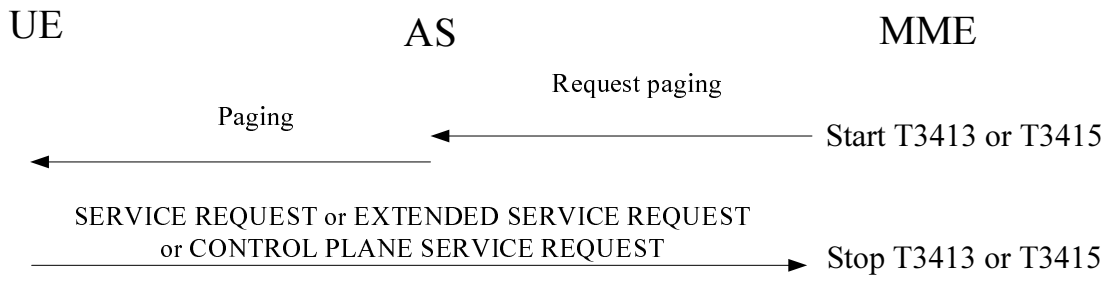


Figure 5.6.2.2.1.1: Paging procedure using S-TMSI

To initiate the procedure the EMM entity in the network requests the lower layer to start paging (see 3GPP TS 36.300 [20], 3GPP TS 36.413 [23]) and shall start the timer:

- T3415 for this paging procedure, if the network accepted to use eDRX for the UE and the UE does not have a PDN connection for emergency bearer services.
- Otherwise, T3413 for this paging procedure.

If the network starts timer T3415, the network shall set timer T3415 to a value smaller than the value of timer T3-RESPONSE (see 3GPP TS 29.274 [16D] for further details on timer T3-RESPONSE).

The EMM entity may provide the lower layer with a list of CSG IDs, including the CSG IDs of both the expired and the not expired subscriptions. If there is a PDN connection for emergency bearer services established, the EMM entity in the network shall not provide the list of CSG IDs to the lower layer.

Upon reception of a paging indication, if control plane CIoT EPS optimization is not used by the UE, the UE shall stop the timer T3346, if running, and shall initiate:

- a service request procedure to respond to the paging (see 3GPP TS 23.401 [10] and 3GPP TS 36.413 [23]); or
- a tracking area update procedure as specified in subclauses 5.5.3.2.2 and 5.5.3.3.2.

and additionally if the UE is in the EMM-IDLE mode with suspend indication, resume the suspended NAS signalling connection to the MME as specified in subclause 5.3.1.3.

Upon reception of a paging indication, if control plane CIoT EPS optimization is used by the UE, the UE shall stop the timer T3346, if running, and shall additionally:

- initiate a service request procedure as specified in subclause 5.6.1.2.2 if the UE is in the EMM-IDLE mode without suspend indication;
- initiate a tracking area update procedure as specified in subclauses 5.5.3.2.2; or
- proceed the behaviour as specified in subclause 5.3.1.3 if the UE is in the EMM-IDLE mode with suspend indication.

NOTE 2: If the UE is in the EMM-IDLE mode without suspend indication and has an uplink user data to be sent to the network using control plane CIoT EPS optimization when receiving the paging indication, the UE can piggyback the uplink user data during the service request procedure initiated to respond to the paging, as specified in subclause 5.6.1.2.2.

If the paging for EPS services was received during an ongoing UE-initiated EMM specific procedure or service request procedure, then the UE shall ignore the paging. The network shall proceed with the EMM specific procedure or the service request procedure, and stop the timer for the paging procedure (i.e. either timer T3413 or timer T3415). If the network receives an ATTACH REQUEST message when the paging procedure is ongoing, it should be considered as an abnormal case, and the behaviour of the UE for this case is specified in subclause 5.6.2.2.1.2.

The network shall stop the timer for the paging procedure (i.e. either timer T3413 or timer T3415) when an integrity-protected response is received from the UE and successfully integrity checked by the network or when the EMM entity in the MME receives an indication from the lower layer that it has received the S1-AP UE context resume request

message as specified in 3GPP TS 36.413 [23]. If the response received is not integrity protected, or the integrity check is unsuccessful, the timer for the paging procedure (i.e. either timer T3413 or timer T3415) shall be kept running unless:

- the UE has a PDN connection for emergency bearer services; or
- the response received is a TRACKING AREA UPDATE REQUEST message and the security mode control procedure or authentication procedure performed during tracking area update procedure has completed successfully.

Upon expiry of timer T3413, the network may reinitiate paging.

If the network, while waiting for a response to the paging sent without paging priority, receives downlink signalling or downlink data associated with priority EPS bearers, the network shall stop the timer for the paging procedure (i.e. either timer T3413 or timer T3415), and then initiate the paging procedure with paging priority.

Upon expiry of timer T3415, the network shall abort the paging procedure and shall proceed as specified in 3GPP TS 23.401 [10].

5.6.2.2.1.2 Abnormal cases on the network side

The following abnormal case can be identified:

a) ATTACH REQUEST message received when paging procedure is ongoing.

   If an integrity-protected ATTACH REQUEST message is received from the UE and successfully integrity checked by the network, the network shall abort the paging procedure. If the ATTACH REQUEST message received is not integrity protected, or the integrity check is unsuccessful, the paging procedure shall be progressed.The paging procedure shall be aborted when the EPS authentication procedure performed during attach procedure is completed successfully.

5.6.2.2.2 Paging for EPS services through E-UTRAN using IMSI

Paging for EPS services using IMSI is an abnormal procedure used for error recovery in the network.

The network may initiate paging for EPS services using IMSI with CN domain indicator set to "PS" if the S-TMSI is not available due to a network failure (see example in figure 5.6.2.2.2.1).

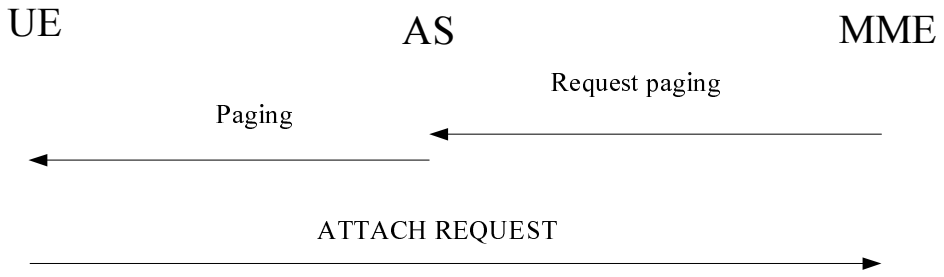


Figure 5.6.2.2.2.1: Paging procedure using IMSI

In S1 mode, to initiate the procedure the EMM entity in the network requests the lower layer to start paging. If the TAI list is not available due to a network failure, the network may perform the paging within all tracking areas served by the MME (see 3GPP TS 36.331 [22] and 3GPP TS 36.413 [23]).

When a UE receives a paging for EPS services using IMSI from the network before a UE initiated EMM specific procedure has been completed, then the UE shall abort the EMM specific procedure and proceed according to the description in this subclause.

Upon reception of a paging for EPS services using IMSI, the UE shall stop timer T3346, if it is running, locally deactivate any EPS bearer context(s), if any, and locally detach from EPS. Additionally the UE shall delete the following parameters: last visited registered TAI, TAI list, GUTI and KSI_{ASME}. The UE shall set the EPS update status to EU2 NOT UPDATED and change the state to EMM-DEREGISTERED. The UE shall stop all timers T3396 that are running.

If A/Gb mode or Iu mode is supported by the UE, the UE shall in addition handle the GMM parameters GMM state, GPRS update status, P-TMSI, P-TMSI signature, RAI, and GPRS ciphering key sequence number as specified in 3GPP TS 24.008 [13] for the case when a paging for GPRS services using IMSI is received.

After performing the local detach, the UE shall then perform an attach procedure as described in subclause 5.5.1.2. If the UE is operating in CS/PS mode 1 or CS/PS mode 2 of operation, then the UE shall perform a combined attach procedure as described in subclause 5.5.1.3.

NOTE 1: In some cases, user interaction can be required, thus the UE cannot activate the dedicated bearer context(s), if any, automatically.

NOTE 2: The UE does not respond to the paging except with the ATTACH REQUEST message, hence timers T3413 and T3415 in the network are not used when paging with IMSI.

5.6.2.3 Paging for CS fallback to A/Gb or Iu mode

5.6.2.3.1 General

The network may initiate the paging procedure for CS fallback when the UE is IMSI attached for non-EPS services (see example in figure 5.6.2.3.1.1).

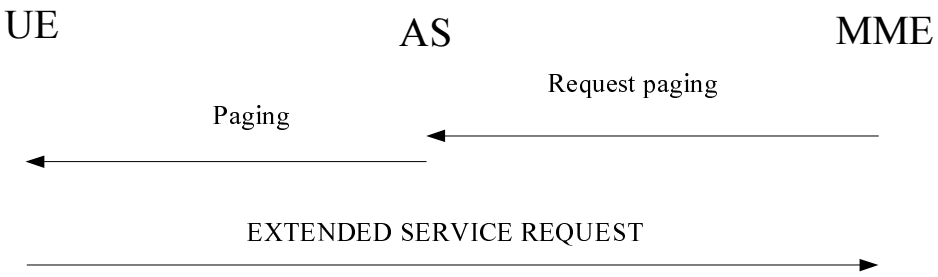


Figure 5.6.2.3.1.1: Paging procedure for CS fallback to A/Gb or Iu mode

To initiate the procedure when no NAS signalling connection exists, the EMM entity in the network requests the lower layer to start paging (see 3GPP TS 36.300 [20], 3GPP TS 36.413 [23]). The EMM entity may provide the lower layer with a list of CSG IDs, including the CSG IDs of both the expired and the not expired subscriptions. If there is a PDN connection for emergency bearer services established, the EMM entity in the network shall not provide the list of CSG IDs to the lower layer. The paging message includes a UE Paging Identity set to either the UE's S-TMSI or the UE's IMSI, and a CN domain indicator set to "CS" in order to indicate that this is paging for CS fallback.

NOTE: The timers T3413 and T3415 are not started in the network when the paging procedure is initiated for CS fallback.

To notify the UE about an incoming mobile terminating CS service excluding SMS over SGs when a NAS signalling connection exists, the EMM entity in the network shall send a CS SERVICE NOTIFICATION message. This message may also include CS service related parameters (e.g. Calling Line Identification, SS or LCS related parameters).

Upon reception of a paging indication, a UE that is IMSI attached for non-EPS services shall stop timer T3346, if it is running, and initiate a service request procedure or combined tracking area update procedure as specified in subclause 5.5.3.3.2. If the paging is received in EMM-IDLE mode, the UE shall respond immediately. If the paging is received as a CS SERVICE NOTIFICATION message in EMM-CONNECTED mode, the UE may request upper layers input i.e. to accept or reject CS fallback before responding with an EXTENDED SERVICE REQUEST. The response is indicated in the CSFB response information element in the EXTENDED SERVICE REQUEST message in both EMM-IDLE and EMM-CONNECTED modes.

5.6.2.3.2 Abnormal cases in the UE

A UE that requested "SMS only" in the combined attach procedure or combined tracking area updating procedure may ignore the CS SERVICE NOTIFICATION message or the paging indication with the CN domain indicator set to "CS".

5.6.2.3.3 Abnormal cases on the network side

The following abnormal case can be identified:

a) Void

b) ATTACH REQUEST message received when paging procedure is ongoing.

If an integrity-protected ATTACH REQUEST message is received from the UE and successfully integrity checked by the network, the network shall abort the paging procedure. If the ATTACH REQUEST message received is not integrity protected, or the integrity check is unsuccessful, the paging procedure shall be progressed.The paging procedure shall be aborted when the EPS authentication procedure performed during attach procedure is completed successfully.

5.6.2.4 Paging for SMS

The network shall initiate the paging procedure when it receives an incoming mobile terminating SMS to the UE if the UE is:

- IMSI attached for non-EPS services or for "SMS only"; or
- attached for EPS services with CIoT EPS optimization and the UE has requested "SMS only" and the UE is in NB-S1 mode,

and no NAS signalling connection exists.

For the UE using eDRX, the network initiates the paging procedure when an incoming mobile terminating SMS is received within the paging time window. If an incoming mobile terminating SMS is received outside the paging time window and the eDRX value that the network provides to the UE in the Extended DRX parameters IE during the last attach procedure or the last tracking area updating procedure is not all zeros (i.e. the E-UTRAN eDRX cycle length duration is higher than 5.12 seconds), the network initiates the paging procedure at T time ahead of the beginning of the next paging time window.

NOTE: T time is a short time period based on implementation. The operator can take possible imperfections in the synchronization between the CN and the UE into account when choosing T time.

To initiate the procedure for SMS when no NAS signalling connection exists, the EMM entity in the network requests the lower layer to start paging (see 3GPP TS 36.413 [23]). The paging message shall include a CN domain indicator set to "PS". If the paging message includes a UE Paging Identity set to the UE's S-TMSI, the paging procedure is performed according to subclause 5.6.2.2.1. If the paging message includes a UE Paging Identity set to the UE's IMSI, the paging procedure is performed according to subclause 5.6.2.2.2. The MME shall not start timers T3413 and T3415 for this procedure.

5.6.3 Transport of NAS messages procedure

5.6.3.1 General

The purpose of the transport of NAS messages procedure is to carry SMS messages in an encapsulated form between the MME and the UE. The procedure may be initiated by the UE or the network and can only be used when the UE is attached for EPS services and non-EPS services or for EPS services and "SMS only", and the UE is in EMM-CONNECTED mode.

NOTE 1: If the UE is in EMM-IDLE mode and is using EPS services with control plane CIoT EPS optimization, the UE transports the first SMS message by encapsulating it in the NAS message container IE in the Control Plane Service Request message.

NOTE 2: When the UE is using EPS services with control plane CIoT EPS optimization, the network can initiate downlink transport of NAS messages procedure even if the UE does not have any PDN connections established.

5.6.3.2 UE initiated transport of NAS messages

Upon request from the SMS entity to send an SMS message, the EMM entity in the UE initiates the procedure by sending an UPLINK NAS TRANSPORT message including the SMS message in the NAS message container IE.

NOTE: When the UE is using for EPS services with control plane CIoT EPS optimization, the UE can initiate uplink transport of NAS messages procedure even if the UE does not any PDN connections established.

5.6.3.3 Network initiated transport of NAS messages

The network initiates the procedure by sending a DOWNLINK NAS TRANSPORT message. When receiving the DOWNLINK NAS TRANSPORT message, the EMM entity in the UE shall forward the contents of the NAS message container IE to the SMS entity.

NOTE: When the UE is using for EPS services with control plane CIoT EPS optimization, the network can initiate downlink transport of NAS messages procedure even if the UE does not any PDN connections established.

5.6.3.4 Abnormal cases in the UE

The following abnormal case can be identified:

a) Timer T3346 is running

The UE shall not send an UPLINK NAS TRANSPORT message unless:

- the UE is a UE configured to use AC11 – 15 in selected PLMN;
- the UE has a PDN connection for emergency bearer services established; or
- the UE is configured for dual priority and has a PDN connection established without low access priority but the timer T3346 was started in response to NAS signalling request with low access priority.

- The UPLINK NAS TRANSPORT message can be sent, if still necessary, when timer T3346 expires or is stopped.

b) Timer T3447 is running

The UE shall not send an UPLINK NAS TRANSPORT message when the UE is in EMM-CONNECTED mode after the UE attached without PDN connection, unless the UE is a UE configured to use AC11 – 15 in the selected PLMN.

The UPLINK NAS TRANSPORT message can be sent, if still necessary, when timer T3447 expires.

5.6.3.5 Abnormal cases on the network side

The following abnormal case can be identified:

a) Lower layer indication of non-delivered NAS PDU

If the DOWNLINK NAS TRANSPORT message is not delivered for any reason, the MME may discard the message.

5.6.4 Generic transport of NAS messages procedure

5.6.4.1 General

The purpose of the generic transport of NAS messages procedure is to carry protocol messages from various applications (e.g., an LCS application to send an LPP message or a location service message) in an encapsulated form between the MME and the UE. The procedure may be initiated by the UE or the network and can only be used when the UE is attached for EPS services and is in EMM-CONNECTED mode.

5.6.4.2 UE initiated generic transport of NAS messages

Upon request from an application to send a message encapsulated in the generic transport of NAS message, the EMM entity in the UE initiates the procedure by sending an UPLINK GENERIC NAS TRANSPORT message including the corresponding message in the generic message container IE. The application may also request additional information to be included in the UPLINK GENERIC NAS TRANSPORT message in the Additional information IE. The content, coding and interpretation of this information element are dependent on the particular application.

The UE shall indicate the application protocol using the generic transport in the corresponding generic message container type. When receiving the UPLINK GENERIC NAS TRANSPORT message, the EMM entity in the MME shall provide the contents of the generic message container IE and the generic message container type IE to the corresponding application. If included, the EMM entity in the MME shall also provide the contents of the Additional information IE.

5.6.4.3 Network initiated transport of NAS messages

Upon request from an application to send a message encapsulated in the generic transport of NAS message, the EMM entity in the MME initiates the procedure by sending a DOWNLINK GENERIC NAS TRANSPORT message including the corresponding message in the generic message container IE. The application may also request additional information to be included in the DOWNLINK GENERIC NAS TRANSPORT message in the Additional information IE. The content, coding and interpretation of this information element are dependent on the particular application.

The MME shall indicate the application protocol using the generic transport in the corresponding generic message container type. When receiving the DOWNLINK GENERIC NAS TRANSPORT message, the EMM entity in the UE shall provide the contents of the generic message container IE and the generic message container type IE to the corresponding application. If included, the EMM entity in the UE shall also provide the contents of the Additional information IE.

5.6.4.4 Abnormal cases in the UE

The following abnormal case can be identified:

a) Timer T3346 is running

The UE shall not send an UPLINK GENERIC NAS TRANSPORT message unless:

the UE is a UE configured to use AC11 – 15 in selected PLMN;

- the UE has a PDN connection for emergency bearer services established; or

the UE is configured for dual priority and has a PDN connection established without low access priority but the timer T3346 was started in response to NAS signalling request with low access priority.

- The UPLINK GENERIC NAS TRANSPORT message can be sent, if still necessary, when timer T3346 expires or is stopped.

5.6.4.5 Abnormal cases on the network side

The following abnormal case can be identified:

a) Lower layer indication of non-delivered NAS PDU

If the DOWNLINK GENERIC NAS TRANSPORT message is not delivered for any reason, the MME may discard the message.

5.7 Reception of an EMM STATUS message by an EMM entity

The purpose of the sending of the EMM STATUS message is to report at any time certain error conditions detected upon receipt of EMM protocol data. The EMM STATUS message can be sent by both the MME and the UE (see example in figure 5.7.1).

On receipt of an EMM STATUS message no state transition and no specific action shall be taken as seen from the radio interface, i.e. local actions are possible. The local actions to be taken by the MME or the UE on receipt of an EMM STATUS message are implementation dependent.

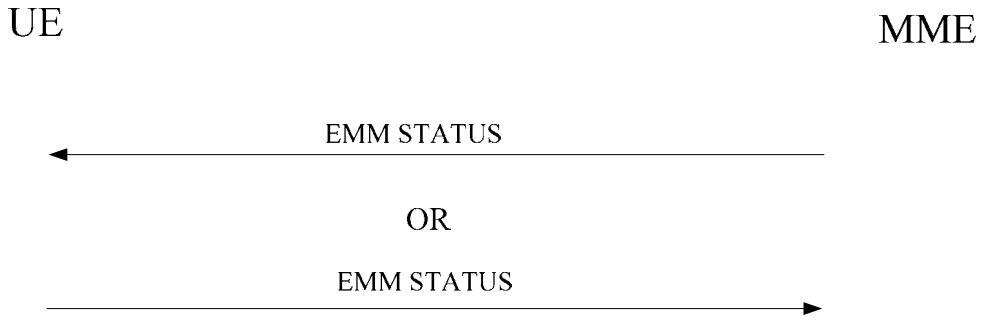


Figure 5.7.1: EMM status procedure

6 Elementary procedures for EPS session management

6.1 Overview

6.1.1 General

This clause describes the procedures used for EPS session management (ESM) at the radio interface (reference point "LTE-Uu").

The main function of the ESM sublayer is to support the EPS bearer context handling in the UE and in the MME.

The ESM comprises procedures for:

- the activation, deactivation and modification of EPS bearer contexts;
- the request for resources (IP connectivity to a PDN or dedicated bearer resources) by the UE; and
- the transport of user data via the control plane between the UE and the MME.

Each EPS bearer context represents an EPS bearer between the UE and a PDN. EPS bearer contexts can remain activated even if the radio and S1 bearers constituting the corresponding EPS bearers between UE and MME are temporarily released.

An EPS bearer context can be either a default bearer context or a dedicated bearer context.

A default EPS bearer context is activated when the UE requests a connection to a PDN.

Generally, ESM procedures can be performed only if an EMM context has been established between the UE and the MME, and the secure exchange of NAS messages has been initiated by the MME by use of the EMM procedures described in clause 5. The first default EPS bearer context, however, can be activated during the EPS attach procedure (see subclause 4.2). Once the UE is successfully attached, and the first default EPS bearer context has been activated during or after the attach procedure, the UE can request the MME to set up connections to additional PDNs. For each additional connection, the MME will activate a separate default EPS bearer context. A default EPS bearer context remains activated throughout the lifetime of the connection to the PDN.

A dedicated EPS bearer context is always linked to a default EPS bearer context and represents additional EPS bearer resources between the UE and the PDN. The network can initiate the activation of dedicated EPS bearer contexts together with the activation of the default EPS bearer context or at any time later, as long as the default EPS bearer context remains activated. However, the network shall not initiate a dedicated bearer context activation procedure for established PDN connection(s) of "non IP" PDN type.

Default and dedicated EPS bearer contexts can be modified. Dedicated EPS bearer contexts can be released without affecting the default EPS bearer context. When the default EPS bearer context is released, then all dedicated EPS bearer contexts linked to it are released too.

The UE can request the network to allocate, modify or release EPS bearer resources. The network can fulfil such a request from the UE by activating a new dedicated EPS bearer context, modifying an EPS bearer context or deactivating an EPS bearer context.

6.1.2 Types of ESM procedures

Two types of ESM procedures can be distinguished:

1) Procedures related to EPS bearer contexts:

   These procedures are initiated by the network and are used for the manipulation of EPS bearer contexts:

   - default EPS bearer context activation;
   - dedicated EPS bearer context activation;
   - EPS bearer context modification;
   - EPS bearer context deactivation.

   This procedure is initiated by the network or by the UE and is used for the transport of user data via the control plane:

   - transport of user data via the control plane procedure.

2) Transaction related procedures:

   These procedures are initiated by the UE to request for resources, i.e. a new PDN connection or dedicated bearer resources, or to release these resources:

   - PDN connectivity procedure;
   - PDN disconnect procedure;
   - bearer resource allocation procedure;
   - bearer resource modification procedure.

   This procedure is initiated by the ProSe UE-to-network relay and is used for the manipulation of EPS bearer contexts:

   - remote UE report.

   When combined with the attach procedure, the PDN connectivity procedure can trigger the network to execute the following transaction related procedure:

   - ESM information request procedure.

   When combined with the attach procedure, if EMM-REGISTERED without PDN connection is supported by the UE and the network and no PDN connectivity procedure is initiated during the attach procedure, the UE or the network executes the following transaction related procedure:

   - ESM dummy message procedure.

A successful transaction related procedure initiated by the UE triggers the network to execute one of the procedures related to EPS bearer contexts. The UE treats the start of the procedure related to the EPS bearer context as completion of the transaction related procedure.

During procedures related to EPS bearer contexts, the MME and the UE shall not initiate the transport of user data via the control plane procedure until the ongoing procedure is completed.

NOTE 1: The UE determination of the completion of the transport of user data via the control plane procedure is left to the implementation.

NOTE 2: NAS signalling prioritization with respect to the transport of user data via the control plane cannot be guaranteed in the downlink direction in this version of the specification.

Except for the remote UE report procedure and ESM information request procedure, during transaction related procedures, the MME and the UE shall not initiate the transport of user data via the control plane procedure until the ongoing procedure is completed.

The following ESM procedures can be related to an EPS bearer context or to a procedure transaction:

- ESM status procedure;
- notification procedure.

6.1.3 ESM sublayer states

6.1.3.1 General

In this subclause the possible states of EPS bearer contexts in the UE and on the network side are described. Each EPS bearer context is associated with an individual state.

6.1.3.2 ESM sublayer states in the UE

6.1.3.2.1 BEARER CONTEXT INACTIVE

No EPS bearer context exists.

6.1.3.2.2 BEARER CONTEXT ACTIVE

The EPS bearer context is active in the UE.

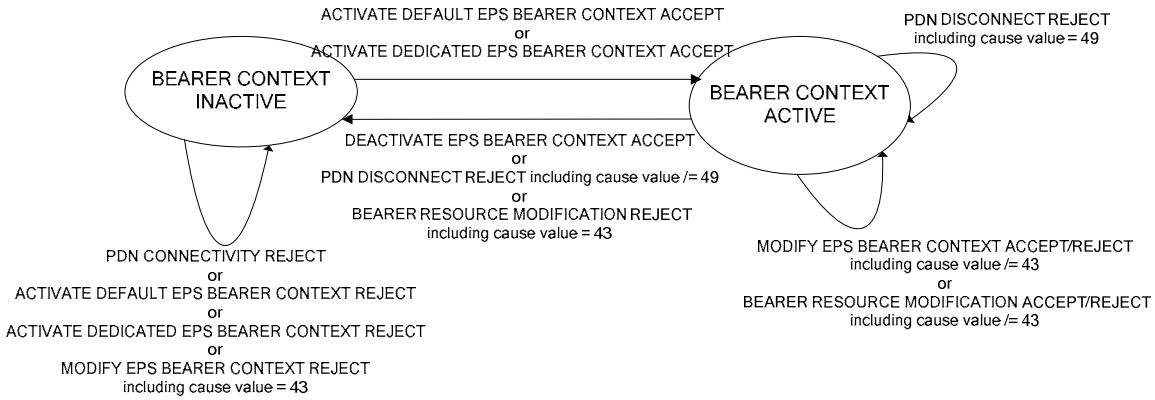


Figure 6.1.3.2.2.1: The ESM sublayer states for EPS bearer context handling in the UE (overview)

6.1.3.2.3 PROCEDURE TRANSACTION INACTIVE

No procedure transaction exists.

6.1.3.2.4 PROCEDURE TRANSACTION PENDING

The UE has initiated a procedure transaction towards the network.

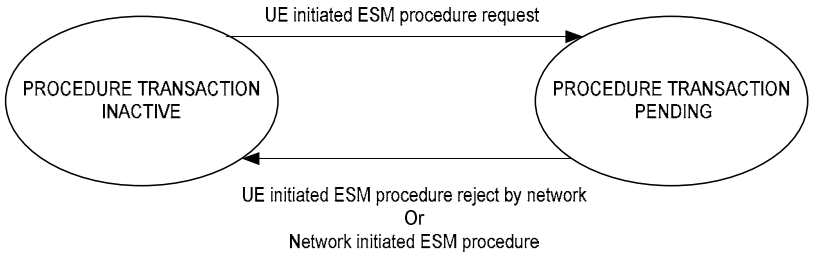


Figure 6.1.3.2.4.1: The procedure transaction states in the UE (overview)

6.1.3.3 ESM sublayer states in the MME

6.1.3.3.1 BEARER CONTEXT INACTIVE

No EPS bearer context exists.

6.1.3.3.2 BEARER CONTEXT ACTIVE PENDING

The network has initiated an EPS bearer context activation towards the UE.

6.1.3.3.3 BEARER CONTEXT ACTIVE

The EPS bearer context is active in the network.

6.1.3.3.4 BEARER CONTEXT INACTIVE PENDING

The network has initiated an EPS bearer context deactivation towards the UE.

6.1.3.3.5 BEARER CONTEXT MODIFY PENDING

The network has initiated an EPS bearer context modification towards the UE.

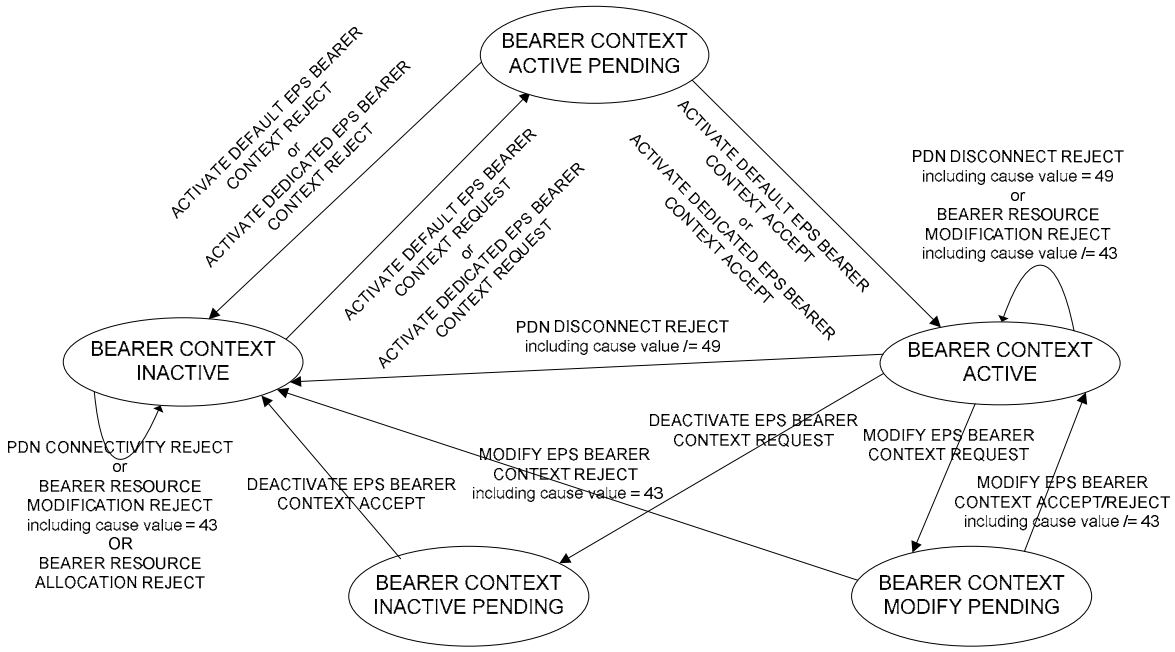


Figure 6.1.3.3.5.1: The ESM sublayer states for EPS bearer context handling in the network (overview)

6.1.3.3.6 PROCEDURE TRANSACTION INACTIVE

No procedure transaction exists.

6.1.3.3.7 PROCEDURE TRANSACTION PENDING

The network has initiated a procedure transaction towards the UE.

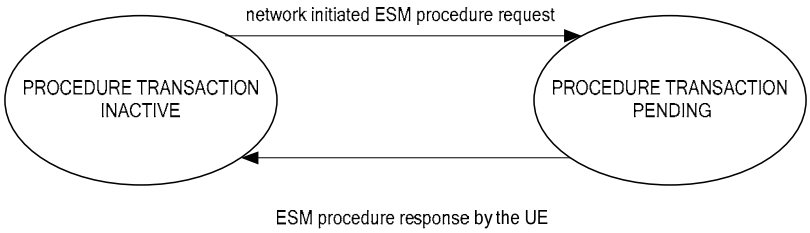


Figure 6.1.3.3.7.1: The procedure transaction states in the network (overview)

6.1.4 Coordination between ESM and SM

For inter-system change from S1 mode to A/Gb mode or Iu mode, SM uses the following parameters from each active EPS bearer context:

- EPS bearer identity to map to NSAPI;

NOTE 1: If the UE and the MME support signalling for a maximum number of 15 EPS bearer contexts, any active EPS bearer contexts using EPS bearer identity 1 to 4 are not mapped but deactivated locally before inter-system change to A/Gb mode or Iu mode.

- linked EPS bearer identity (if available) to map to linked TI;
- PDN address and APN of the default EPS bearer context to map to PDP address and APN of the default PDP context;
- TFT of the default EPS bearer context, if any, to map to the TFT of the default PDP context;
- TFTs of the dedicated EPS bearer contexts to map to TFTs of the secondary PDP contexts; and
- GERAN/UTRAN parameters as provided by the MME while on E-UTRAN access, i.e. R99 QoS, LLC SAPI, radio priority, packet flow identifier, transaction identifier and BCM (if available). If the MME also provided an Extended EPS QoS IE, then the bit rates signalled with this IE are also applicable to the R99 QoS.

NOTE 2: Some networks not supporting mobility from S1 mode to A/Gb mode or Iu mode or both do not provide the UE with the GERAN/UTRAN parameters. However, for this case there is no need for the UE to perform mapping to GERAN/UTRAN parameters (i.e. the PDP contexts cannot be transferred to A/Gb mode or Iu mode).

The MME performs the mapping from EPS to R99 QoS parameters according to 3GPP TS 23.401 [10], annex E.

At inter-system change from S1 mode to A/Gb mode, SM shall not activate the PDP context(s) if SM does not have the following parameters from the active EPS bearer context(s):

- LLC SAPI;
- radio priority;
- transaction identifier; and
- R99 QoS.

At inter-system change from S1 mode to Iu mode, SM shall not activate the PDP context(s) if SM does not have the following parameter from the active EPS bearer context(s):

- transaction identifier; and
- R99 QoS.

For inter-system change from A/Gb mode or Iu mode to S1 mode, ESM uses the following parameters from each active PDP context:

- NSAPI to map to EPS bearer identity;

- NSAPI of the default PDP context to map to linked EPS bearer identity;
- PDP address and APN of the default PDP context to map to PDN address and APN of the default EPS bearer context;
- TFT of the default PDP context, if any, to map to the TFT of the default EPS bearer context; and
- TFTs of the secondary PDP contexts to map to the TFTs of the dedicated EPS bearer contexts.

The MME and the UE perform the mapping from R99 to EPS QoS parameters according to 3GPP TS 23.401 [10], annex E. In particular the MME derives the APN-AMBR for the corresponding PDN connection from the MBR of the R99 subscribed QoS profile and the UE maps the MBR of its default PDP context to the APN-AMBR of the corresponding PDN connection.

6.1.4A Coordination between ESM and 5GSM

See subclause 6.1.4 in 3GPP TS 24.501 [54].

6.1.5 Coordination between ESM and EMM for supporting ISR

The UE with its TIN set as "RAT-related TMSI" for which ISR is activated shall change its TIN to "GUTI" to locally deactivate ISR and stop the periodic routing area update timer T3312 or T3323, if running:

- upon modification of any EPS bearer context which was activated before the ISR is activated in the UE;
- at the time when the UE changes from S1 mode to A/Gb mode or Iu mode not due to PS handover procedure (see 3GPP TS 24.008 [13]), if any EPS bearer context activated after the ISR was activated in the UE exists; or
- upon deactivation of the last non-emergency EPS bearer context in the UE, if the UE has only a PDN connection for emergency bearer services remaining.

ISR remains activated on the network side in the above cases.

6.2 IP address allocation

6.2.1 General

The UE can configure an IPv4 address during the establishment of a default EPS bearer context. The UE can obtain an IPv4 address or an IPv6 prefix or both via an IETF-based IP address allocation mechanism once the default bearer is established.

The following IETF-based IP address/prefix allocation methods are specified for EPS (the corresponding procedures are specified in 3GPP TS 29.061 [16]):

a) /64 IPv6 default prefix allocation via IPv6 stateless address autoconfiguration. Optionally, allocation of additional IPv6 prefix(es) with length /64 or shorter via stateful DHCPv6 Prefix Delegation (see IETF RFC 3633 [24A]);

b) IPv4 address allocation and IPv4 parameter configuration via DHCPv4;

c) IPv6 parameter configuration via stateless DHCPv6.

NOTE: From the perspective of the UE, the procedure used to allocate a static IP address via NAS signalling is the same as the procedure used to allocate a dynamic IP address specified in subclause 6.2.2.

Upon deactivation of the default bearer of a PDN connection, the UE shall locally release any IPv4 address or IPv6 prefix allocated to the UE for the corresponding PDN connection.

6.2.2 IP address allocation via NAS signalling

The UE shall set the PDN type IE in the PDN CONNECTIVITY REQUEST message, based on its IP stack configuration if it requests IP connectivity (e.g. the per APN settings specified in 3GPP TS 23.401 [10]) as follows:

a)- A UE, which is IPv6 and IPv4 capable and

- has not been allocated an IP address for this APN, shall set the PDN type IE to IPv4v6.
- has been allocated an IPv4 address for this APN and received the ESM cause #52 "single address bearers only allowed", and is requesting an IPv6 address, shall set the PDN type IE to IPv6.
- has been allocated an IPv6 address for this APN and received the ESM cause #52 "single address bearers only allowed", and is requesting an IPv4 address, shall set the PDN type IE to IPv4.

b) A UE, which is only IPv4 capable, shall set the PDN type IE to IPv4.

c) A UE, which is only IPv6 capable, shall set the PDN type IE to IPv6.

d) When the IP version capability of the UE is unknown in the UE (as in the case when the MT and TE are separated and the capability of the TE is not known in the MT), the UE shall set the PDN type IE to IPv4v6.

If the UE wants to use DHCPv4 for IPv4 address assignment, it shall indicate that to the network within the Protocol Configuration Options IE in the PDN CONNECTIVITY REQUEST.

If the UE wants to get PDN connectivity without IP, the UE shall set the PDN type IE in the PDN CONNECTIVITY REQUEST message to "non IP".

On receipt of the PDN CONNECTIVITY REQUEST message sent by the UE, the network when allocating an IP address shall take into account the PDN type IE, the operator policies of the home and visited network, and the user's subscription data and:

- if the UE requests for PDN type IPv4v6, but the subscription is limited to IPv4 only or IPv6 only for the requested APN, the network shall override the PDN type requested by the UE to be limited to a single address PDN type (IPv4 or IPv6). In the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message sent to the UE, the network shall set the PDN type value to either "IPv4" or "IPv6" and the ESM cause value to #50 "PDN type IPv4 only allowed", or #51 "PDN type IPv6 only allowed", respectively. The UE shall not subsequently initiate another UE requested PDN connectivity procedure to the same APN to obtain a PDN type different from the one allowed by the network until:

  a) all EPS bearer contexts to the given APN are deactivated at the UE as a result of:

     i) EPS bearer context synchronization during tracking area updating or service request procedure;

     ii) an EPS bearer context deactivation procedure initiated by the network;

     iii) a local EPS bearer context deactivation without NAS signalling as specified in subclause 6.4.4.6;

     iv) a detach procedure; or

     v) a tracking area updating procedure or service request procedure that is rejected with a cause which results in the UE entering state EMM-DEREGISTERED;

  b) the PDN type which is used to access to the APN is changed;

  NOTE 1: Request to send another PDN CONNECTIVITY REQUEST message with a specific PDN type has to come from upper layers.

- if the UE requests PDN type IPv4v6, but the PDN GW configuration dictates the use of IPv4 addressing only or IPv6 addressing only for this APN, the network shall override the PDN type requested by the UE to limit it to a single address PDN type (IPv4 or IPv6). In the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message sent to the UE, the network shall set the PDN type value to either "IPv4" or "IPv6" and the ESM cause value to #50 "PDN type IPv4 only allowed", or #51 "PDN type IPv6 only allowed", respectively. The UE shall not subsequently initiate another UE requested PDN connectivity procedure to the same APN to obtain a PDN type different from the one allowed by the network until:

  a) all EPS bearer contexs to the given APN are deactivated at the UE and the network as a result of:

     i) EPS bearer context synchronization during tracking area updating or service request procedure;

     ii) an EPS bearer context deactivation procedure initiated by the network;

     iii) a local EPS bearer context deactivation without NAS signalling as specified in subclause 6.4.4.6;

iv) a detach procedure; or

v) a tracking area updating procedure or service request procedure that is rejected with a cause which results in the UE entering state EMM-DEREGISTERED ;

b) the PDN type which is used to access to the APN is changed;

NOTE 2: Request to send another PDN CONNECTIVITY REQUEST message with a specific PDN type has to come from upper layers.

- if the UE requests PDN type IPv4v6, but the operator uses single addressing per bearer, e.g. due to interworking with nodes of earlier releases, the network shall override the PDN type requested by the UE to a single IP version only. In the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message sent to the UE, the network shall set the PDN type value to either "IPv4" or "IPv6" and the ESM cause value to #52 "single address bearers only allowed". The UE should subsequently request another PDN connection for the other IP version using the UE requested PDN connectivity procedure to the same APN with a single address PDN type (IPv4 or IPv6) other than the one already activated;

NOTE 3: If the MT and TE are separated, the UE might not be able to use ESM cause #52 "single address bearers only allowed" as a trigger for activating a second single-IP-stack EPS bearer context.

- if the network sets the PDN type to IPv4 or IPv4v6, the network shall include an IPv4 address in the PDN address information. In this case, if the IPv4 address is to be configured using DHCPv4, the network shall set the IPv4 address to 0.0.0.0; and

- if the network sets the PDN type to IPv6 or IPv4v6, the network shall include the interface identifier that the UE shall use for the link local address in the PDN address information.

The network shall include the PDN type and the PDN address information within the PDN address IE in the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message sent to the UE.

6.2A IP header compression

The UE and the MME may support robust header compression (ROHC) framework (see IETF RFC 5795 [37]) for IP header compression if control plane CIoT EPS optimization is supported for PDN connections of IP PDN type. If IP header compression for control plane CIoT EPS optimization is supported, the ROHC profiles defined in 3GPP TS 36.323 [38] may be supported. The ROHC configuration is negotiated and established during the UE requested PDN connectivity procedure as specified in subclause 6.5.1. Both the UE and the MME indicate whether IP header compression for control plane CIoT EPS optimization is supported during attach and tracking area updating procedures (see subclauses 5.5.1 and 5.5.3). The ROHC configuration can be re-negotiated by using the UE requested bearer resource modification procedure or the EPS bearer context modification procedure as specified in subclauses 6.4.3 and 6.5.4.

6.3 General on elementary ESM procedures

6.3.1 Services provided by lower layers

Unless explicitly stated otherwise, the procedures described in the following subclauses can only be executed whilst a NAS signalling exists between the UE and the MME.

6.3.2 Principles of address handling for ESM procedures

Transaction related procedures use the procedure transaction identity as address parameter in the ESM message header. When the UE or the network initiates a transaction related procedure, it shall include a valid procedure transaction identity value in the message header and set the EPS bearer identity to "no EPS bearer identity assigned". When the ProSe UE-to-network relay initiates the transaction related procedure remote UE report, it shall include a valid procedure transaction identity value in the message header and set the EPS bearer identity to a valid EPS bearer identity value.

If the response message is again a transaction related message, e.g. a PDN CONNECTIVITY REJECT, PDN DISCONNECT REJECT, BEARER RESOURCE ALLOCATION REJECT, BEARER RESOURCE MODIFICATION REJECT, ESM INFORMATION REQUEST message or ESM DUMMY MESSAGE from the network or an ESM INFORMATION RESPONSE message or ESM DUMMY MESSAGE from the UE, the sending entity shall include the

procedure transaction identity value received with the request message and set the EPS bearer identity to "no EPS bearer identity assigned" (see examples in figures 6.3.2.1, 6.3.2.1a and 6.3.2.2). If the response message is the transaction related message REMOTE UE REPORT RESPONSE message from the network, the network shall include the procedure transaction identity value received with the request message and set the EPS bearer identity to the EPS bearer identity value received from the ProSe UE-to-network relay (see example in figure 6.3.2.3).

If an ESM DUMMY MESSAGE is sent in response to a received ESM DUMMY MESSAGE, the sending entity shall include the received procedure transaction identity value in the message header and set the EPS bearer identity to "no EPS bearer identity assigned".

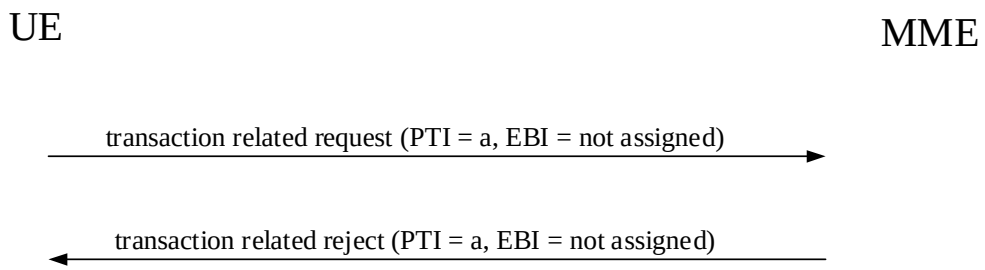


Figure 6.3.2.1: Transaction related procedure initiated by the UE and rejected by the network

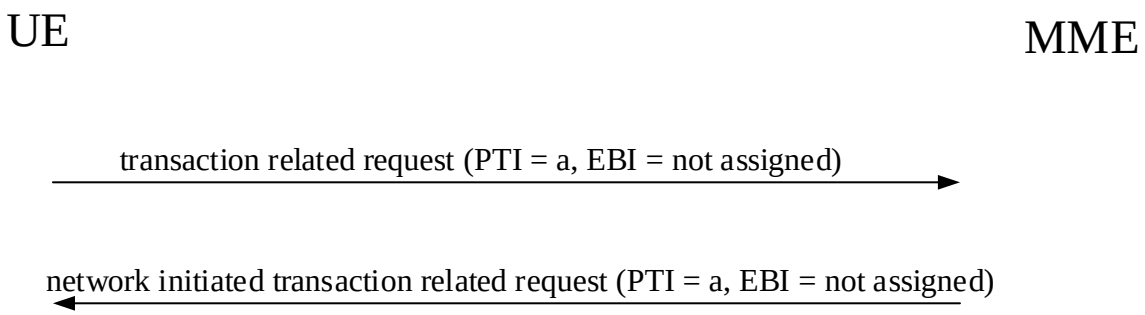


Figure 6.3.2.1a: Transaction related procedure initiated by the UE and responded by a network initiated transaction related request

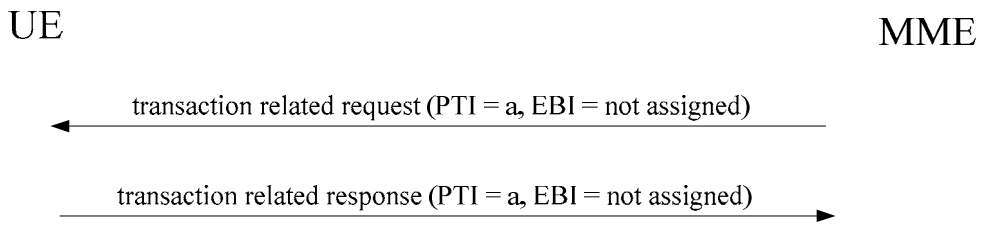


Figure 6.3.2.2: Transaction related procedure initiated by the network

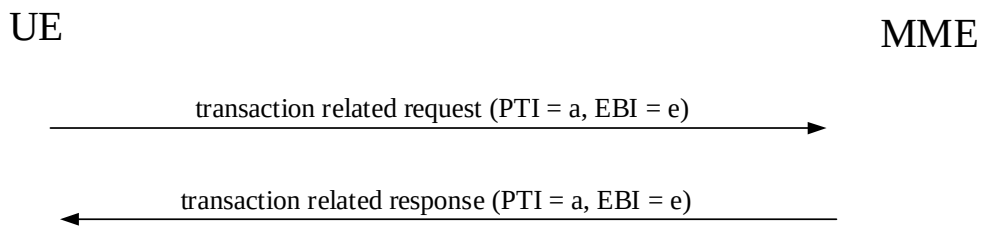


Figure 6.3.2.3: Transaction related procedure initiated by the UE

EPS bearer context related procedures use the EPS bearer identity as address parameter in the ESM message header. When the network initiates an EPS bearer context related procedure, it shall include a valid EPS bearer identity value in the message header. The procedure transaction identity value shall be set as follows:

- If the EPS bearer context related procedure was triggered by the receipt of a transaction related request message from the UE, the network shall include the procedure transaction identity value received with the transaction related request message in the message header of the EPS bearer context related request message (see example in figure 6.3.2.3).
- If the procedure was triggered network-internally, the network shall set the procedure transaction identity value in the message header of the EPS bearer context related request message to "no procedure transaction identity assigned" (see example in figure 6.3.2.4).
- If the procedure was triggered by the transport of user data via the control plane, the network shall set the procedure transaction identity value in the message header of the EPS bearer context related request message to "no procedure transaction identity assigned" (see example in figure 6.3.2.5).

In the response message of the EPS bearer context related procedure, the UE shall include the EPS bearer identity value received from the network and set the procedure transaction identity value to "no procedure transaction identity assigned".

When the UE initiates an EPS bearer context related procedure and the procedure was triggered by the transport of user data via the control plane, it shall include a valid EPS bearer identity value and set the procedure transaction identity value to "no procedure transaction identity assigned" in the message header (see example in figure 6.3.2.6).

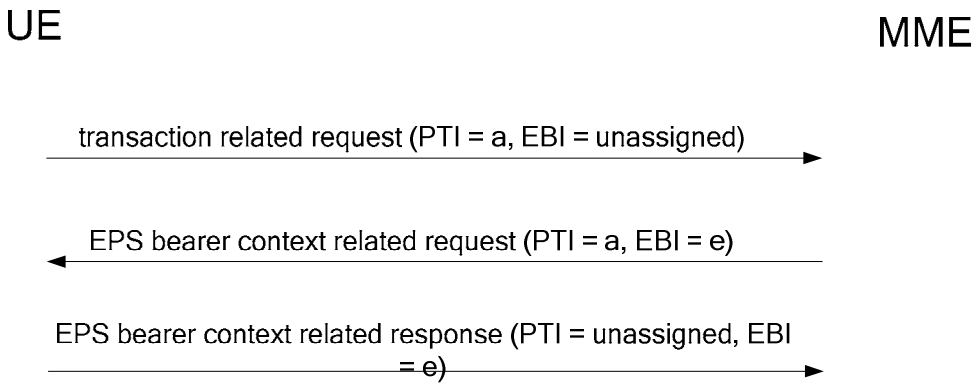


Figure 6.3.2.3: EPS bearer context related procedure triggered by a transaction related request

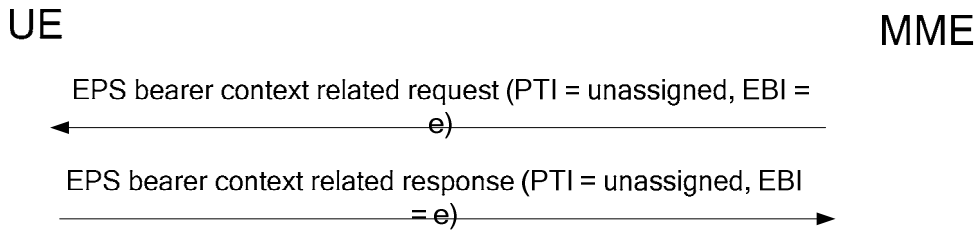


Figure 6.3.2.4: EPS bearer context related procedure triggered network-internally

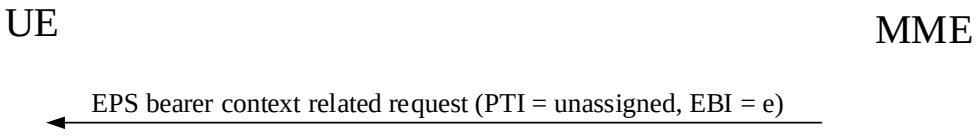


Figure 6.3.2.5: EPS bearer context related procedure triggered by network for the transport of user data via the control plane

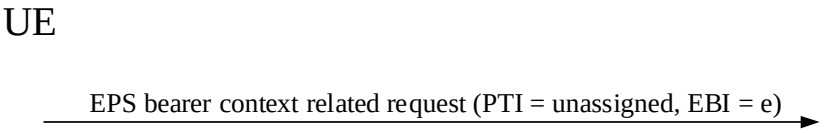


Figure 6.3.2.6: EPS bearer context related procedure triggered by UE for the transport of user data via the control plane

6.3.3 Abnormal cases in the UE

The following abnormal case can be identified:

a) ESM uplink message transmission failure indication by lower layers

Unless the procedure descriptions in subclause 6.6 specify a different behaviour, the following applies:

If lower layers indicate a TAI change, but the current TAI is not in the TAI list, the ESM procedure shall be aborted and re-initiated after successfully performing a tracking area updating procedure.

If lower layers indicate a TAI change, but the current TAI is still part of the TAI list, it is up to the UE implementation how the ESM procedure is re-initiated.

If lower layers indicate the TAI has not changed, it is up to the UE implementation how the ESM procedure is re-initiated.

NOTE 1: The ESM procedure can typically be re-initiated using a retransmission mechanism of the uplink message (the one that has previously failed to be transmitted) with new sequence number and message authentication code information thus avoiding to restart the whole procedure.

The case a) above does not apply to the ESM INFORMATION RESPONSE message.

NOTE 2: The ESM INFORMATION RESPONSE message can not be subjected to a transmission failure by lower layers due to handover as no handover message can be accepted by the UE prior to reception of the ATTACH ACCEPT message (see 3GPP TS 36.331 [22]).

b) Transmission failure of the ACTIVATE DEFAULT EPS BEARER CONTEXT ACCEPT message indication from EMM sublayer when the UE received any ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST messages during the attach procedure

It is up to the UE implementation how the dedicated EPS bearer context activation procedure is re-initiated.

NOTE 3: The ESM procedure can typically be re-initiated using a retransmission mechanism of the ACTIVATE DEDICATED EPS BEARER CONTEXT ACCEPT message or ACTIVATE DEDICATED EPS BEARER CONTEXT REJECT message with new sequence number and message authentication code information thus avoiding to restart the whole procedure.

6.3.4 Abnormal cases in the network

The following abnormal case can be identified:

a) Lower layer indication of non-delivered NAS PDU due to handover

Unless the procedure descriptions in subclause 6.4, 6.5 or 6.6 specify a different behaviour, the following applies:

If the downlink ESM NAS message could not be delivered due to an intra MME handover and the target TA is included in the TAI list, then upon successful completion of the intra MME handover the MME shall retransmit the ESM message. If a failure of the handover procedure is reported by the lower layer and the S1 signalling connection exists, the MME shall retransmit the downlink ESM NAS message.

b) Lower layer indication of non-delivered NAS PDU due to inter-eNodeB connected mode mobility when the transport of user data via the control plane is used

If the downlink ESM NAS message could not be delivered due to inter-eNodeB connected mode mobility and the MME is not changed, then upon successful completion of inter-eNodeB connected mode mobility the MME shall retransmit the ESM message. If a failure of inter-eNodeB connected mode mobility is reported by the lower layer and the S1 signalling connection exists, the MME shall retransmit the downlink ESM NAS message.

NOTE: If the downlink ESM NAS message could not be delivered due to inter-eNodeB connected mode mobility and the MME is changed, the retransmission of downlink ESM NAS message is not supported.

6.3.5 Handling of APN based congestion control

The network may detect and start performing the APN based congestion control when one or more APN congestion criteria as specified in 3GPP TS 23.401 [10] are met. The network may store an APN congestion back-off time on a per UE and congested APN basis. If the UE does not provide an APN for a non-emergency PDN connection, then the MME uses the APN which is used in PDN GW selection procedure as congested APN. When APN based congestion control is active, the network may reject session management requests from UEs or disconnect existing PDN connections with ESM cause value #26 "insufficient resources".

In the UE, EPS session management timers T3396 for APN based congestion control are started and stopped on a per APN basis. The APN associated with T3396 is the APN provided by the UE when the PDN connection is established. If no APN is included in the PDN CONNECTIVITY REQUEST or, when applicable, in the ESM INFORMATION RESPONSE message, then T3396 is associated with no APN. For this purpose the UE shall memorize the APN provided to the network during the PDN connection establishment. The timer T3396 associated with no APN will never be started due to any ESM procedure related to an emergency PDN connection. If the timer T3396 associated with no APN is running, it does not affect the ability of the UE to request an emergency PDN connection.

If timer T3396 is running or is deactivated, and the UE is a UE configured to use AC11 – 15 in selected PLMN, then the UE is allowed to initiate an attach procedure or any EPS session management procedure for the respective APN.

6.3.5A Handling of group specific session management congestion control

The network may detect and start performing the group specific session management congestion control when one or more group congestion criteria as specified in 3GPP TS 23.401 [10] are met. When group specific session management congestion control is active, the mechanism for APN based congestion control as specified in subclause 6.3.5 shall be followed.

6.3.6 Handling of network rejection not due to APN based congestion control

The network may include a back-off timer value in an EPS session management reject message to regulate the time interval at which the UE may retry the same procedure. For ESM cause values other than #26 "insufficient resources", the network may also include the re-attempt indicator to indicate whether the UE is allowed to re-attempt the corresponding session management procedure for the same APN in A/Gb or Iu mode after inter-system change.

NOTE 1: If the network includes this back-off timer value, then the UE is blocked from sending another ESM request for the same procedure for the same PLMN and APN combination for the specified duration. Therefore, the operator needs to exercise caution in determining the use of this timer value.

NOTE 2: If the re-attempt indicator is not provided by the network, a UE registered in its HPLMN or in an EHPLMN can use the configured SM_RetryAtRATChange value specified in the NAS configuration MO or in the USIM NAS_{CONFIG} file to derive the re-attempt indicator as specified in subclauses 6.5.1.4.3, 6.5.3.4.3, and 6.5.4.4.3.

If re-attempt in A/Gb or Iu mode is allowed, the UE shall consider the back-off timer to be applicable only to the EPS session management in S1 mode for the rejected EPS session management procedure and the given PLMN and APN combination. If re-attempt in A/Gb or Iu mode is not allowed, the UE shall consider the back-off timer to be applicable to both NAS protocols, i.e. applicable to the EPS session management in S1 mode for the rejected EPS session management procedure and to the GPRS session management in A/Gb and Iu mode for the corresponding session management procedure and the given PLMN and APN combination.

The APN of the PLMN and APN combination associated with the back-off timer is the APN provided by the UE when the PDN connection is established. If no APN is included in the PDN CONNECTIVITY REQUEST or, when applicable, in the ESM INFORMATION RESPONSE message, then the back-off timer is associated with the combination of the PLMN and no APN. For this purpose the UE shall memorize the APN provided to the network

during the PDN connection establishment. The back-off timer associated with the combination of a PLMN with no APN will never be started due to any ESM procedure related to an emergency PDN connection. If the back-off timer associated with the combination of a PLMN with no APN is running, it does not affect the ability of the UE to request an emergency PDN connection.

The network may additionally indicate in the re-attempt indicator that a command to back-off is applicable not only for the PLMN in which the UE received the EPS session management reject message, but for each PLMN included in the equivalent PLMN list at the time when the EPS session management reject message was received.

If the back-off timer is running or is deactivated for a given PLMN and APN combination, and the UE is a UE configured to use AC11 – 15 in selected PLMN, then the UE is allowed to initiate an attach procedure or any EPS session management procedure for this PLMN and APN combination.

6.3.7 Handling of WLAN offload control

In networks that support offloading of traffic to WLAN, as specified in 3GPP TS 36.331 [22], a permission to offload is determined for the UE and the PDN connection in accordance with 3GPP TS 23.401 [10] subclause 4.3.23.

6.3.8 Handling of serving PLMN rate control

Serving PLMN rate control enables the serving PLMN to protect its MME and the signalling radio bearers in the E-UTRAN from load generated by NAS messages with user data over control plane. The MME can inform the UE of any local serving PLMN rate control during the default EPS bearer context activation procedure (see subclause 6.4.1). The UE shall limit the rate at which it generates uplink NAS messages with user data over control plane to comply with the serving PLMN policy provided by the network. The indicated rate in a NAS procedure applies to the PDN connection the NAS procedure corresponds to, and the indicated rate is valid until the PDN connection is released.

Serving PLMN rate control is applicable for PDN connections established for control plane CIoT EPS optimization only.

Any Serving PLMN rate control information provided by the network to the UE is only applicable for the PLMN which provided this information. This Serving PLMN rate control information shall be discarded when the UE successfully registers to another PLMN.

NOTE: The serving PLMN can discard or delay NAS messages including user data over control plane that exceed the limit provided for serving PLMN rate control.

6.3.9 Handling of APN rate control

APN rate control controls the maximum number of uplink user data messages including uplink exception data reporting sent by the UE in a time interval for the APN in accordance with 3GPP TS 23.401 [10]. The UE shall limit the rate at which it generates uplink user data messages to comply with the APN rate control policy. The NAS shall provide the indicated rates to upper layers for enforcement. The indicated rates in a NAS procedure applies to the APN the NAS procedure corresponds to, and the indicated rates are valid until a new value is indicated or the last PDN connection using this APN is released.

If the UE supports APN rate control, the UE shall provide the support indication of APN rate control and additional APN rate control for exception data reporting to the network. If the UE indicates support of additional APN rate control for exception data reporting, the network may provide the APN rate control parameters for exception data to the UE. If the UE does not indicate support of additional APN rate control for exception data reporting, the network shall not provide the APN rate control parameters for exception data to the UE.

If an allowed indication of additional exception reports is provided with the APN rate control parameters and:

- the additional APN rate control parameters for exception data is provided and the limit for additional rate for exception data reporting is not reached; or
- the additional APN rate control parameters for exception data is not provided,

the UE is allowed to send uplink exception reports even if the limit for the APN rate control has been reached.

NOTE: The HPLMN can discard or delay user data that exceeds the limit provided for APN rate control.

6.3.10 Handling of 3GPP PS data off

A UE, which supports 3GPP PS data off (see 3GPP TS 23.401 [10]), can be configured with up to two lists of 3GPP PS data off exempt services as specified in 3GPP TS 24.368 [15A] or in the $EF_{3GPPPSDATAOFF}$ USIM file as specified in 3GPP TS 31.102 [17]:

- a list of 3GPP PS data off exempt services to be used in the HPLMN or EHPLMN; and
- a list of 3GPP PS data off exempt services to be used in the VPLMN.

If only the list of 3GPP PS data off exempt services to be used in the HPLMN or EHPLMN is configured at the UE, this list shall be also used in the VPLMN.

If the UE supports 3GPP PS data off, the UE shall provide the 3GPP PS data off UE status in the protocol configuration options IE during attach, UE-requested PDN connectivity, and UE-requested bearer modification procedure (see subclause 5.5.1, 6.5.1, and 6.5.4).

NOTE 1: The sending of the 3GPP PS data off UE status to the network happens also when the user activates or deactivates 3GPP PS data off while connected via WLAN access only, and then handover to 3GPP access occur.

The network informs the UE about the support of 3GPP PS data off during the activation of the the default bearer of a PDN connection (see subclause 6.4.1). If 3GPP PS data off support is not indicated in the protocol configuration options IE in the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message, the UE shall not indicate any change of 3GPP PS data off UE status for the PDN connection established by the default EPS bearer context activation procedure; otherwise the UE shall indicate change of the 3GPP PS data off UE status for the PDN connection by using the UE-requested bearer modification procedure as specified in subclause 6.5.4. If the network does not provide indication of support of 3GPP PS data off during default EPS bearer context activation procedure of the PDN connection, the UE behaviour for non-exempt service requests from the network is implementation dependent.

When the 3GPP PS data off UE status is "activated", the UE does not send uplink IP packets except:

- for those services indicated in the list of 3GPP PS data off exempt services to be used in the HPLMN or EHPLMN as specified in 3GPP TS 24.368 [15A] when the UE is in its HPLMN or EHPLMN;
- for those services indicated in the list of 3GPP PS data off exempt services to be used in the HPLMN or EHPLMN when the UE is in the VPLMN, if only the list of 3GPP PS data off exempt services to be used in the HPLMN or EHPLMN is configured to the UE as specified in 3GPP TS 24.368 [15A];
- for those services indicated in the list of 3GPP PS data off exempt services to be used in the VPLMN when the UE is in the VPLMN, if the list of 3GPP PS data off exempt services to be used in the VPLMN is configured to the UE as specified in 3GPP TS 24.368 [15A];
- for those services indicated in the $EF_{3GPPPSDATAOFF}$ USIM file as specified in 3GPP TS 31.102 [17];
- any uplink traffic due to procedures specified in 3GPP TS 24.229 [13D]; and
- any uplink traffic due to procedures specified in 3GPP TS 24.623 [50].

Otherwise the UE sends uplink IP packets without restriction.

NOTE 2: If the UE supports 3GPP PS data off, uplink IP packets are filtered as specified in 3GPP TS 24.229 [13D] in L.3.1.5.

6.3.11 Handling of Reliable Data Service

If the UE supports Reliable Data Service (see 3GPP TS 24.250 [51]), the UE may request data transfer using Reliable Data Service for a PDN connection in the extended protocol configuration options IE during attach and UE-requested PDN connectivity procedures (see subclause 5.5.1 and 6.5.1).

The Reliable Data Service may only be used with PDN connections for which the "Control plane only" indicator is set or with PDN connections using the control plane CIoT EPS optimization when the MME does not move such PDN connections to the user plane.

The SCEF or P-GW shall inform the UE about the acceptance of UE's request for Reliable Data Service usage during the activation of the default bearer of a PDN connection (see subclause 6.4.1) in the extended protocol configuration options IE in the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message.

If the SCEF or P-GW accepts the use of Reliable Data Service to transfer data for the specified PDN connection, the UE shall use this PDN connection exclusively for data transfer using Reliable Data Service; otherwise the UE shall not use this PDN connection for data transfer using Reliable Data Service.

6.4 Network initiated ESM procedures

6.4.1 Default EPS bearer context activation procedure

6.4.1.1 General

The purpose of the default bearer context activation procedure is to establish a default EPS bearer context between the UE and the EPC. The default EPS bearer context activation procedure is initiated by the network as a response to the PDN CONNECTIVITY REQUEST message from the UE. The default bearer context activation procedure can be part of the attach procedure, and if the attach procedure fails, the UE shall consider that the default bearer activation has implicitly failed. The default EPS bearer context does not have any TFT assigned during the activation procedure. This corresponds to using a match-all packet filter. The network may at anytime after the establishment of this bearer assign a TFT to the default EPS bearer and may subsequently modify the TFT or the packet filters of this default bearer.

6.4.1.2 Default EPS bearer context activation initiated by the network

The MME shall initiate the default bearer context activation procedure by sending an ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message and enter the state BEARER CONTEXT ACTIVE PENDING (see example in figure 6.4.1.2.1). When the default bearer is activated as part of the attach procedure, the MME shall send the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message together with ATTACH ACCEPT and shall not start the timer T3485. When the default bearer is activated as the response to a stand-alone PDN CONNECTIVITY REQUEST message apart from the attach procedure, the MME shall send the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message alone, and start the timer T3485.

The MME shall assign and include an EPS bearer identity in the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message selecting a value as specified by subclause 9.3.2. The MME shall retrieve the PTI from the PDN CONNECTIVITY REQUEST message and include it in the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message. Both the network identifier part and the operator identifier part shall be included in the Access Point Name IE.

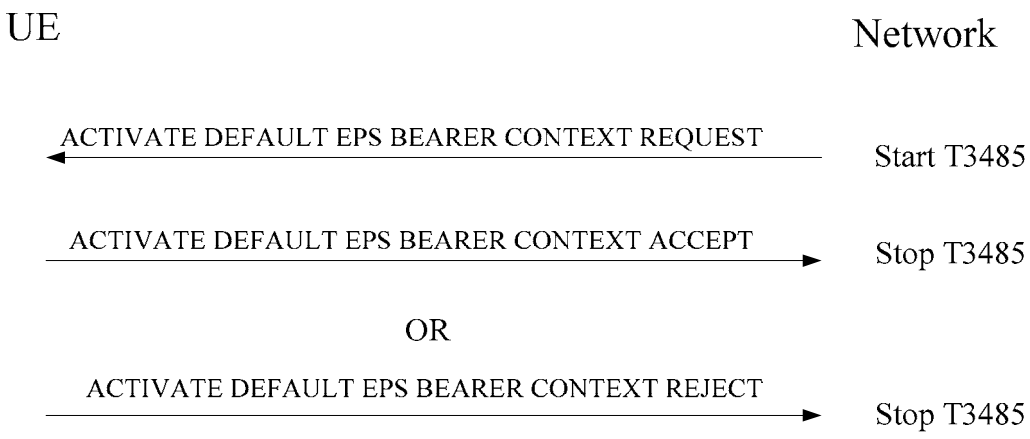


Figure 6.4.1.2.1: Default EPS bearer context activation procedure

6.4.1.3 Default EPS bearer context activation accepted by the UE

Upon receipt of the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message, if the UE provided an APN for the establishment of the PDN connection, the UE shall stop timer T3396 if it is running for the APN provided by the UE. If the UE did not provide an APN for the establishment of the PDN connection and the request type was different from "emergency" and from "handover of emergency bearer services", the UE shall stop the timer T3396

associated with no APN if it is running. If the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message was received in response to a request for an emergency PDN connection, the UE shall not stop the timer T3396 associated with no APN if it is running. For any case, the UE shall then send an ACTIVATE DEFAULT EPS BEARER CONTEXT ACCEPT message and enter the state BEARER CONTEXT ACTIVE. When the default bearer is activated as part of the attach procedure, the UE shall send the ACTIVATE DEFAULT EPS BEARER CONTEXT ACCEPT message together with ATTACH COMPLETE message. When the default bearer is activated as the response to the stand-alone PDN CONNECTIVITY REQUEST message, the UE shall send the ACTIVATE DEFAULT EPS BEARER CONTEXT ACCEPT message alone.

If a WLAN offload indication information element is included in the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message, the UE shall store the WLAN offload acceptability values for this PDN connection and use the E-UTRAN offload acceptability value to determine whether this PDN connection is offloadable to WLAN or not.

The UE checks the PTI in the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message to identify the UE requested PDN connectivity procedure to which the default bearer context activation is related (see subclause 6.5.1).

If the UE receives a serving PLMN rate control IE in the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message, the UE shall store the serving PLMN rate control IE value and use the stored serving PLMN rate control value as the maximum allowed limit of uplink User data container IEs included in ESM DATA TRANSPORT messages for the corresponding PDN connection in accordance with 3GPP TS 23.401 [10].

If the UE receives an APN rate control parameters container in the protocol configuration options IE or extended protocol configuration options IE in the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message, the UE shall store the APN rate control parameters value and use the stored APN rate control parameters value as the maximum allowed limit of uplink user data related to the APN indicated in the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message in accordance with 3GPP TS 23.401 [10]. If the UE has a previously stored APN rate control parameters value for this APN, the UE shall replace the stored APN rate control parameters value for this APN with the received APN rate control parameters value.

If the UE receives an additional APN rate control parameters for exception data container in the protocol configuration options IE or extended protocol configuration options IE in the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message, the UE shall store the additional APN rate control parameters for exception data value and use the stored additional APN rate control parameters for exception data value as the maximum allowed limit of uplink exception data related to the APN indicated in the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message in accordance with 3GPP TS 23.401 [10]. If the UE has a previously stored additional APN rate control parameters for exception data value for this APN, the UE shall replace the stored additional APN rate control parameters for exception data value for this APN with the received additional APN rate control parameters for exception data value.

If the UE receives non-IP Link MTU parameter or IPv4 Link MTU parameter of the protocol configuration options IE in the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message, the UE shall pass the received Non-IP Link MTU or IPv4 Link MTU to the upper layer.

NOTE: The Non-IP Link MTU and the IPv4 Link MTU size correspond to the maximum length of user data that can be sent either in the user data container in the ESM DATA TRANSPORT message or via S1-U interface.

If the UE receives a session-AMBR and QoS rule(s), which correspond to the default EPS bearer of the PDN connectivity being activated, in the protocol configuration options IE or the extended protocol configuration options IE in the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message, the UE stores the session-AMBR and QoS rule(s) for use during inter-system change from S1 mode to N1 mode.

Upon receipt of the ACTIVATE DEFAULT EPS BEARER CONTEXT ACCEPT message, the MME shall enter the state BEARER CONTEXT ACTIVE and stop the timer T3485, if the timer is running. If the PDN CONNECTIVITY REQUEST message included a low priority indicator set to "MS is configured for NAS signalling low priority", the MME shall store the NAS signalling low priority indication within the default EPS bearer context.

6.4.1.4 Default EPS bearer context activation not accepted by the UE

If the default EPS bearer context activation is part of the attach procedure, the ESM sublayer shall notify the EMM sublayer of an ESM failure. If EMM-REGISTERED without PDN connection is supported by the UE and the MME, the ESM sublayer shall additionally provide an ACTIVATE DEFAULT EPS BEARER CONTEXT REJECT message to the EMM sublayer.

If the default EPS bearer context activation is not part of the attach procedure, the UE shall send an ACTIVATE DEFAULT EPS BEARER CONTEXT REJECT message and enter the state BEARER CONTEXT INACTIVE.

The ACTIVATE DEFAULT EPS BEARER CONTEXT REJECT message contains an ESM cause that typically indicates one of the following cause values:

#26: insufficient resources;

#31: request rejected, unspecified; or

#95 – 111: protocol errors.

Upon receipt of the ACTIVATE DEFAULT EPS BEARER CONTEXT REJECT message, the MME shall enter the state BEARER CONTEXT INACTIVE and stop the timer T3485, if the timer is running.

6.4.1.5 Abnormal cases in the UE

The following abnormal cases can be identified:

a) Default EPS bearer context activation request for an already activated default EPS bearer context:

   If the UE receives an ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message with an EPS bearer identity identical to the EPS bearer identity of an already activated default EPS bearer context, the UE shall locally deactivate the existing default EPS bearer context and all the associated dedicated EPS bearer contexts, if any, and proceed with the requested default EPS bearer context activation.

b) Default EPS bearer context activation request for an already activated dedicated EPS bearer context:

   If the UE receives an ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message with an EPS bearer identity identical to the EPS bearer identity of an already activated dedicated EPS bearer context, the UE shall locally deactivate the existing dedicated EPS bearer context and proceed with the requested default EPS bearer context activation.

6.4.1.6 Abnormal cases on the network side

The following abnormal cases can be identified:

a) Expiry of timer T3485:

   On the first expiry of the timer T3485, the MME shall resend the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST and shall reset and restart timer T3485. This retransmission is repeated four times, i.e. on the fifth expiry of timer T3485, the MME shall release possibly allocated resources for this activation and shall abort the procedure.

b) Lower layer indicates that the HeNB rejected the establishment of the default bearer (see 3GPP TS 36.413 [23]) for a LIPA PDN connection or SIPTO at the local network PDN connection due to a triggered handover:

   The MME shall enter the state BEARER CONTEXT INACTIVE,stop timer T3485 and reject the PDN connectivity request procedure including the ESM cause value #34 "service option temporarily out of order" in the PDN CONNECTIVITY REJECT message. The MME shall release possibly allocated resources for this activation.

6.4.2 Dedicated EPS bearer context activation procedure

6.4.2.1 General

The purpose of the dedicated EPS bearer context activation procedure is to establish an EPS bearer context with specific QoS and TFT between the UE and the EPC.

In WB-S1 mode, the dedicated EPS bearer context activation procedure is initiated by the network, but may be requested by the UE by means of the UE requested bearer resource allocation procedure (see subclause 6.5.3) or the UE requested bearer resource modification procedure (see subclause 6.5.4). The dedicated bearer context activation procedure can be part of the attach procedure or be initiated together with the default EPS bearer context activation procedure when the UE initiated stand-alone PDN connectivity procedure. If the attach procedure or the default EPS bearer context activation procedure fails, the UE shall consider that the dedicated bearer activation has implicitly failed.

The network may initiate the dedicated EPS bearer context activation procedure together with the completion of the service request procedure.

In NB-S1 mode, the dedicated EPS bearer contexts activation procedure is not used.

NOTE: 3GPP TS 23.060 [74] subclause 9.3 specifies that a packet filter applicable for the downlink direction is not mandatory in a TFT.

6.4.2.2 Dedicated EPS bearer context activation initiated by the network

In WB-S1 mode, the MME shall initiate the dedicated bearer context activation procedure by sending an ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST message, start the timer T3485, and enter the state BEARER CONTEXT ACTIVE PENDING (see example in figure 6.4.2.2.1).

The MME allocates the EPS bearer identity selecting a value as specified by subclause 9.3.2, and includes it in the ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST message. The MME shall include the EPS bearer identity of the associated default bearer as the linked EPS bearer identity in the ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST message. If this procedure was initiated by a UE requested bearer resource allocation procedure or a UE requested bearer resource modification procedure, the ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST shall contain the procedure transaction identity (PTI) value received by the MME in the BEARER RESOURCE ALLOCATION REQUEST or BEARER RESOURCE MODIFICATION REQUEST respectively.

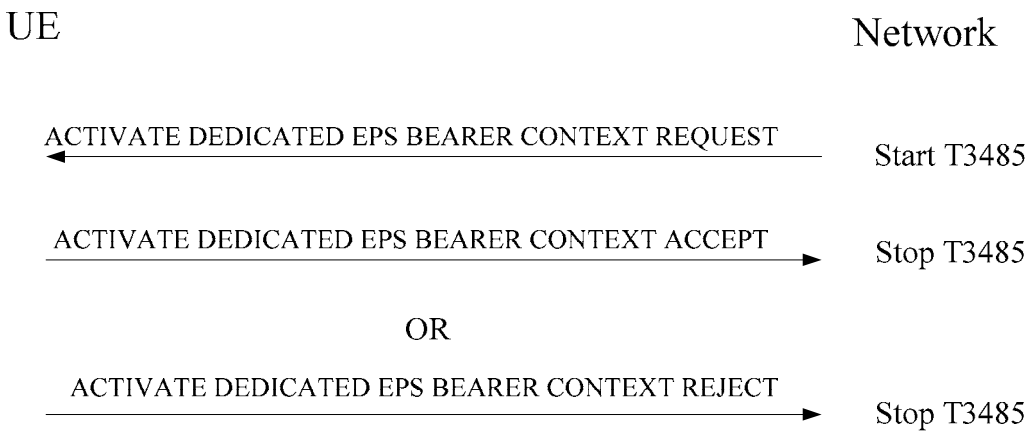


Figure 6.4.2.2.1: Dedicated EPS bearer context activation procedure

6.4.2.3 Dedicated EPS bearer context activation accepted by the UE

Upon receipt of the ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST message, if the UE provided an APN for the establishment of the PDN connection, the UE shall stop timer T3396, if it is running for the APN provided by the UE. If the UE did not provide an APN for the establishment of the PDN connection and the request type was different from "emergency" and from "handover of emergency bearer services", the UE shall stop the timer T3396 associated with no APN if it is running. If the ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST message was received for an emergency PDN connection, the UE shall not stop the timer T3396 associated with no APN if it is running. For any case, the UE shall then check the received TFT before taking it into use, send an ACTIVATE DEDICATED EPS BEARER CONTEXT ACCEPT message and enter the state BEARER CONTEXT ACTIVE. The ACTIVATE DEDICATED EPS BEARER CONTEXT ACCEPT message shall include the EPS bearer identity.

The linked EPS bearer identity included in the ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST message indicates to the UE to which default bearer, IP address and PDN the dedicated bearer is linked.

If the ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST message contains a PTI value other than "no procedure transaction identity assigned" and "reserved" (see 3GPP TS 24.007 [12]), the UE uses the PTI to identify the UE requested bearer resource allocation procedure or the UE requested bearer resource modification procedure to which the dedicated bearer context activation is related.

If the ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST message contains a PTI value other than "no procedure transaction identity assigned" and "reserved" (see 3GPP TS 24.007 [12]) and the PTI is associated to a UE requested bearer resource allocation procedure or a UE requested bearer resource modification procedure, the UE shall release the traffic flow aggregate description associated to the PTI value provided.

The UE shall use the received TFT to apply mapping of uplink traffic flows to the radio bearer.

The UE shall treat any packet filter without explicit direction as being bi-directional.

If the UE receives an APN rate control parameters container in the protocol configuration options IE or extended protocol configuration options IE in the ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST message, the UE shall store the APN rate control parameters value and use the stored APN rate control parameters value as the maximum allowed limit of uplink user data related to the corresponding APN in accordance with 3GPP TS 23.401 [10]. If the UE has a previously stored APN rate control parameters value for this APN, the UE shall replace the stored APN rate control parameters value for this APN with the received APN rate control parameters value.

If the UE receives an additional APN rate control parameters for exception data container in the protocol configuration options IE or extended protocol configuration options IE in the ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST message, the UE shall store the additional APN rate control parameters for exception data value and use the stored additional APN rate control parameters for exception data value as the maximum allowed limit of uplink exception data related to the corresponding APN in accordance with 3GPP TS 23.401 [10]. If the UE has a previously stored additional APN rate control parameters for exception data value for this APN, the UE shall replace the stored additional APN rate control parameters for exception data value for this APN with the received additional APN rate control parameters for exception data value.

If the UE receives QoS rule(s) of the 5GS QoS flow(s), which corresponds to the dedicated EPS bearer being activated, in the protocol configuration options IE or the extended protocol configuration options IE of the ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST message, the UE stores the QoS rule(s) for use during inter-system change from S1 mode to N1 mode.

Upon receipt of the ACTIVATE DEDICATED EPS BEARER CONTEXT ACCEPT message, the MME shall stop the timerT3485 and enter the state BEARER CONTEXT ACTIVE.

6.4.2.4 Dedicated EPS bearer context activation not accepted by the UE

Upon receipt of the ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST message, the UE may reject the request from the MME by sending an ACTIVATE DEDICATED EPS BEARER CONTEXT REJECT message. The message shall include the EPS bearer identity and an ESM cause value indicating the reason for rejecting the dedicated EPS bearer context activation request.

The ACTIVATE DEDICATED EPS BEARER CONTEXT REJECT message contains an ESM cause that typically indicates one of the following ESM cause values:

#26: insufficient resources;

#31: request rejected, unspecified;

#41: semantic error in the TFT operation;

#42: syntactical error in the TFT operation;

#43: invalid EPS bearer identity;

#44: semantic error(s) in packet filter(s);

#45: syntactical error(s) in packet filter(s); or

#95 – 111: protocol errors.

The UE shall check the TFT in the request message for different types of TFT IE errors as follows:

a) Semantic errors in TFT operations:

   1) When the *TFT operation* is an operation other than "Create a new TFT"

   The UE shall reject the activation request with ESM cause #41 "semantic error in the TFT operation".

b) Syntactical errors in TFT operations:

1) When the *TFT operation* = "Create a new TFT" and the packet filter list in the TFT IE is empty.

2) When there are other types of syntactical errors in the coding of the TFT IE, such as a mismatch between the number of packet filters subfield, and the number of packet filters in the packet filter list.

The UE shall reject the activation request with ESM cause #42 "syntactical error in the TFT operation".

c) Semantic errors in packet filters:

1) When a packet filter consists of conflicting packet filter components which would render the packet filter ineffective, i.e. no IP packet will ever fit this packet filter. How the UE determines a semantic error in a packet filter is outside the scope of the present document.

2) When the resulting TFT does not contain any packet filter which applicable for the uplink direction.

The UE shall reject the activation request with ESM cause #44 "semantic errors in packet filter(s)".

d) Syntactical errors in packet filters:

1) When the *TFT operation* = "Create a new TFT" and two or more packet filters in the resultant TFT would have identical packet filter identifiers.

2) When the *TFT operation* = "Create a new TFT" and two or more packet filters in all TFTs associated with this PDN connection would have identical packet filter precedence values.

3) When there are other types of syntactical errors in the coding of packet filters, such as the use of a reserved value for a packet filter component identifier.

In case 2, if the old packet filters do not belong to the default EPS bearer context, the UE shall not diagnose an error, shall further process the new activation request and, if it was processed successfully, shall delete the old packet filters which have identical filter precedence values. Furthermore, by means of explicit peer-to-peer signalling between the network and the UE, the UE shall perform a UE requested bearer resource modification procedure to deactivate the EPS bearer context(s) for which it has deleted the packet filters.

In case 2, if one or more old packet filters belong to the default EPS bearer context, the UE shall release the relevant PDN connection. If the relevant PDN connection is the last one that the UE has and EMM-REGISTERED without PDN connection is not supported by the UE or the MME, the UE shall detach and re-attach to the network.

In cases 1 and 3 the UE shall reject the activation request with ESM cause #45 "syntactical errors in packet filter(s)".

Upon receipt of the ACTIVATE DEDICATED EPS BEARER CONTEXT REJECT message in state BEARER CONTEXT ACTIVE PENDING, the MME shall stop the timer T3485, enter the state BEARER CONTEXT INACTIVE and abort the dedicated EPS bearer context activation procedure. The MME also requests the lower layer to release the radio resources that were established during the dedicated EPS bearer context activation procedure.

6.4.2.5 Abnormal cases in the UE

The following abnormal cases can be identified:

a) Dedicated EPS bearer context activation request for an already activated default EPS bearer context:

If the UE receives an ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST message with an EPS bearer identity identical to the EPS bearer identity of an already activated default EPS bearer context, the UE shall locally deactivate the existing default EPS bearer context and all the associated dedicated EPS bearer contexts, if any, and proceed with the requested dedicated EPS bearer context activation.

b) Dedicated EPS bearer context activation request for an already activated dedicated EPS bearer context

If the UE receives an ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST message with an EPS bearer identity identical to the EPS bearer identity of an already activated dedicated EPS bearer context, the UE shall locally deactivate the existing dedicated EPS bearer context and proceed with the requested dedicated EPS bearer context activation.

c) No default EPS bearer context with linked EPS bearer identity activated

If the linked EPS bearer identity included in the ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST message does not match the EPS bearer identity of any activated default EPS bearer context, the UE shall reply with an ACTIVATE DEDICATED EPS BEARER CONTEXT REJECT message with ESM cause #43 "invalid EPS bearer identity".

6.4.2.6 Abnormal cases on the network side

The following abnormal cases can be identified:

a) Expiry of timer T3485:

On the first expiry of the timer T3485, the MME shall resend the ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST and shall reset and restart timer T3485. This retransmission is repeated four times, i.e. on the fifth expiry of timer T3485, the MME shall abort the procedure, release any resources allocated for this activation and enter the state BEARER CONTEXT INACTIVE.

b) Collision of UE requested PDN disconnect procedure and dedicated EPS bearer context activation procedure:

When the MME receives a PDN DISCONNECT REQUEST message during the dedicated EPS bearer context activation procedure, and the EPS bearer to be activated belongs to the PDN connection the UE wants to disconnect, the MME shall terminate the dedicated bearer context activation procedure locally, release any resources related to this procedure and proceed with the PDN disconnect procedure.

6.4.3 EPS bearer context modification procedure

6.4.3.1 General

The purpose of the EPS bearer context modification procedure is to modify an EPS bearer context with a specific QoS and TFT, or re-negotiate header compression configuration associated to an EPS bearer context. The EPS bearer context modification procedure is initiated by the network, but it may also be initiated as part of the UE requested bearer resource allocation procedure or the UE requested bearer resource modification procedure.

The network may also initiate the EPS bearer context modification procedure to update the APN-AMBR of the UE, for instance after an inter-system handover. See 3GPP TS 23.401 [10] annex E.

The MME may also initiate the EPS bearer context modification procedure to update the WLAN offload indication to the UE, for instance after the MME received an updated WLAN offload indication of a PDN Connection from HSS. See 3GPP TS 23.401 [10] subclause 4.3.23.

The network may initiate the EPS bearer context modification procedure together with the completion of the service request procedure.

6.4.3.2 EPS bearer context modification initiated by the network

The MME shall initiate the EPS bearer context modification procedure by sending a MODIFY EPS BEARER CONTEXT REQUEST message to the UE, starting the timer T3486, and entering the state BEARER CONTEXT MODIFY PENDING (see example in figure 6.4.3.2.1).

The MME shall include an EPS bearer identity that identifies the EPS bearer context to be modified in the MODIFY EPS BEARER CONTEXT REQUEST message.

If this procedure was initiated by a UE requested bearer resource allocation procedure or a UE requested bearer resource modification procedure, the MODIFY EPS BEARER CONTEXT REQUEST shall contain the procedure transaction identity (PTI) value received by the MME in the BEARER RESOURCE ALLOCATION REQUEST or BEARER RESOURCE MODIFICATION REQUEST respectively.

If the UE indicated "Control plane CIoT EPS optimization supported" and "Header compression for control plane CIoT EPS optimization supported" in the UE network capability IE in the latest ATTACH REQUEST message or the TRACKING AREA UPDATE REQUEST message, and the MME supports Control plane CIoT EPS optimization and Header compression for control plane CIoT EPS optimization, the MME may include the Header compression configuration IE in the MODIFY EPS BEARER CONTEXT REQUEST message to re-negotiate header compression configuration associated to an EPS bearer context.

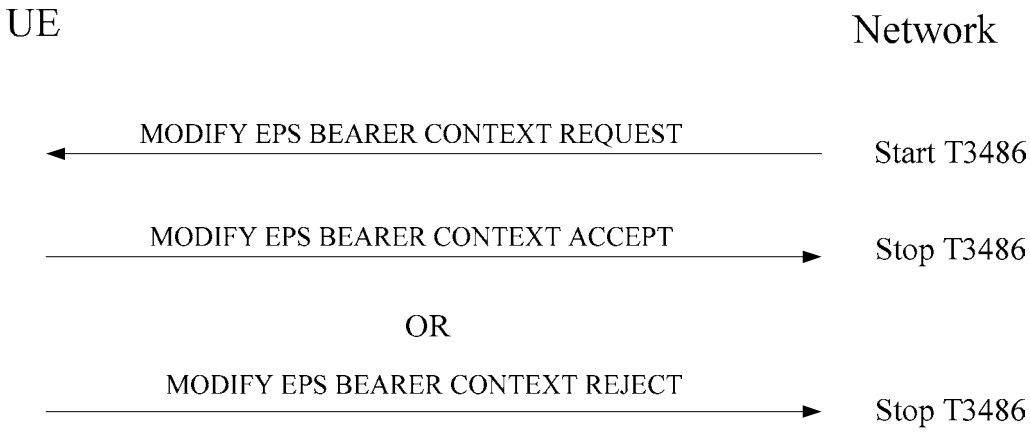


Figure 6.4.3.2.1: EPS bearer context modification procedure

6.4.3.3 EPS bearer context modification accepted by the UE

Upon receipt of the MODIFY EPS BEARER CONTEXT REQUEST message, if the UE provided an APN for the establishment of the PDN connection, the UE shall stop timer T3396, if it is running for the APN provided by the UE. If the UE did not provide an APN for the establishment of the PDN connection and the request type was different from "emergency" and from "handover of emergency bearer services", the UE shall stop the timer T3396 associated with no APN if it is running. If the MODIFY EPS BEARER CONTEXT REQUEST message was received for an emergency PDN connection, the UE shall not stop the timer T3396 associated with no APN if it is running. For any case, the UE shall then check the received TFT before taking it into use and send a MODIFY EPS BEARER CONTEXT ACCEPT message to the MME.

If the MODIFY EPS BEARER CONTEXT REQUEST message contains a PTI value other than "no procedure transaction identity assigned" and "reserved" (see 3GPP TS 24.007 [12]), the UE uses the PTI to identify the UE requested bearer resource allocation procedure or the UE requested bearer resource modification procedure to which the EPS bearer context modification is related (see subclause 6.5.3 and subclause 6.5.4).

If the MODIFY EPS BEARER CONTEXT REQUEST message contains a PTI value other than "no procedure transaction identity assigned" and "reserved" (see 3GPP TS 24.007 [12]) and the PTI is associated to a UE requested bearer resource allocation procedure or a UE requested bearer resource modification procedure, the UE shall release the traffic flow aggregate description associated to the PTI value provided.

If the EPS bearer context that is modified is a GBR bearer and the MODIFY EPS BEARER CONTEXT REQUEST message does not contain the Guaranteed Bit Rate (GBR) and the Maximum Bit Rate (MBR) values for uplink and downlink, the UE shall continue to use the previously received values for the Guaranteed Bit Rate (GBR) and the Maximum Bit Rate (MBR) for the corresponding bearer.

The UE shall use the received TFT to apply mapping of uplink traffic flows to the radio bearer if the TFT contains packet filters for the uplink direction.

If a WLAN offload indication information element is included in the MODIFY EPS BEARER CONTEXT REQUEST message, the UE shall store the WLAN offload acceptability values for this PDN connection and use the E-UTRAN offload acceptability value to determine whether this PDN connection is offloadable to WLAN or not.

If the UE receives an APN rate control parameters container in the protocol configuration options IE or extended protocol configuration options IE in the MODIFY EPS BEARER CONTEXT REQUEST message, the UE shall store the APN rate control parameters value and use the stored APN rate control parameters value as the maximum allowed limit of uplink user data related to the corresponding APN in accordance with 3GPP TS 23.401 [10]. If the UE has a previously stored APN rate control parameters value for this APN, the UE shall replace the stored APN rate control parameters value for this APN with the received APN rate control parameters value.

If the UE receives an additional APN rate control parameters for exception data container in the protocol configuration options IE or extended protocol configuration options IE in the MODIFY EPS BEARER CONTEXT REQUEST message, the UE shall store the additional APN rate control parameters for exception data value and use the stored additional APN rate control parameters for exception data value as the maximum allowed limit of uplink exception data related to the corresponding APN in accordance with 3GPP TS 23.401 [10]. If the UE has a previously stored additional

APN rate control parameters for exception data value for this APN, the UE shall replace the stored additional APN rate control parameters for exception data value for this APN with the received additional APN rate control parameters for exception data value.

If the UE receives QoS rule(s) of the 5GS QoS flow(s), which corresponds to the EPS bearer being modified, in the protocol configuration options IE or the extended protocol configuration options IE of the MODIFY EPS BEARER CONTEXT REQUEST message, the UE stores the QoS rule(s) for use during inter-system change from S1 mode to N1 mode.

Upon receipt of the MODIFY EPS BEARER CONTEXT ACCEPT message, the MME shall stop the timer T3486 and enter the state BEARER CONTEXT ACTIVE.

6.4.3.4 EPS bearer context modification not accepted by the UE

Upon receipt of the MODIFY EPS BEARER CONTEXT REQUEST message, the UE may reject the request from the MME by sending a MODIFY EPS BEARER CONTEXT REJECT message to the MME. The message shall include the EPS bearer identity and an ESM cause value indicating the reason for rejecting the EPS bearer context modification request.

The MODIFY EPS BEARER CONTEXT REJECT message contains an ESM cause that typically indicates one of the following ESM cause values:

#26: insufficient resources;

#41: semantic error in the TFT operation;

#42: syntactical error in the TFT operation;

#43: invalid EPS bearer identity;

#44: semantic error(s) in packet filter(s);

#45: syntactical error(s) in packet filter(s); or

#95 – 111: protocol errors.

The UE shall check the TFT in the request message for different types of TFT IE errors as follows:

a) Semantic errors in TFT operations:

1) *TFT operation* = "Create a new TFT" when there is already an existing TFT for the EPS bearer context.

2) When the *TFT operation* is an operation other than "Create a new TFT" and there is no TFT for the EPS bearer context.

3) *TFT operation* = "Delete packet filters from existing TFT" when it would render the TFT empty.

4) *TFT operation* = "Delete existing TFT" for a dedicated EPS bearer context.

In case 4 the UE shall reject the modification request with ESM cause #41 "semantic error in the TFT operation".

In the other cases the UE shall not diagnose an error and perform the following actions to resolve the inconsistency:

In case 1 the UE shall further process the new activation request and, if it was processed successfully, delete the old TFT.

In case 2 the UE shall:

- process the new request and if the TFT operation is "Delete existing TFT" or "Delete packet filters from existing TFT", and if no error according to items b, c, and d was detected, consider the TFT as successfully deleted;

- process the new request as an activation request, if the TFT operation is "Add packet filters in existing TFT" or "Replace packet filters in existing TFT".

In case 3, if the packet filters belong to a dedicated EPS bearer context, the UE shall process the new deletion request and, if no error according to items b, c, and d was detected, the UE shall reject the modification request with ESM cause #41 "semantic error in the TFT operation".

In case 3, if the packet filters belong to the default EPS bearer context, the UE shall process the new deletion request and if no error according to items b, c, and d was detected then delete the existing TFT, this corresponds to using match-all packet filter for the default EPS bearer context.

b) Syntactical errors in TFT operations:

1) When the *TFT operation* = "Create a new TFT", "Add packet filters in existing TFT", "Replace packet filters in existing TFT" or "Delete packet filters from existing TFT" and the packet filter list in the TFT IE is empty.

2) *TFT operation* = "Delete existing TFT" or "No TFT operation" with a non-empty packet filter list in the TFT IE.

3) *TFT operation* = "Replace packet filters in existing TFT" when the packet filter to be replaced does not exist in the original TFT.

4) *TFT operation* = "Delete packet filters from existing TFT" when the packet filter to be deleted does not exist in the original TFT.

5) *TFT operation* = "Delete packet filters from existing TFT" with a packet filter list also including packet filters in addition to the packet filter identifiers.

6) When there are other types of syntactical errors in the coding of the TFT IE, such as a mismatch between the number of packet filters subfield, and the number of packet filters in the packet filter list.

In case 3 the UE shall not diagnose an error, further process the replace request and, if no error according to items c and d was detected, include the packet filters received to the existing TFT.

In case 4 the UE shall not diagnose an error, further process the deletion request and, if no error according to items c and d was detected, consider the respective packet filter as successfully deleted.

Otherwise the UE shall reject the modification request with ESM cause #42 "syntactical error in the TFT operation".

c) Semantic errors in packet filters:

1) When a packet filter consists of conflicting packet filter components which would render the packet filter ineffective, i.e. no IP packet will ever fit this packet filter. How the UE determines a semantic error in a packet filter is outside the scope of the present document.

2) When the resulting TFT, which is assigned to a dedicated EPS bearer context, does not contain any packet filter applicable for the uplink direction among the packet filters created on request from the network.

The UE shall reject the modification request with ESM cause #44 "semantic errors in packet filter(s)".

d) Syntactical errors in packet filters:

1) When the *TFT operation* = "Create a new TFT", "Add packet filters to existing TFT", and two or more packet filters in the resultant TFT would have identical packet filter identifiers.

2) When the *TFT operation* = "Create a new TFT", "Add packet filters to existing TFT" or "Replace packet filters in existing TFT", and two or more packet filters among all TFTs associated with this PDN connection would have identical packet filter precedence values.

3) When there are other types of syntactical errors in the coding of packet filters, such as the use of a reserved value for a packet filter component identifier.

In case 1, if two or more packet filters with identical packet filter identifiers are contained in the new request, the UE shall reject the modification request with ESM cause #45 "syntactical errors in packet filter(s)". Otherwise, the UE shall not diagnose an error, further process the new request and, if it was processed successfully, delete the old packet filters which have the identical packet filter identifiers.

In case 2, if the old packet filters do not belong to the default EPS bearer context, the UE shall not diagnose an error, shall further process the new request and, if it was processed successfully, shall delete the old packet filters which have identical filter precedence values. Furthermore, the UE shall perform a UE requested bearer resource modification request procedure to deactivate the dedicated EPS bearer context(s) for which it has deleted the packet filters.

In case 2, if one or more old packet filters belong to the default EPS bearer context, the UE shall release the relevant PDN connection. If the relevant PDN connection is the last one that the UE has and EMM-REGISTERED without PDN connection is not supported by the UE or the MME, the UE shall detach and re-attach to the network.

Otherwise the UE shall reject the modification request with ESM cause #45 "syntactical errors in packet filter(s)".

Upon receipt of the MODIFY EPS BEARER CONTEXT REJECT message with ESM cause value other than #43 "invalid EPS bearer identity" in state BEARER CONTEXT MODIFY PENDING, the MME shall stop the timer T3486, enter the state BEARER CONTEXT ACTIVE and abort the EPS bearer context modification procedure. If the network receives the MODIFY EPS BEARER CONTEXT REJECT message with ESM cause #43 "invalid EPS bearer identity", the MME locally deactivates the EPS bearer context(s) without peer-to-peer ESM signalling.When the MME detects that after the failed EPS bearer context modification there is a misalignment between the EPS bearer configuration and the EPS bearer context configuration or between the QoS on NAS and AS level, the MME should initiate the necessary procedures to achieve a re-alignment.

6.4.3.5 Abnormal cases in the UE

Apart from the case described in subclause 6.3.3, no abnormal cases have been identified.

6.4.3.6 Abnormal cases on the network side

The following abnormal cases can be identified:

a) Expiry of timer T3486:

   On the first expiry of the timer T3486, the MME shall resend the MODIFY EPS BEARER CONTEXT REQUEST and shall reset and restart timer T3486. This retransmission is repeated four times, i.e. on the fifth expiry of timer T3486, the MME shall abort the procedure and enter the state BEARER CONTEXT ACTIVE.

   The MME may continue to use the previous configuration of the EPS bearer context or initiate an EPS bearer context deactivation procedure.

b) Collision of UE requested PDN disconnect procedure and EPS bearer context modification:

   When the MME receives a PDN DISCONNECT REQUEST message during an EPS bearer context modification procedure, and the EPS bearer to be modified belongs to the PDN connection the UE wants to disconnect, the MME shall terminate the EPS bearer context modification procedure locally, release any resources related to this procedure and proceed with the PDN disconnect procedure.

6.4.4 EPS bearer context deactivation procedure

6.4.4.1 General

The purpose of the EPS bearer context deactivation procedure is to deactivate an EPS bearer context or disconnect from a PDN by deactivating all EPS bearer contexts to the PDN. The EPS bearer context deactivation procedure is initiated by the network, and it may be triggered by the UE by means of the UE requested bearer resource modification procedure or UE requested PDN disconnect procedure.

In the case of EPS bearer context deactivation with reactivation requested for a PDN connection, if no NAS signalling connection exists, the MME follows the procedures for re-establishing the NAS signalling connection and deactivating the EPS bearer contexts to the PDN with reactivation requested, as specified in 3GPP TS 23.401 [10] subclauses 5.4.4.1 and 5.10.3 and 3GPP TS 23.380 [33] subclause 5.4.2.1.

If a UE is receiving emergency bearer services from a CSG cell, and the CSG subscription expires or is removed, the MME shall deactivate all non-emergency EPS bearers if any. The MME shall not deactivate the emergency EPS bearers.

If a detach is requested by the HSS for a UE that has bearers for emergency services, the MME shall send a DEACTIVATE EPS BEARER CONTEXT REQUEST message to the UE for all bearers that are not allocated for emergency services.

6.4.4.2 EPS bearer context deactivation initiated by the network

If a NAS signalling connection exists when the MME initiates the EPS bearer context deactivation procedure, the MME shall initiate the EPS bearer context deactivation procedure by sending a DEACTIVATE EPS BEARER CONTEXT REQUEST message to the UE, start the timer T3495, and enter the state BEARER CONTEXT INACTIVE PENDING (see example in figure 6.4.4.2.1). The DEACTIVATE EPS BEARER CONTEXT REQUEST message contains an ESM cause typically indicating one of the following:

#8: operator determined barring;

#26: insufficient resources;

#29: user authentication or authorization failed;

#36: regular deactivation;

#38: network failure;

#39: reactivation requested;

#112: APN restriction value incompatible with active EPS bearer context; or

#113: Multiple accesses to a PDN connection not allowed.

If the deactivation is triggered by a UE initiated bearer resource modification procedure or UE requested PDN disconnect procedure, the DEACTIVATE EPS BEARER CONTEXT REQUEST message shall contain the procedure transaction identity (PTI) value received by the MME in the BEARER RESOURCE MODIFICATION REQUEST or PDN DISCONNECT REQUEST respectively.

When the MME wants to deactivate all EPS bearer contexts of a PDN connection and thus disconnect the UE from the PDN, the MME shall include the EPS bearer identity of the default bearer associated to the PDN in the DEACTIVATE EPS BEARER CONTEXT REQUEST message. In this case, the MME shall not include the WLAN offload indication in the DEACTIVATE EPS BEARER CONTEXT REQUEST message, and if the UE receives the WLAN offload indication, the UE shall ignore the indication.

If no NAS signalling connection exists when the MME initiates the EPS bearer context deactivation, the ESM entity in the MME shall locally deactivate the EPS bearer context towards the UE without any peer-to-peer ESM signalling between the MME and the UE.

NOTE: The EPS bearer context state(s) can be synchronized between the UE and the MME at the next EMM-IDLE to EMM-CONNECTED transition, e.g. during a service request or tracking area updating procedure.

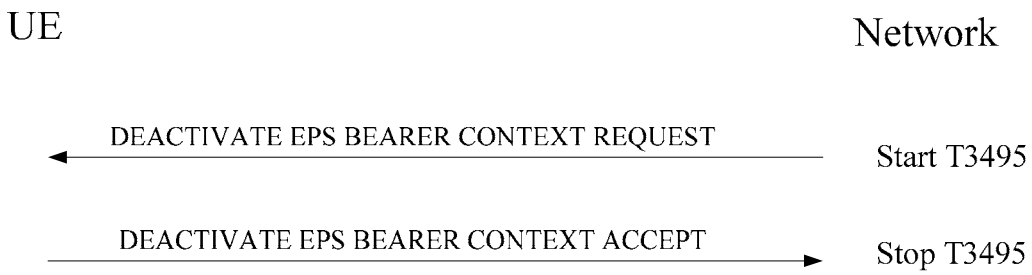


Figure 6.4.4.2.1: EPS bearer context deactivation procedure

6.4.4.3 EPS bearer context deactivation accepted by the UE

Upon receipt of the DEACTIVATE EPS BEARER CONTEXT REQUEST message, the UE shall delete the EPS bearer context identified by the EPS bearer identity. After deactivating the identified EPS bearer context, the UE shall respond to the MME with the DEACTIVATE EPS BEARER CONTEXT ACCEPT.

If the EPS bearer identity indicated in the DEACTIVATE EPS BEARER CONTEXT REQUEST is that of the default bearer to a PDN, the UE shall delete all EPS bearer contexts associated to the PDN. After deactivating all EPS bearer contexts, the UE shall respond to the MME with the DEACTIVATE EPS BEARER CONTEXT ACCEPT.

Upon sending the DEACTIVATE EPS BEARER CONTEXT ACCEPT message, the UE shall enter the state BEARER CONTEXT INACTIVE. If due to the EPS bearer context deactivation only the PDN connection for emergency bearer services remains established, the UE shall consider itself attached for emergency bearer services only.

If the DEACTIVATE EPS BEARER CONTEXT REQUEST includes ESM cause #39 "reactivation requested" and the EPS bearer context is a default EPS bearer context, and the UE provided an APN for the establishment of the PDN connection, the UE shall stop timer T3396 if it is running for the APN provided by the UE. The UE should then re-initiate the UE requested PDN connectivity procedure for the same APN as the deactivated default EPS bearer context to reactivate the EPS bearer context. If the UE did not provide an APN for the establishment of the PDN connection and the request type was different from "emergency" and from "handover of emergency bearer services", the UE shall stop the timer T3396 associated with no APN if it is running, and should re-initiate the UE requested PDN connectivity procedure without including an APN. Additionally, the UE should re-initiate the request(s) for dedicated bearer resources that have been activated on request of the UE and released as a result of this EPS bearer context deactivation procedure. If the DEACTIVATE EPS BEARER CONTEXT REQUEST message was received for an emergency PDN connection, the UE shall not stop the timer T3396 associated with no APN if it is running. The UE should then re-initiate the UE requested PDN connectivity procedure for the emergency PDN connection.

NOTE 1: User interaction is necessary in some cases when the UE cannot re-activate the EPS bearer context(s) automatically.

NOTE 2: The UE behaviour is not specified for the case where the DEACTIVATE EPS BEARER CONTEXT REQUEST includes ESM cause #39 "reactivation requested" and the deactivated EPS bearer context was a dedicated EPS bearer context.

If the DEACTIVATE EPS BEARER CONTEXT REQUEST message contains a PTI value other than "no procedure transaction identity assigned" and "reserved" (see 3GPP TS 24.007 [12]), the UE uses the PTI to identify the UE requested bearer resource modification procedure or UE requested PDN disconnect procedure to which the EPS bearer context deactivation is related (see subclause 6.5.4).

If the DEACTIVATE EPS BEARER CONTEXT REQUEST message contains a PTI value other than "no procedure transaction identity assigned" and "reserved" (see 3GPP TS 24.007 [12]), the UE shall release the traffic flow aggregate description associated to the PTI value provided.

If the ESM cause value is #26 "insufficient resources", the network may include a value for timer T3396 in the DEACTIVATE EPS BEARER CONTEXT REQUEST message. The UE shall take different actions depending on the timer value received for timer T3396 (if the UE is configured for dual priority, exceptions are specified in subclause 6.5.5; if the UE is a UE configured to use AC11 – 15 in selected PLMN, exceptions are specified in subclause 6.3.5):

i) if the timer value indicates neither zero nor deactivated, the UE shall stop timer T3396 associated with the corresponding APN, if it is running. The UE shall start timer T3396 with received value and not send another PDN CONNECTIVITY REQUEST, BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message for the same APN until timer T3396 expires or the timer T3396 is stopped. If the UE did not provide an APN for the establishment of the PDN connection and the request type was different from "emergency" and from "handover of emergency bearer services", the UE shall stop timer T3396 associated with no APN, if it is running. The UE shall start timer T3396 with the received value and not send another PDN CONNECTIVITY REQUEST message without an APN and with request type different from "emergency" and from "handover of emergency bearer services", or another BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message for a non-emergency PDN connection established without an APN provided by the UE, until timer T3396 expires or timer T3396 is stopped. The UE shall not stop timer T3396 upon a PLMN change or inter-system change;

ii) if the timer value indicates that this timer is deactivated, the UE shall not send another PDN CONNECTIVITY REQUEST, BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION

REQUEST message for the same APN until the UE is switched off or the USIM is removed, or the UE receives an ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST, ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST or MODIFY EPS BEARER CONTEXT REQUEST message for the same APN from the network or a DEACTIVATE EPS BEARER CONTEXT REQUEST message including ESM cause #39 "reactivation requested" for a default EPS bearer context for the same APN from the network. If the UE did not provide an APN for the establishment of the PDN connection and the request type was different from "emergency" and from "handover of emergency bearer services", the UE shall not send another PDN CONNECTIVITY REQUEST message without an APN and with request type different from "emergency" and from "handover of emergency bearer services", or another BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message for a non-emergency PDN connection established without APN provided by the UE , until the UE is switched off or the USIM is removed, or the UE receives an ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST, ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST or MODIFY EPS BEARER CONTEXT REQUEST message for a non-emergency PDN connection established without an APN provided by the UE, or a DEACTIVATE EPS BEARER CONTEXT REQUEST message including ESM cause #39 "reactivation requested" for a default EPS bearer context of a non-emergency PDN connection established without an APN provided by the UE. The timer T3396 remains deactivated upon a PLMN change or inter-system change; and

iii) if the timer value indicates zero, the UE:

- shall stop timer T3396 associated with the corresponding APN, if running, and may send another PDN CONNECTIVITY REQUEST, BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message for the same APN; and

- if the UE did not provide an APN for the establishment of the PDN connection and the request type was different from "emergency" and from "handover of emergency bearer services", the UE shall stop timer T3396 associated with no APN, if running, and may send another PDN CONNECTIVITY REQUEST message without an APN, or another BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message for a non-emergency PDN connection established without an APN provided by the UE.

If the timer T3396 is running when the UE enters state EMM-DEREGISTERED, the UE remains switched on, and the USIM in the UE remains the same, then timer T3396 is kept running until it expires or it is stopped.

If the UE is switched off when the timer T3396 is running, the UE shall behave as follows when the UE is switched on and the USIM in the UE remains the same:

- let t1 be the time remaining for T3396 timeout at switch off and let t be the time elapsed between switch off and switch on. If t1 is greater than t, then the timer shall be restarted with the value t1 – t. If t1 is equal to or less than t, then the timer need not be restarted. If the UE is not capable of determining t, then the UE shall restart the timer with the value t1;

- if prior to switch off, timer T3396 was running for a specific APN, because a PDN CONNECTIVITY REQUEST, BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message containing the low priority indicator set to "MS is configured for NAS signalling low priority" was rejected with timer T3396, and if timer T3396 is restarted at switch on, then the UE configured for dual priority shall handle session management requests as indicated in subclause 6.5.5; and

- if prior to switch off timer T3396 was running because a PDN CONNECTIVITY REQUEST without APN sent together with an ATTACH REQUEST message containing the low priority indicator set to "MS is configured for NAS signalling low priority" was rejected with timer T3396, and if timer T3396 is restarted at switch on, then the UE configured for dual priority shall handle session management requests as indicated in subclause 6.5.5.

If the T3396 IE is not included, the UE shall proceed with deactivation procedure and then send DEACTIVATE EPS BEARER CONTEXT ACCEPT message.

Upon receipt of the DEACTIVATE EPS BEARER CONTEXT ACCEPT message, the MME shall enter the state BEARER CONTEXT INACTIVE and stop the timer T3495.

6.4.4.4 Abnormal cases in the UE

The following abnormal case can be identified:

a) UE is requested to deactivate a default EPS bearer context of the last PDN connection:

If EMM-REGISTERED without PDN connection is not supported by the UE or the MME, and the UE determines that the EPS bearer indicated in the DEACTIVATE EPS BEARER CONTEXT REQUEST message is the default EPS bearer of the last PDN connection that the UE has, then the UE shall respond by performing a detach procedure. Additionally, the UE should perform an attach procedure.

If EMM-REGISTERED without PDN connection is supported by the UE and the MME, the UE shall proceed with the deactivation procedure as specified in subclause 6.4.4.3.

NOTE: User interaction is necessary in some cases when the UE cannot re-activate the EPS bearer(s), if any, automatically.

6.4.4.5 Abnormal cases on the network side

The following abnormal cases can be identified:

a) Expiry of timer T3495:

On the first expiry of the timer T3495, the MME shall resend the DEACTIVATE EPS BEARER CONTEXT REQUEST and shall reset and restart timer T3495. This retransmission is repeated four times, i.e. on the fifth expiry of timer T3495, the MME shall abort the procedure and deactivate the EPS bearer context locally without any peer-to-peer ESM signalling between the MME and the UE.

b) Collision of UE requested PDN disconnect procedure and EPS bearer context deactivation:

When the MME receives a PDN DISCONNECT REQUEST message during the EPS bearer context deactivation procedure, and the EPS bearer indicated in the DEACTIVATE EPS BEARER CONTEXT REQUEST message is a dedicated EPS bearer belonging to the PDN connection the UE wants to disconnect, the MME shall proceed with both procedures. If the EPS bearer indicated in the DEACTIVATE EPS BEARER CONTEXT REQUEST message is the default EPS bearer, the MME shall proceed with the EPS bearer context deactivation procedure.

6.4.4.6 Local EPS bearer context deactivation without NAS signalling

The UE and the MME deactivate EPS bearer contexts locally without peer-to-peer ESM signalling in the following cases:

1) during the service request procedure, if the E-UTRAN establishes the user plane radio bearers for one or more EPS bearer contexts but not for all the EPS bearer contexts, e.g. due to radio access control (see subclause 5.6.1.4 for details);

1a) during the resume of NAS signalling connection procedure as specified in subclause 5.3.1.3, if one or more but not all the suspended user plane radio bearers are resumed;

2) during the tracking area updating procedure with "active" flag, or without "active" flag but the network established the user plane radio bearers due to downlink pending data, if the E-UTRAN establishes the user plane radio bearers for one or more EPS bearer contexts but not for all the EPS bearer contexts indicated active by both UE and network;

NOTE 1: The synchronisation of the EPS bearers, for which the user plane radio bearers need to be established, indicated in EPS bearer context status information element in TRACKING AREA UPDATE ACCEPT message is not applicable in item 2.

3) during handover, if the target E-UTRAN does not establish all the user plane radio bearers for the UE;

4) if the E-UTRAN releases one or more user plane radio bearers but not all the user plane radio bearers of the UE due to E-UTRAN specific reasons; or

5) if triggered by an NBIFOM procedure (see 3GPP TS 24.161 [36]), for an NBIFOM multi-access PDN connection.

For cases 1) to 4), based on the indication from the lower layers, the UE and the MME shall locally deactivate the EPS bearer contexts for which no user plane radio bearers are set up.

NOTE 2: The above cases 1) to 4) do not apply for the UE when an RRC connection release occurs. The lower layers in the UE provide the user plane radio bearer context status to the ESM sublayer when a change in the user plane radio bearers is detected by the lower layers including establishment and release of user plane radio bearers for the UE in connected mode.

NOTE 3: The above cases 1) to 4) do not apply for the MME when the S1 release procedure occurs as specified in 3GPP TS 23.401 [10]).

If due to any of the cases described above the UE locally deactivates a default EPS bearer context, the UE shall locally deactivate all EPS bearer contexts associated to the PDN connection with the default EPS bearer context.

If the UE locally deactivates the EPS bearer context(s) of the last remaining PDN connection, and EMM-REGISTERED without PDN connection is not supported by the UE or the MME, the UE shall perform a local detach and enter state EMM-DEREGISTERED. If this occurs during a service request procedure for CS fallback, the UE shall reselect to GERAN or UTRAN and continue with the CS service, otherwise the UE shall initiate an attach procedure.

If the UE locally deactivates the EPS bearer context(s) of the last remaining PDN connection, and EMM-REGISTERED without PDN connection is supported by the UE and the MME, the UE shall enter state EMM-REGISTERED.

If the UE locally deactivates the EPS bearer context(s) of the last remaining PDN connection for non-emergency bearer services and only the PDN connection for emergency bearer services remains established, the UE shall consider itself attached for emergency bearer services only.

The MME shall deactivate the GBR EPS bearer contexts locally without peer-to-peer ESM signalling, when the MME performs locally the release of the S1AP signalling connection due to the S1AP signalling connection is lost. All non-GBR EPS bearers established are preserved in the MME and in the PDN GW.

If the E-UTRAN requests the MME to release the S1AP signalling connection, the MME shall deactivate or preserve the GBR EPS bearer contexts according to 3GPP TS 23.401 [10], subclause 5.3.5. All non-GBR EPS bearer contexts established are preserved in the MME and in the PDN GW.

NOTE 4: The UE and the MME will synchronize the EPS bearer contexts subsequently during the next service request procedure, tracking area updating procedure or routing area updating procedure.

If due to any of the cases described above the MME locally deactivates a default EPS bearer context, the MME shall locally deactivate all EPS bearer contexts associated to the PDN connection with the default EPS bearer context without peer-to-peer ESM signalling to the UE.

If the MME locally deactivates the EPS bearer context(s) of the last remaining PDN connection, and EMM-REGISTERED without PDN connection is not supported by the UE or the MME, the MME shall perform a local detach and enter state EMM-DEREGISTERED.

If the MME locally deactivates the EPS bearer context(s) of the last remaining PDN connection, and EMM-REGISTERED without PDN connection is supported by the UE and the MME, the MME shall enter state EMM-REGISTERED.

For EPS bearer context deactivation procedure initiated by the network, if no NAS signalling connection exists, the MME locally deactivates the EPS bearer context(s) without peer-to-peer ESM signalling In the case of reactivation requested, the MME can perform this local deactivation only when the EMM-entity in the network was unable to re-establish the NAS signalling connection. The EPS bearer context deactivation procedure is not initiated by the network when the MME disconnects the UE from the last remaining PDN to which it is connected and EMM-REGISTERED without PDN connection is not supported by the UE or the MME. In this case, the MME initiates a network initiated detach procedure.

If the MME locally deactivates the EPS bearer context(s) of the last remaining PDN connection for non-emergency bearer services and only the PDN connection for emergency bearer services remains established for the UE, the MME shall consider the UE to be attached for emergency bearer services only.

6.5 UE requested ESM procedures

6.5.0 General

The UE's maximum number of active EPS bearer contexts in a PLMN is determined by whichever is the lowest of the maximum number of EPS bearer identities allowed by the protocol (as specified in 3GPP TS 24.007 [12] subclause 11.2.3.1.5), the PLMN's maximum number of EPS bearer contexts in S1 mode and the UE's implementation-specific maximum number of EPS bearer contexts.

NOTE 1: Subclauses 6.5.1.4 and 6.5.3.4 specify how the UE determines the PLMN's maximum number of EPS bearer contexts in S1 mode.

In earlier versions of the protocol, the maximum number of simultaneously active EPS bearer contexts was limited by lower layer protocols to 8.

In the present version of the protocol, the UE and the network may support a maximum number of 15 EPS bearer contexts.

A UE supporting signalling for a maximum number of 15 EPS bearer contexts shall support the extended range or EPS bearer identities from 0 to 15 (as specified in 3GPP TS 24.007 [12] subclause 11.2.3.1.5). The UE indicates support of signalling for a maximum number of 15 EPS bearer contexts by setting the 15 bearers bit in the UE Network Capability IE.

A network supporting signalling for a maximum number of 15 EPS bearer contexts shall support the extended range or EPS bearer identities from 0 to 15 (as specified in 3GPP TS 24.007 [12] subclause 11.2.3.1.5). The network indicates support of signalling for a maximum number of 15 EPS bearer contexts by setting the 15 bearers bit in the EPS network feature support IE.

NOTE 2: A UE and a network not supporting signalling for a maximum number of 15 EPS bearer contexts will treat the EPS bearer identity values 1 to 4 as 'reserved' values.

6.5.1 UE requested PDN connectivity procedure

6.5.1.1 General

The purpose of the UE requested PDN connectivity procedure is for a UE to request the setup of a default EPS bearer to a PDN. The UE requests connectivity to a PDN by sending a PDN CONNECTIVITY REQUEST message to the network. If accepted by the network, this procedure initiates the establishment of a default EPS bearer context. If EMM-REGISTERED without PDN connection is not supported by the UE or the MME, the procedure is used either to establish the first default bearer by including the PDN CONNECTIVITY REQUEST message into the initial attach message, or to establish subsequent default bearers to additional PDNs in order to allow the UE simultaneous access to multiple PDNs by sending the message stand-alone. If EMM-REGISTERED without PDN connection is supported by the UE and the MME, the procedure is used to establish the first or subsequent default bearers to a PDN or additional PDNs by sending the PDN CONNECTIVITY REQUEST message stand-alone.

If the UE requests PDN connectivity for emergency bearer services, the MME shall not check for regional restrictions or subscription restrictions when processing the PDN CONNECTIVITY REQUEST message.

If there is already a PDN connection for emergency bearer services established, the UE shall not request an additional PDN connection for emergency bearer services.

A UE attached for emergency bearer services shall not request a PDN connection to any other PDN.

The UE may also initiate the UE requested PDN connectivity procedure to add 3GPP access to the PDN connection which is already established over WLAN as specified in the subclause 6.2.2 of 3GPP TS 23.161 [34].

6.5.1.2 UE requested PDN connectivity procedure initiation

In order to request connectivity to a PDN, the UE shall send a PDN CONNECTIVITY REQUEST message to the MME, start timer T3482 and enter the state PROCEDURE TRANSACTION PENDING (see example in figure 6.5.1.2.1).

When the PDN CONNECTIVITY REQUEST message is sent together with an ATTACH REQUEST message, the UE shall not start timer T3482 and shall not include the APN.

NOTE 1: If the UE needs to provide protocol configuration options which require ciphering or provide an APN, or both, during the attach procedure, the ESM information transfer flag is included in the PDN CONNECTIVITY REQUEST. The MME then at a later stage in the PDN connectivity procedure initiates the ESM information request procedure in which the UE can provide the MME with protocol configuration options or APN or both.

In order to request a PDN connection for emergency bearer services, the UE shall not include an APN in the PDN CONNECTIVITY REQUEST message or, when applicable, in the ESM INFORMATION RESPONSE message.

In order to request connectivity to a PDN using the default APN, the UE includes the access point name IE in the PDN CONNECTIVITY REQUEST message or, when applicable, in the ESM INFORMATION RESPONSE message, according to the following conditions:

- if use of a PDN using the default APN requires PAP/CHAP, then the UE should include the Access point name IE; and

- in all other conditions, the UE need not include the Access point name IE.

In order to request connectivity to an additional PDN using a specific APN, the UE shall include the requested APN in the PDN CONNECTIVITY REQUEST message.

In the PDN type IE the UE shall either indicate the IP version capability of the IP stack associated with the UE or non IP as specified in subclause 6.2.2.

If the PDN type value of the PDN type IE is set to IPv4 or IPv6 or IPv4v6 and the UE indicates "Control plane CIoT EPS optimization supported" in the UE network capability IE of the ATTACH REQUEST message, the UE may include the Header compression configuration IE in the PDN CONNECTIVITY REQUEST message.

The UE shall set the request type to "initial request" when the UE is establishing a new PDN connectivity to a PDN in an attach procedure or in a stand-alone PDN connectivity procedure. The UE shall set the request type to "emergency" when the UE is requesting a new PDN connectivity for emergency bearer services. The UE shall set the request type to "handover" when the connectivity to a PDN is to be transferred from a non-3GPP access network to the 3GPP access network, or when the UE initiates the procedure to add 3GPP access to the PDN connection which is already established over WLAN. The UE shall set the request type to "handover of emergency bearer services" when a PDN connection for emergency bearer services is to be transferred from a WLAN to the 3GPP access network.

If the UE supports DSMIPv6, the UE may include a request for obtaining the IPv6 address and optionally the IPv4 address of the home agent in the Protocol configuration options IE in the PDN CONNECTIVITY REQUEST message. The UE may also include a request for obtaining the IPv6 Home Network Prefix. The UE shall request the IPv6 Home Network Prefix only if the UE has requested the home agent IPv6 address. The requested home agent address(es) and the Home Network Prefix are related to the APN the UE requested connectivity for.

The UE may set the ESM information transfer flag in the PDN CONNECTIVITY REQUEST message to indicate that it has ESM information, i.e. protocol configuration options, APN, or both, that needs to be sent after the NAS signalling security has been activated between the UE and the MME.

If the UE supports A/Gb mode or Iu mode or both, the UE shall indicate the support of the network requested bearer control procedures (see 3GPP TS 24.008 [13]) in A/Gb mode or Iu mode in the protocol configuration options IE.

If the UE supports N1 mode, the UE shall generate a PDU session ID and include it in the protocol configuration options IE or the extended protocol configuration options IE.

Protocol configuration options provided in the ESM INFORMATION RESPONSE message replace any protocol configuration options provided in the PDN CONNECTIVITY REQUEST message.

When the UE initiates the procedure to add 3GPP access to the PDN connection that is already established over WLAN, the UE shall provide the same APN as that of the PDN connection established over WLAN in the PDN connectivity procedure as specified in the subclause 6.2.2 of 3GPP TS 23.161 [34].

If the UE supports APN rate control, the UE shall include an APN rate control support indicator and an additional APN rate control for exception data support indicator in the protocol configuration options IE or extended protocol configuration options IE.

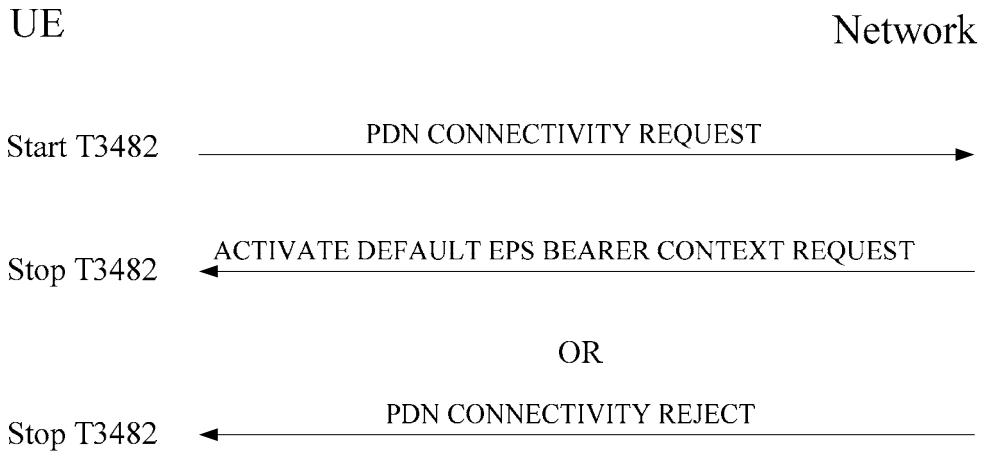


Figure 6.5.1.2.1: UE requested PDN connectivity procedure

6.5.1.3 UE requested PDN connectivity procedure accepted by the network

Upon receipt of the PDN CONNECTIVITY REQUEST message, the MME checks whether the ESM information transfer flag is included. If the flag is included the MME waits for completion of the ESM information request procedure before proceeding with the PDN connectivity procedure. The MME then checks if connectivity with the requested PDN can be established. If no requested APN is included in the PDN CONNECTIVITY REQUEST message or the ESM INFORMATION RESPONSE message and the request type is different from "emergency" and from "handover of emergency bearer services", the MME shall use the default APN as the requested APN. If the request type is "emergency" or "handover of emergency bearer services", the MME shall use the APN configured for emergency bearer services or select the statically configured PDN GW for unauthenticated UEs, if applicable.

If the network receives a PDN CONNECTIVITY REQUEST message with the same combination of APN and PDN type as an already existing PDN connection, and multiple PDN connections for a given APN are allowed, the network retains the existing EPS bearer contexts for the PDN connection and proceeds with the requested PDN connectivity procedure.

If the lower layers provide a GW Transport Layer Address value identifying a L-GW together with the PDN CONNECTIVITY REQUEST message and a PDN connection is established as a LIPA PDN connection due to the PDN CONNECTIVITY REQUEST message, then the MME shall store the GW Transport Layer Address value as the P-GW address in the EPS bearer context of the LIPA PDN connection.

If the lower layers provide a SIPTO L-GW Transport Layer Address value identifying a L-GW together with the PDN CONNECTIVITY REQUEST message and a PDN connection is established as a SIPTO at the local network PDN connection due to the PDN CONNECTIVITY REQUEST message, then the MME shall store the SIPTO L-GW Transport Layer Address value as the P-GW address in the EPS bearer context of the SIPTO at the local network PDN connection.

If the lower layers provide a LHN-ID value together with the PDN CONNECTIVITY REQUEST message and a PDN connection is established as a SIPTO at the local network PDN connection due to the PDN CONNECTIVITY REQUEST message, then the MME shall store the LHN-ID value in the EPS bearer context of the SIPTO at the local network PDN connection.

NOTE: The receipt of a LHN-ID value during the establishment of the PDN connection, during tracking area updating procedure or during inter-MME handover can be used as an indication by the MME that the SIPTO at the local nework PDN connection is established to a stand-alone GW (see 3GPP TS 23.401 [10]).

If connectivity with the requested PDN is accepted by the network, the MME shall initiate the default EPS bearer context activation procedure (see subclause 6.4.1).

If connectivity with the requested PDN is accepted and the network considers this PDN connection a LIPA PDN connection, then subject to operator policy the MME shall include in the ACTIVATE DEFAULT EPS BEARER

CONTEXT REQUEST message the Connectivity type IE indicating "the PDN connection is considered a LIPA PDN connection".

If connectivity with the requested PDN is accepted, but with a restriction of IP version (i.e. both an IPv4 address and an IPv6 prefix is requested, but only one particular IP version, or only single IP version bearers are supported/allowed by the network), ESM cause #50 "PDN type IPv4 only allowed", #51 "PDN type IPv6 only allowed", or #52 "single address bearers only allowed", respectively, shall be included in the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message.

If connectivity with the requested PDN is accepted and the UE provided the Header compression configuration IE in the PDN CONNECTIVITY REQUEST message, the MME may include the Header compression configuration IE in the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message. Furthermore, if the MME decides that the associated PDN connection is only for control plane CIoT EPS optimization (see subclause 5.3.15), the MME shall include the Control plane only indication in the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message.

Upon receipt of the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message, the UE shall stop timer T3482 and enter the state PROCEDURE TRANSACTION INACTIVE. The UE should ensure that the procedure transaction identity (PTI) assigned to this procedure is not released immediately. The way to achieve this is implementation dependent. While the PTI value is not released, the UE regards any received ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message with the same PTI value as a network retransmission (see subclause 7.3.1).

Upon receipt of the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message with the Connectivity type IE indicating "the PDN connection is considered a LIPA PDN connection", the UE provides an indication to the upper layers that the connectivity is provided by a LIPA PDN connection.

Upon receipt of the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message, if the 3GPP PS data off UE status is "activated", the UE behaves as described in subclause 6.3.10.

Upon receipt of the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message, if the SCEF or P-GW indicates acceptance of use of Reliable Data Service to transfer data for the PDN connection, the UE behaves as described in subclause 6.3.11.

Upon receipt of the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message, if an S-NSSAI and the PLMN ID that this S-NSSAI relates to are provided in the protocol configuration options IE or extended protocol configuration options IE, the UE shall store the S-NSSAI and the associated PLMN ID along with the corresponding PDU session ID that the UE provided in the PDN CONNECTIVITY REQUEST message. The usage of the PDU session ID and the corresponding S-NSSAI with the associated PLMN ID is specified in 3GPP TS 24.501 [54].

Upon receipt of the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message with a session-AMBR and QoS rule(s), which correspond to the default EPS bearer of the PDN connectivity being activated, in the protocol configuration options IE or the extended protocol configuration options IE, the UE stores the session-AMBR and QoS rule(s) for use during inter-system change from S1 mode to N1 mode.

6.5.1.4 UE requested PDN connectivity procedure not accepted by the network

6.5.1.4.1 General

If connectivity with the requested PDN cannot be accepted by the network, the MME shall send a PDN CONNECTIVITY REJECT message to the UE. The message shall contain the PTI and an ESM cause value indicating the reason for rejecting the UE requested PDN connectivity.

The ESM cause IE typically indicates one of the following ESM cause values:

#8: operator determined barring;

#26: insufficient resources;

#27: missing or unknown APN;

#28: unknown PDN type;

#29: user authentication or authorization failed;

#30: request rejected by Serving GW or PDN GW;

#31: request rejected, unspecified;

#32: service option not supported;

#33: requested service option not subscribed;

#34: service option temporarily out of order;

#35: PTI already in use;

#38: network failure;

#50: PDN type IPv4 only allowed;

#51: PDN type IPv6 only allowed;

#53: ESM information not received;

#54: PDN connection does not exist;

#55: multiple PDN connections for a given APN not allowed;

#57: PDN type IPv4v6 only allowed;

#58: PDN type non IP only allowed;

#65: maximum number of EPS bearers reached;

#66: requested APN not supported in current RAT and PLMN combination;

#95 – 111: protocol errors;

#112: APN restriction value incompatible with active EPS bearer context;

#113: Multiple accesses to a PDN connection not allowed.

The network may include a Back-off timer value IE in the PDN CONNECTIVITY REJECT message. If the ESM cause value is #26 "insufficient resources" and the PDN CONNECTIVITY REQUEST message was received via a NAS signalling connection established with RRC establishment cause "High priority access AC 11 – 15" or the request type in the PDN CONNECTIVITY REQUEST message was set to "emergency" or "handover of emergency bearer services", the network shall not include a Back-off timer value IE.

If the Back-off timer value IE is included and the ESM cause value is different from #26 "insufficient resources", #50 "PDN type IPv4 only allowed", #51 "PDN type IPv6 only allowed", #57 "PDN type IPv4v6 only allowed", #58 "PDN type non IP only allowed" and #65 "maximum number of EPS bearers reached", the network may include the Re-attempt indicator IE to indicate whether the UE is allowed to attempt a PDP context activation procedure in the PLMN for the same APN in A/Gb or Iu mode, and whether another attempt in A/Gb and Iu mode or in S1 mode is allowed in an equivalent PLMN.

If the ESM cause value is #50 "PDN type IPv4 only allowed", #51 "PDN type IPv6 only allowed", #57 "PDN type IPv4v6 only allowed" or #58 "PDN type non IP only allowed", the network may include the Re-attempt indicator IE without Back-off timer value IE to indicate whether the UE is allowed to attempt a PDN connectivity procedure in an equivalent PLMN for the same APN in S1 mode using the same PDN type.

If the ESM cause value is #66 "requested APN not supported in current RAT and PLMN combination", the network may include the Re-attempt indicator IE without Back-off timer value IE to indicate whether the UE is allowed to attempt a PDN connectivity procedure in an equivalent PLMN for the same APN in S1 mode.

Upon receipt of the PDN CONNECTIVITY REJECT message, the UE shall stop timer T3482 and enter the state PROCEDURE TRANSACTION INACTIVE.

If the PDN CONNECTIVITY REJECT message is due to an ESM failure notified by EMM layer (i.e., EMM cause #19 "ESM failure" included in an ATTACH REJECT message), the UE may include a different APN in the PDN CONNECTIVITY REQUEST message.

NOTE 1: When receiving EMM cause #19 "ESM failure", coordination is required between the EMM and ESM sublayers in the UE to notify the ESM failure.

If the PDN CONNECTIVITY REQUEST message was sent with request type set to "emergency" or "handover of emergency bearer services" in a stand-alone PDN connectivity procedure and the UE receives a PDN CONNECTIVITY REJECT message, then the UE may:

a) inform the upper layers of the failure to establish the emergency bearer; or

NOTE 2: This can result in the upper layers requesting establishment of a CS emergency call (if not already attempted in the CS domain) or other implementation specific mechanisms, e.g. procedures specified in 3GPP TS 24.229 [13D] can result in the emergency call being attempted to another IP-CAN.

b) detach locally, if not detached already, attempt EPS attach for emergency bearer services.

6.5.1.4.2 Handling of network rejection due to ESM cause #26

If the ESM cause value is #26 "insufficient resources" and the Back-off timer value IE is included, the UE shall ignore the Re-attempt indicator IE provided by the network, if any, and behave as follows:

1) if the PDN CONNECTIVITY REQUEST message was sent standalone, the UE shall take different actions depending on the timer value received for timer T3396 in the Back-off timer value IE (if the UE is configured for dual priority, exceptions are specified in subclause 6.5.5; if the UE is a UE configured to use AC11 – 15 in selected PLMN, exceptions are specified in subclause 6.3.5):

   i) if the timer value indicates neither zero nor deactivated and an APN was included in the PDN CONNECTIVITY REQUEST message, the UE shall stop timer T3396 associated with the corresponding APN, if it is running. If the timer value indicates neither zero nor deactivated and no APN was included in the PDN CONNECTIVITY REQUEST message, the UE shall stop timer T3396 associated with no APN if it is running. The UE shall then start timer T3396 with the value provided in the Back-off timer value IE and:

      - shall not send another PDN CONNECTIVITY REQUEST, BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message for the same APN that was sent by the UE, until timer T3396 expires or timer T3396 is stopped; and

      - shall not send another PDN CONNECTIVITY REQUEST message without an APN and with request type different from "emergency" and from "handover of emergency bearer services", or another BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST for a non-emergency PDN connection established without an APN provided by the UE, if no APN was included in the PDN CONNECTIVITY REQUEST message and the request type was different from "emergency" and from "handover of emergency bearer services", until timer T3396 expires or timer T3396 is stopped.

      The UE shall not stop timer T3396 upon a PLMN change or inter-system change;

   ii) if the timer value indicates that this timer is deactivated, the UE:

      - shall not send another PDN CONNECTIVITY REQUEST, BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message for the same APN until the UE is switched off or the USIM is removed, or the UE receives an ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST, ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST or MODIFY EPS BEARER CONTEXT REQUEST message for the same APN from the network or a DEACTIVATE EPS BEARER CONTEXT REQUEST message including ESM cause #39 "reactivation requested" for a default EPS bearer context for the same APN from the network; and

      - shall not send another PDN CONNECTIVITY REQUEST message without an APN and with request type different from "emergency" and from "handover of emergency bearer services", or another BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message for a non-emergency PDN connection established without an APN provided by the UE, if no APN was included in the PDN CONNECTIVITY REQUEST message and the request type was different from "emergency" and from "handover of emergency bearer services", until the UE is switched off or the USIM is removed, or the UE receives an ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST, ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST or MODIFY EPS BEARER CONTEXT REQUEST message for a non-emergency PDN connection established without an APN provided by the UE, or a DEACTIVATE EPS BEARER CONTEXT REQUEST message including ESM

cause #39 "reactivation requested" for a default EPS bearer context of a non-emergency PDN connection established without an APN provided by the UE.

The timer T3396 remains deactivated upon a PLMN change or inter-system change; and

iii) if the timer value indicates zero, the UE:

- shall stop timer T3396 associated with the corresponding APN, if running, and may send another PDN CONNECTIVITY REQUEST, BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message for the same APN; and

- if no APN was included in the PDN CONNECTIVITY REQUEST message and the request type was different from "emergency" and from "handover of emergency bearer services", the UE shall stop timer T3396 associated with no APN, if running, and may send another PDN CONNECTIVITY REQUEST message without an APN, or another BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message for a non-emergency PDN connection established without an APN provided by the UE; and

2) if the PDN CONNECTIVITY REQUEST message was sent together with an ATTACH REQUEST, the UE shall take different actions depending on the timer value received for timer T3396 in the Back-off timer value IE and on the integrity protection of the ATTACH REJECT message (if the UE is configured for dual priority, exceptions are specified in subclause 6.5.5; if the UE is a UE configured to use AC11 – 15 in selected PLMN, exceptions are specified in subclause 6.3.5):

i) if the ATTACH REJECT message is not integrity protected and an APN was sent by the UE during the attach procedure, the UE shall stop timer T3396 associated with the corresponding APN if it is running. If the ATTACH REJECT message is not integrity protected, the request type was different from "emergency" and from "handover of emergency bearer services", and an APN was not sent by the UE, the UE shall stop timer T3396 associated with no APN if it is running. The UE shall then start timer T3396 with a random value from a default range specified in table 11.2.3 defined in 3GPP TS 24.008 [13], and:

a) shall not initiate a new attach procedure with the same APN or send another PDN CONNECTIVITY REQUEST with the same APN that was sent by the UE, until timer T3396 expires or timer T3396 is stopped; and

b) shall not initiate a new attach procedure without an APN and with request type different from "emergency" and from "handover of emergency bearer services" or send another PDN CONNECTIVITY REQUEST without an APN and with request type different from "emergency" and from "handover of emergency bearer services", if the UE did not provide any APN during the attach procedure and the request type was different from "emergency" and from "handover of emergency bearer services", until timer T3396 expires.

The UE shall not stop timer T3396 upon a PLMN change or inter-system change;

ii) if the ATTACH REJECT message is integrity protected, the UE shall proceed as follows:

a) if the timer value indicates neither zero nor deactivated and an APN was sent by the UE during the attach procedure, the UE shall stop timer T3396 associated with the corresponding APN if it is running. If the timer value indicates neither zero nor deactivated, the request type was different from "emergency" and from "handover of emergency bearer services", and an APN was not sent by the UE during the attach procedure, the UE shall stop timer T3396 associated with no APN if it is running. The UE shall then start timer T3396 with the value provided in the Back-off timer value IE and:

- shall not initiate a new attach procedure with the same APN or send another PDN CONNECTIVITY REQUEST with the same APN that was sent by the UE, until timer T3396 expires or timer T3396 is stopped; and

- shall not initiate a new attach procedure without an APN and with request type different from "emergency" and from "handover of emergency bearer services" or send another PDN CONNECTIVITY REQUEST without an APN and with request type different from "emergency" and from "handover of emergency bearer services", if the UE did not provide any APN during the attach procedure and the request type was different from "emergency" and from "handover of emergency bearer services", until timer T3396 expires.

The UE shall not stop timer T3396 upon a PLMN change or inter-system change;

b) if the timer value indicates that this timer is deactivated, the UE:

- shall not initiate a new attach procedure with the same APN or send another PDN CONNECTIVITY REQUEST with the same APN that was sent by the UE, until the UE is switched off or the USIM is removed, or the UE receives an ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message for the same APN from the network; and

- shall not initiate a new attach procedure without an APN and with request type different from "emergency" and from "handover of emergency bearer services" or send another PDN CONNECTIVITY REQUEST without an APN and with request type different from "emergency" and from "handover of emergency bearer services", if the UE did not provide any APN during the attach procedure and the request type was different from "emergency" and from "handover of emergency bearer services", until the UE is switched off or the USIM is removed, or the UE receives an ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message for a non-emergency PDN connection established without an APN provided by the UE.

The timer T3396 remains deactivated upon a PLMN change or inter-system change; and

c) if the timer value indicates that this timer is zero, the UE shall proceed as specified in subclause 5.5.1.2.6 item d.

If the Back-off timer value IE is not included and the PDN CONNECTIVITY REQUEST was sent standalone, then the UE may send another PDN CONNECTIVITY REQUEST, BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message for the same APN.

When the timer T3396 is running or the timer is deactivated, the UE is allowed to initiate an attach procedure or PDN connectivity procedure if the procedure is for emergency bearer services.

If the timer T3396 is running when the UE enters state EMM-DEREGISTERED, the UE remains switched on, and the USIM in the UE remains the same, then timer T3396 is kept running until it expires or it is stopped.

If the UE is switched off when the timer T3396 is running, and if the USIM in the UE remains the same when the UE is switched on, the UE shall behave as follows:

- let t1 be the time remaining for T3396 timeout at switch off and let t be the time elapsed between switch off and switch on. If t1 is greater than t, then the timer shall be restarted with the value t1 – t. If t1 is equal to or less than t, then the timer need not be restarted. If the UE is not capable of determining t, then the UE shall restart the timer with the value t1;

- if prior to switch off, timer T3396 was running for a specific APN, because a PDN CONNECTIVITY REQUEST, BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message containing the low priority indicator set to "MS is configured for NAS signalling low priority" was rejected with a timer value for timer T3396, and if timer T3396 is restarted at switch on, then the UE configured for dual priority shall handle session management requests as indicated in subclause 6.5.5; and

- if prior to switch off timer T3396 was running because a PDN CONNECTIVITY REQUEST without APN sent together with an ATTACH REQUEST message containing the low priority indicator set to "MS is configured for NAS signalling low priority" was rejected with a timer value for timer T3396, and if timer T3396 is restarted at switch on, then the UE configured for dual priority shall handle session management requests as indicated in subclause 6.5.5.

6.5.1.4.3 Handling of network rejection due to ESM cause other than ESM cause #26

If the ESM cause value is different from #26 "insufficient resources", #50 "PDN type IPv4 only allowed", #51 "PDN type IPv6 only allowed", #54 "PDN connection does not exist", #57 "PDN type IPv4v6 only allowed", #58 "PDN type non IP only allowed", #65 "maximum number of EPS bearers reached", and #66 "requested APN not supported in current RAT and PLMN combination", and the Back-off timer value IE is included, the UE shall behave as follows:

1) if the PDN CONNECTIVITY REQUEST message was sent standalone, the UE shall take different actions depending on the timer value received in the Back-off timer value IE (if the UE is a UE configured to use AC11 – 15 in selected PLMN, exceptions are specified in subclause 6.3.6):

   i) if the timer value indicates neither zero nor deactivated, the UE shall start the back-off timer with the value provided in the Back-off timer value IE for the PDN connectivity procedure and PLMN and APN combination and

- shall not send another PDN CONNECTIVITY REQUEST message in the PLMN for the same APN that was sent by the UE, until the back-off timer expires, the UE is switched off or the USIM is removed; and

- shall not send another PDN CONNECTIVITY REQUEST message in the PLMN without an APN and with request type different from "emergency" and from "handover of emergency bearer services" if no APN was included in the PDN CONNECTIVITY REQUEST message, until the back-off timer expires, the UE is switched off or the USIM is removed;

ii) if the timer value indicates that this timer is deactivated, the UE:

- shall not send another PDN CONNECTIVITY REQUEST message in the PLMN for the same APN until the UE is switched off or the USIM is removed; and

- shall not send another PDN CONNECTIVITY REQUEST message in the PLMN without an APN and with request type different from "emergency" and from "handover of emergency bearer services" if no APN was included in the PDN CONNECTIVITY REQUEST message, until the UE is switched off or the USIM is removed; and

iii) if the timer value indicates zero, the UE:

- may send another PDN CONNECTIVITY REQUEST message in the PLMN for the same APN; and

- may send another PDN CONNECTIVITY REQUEST message in the PLMN without an APN; and

2) if the PDN CONNECTIVITY REQUEST message was sent together with an ATTACH REQUEST, the UE shall take different actions depending on the timer value received in the Back-off timer value IE and on the integrity protection of the ATTACH REJECT message (if the UE is a UE configured to use AC11 – 15 in selected PLMN, exceptions are specified in subclause 6.3.6):

i) if the ATTACH REJECT message is not integrity protected, the UE shall start the back-off timer with a random value from a default range specified in table 11.2.3(see 3GPP TS 24.008 [13]), and:

a) shall not initiate a new attach procedure or send another PDN CONNECTIVITY REQUEST message in the PLMN with the same APN that was sent by the UE, until the back-off timer expires, the UE is switched off or the USIM is removed; and

b) shall not initiate a new attach procedure or send another PDN CONNECTIVITY REQUEST message in the PLMN without an APN and with request type different from "emergency" and from "handover of emergency bearer services", if the UE did not provide any APN during the attach procedure and the request type was different from "emergency", until the back-off timer expires, the UE is switched off or the USIM is removed; and

ii) if the ATTACH REJECT message is integrity protected, the UE shall proceed as follows:

a) if the timer value indicates neither zero nor deactivated, the UE shall start the back-off timer with the value provided in the Back-off timer value IE for the PDN connectivity procedure and PLMN and APN combination and:

- shall not initiate a new attach procedure or send another PDN CONNECTIVITY REQUEST message in the PLMN with the same APN that was sent by the UE, until the back-off timer expires, the UE is switched off or the USIM is removed; and

- shall not initiate a new attach procedure or send another PDN CONNECTIVITY REQUEST message in the PLMN without an APN and with request type different from "emergency" and from "handover of emergency bearer services", if the UE did not provide any APN during the attach procedure and the request type was different from "emergency" and from "handover of emergency bearer services", until the back-off timer expires, the UE is switched off or the USIM is removed;

b) if the timer value indicates that this timer is deactivated, the UE:

- shall not initiate a new attach procedure or send another PDN CONNECTIVITY REQUEST message in the PLMN with the same APN that was sent by the UE, until the UE is switched off or the USIM is removed; and

- shall not initiate a new attach procedure or send another PDN CONNECTIVITY REQUEST message in the PLMN without an APN and with request type different from "emergency" and from "handover

of emergency bearer services", if the UE did not provide any APN during the attach procedure and the request type was different from "emergency" and from "handover of emergency bearer services", until the UE is switched off or the USIM is removed; and

c) if the timer value indicates that this timer is zero, the UE shall proceed as specified in subclause 5.5.1.2.6 item d.

If the Back-off timer value IE is not included and the PDN CONNECTIVITY REQUEST was sent standalone, then the UE shall ignore the Re-attempt indicator IE provided by the network in PDN CONNECTIVITY REJECT, if any.

1) Additionally, if the ESM cause value is #8 "operator determined barring", #27 "missing or unknown APN", #32 "service option not supported", or #33 "requested service option not subscribed", the UE shall proceed as follows:

   - if the UE is registered in the HPLMN or in a PLMN that is within the EHPLMN list, the UE shall behave as described above in the present subclause, using the configured SM_RetryWaitTime value as specified in 3GPP TS 24.368 [15A] or in USIM file NAS_{CONFIG} as specified in 3GPP TS 31.102 [17], if available, as back-off timer value; and

   - otherwise, if the UE is not registered in its HPLMN or in a PLMN that is within the EHPLMN list, or if the SM_RetryWaitTime value is not configured, the UE shall behave as described above in the present subclause, using the default value of 12 minutes for the back-off timer.

2) For ESM cause values different from #8 "operator determined barring", #27 "missing or unknown APN", #32 "service option not supported", or #33 "requested service option not subscribed", the UE behaviour regarding the start of a back-off timer is unspecified.

The UE shall not stop any back-off timer upon a PLMN change or inter-system change. If the network indicates that a back-off timer for the PDN connectivity procedure and PLMN and APN combination is deactivated, then it remains deactivated upon a PLMN change or inter-system change.

NOTE 1: This means the back-off timer can still be running or be deactivated for the given ESM procedure and PLMN and APN combination when the UE returns to the PLMN or when it performs inter-system change back from A/Gb or Iu mode to S1 mode. Thus the UE can still be prevented from sending another PDN CONNECTIVITY REQUEST message in the PLMN for the same APN.

If the Back-off timer value IE is not included and the PDN CONNECTIVITY REQUEST was sent together with an ATTACH REQUEST, the UE shall ignore the Re-attempt indicator IE provided by the network in PDN CONNECTIVITY REJECT, if any, and proceed as specified in subclause 5.5.1.2.6, item d.

If the back-off timer is started upon receipt of a PDN CONNECTIVITY REJECT (i.e. the timer value was provided by the network, a configured value is available or the default value is used as explained above) or the back-off timer is deactivated, the UE behaves as follows:

1) after a PLMN change the UE may send a PDN CONNECTIVITY REQUEST message for the same APN in the new PLMN, if the back-off timer is not running and is not deactivated for the PDN connectivity procedure and the combination of new PLMN and APN;

   Furthermore as an implementation option, for the ESM cause values #8 "operator determined barring", #27 "missing or unknown APN", #32 "service option not supported" or #33 "requested service option not subscribed", if the network does not include a Re-attempt indicator IE, the UE may decide not to automatically send another PDN CONNECTIVITY REQUEST message for the same APN that was sent by the UE using the same PDN type, or the UE may decide not to automatically send another PDN CONNECTIVITY REQUEST message included in an ATTACH REQUEST message without an APN using the same PDN type if the UE did not provide any APN in the PDN connectivity procedure, if the UE is registered to a new PLMN which is in the list of equivalent PLMNs.

2) if the network does not include the Re-attempt indicator IE to indicate whether re-attempt in A/Gb or Iu mode is allowed, or the UE ignores the Re-attempt indicator IE, e.g. because the Back-off timer value IE is not included, then:

   - if the UE is registered in its HPLMN or in a PLMN that is within the EHPLMN list, the UE shall apply the configured SM_RetryAtRATChange value as specified in 3GPP TS 24.368 [15A] or in USIM file NAS_{CONFIG} as specified in 3GPP TS 31.102 [17], if available, to determine whether the UE may attempt a PDP context activation procedure for the same PLMN and APN combination in A/Gb or Iu mode; and

- if the UE is not registered in its HPLMN or in a PLMN that is within the EHPLMN list, or if the NAS configuration MO as specified in 3GPP TS 24.368 [15A] is not available and the value for inter-system change is not configured in the USIM file NAS_{CONFIG}, then the UE behaviour regarding a PDP context activation procedure for the same PLMN and APN combination in A/Gb or Iu mode is unspecified; and

3) if the network includes the Re-attempt indicator IE indicating that re-attempt in an equivalent PLMN is not allowed, then depending on the timer value received in the Back-off timer value IE, for each combination of a PLMN from the equivalent PLMN list and the APN the UE shall start a back-off timer for the PDP connectivity procedure with the value provided by the network, or deactivate the respective back-off timer as follows:

   - If the Re-attempt indicator IE additionally indicates that re-attempt in A/Gb or Iu mode is allowed, the UE shall start or deactivate the back-off timer for S1 mode only; and

   - otherwise the UE shall start or deactivate the back-off timer for A/Gb, Iu, and S1 mode.

If the back-off timer for a PLMN and APN combination was started or deactivated in A/Gb or Iu mode upon receipt of an ACTIVATE PDP CONTEXT REJECT message (see 3GPP TS 24.008 [13]) and the network indicated that re-attempt in S1 mode is allowed, then this back-off timer does not prevent the UE from sending a PDN CONNECTIVITY REQUEST message in this PLMN for the same APN after inter-system change to S1 mode. If the network indicated that re-attempt in S1 mode is not allowed, the UE shall not send any PDN CONNECTIVITY REQUEST message in this PLMN for the same APN after inter-system change to S1 mode until the timer expires, the UE is switched off or the USIM is removed.

NOTE 2: The back-off timer is used to describe a logical model of the required UE behaviour. This model does not imply any specific implementation, e.g. as a timer or timestamp.

NOTE 3: Reference to back-off timer in this section can either refer to use of timer T3396 or to use of a different packet system specific timer within the UE. Whether the UE uses T3396 as a back-off timer or it uses different packet system specific timers as back-off timers is left up to UE implementation. This back-off timer is stopped when the UE is switched off or the USIM is removed.

When the back-off timer is running or the timer is deactivated, the UE is allowed to initiate an attach procedure or PDN connectivity procedure if the procedure is for emergency bearer services.

If the ESM cause value is #50 "PDN type IPv4 only allowed", #51 "PDN type IPv6 only allowed", #57 "PDN type IPv4v6 only allowed" or #58 "PDN type non IP only allowed", the UE shall ignore the Back-off timer value IE provided by the network, if any. The UE shall not automatically send another PDN CONNECTIVITY REQUEST message for the same APN that was sent by the UE using the same PDN type until any of the following conditions is fulfilled:

- the UE is registered to a new PLMN, and either the network did not include a Re-attempt indicator IE in the PDN CONNECTIVITY REJECT message or the Re-attempt indicator IE included in the message indicated that re-attempt in an equivalent PLMN is allowed;

- the UE is registered to a new PLMN which was not in the list of equivalent PLMNs at the time when the PDN CONNECTIVITY REJECT message was received;

- the PDN type which is used to access to the APN is changed;

- the UE is switched off; or

- the USIM is removed.

For the ESM cause values #50 "PDN type IPv4 only allowed", #51 "PDN type IPv6 only allowed", #57 "PDN type IPv4v6 only allowed" and #58 "PDN type non IP only allowed", the UE shall ignore the value of the RATC bit in the Re-attempt indicator IE provided by the network, if any.

Furthermore as an implementation option, for the SM cause values #50 "PDN type IPv4 only allowed", #51 "PDN type IPv6 only allowed", #57 "PDN type IPv4v6 only allowed" and #58 "PDN type non IP only allowed", if the network does not include a Re-attempt indicator IE the UE may decide not to automatically send another PDN CONNECTIVITY REQUEST message for the same APN that was sent by the UE using the same PDN type, if the UE is registered to a new PLMN which is in the list of equivalent PLMNs.

NOTE 4: Request to send another PDN CONNECTIVITY REQUEST message with a specific PDN type has to come from upper layers.

If the ESM cause value is #65 "maximum number of EPS bearers reached", the UE shall determine the PLMN's maximum number of EPS bearer contexts in S1 mode (see subclause 6.5.0) as the number of active EPS bearer contexts it has. The UE shall ignore the Back-off timer value IE and Re-attempt indicator IE provided by the network, if any.

NOTE 5: In some situations, when attempting to establish multiple EPS bearer contexts, the number of active EPS bearer contexts that the UE has when ESM cause #65 is received is not equal to the maximum number of EPS bearer contexts reached in the network.

NOTE 6: When the network supports emergency bearer services, it is not expected that ESM cause #65 is returned by the network when the UE requests a PDN connection for emergency bearer services.

The PLMN's maximum number of EPS bearer contexts in S1 mode applies to the PLMN in which the ESM cause #65 "maximum number of EPS bearers reached" is received. When the UE is switched off, when the USIM is removed, or when there is a change in the value indicated by the network in the 15 bearers bit of the EPS network feature support IE, the UE shall clear all previous determinations representing PLMNs maximum number of EPS bearer contexts in S1 mode. Upon successful registration with a new PLMN, the UE may clear previous determinations representing any PLMN's maximum number(s) of EPS bearer contexts in S1 mode.

If the ESM cause value is #66 "requested APN not supported in current RAT and PLMN combination", the UE shall take different actions depending on the Back-off timer value IE and the Re-attempt indicator IE optionally included:

1) If the PDN CONNECTIVITY REQUEST message was sent standalone, the Back-off timer value IE is not included, and either the Re-attempt indicator IE is not included or the Re-attempt indicator IE is included indicating that re-attempt in an equivalent PLMN is allowed, the UE shall not initiate an attach procedure or send another PDN CONNECTIVITY REQUEST message for the same APN in the current PLMN in S1 mode until the UE is switched off or the USIM is removed;

2) if the PDN CONNECTIVITY REQUEST message was sent standalone, the Back-off timer value IE is not included, and the Re-attempt indicator IE is included and indicates that re-attempt in an equivalent PLMN is not allowed, the UE shall not initiate an attach procedure or send a PDN CONNECTIVITY REQUEST message for the same APN in any PLMN in the list of equivalent PLMNs in S1 mode until the UE is switched off or the USIM is removed;

3) if the PDN CONNECTIVITY REQUEST message was sent standalone and the Back-off timer value IE is included, the UE shall take different actions depending on the timer value received in the Back-off timer value IE (if the UE is a UE configured to use AC11 – 15 in selected PLMN, exceptions are specified in subclause 6.3.6):

   i) if the timer value indicates neither zero nor deactivated, the UE shall start the back-off timer with the value provided in the Back-off timer value IE for the PLMN and APN combination and shall not send another PDN CONNECTIVITY REQUEST for the same APN in the current PLMN in S1 mode until the back-off timer expires, the UE is switched off or the USIM is removed;

   ii) if the timer value indicates that this timer is deactivated, the UE shall not send another PDN CONNECTIVITY REQUEST message for the same APN in the current PLMN in S1 mode until the UE is switched off or the USIM is removed; and

   iii) if the timer value indicates that this timer is zero, the UE may send a PDN CONNECTIVITY REQUEST message for the same APN in the current PLMN; and

4) if the PDN CONNECTIVITY REQUEST message was sent together with an ATTACH REQUEST, the UE shall take different actions depending on the integrity protection of the ATTACH REJECT message (if the UE is a UE configured to use AC11 – 15 in selected PLMN, exceptions are specified in subclause 6.3.6):

   i) if the ATTACH REJECT message is not integrity protected, regardless whether the Back-off timer IE is included, the UE shall start the back-off timer with a random value from a default range specified in table 11.2.3(see 3GPP TS 24.008 [13]), and shall not initiate a new attach procedure or send another PDN CONNECTIVITY REQUEST message in the current PLMN in S1 mode with the same APN that was sent by the UE, until the back-off timer expires, the UE is switched off or the USIM is removed; and

   ii) if the ATTACH REJECT message is integrity protected, the UE shall proceed as follows:

      a) if the Back-off timer value IE is included and the timer value indicates neither zero nor deactivated, the UE shall start the back-off timer with the value provided in the Back-off timer value IE for the PDN connectivity procedure and PLMN and APN combination and shall not initiate a new attach procedure or

send another PDN CONNECTIVITY REQUEST message in the current PLMN in S1 mode with the same APN that was sent by the UE, until the back-off timer expires, the UE is switched off or the USIM is removed;

b) if the Back-off timer value IE is included and the timer value indicates that this timer is deactivated, the UE shall not initiate a new attach procedure or send another PDN CONNECTIVITY REQUEST message in the current PLMN in S1 mode with the same APN that was sent by the UE, until the UE is switched off or the USIM is removed;

c) if the Back-off timer value IE is included and the timer value indicates that this timer is zero, the UE shall proceed as specified in subclause 5.5.1.2.6 item d;

d) if the Back-off timer value IE is not included, and either the Re-attempt indicator IE is not included or the Re-attempt indicator IE is included indicating that re-attempt in an equivalent PLMN is allowed, the UE shall not initiate a new attach procedure or send another PDN CONNECTIVITY REQUEST message for the same APN in the current PLMN in S1 mode until the UE is switched off or the USIM is removed; and

e) if the Back-off timer value IE is not included, and the Re-attempt indicator IE is included and indicates that re-attempt in an equivalent PLMN is not allowed, the UE shall not initiate a new attach procedure or send a PDN CONNECTIVITY REQUEST message for the same APN in any PLMN in the list of equivalent PLMNs in S1 mode until the UE is switched off or the USIM is removed.

NOTE 7: Receiving ESM cause value #66 during an attach procedure without APN is not expected and the UE behaviour is implementation specific.

If the network includes the Re-attempt indicator IE indicating that re-attempt in an equivalent PLMN is not allowed, then

- for cases 3.i, 4.i and 4.ii.a the UE shall additionally start a back-off timer with the value provided in the Back-off timer value IE for the PDN connectivity procedure for each combination of a PLMN from the equivalent PLMN list and the APN; and

- for cases 3.ii and 4.ii.b the UE shall deactivate the respective back-off timers for the PDN connectivity procedure for each combination of a PLMN from the equivalent PLMN list and the APN.

For the ESM cause value #66 "requested APN not supported in current RAT and PLMN combination" the UE shall ignore the value of the RATC bit in the Re-attempt indicator IE provided by the network, if any.

As an implementation option, for cases 1, 3.i, 3.ii, 4.iv, 4.v.a and 4.v.b, if the Re-attempt indicator IE is not included, the UE may decide not to automatically send another PDN CONNECTIVITY REQUEST message for the same APN in a PLMN which is in the list of equivalent PLMNs.

If the ESM cause value is #54 "PDN connection does not exist", the UE shall ignore the Back-off timer value IE and Re-attempt indicator IE provided by the network, if any, and take different actions as follows:

- if the PDN CONNECTIVITY REQUEST message was sent standalone, the UE shall set the request type to "initial request" in the subsequent PDN CONNECTIVITY REQUEST message to establish a PDN connectivity to the same APN;

- if the PDN CONNECTIVITY REQUEST message was sent together with an ATTACH REQUEST message, the UE shall set the request type to "initial request" in the PDN CONNECTIVITY REQUEST message which is included in the subsequent ATTACH REQUEST message to establish a PDN connectivity to the same APN.

NOTE 8: User interaction is necessary in some cases when the UE cannot re-activate the EPS bearer context(s) automatically.

6.5.1.4A Handling the maximum number of active EPS bearer contexts

If the maximum number of active EPS bearer contexts is reached at the UE (see subclause 6.5.0) and the upper layers of the UE request connectivity to a PDN the UE shall not send a PDN CONNECTIVITY REQUEST message unless an active EPS bearer is deactivated. If the UE needs to de-activate an active EPS bearer context, choosing which EPS bearer context to de-activate is implementation specific, however the UE shall not deactivate an EPS bearer context for emergency.

NOTE: Subclause 6.5.1.6 specifies that a PDN CONNECTIVITY REQUEST message with the same combination of APN and PDN type as an already existing, non-emergency PDN connection can be acceptable, in some cases. In these cases the UE does not need to de-activate an active EPS bearer context if the maximum number of active EPS bearer contexts is reached at the UE.

If the UE needs to de-activate an EPS bearer context in order to request an emergency EPS bearer context, it shall either de-activate an EPS bearer context locally or via explicit signalling. If the UE performs local de-activation, the UE shall perform tracking area updating procedure to indicate EPS bearer context status to the network.

6.5.1.4B Void

6.5.1.5 Abnormal cases in the UE

The following abnormal cases can be identified:

a) T3482 expired

On the first expiry of the timer T3482:

- if the PDN CONNECTIVITY REQUEST message was sent with request type set to "emergency" or "handover of emergency bearer services" in a stand-alone PDN connectivity procedure, then the UE shall:

  a) inform the upper layers of the failure to establish the emergency bearer; or

NOTE: This can result in the upper layers requesting establishment of a CS emergency call (if not already attempted in the CS domain), or other implementation specific mechanisms, e.g. procedures specified in 3GPP TS 24.229 [13D] can result in the emergency call being attempted to another IP-CAN.

  b) detach locally, if not detached already, attempt EPS attach for emergency bearer services.

- otherwise, the UE shall resend the PDN CONNECTIVITY REQUEST and shall reset and restart timer T3482. This retransmission is repeated four times, i.e. on the fifth expiry of timer T3482, the UE shall abort the procedure, release the PTI allocated for this invocation and enter the state PROCEDURE TRANSACTION INACTIVE.

b) T3447 is running

The UE shall not send a PDN CONNECTIVITY REQUEST message when the UE is in EMM-CONNECTED mode after the UE attached without PDN connection, unless:

- establishment of a PDN connection for emergency bearer services is requested; or

- the UE is a UE configured to use AC11 – 15 in the selected PLMN.

The PDN CONNECTIVITY REQUEST message can be sent, if still necessary, when timer T3447 expires.

6.5.1.6 Abnormal cases on the network side

The following abnormal cases can be identified:

a) UE initiated PDN connectivity request for an already existing PDN connection:

If the network receives a PDN CONNECTIVITY REQUEST message with the same combination of APN and PDN type as an already existing PDN connection,

If the information elements in the PDN CONNECTIVITY REQUEST message do not differ from the ones received within the previous PDN CONNECTIVITY REQUEST message, and the MME has not received the ACTIVATE DEFAULT EPS BEARER CONTEXT ACCEPT message from UE, the network shall resend the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message and continue the previous procedure.

If one or more information elements in the PDN CONNECTIVITY REQUEST message differ from the ones received within the previous PDN CONNECTIVITY REQUEST message, and multiple PDN connections for a given APN are not allowed, the network may deactivate the existing EPS bearer contexts for the PDN connection locally without notification to the UE and proceed with the requested PDN connectivity

procedure or may reject this PDN connectivity procedure including the ESM cause #55 "multiple PDN connections for a given APN not allowed", in the PDN CONNECTIVITY REJECT message.

If the network receives a PDN CONNECTIVITY REQUEST message with request type "emergency" and the MME has not received the ACTIVATE DEFAULT EPS BEARER CONTEXT ACCEPT message from UE for the previous PDN connectivity request for emergency bearer services, the network shall resend the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message and continue the previous procedure. If there is already a PDN connection for emergency bearer services existing, the MME shall reject the request with ESM cause #55 "multiple PDN connections for a given APN not allowed" or deactivate the existing EPS bearer contexts for the PDN connection locally without notification to the UE and proceed with the requested PDN connectivity procedure.

b) UE initiated PDN connectivity request with request type "handover" for a PDN connection that does not exist:

If the network receives a PDN CONNECTIVITY REQUEST message for either a default APN or a specific APN with request type set to "handover" and the MME does not have any information about that PDN connection, then MME shall reject the PDN connectivity request procedure including the ESM cause #54 "PDN connection does not exist", in the PDN CONNECTIVITY REJECT message.

c) ESM information not received:

If the ESM information transfer flag in the PDN CONNECTIVITY REQUEST message has been set and the ESM information is not received before the final expiry of timer T3489 as described in subclause 6.6.1.2.6, the MME shall reject the PDN connectivity request procedure including the ESM cause #53 "ESM information not received", in the PDN CONNECTIVITY REJECT message.

d) Additional UE initiated PDN connectivity request received from a UE that is attached for emergency bearer services:

The MME shall reject the request with ESM cause #31 "request rejected, unspecified".

e) A PDN CONNECTIVITY REQUEST message with request type "handover of emergency bearer services" received from a UE and the MME does not have any information about a P-GW currently providing emergency bearer services for the UE or the MME is not configured with an address of a P-GW in the MME emergency configuration data:

MME shall reject the PDN connectivity request procedure including the ESM cause #54 "PDN connection does not exist", in the PDN CONNECTIVITY REJECT message.

6.5.1.7 Handling PDN connectivity request for UE configured for dual priority

If a PDN connection exists that was established due to a request including a low priority indicator set to "MS is configured for NAS signalling low priority" and the upper layers of the UE request to establish a PDN connection with the same APN and a low priority indicator set to "MS is not configured for NAS signalling low priority", when initiating the PDN connectivity request procedure, the UE shall:

- send a PDN CONNECTIVITY REQUEST message with the same combination of APN and PDN type as the existing PDN connection. If the UE receives a PDN CONNECTIVITY REJECT message with ESM cause #55 "multiple PDN connections for a given APN not allowed", the upper layers are informed of this; or

- send a PDN CONNECTIVITY REQUEST message with the same APN after the successful deactivation of the existing PDN connection.

NOTE: The above list of options also apply for the case when the existing PDN connection was established due to a request including a low priority indicator set to "MS is not configured for NAS signalling low priority" and the new request to establish a PDN connection with the same APN contains a low priority indicator set to "MS is configured for NAS signalling low priority".

As an alternative the upper layers of the UE can request to establish a PDN connection with a different APN.

6.5.2 UE requested PDN disconnect procedure

6.5.2.1 General

The purpose of the UE requested PDN disconnection procedure is for a UE to request disconnection from one PDN. If EMM-REGISTERED without PDN connection is not supported by the UE or the MME, the UE can initiate this procedure to disconnect from any PDN as long as it is connected to at least one other PDN. If EMM-REGISTERED without PDN connection is supported by the UE and the MME, the UE can initiate this procedure to disconnect from any PDN. With this procedure, all EPS bearer contexts established towards this PDN, including the default EPS bearer context, are released.

The UE is allowed to initiate the PDN disconnection procedure even if the timer T3396 is running.

6.5.2.2 UE requested PDN disconnection procedure initiation

In order to request PDN disconnection from a PDN, the UE shall send a PDN DISCONNECT REQUEST message to the MME, start the timer T3492 and enter the state PROCEDURE TRANSACTION PENDING (see example in figure 6.5.2.2.1). The PDN DISCONNECT REQUEST message shall include the EPS bearer identity of the default bearer associated with the PDN to disconnect from as the linked EPS bearer identity in the PDN DISCONNECT REQUEST message.

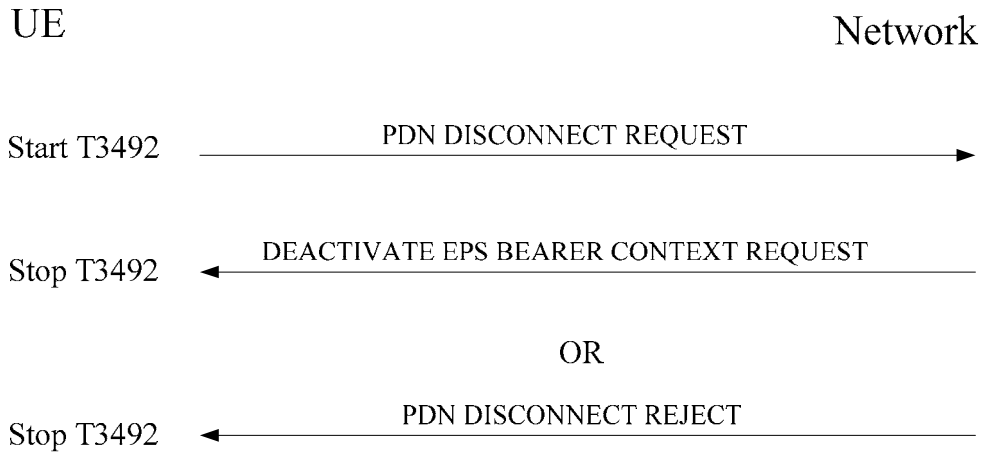


Figure 6.5.2.2.1: UE requested PDN disconnection procedure

6.5.2.3 UE requested PDN disconnection procedure accepted by the network

Upon receipt of the PDN DISCONNECT REQUEST message, if it is accepted by the network, the MME shall initiate the bearer context deactivation procedure by sending the DEACTIVATE EPS BEARER CONTEXT REQUEST message including the linked EPS bearer identity of the default bearer associated with the PDN to disconnect from and the PTI. The behaviour of the MME is described in subclause 6.4.4.

Upon receipt of the DEACTIVATE EPS BEARER CONTEXT REQUEST message with a PTI which matches the value used for the PDN DISCONNECT REQUEST message, the UE shall stop the timer T3492 and enter the state PROCEDURE TRANSACTION INACTIVE. The behaviour of the UE is described in subclause 6.4.4. The UE should ensure that the procedure transaction identity (PTI) assigned to this procedure is not released immediately. The way to achieve this is implementation dependent. While the PTI value is not released, the UE regards any received DEACTIVATE EPS BEARER CONTEXT REQUEST message with the same PTI value as a network retransmission (see subclause 7.3.1).

On reception of DEACTIVATE EPS BEARER CONTEXT ACCEPT message from the UE, the MME releases all the resources reserved for the PDN in the network.

6.5.2.4 UE requested PDN disconnection procedure not accepted by the network

Upon receipt of the PDN DISCONNECT REQUEST message, if it is not accepted by the network, the MME shall send a PDN DISCONNECT REJECT message to the UE. The PDN DISCONNECT REJECT message shall contain the PTI and an ESM cause IE that typically indicates one of the following ESM cause values:

#35: PTI already in use;

#43: invalid EPS bearer identity;

#49: last PDN disconnection not allowed;

#95 – 111: protocol errors.

If EMM-REGISTERED without PDN connection is supported by the UE and the MME, then ESM cause #49 "last PDN disconnection not allowed" is not applicable.

Upon receipt of the PDN DISCONNECT REJECT message, the UE shall stop the timer T3492, enter the state PROCEDURE TRANSACTION INACTIVE and abort the PDN disconnection procedure. Additionally, in all cases with the exception of the UE having received ESM cause #49 "last PDN disconnection not allowed" if EMM-REGISTERED without PDN connection is not supported by the UE or the MME, the UE shall deactivate all EPS bearer contexts for this PDN connection locally without peer-to-peer signalling between the UE and the MME. If the UE receives ESM cause #49 "last PDN disconnection not allowed" and the UE has any other PDN connections established, the UE may locally deactivate, without peer-to-peer signalling between the UE and the MME, all EPS bearer contexts associated with those other PDN connections.

6.5.2.5 Abnormal cases in the UE

The following abnormal cases can be identified:

a) Expiry of timer T3492:

On the first expiry of the timer T3492, the UE shall resend the PDN DISCONNECT REQUEST and shall reset and restart timer T3492. This retransmission is repeated four times, i.e. on the fifth expiry of timer T3492, the UE shall abort the procedure, deactivate all EPS bearer contexts for this PDN connection locally without peer-to-peer signalling between the UE and the MME, release the PTI allocated for this invocation and enter the state PROCEDURE TRANSACTION INACTIVE. In order to synchronize EPS bearer contexts status with the MME, on indication of "back to E-UTRAN coverage" from the lower layers, the UE shall send a TRACKING AREA UPDATE REQUEST message that includes the EPS bearer context status IE to the MME.

b) Collision of UE requested PDN disconnect procedure and dedicated EPS bearer context activation procedure:

When the UE receives an ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST message during the PDN disconnect procedure, and the EPS bearer to be activated belongs to the PDN connection the UE wants to disconnect, the UE shall ignore the ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST message and proceed with the PDN disconnect procedure.

c) Collision of UE requested PDN disconnect procedure and EPS bearer context modification:

When the UE receives a MODIFY EPS BEARER CONTEXT REQUEST message during the PDN disconnect procedure, and the EPS bearer to be modified belongs to the PDN connection the UE wants to disconnect, the UE shall ignore the MODIFY EPS BEARER CONTEXT REQUEST message and proceed with the PDN disconnect procedure.

d) Collision of UE requested PDN disconnect procedure and EPS bearer context deactivation procedure:

When the UE receives a DEACTIVATE EPS BEARER CONTEXT REQUEST message during the PDN disconnect procedure, and the EPS bearer indicated in the DEACTIVATE EPS BEARER CONTEXT REQUEST message is a dedicated EPS bearer belonging to the PDN connection the UE wants to disconnect, the UE shall proceed with both procedures.

6.5.2.6 Abnormal cases on the network side

The following abnormal cases can be identified:

a) No PDN connection with the linked EPS bearer identity activated:

If the linked EPS bearer identity included in the PDN DISCONNECT REQUEST message does not belong to the default EPS bearer context of an established PDN connection, the MME shall reply with a PDN DISCONNECT REJECT message with ESM cause #43 "invalid EPS bearer identity".

6.5.3 UE requested bearer resource allocation procedure

6.5.3.1 General

The purpose of the UE requested bearer resource allocation procedure is for a UE to request an allocation of bearer resources for a traffic flow aggregate. The UE requests a specific QoS demand (QCI) and optionally sends a GBR requirement for a new traffic flow aggregate. If accepted by the network, this procedure invokes a dedicated EPS bearer context activation procedure (see subclause 6.4.2) or an EPS bearer context modification procedure (see subclause 6.4.3).

If there is a PDN connection for emergency bearer services established, the UE shall not request additional bearer resources for this PDN connection.

6.5.3.2 UE requested bearer resource allocation procedure initiation

In order to request the allocation of bearer resources for one traffic flow aggregate, the UE shall send a BEARER RESOURCE ALLOCATION REQUEST message to the MME, start timer T3480 and enter the state PROCEDURE TRANSACTION PENDING (see example in figure 6.5.3.2.1).

The UE shall include the EPS bearer identity of the default EPS bearer associated with the requested bearer resource in the Linked EPS bearer identity IE. The UE shall set the TFT operation code in the Traffic flow aggregate IE to "Create new TFT". The packet filters in the Traffic flow aggregate IE shall include at least one packet filter applicable for the uplink direction. In the Required traffic flow QoS IE, the UE shall indicate a QCI and, if the UE also includes a GBR, the additional GBR required for the traffic flow aggregate.

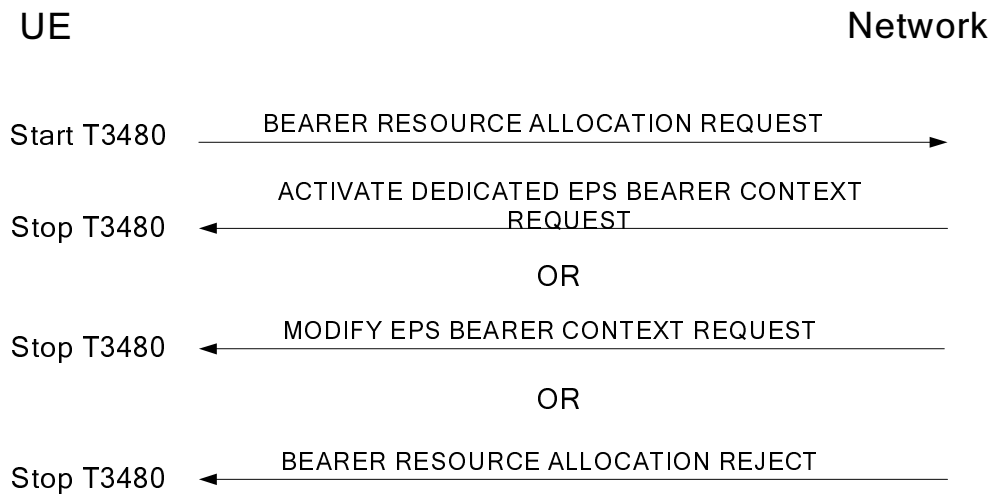


Figure 6.5.3.2.1: UE requested bearer resource allocation procedure

For the NBIFOM procedures as defined in 3GPP TS 24.161 [36], the UE may send a BEARER RESOURCE ALLOCATION REQUEST message to the MME. If the traffic flow aggregate IE is not needed in those procedures, the UE shall set:

- the length indicator of the Traffic flow aggregate IE to the value 1;
- the TFT operation code to "000";
- the E bit to zero; and
- the number of packet filters to zero;

and in the Required traffic flow QoS IE:

- the length indicator to the value 1; and
- the QCI to zero.

6.5.3.3 UE requested bearer resource allocation procedure accepted by the network

Upon receipt of the BEARER RESOURCE ALLOCATION REQUEST message, the MME checks whether the resources requested by the UE can be established by verifying the EPS bearer identity given in the Linked EPS bearer identity IE to be any of the active default EPS bearer context(s).

If the bearer resource allocation requested is accepted by the network, the MME shall initiate either a dedicated EPS bearer context activation procedure or an EPS bearer context modification procedure. Upon receipt of an ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST or MODIFY EPS BEARER CONTEXT REQUEST message with a PTI which matches the value used for the BEARER RESOURCE ALLOCATION REQUEST message, the UE shall stop timer T3480 and enter the state PROCEDURE TRANSACTION INACTIVE. The UE should ensure that the procedure transaction identity (PTI) assigned to this procedure is not released immediately. The way to achieve this is implementation dependent. While the PTI value is not released, the UE regards any received ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST or MODIFY EPS BEARER CONTEXT REQUEST message with the same PTI value as a network retransmission (see subclause 7.3.1).

If the ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST message is received, the UE shall verify that the EPS bearer identity given in the EPS bearer identity IE is not already used by any EPS bearer context. The UE shall then proceed as described in subclause 6.4.2.3 or subclause 6.4.2.4.

If the MODIFY EPS BEARER CONTEXT REQUEST message is received, the UE verifies that the EPS bearer identity given in the EPS bearer identity IE is any of the active EPS bearer contexts. The UE shall then proceed as described in subclause 6.4.3.3 or subclause 6.4.3.4.

6.5.3.4 UE requested bearer resource allocation procedure not accepted by the network

6.5.3.4.1 General

If the bearer resource allocation requested cannot be accepted by the network, the MME shall send a BEARER RESOURCE ALLOCATION REJECT message to the UE. The message shall contain the PTI and an ESM cause value indicating the reason for rejecting the UE requested bearer resource allocation.

The ESM cause value typically indicates one of the following:

#26: insufficient resources;

#30: request rejected by Serving GW or PDN GW;

#31: request rejected, unspecified;

#32: service option not supported;

#33: requested service option not subscribed;

#34: service option temporarily out of order;

#35: PTI already in use;

#37: EPS QoS not accepted;

#41: semantic error in the TFT operation;

#42: syntactical error in the TFT operation;

#43: invalid EPS bearer identity;

#44: semantic error(s) in packet filter(s);

#45: syntactical error(s) in packet filter(s);

#56: collision with network initiated request;

#59: unsupported QCI value;

#60: bearer handling not supported;

#65: maximum number of EPS bearers reached; or

#95 – 111: protocol errors.

If the bearer resource allocation requested is for an established LIPA PDN connection or SIPTO at the local network PDN connection, then the network shall reply with a BEARER RESOURCE ALLOCATION REJECT message with ESM cause #60 "bearer handling not supported".

If the requested new TFT is not available, then the BEARER RESOURCE ALLOCATION REJECT message shall be sent.

The TFT in the request message is checked by the network for different types of TFT IE errors as follows:

a) Semantic errors in TFT operations:

   1) When the *TFT operation* is an operation other than "Create a new TFT".

   The network shall reject the allocation request with ESM cause #41 "semantic error in the TFT operation".

b) Syntactical errors in TFT operations:

   1) When the *TFT operation* = "Create a new TFT" and the packet filter list in the TFT IE is empty.

   2) When there are other types of syntactical errors in the coding of the TFT IE, such as a mismatch between the number of packet filters subfield, and the number of packet filters in the packet filter list.

   The network shall reject the allocation request with ESM cause #42 "syntactical error in the TFT operation".

c) Semantic errors in packet filters:

   When a packet filter consists of conflicting packet filter components which would render the packet filter ineffective, i.e. no IP packet will ever fit this packet filter. How the network determines a semantic error in a packet filter is outside the scope of the present document.

   The network shall reject the allocation request with ESM cause #44 "semantic errors in packet filter(s)".

d) Syntactical errors in packet filters:

   1) When the *TFT operation* = "Create a new TFT" and two or more packet filters among all TFTs associated with the PDN connection would have identical packet filter precedence values.

   2) When there are other types of syntactical errors in the coding of packet filters, such as the use of a reserved value for a packet filter component identifier.

   In case 1, if the old packet filters do not belong to the default EPS bearer context, the network shall not diagnose an error, shall further process the new request and, if it was processed successfully, shall delete the old packet filters which have identical filter precedence values. Furthermore, the network shall perform an EPS bearer context deactivation request procedure to deactivate the dedicated EPS bearer context(s) for which it has deleted the packet filters.

   In case 1, if one or more old packet filters belong to the default EPS bearer context, the network shall release the relevant PDN connection using the EPS bearer context deactivation procedure.If it is the last remaining PDN connection and EMM-REGISTERED without PDN connection is not supported by the UE or the MME, the network shall detach the UE using detach type "re-attach required".

   Otherwise the network shall reject the allocation request with ESM cause #45 "syntactical errors in packet filter(s)".

The network may include a Back-off timer value IE in the BEARER RESOURCE ALLOCATION REJECT message.

If the Back-off timer value IE is included and the ESM cause value is different from #26 "insufficient resources" and #65 "maximum number of EPS bearers reached", the network may include the Re-attempt indicator IE to indicate

whether the UE is allowed to attempt a secondary PDP context activation procedure in the PLMN for the same APN in A/Gb or Iu mode, and whether another attempt in A/Gb and Iu mode or in S1 mode is allowed in an equivalent PLMN.

Upon receipt of a BEARER RESOURCE ALLOCATION REJECT message, the UE shall stop the timer T3480, release the traffic flow aggregate description associated to the PTI value, and enter the state PROCEDURE TRANSACTION INACTIVE.

6.5.3.4.2 Handling of network rejection due to ESM cause #26

If the ESM cause value is #26 "insufficient resources" and the Back-off timer value IE is included, the UE shall ignore the Re-attempt indicator IE provided by the network, if any, and take different actions depending on the timer value received for timer T3396 in the Back-off timer value IE (if the UE is configured for dual priority, exceptions are specified in subclause 6.5.5; if the UE is a UE configured to use AC11 – 15 in selected PLMN, exceptions are specified in subclause 6.3.5):

i) if the timer value indicates neither zero nor deactivated, the UE shall stop timer T3396 associated with the corresponding APN, if it is running. The UE shall then start T3396 with the value provided in the Back-off timer value IE and not send another PDN CONNECTIVITY REQUEST, BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message for the same APN until timer T3396 expires or timer T3396 is stopped. If the UE did not provide an APN for the establishment of the PDN connection and the request type was different from "emergency" and from "handover of emergency bearer services", the UE shall stop the timer T3396 associated with no APN if it is running. The UE shall start timer T3396 with the received value and not send another PDN CONNECTIVITY REQUEST message without an APN and with request type different from "emergency" and from "handover of emergency bearer services", or another BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message for a non-emergency PDN connection established without an APN provided by the UE, until timer T3396 expires or timer T3396 is stopped. The UE shall not stop timer T3396 upon a PLMN change or inter-system change;

ii) if the timer value indicates that this timer is deactivated, the UE shall not send another PDN CONNECTIVITY REQUEST, BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message for the same APN until the UE is switched off or the USIM is removed or the UE receives an ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST, ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST or MODIFY EPS BEARER CONTEXT REQUEST message for the same APN from the network or a DEACTIVATE EPS BEARER CONTEXT REQUEST message including ESM cause #39 "reactivation requested" for a default EPS bearer context for the same APN from the network. If the UE did not provide an APN for the establishment of the PDN connection and the request type was different from "emergency" and from "handover of emergency bearer services", the UE shall not send another PDN CONNECTIVITY REQUEST message without an APN and with request type different from "emergency" and from "handover of emergency bearer services", or another BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message for a non-emergency PDN connection established without APN provided by the UE, until the UE is switched off or the USIM is removed, or the UE receives an ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST, ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST or MODIFY EPS BEARER CONTEXT REQUEST message for a non-emergency PDN connection established without an APN provided by the UE, or a DEACTIVATE EPS BEARER CONTEXT REQUEST message including ESM cause #39 "reactivation requested" for a default EPS bearer context of a non-emergency PDN connection established without an APN provided by the UE. The timer T3396 remains deactivated upon a PLMN change or inter-system change; or

iii) if the timer value indicates zero, the UE:

- shall stop timer T3396 associated with the corresponding APN, if running, and may send another PDN CONNECTIVITY REQUEST, BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message for the same APN; and

- if the UE did not provide an APN for the establishment of the PDN connection and the request type was different from "emergency" and from "handover of emergency bearer services", the UE shall stop timer T3396 associated with no APN, if running, and may send another PDN CONNECTIVITY REQUEST message without an APN, or another BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message for a non-emergency PDN connection established without an APN provided by the UE.

If the Back-off timer value IE is not included, the UE may send a PDN CONNECTIVITY REQUEST, BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST messages for the same APN.

The further actions to be performed by the UE are implementation dependent as part of upper layers responsibility.

If the timer T3396 is running when the UE enters state EMM-DEREGISTERED, the UE remains switched on, and the USIM in the UE remains the same, then timer T3396 is kept running until it expires or it is stopped.

If the UE is switched off when the timer T3396 is running, and if the USIM in the UE remains the same when the UE is switched on, the UE behaves as follows:

- let t1 be the time remaining for T3396 timeout at switch off and let t be the time elapsed between switch off and switch on. If t1 is greater than t, then the timer shall be restarted with the value t1 – t. If t1 is equal to or less than t, then the timer need not be restarted. If the UE is not capable of determining t, then the UE shall restart the timer with the value t1;

- if prior to switch off, timer T3396 was running for a specific APN, because a PDN CONNECTIVITY REQUEST, BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message containing the low priority indicator set to "MS is configured for NAS signalling low priority" was rejected with a timer value for timer T3396, and if timer T3396 is restarted at switch on, then the UE configured for dual priority shall handle session management requests as indicated in subclause 6.5.5; and

- if prior to switch off timer T3396 was running because a PDN CONNECTIVITY REQUEST without APN sent together with an ATTACH REQUEST message containing the low priority indicator set to "MS is configured for NAS signalling low priority" was rejected with a timer value for timer T3396, and if timer T3396 is restarted at switch on, then the UE configured for dual priority shall handle session management requests as indicated in subclause 6.5.5.

6.5.3.4.3 Handling of network rejection due to ESM cause other than ESM cause #26

If the ESM cause value is different from #26 "insufficient resources" and #65 "maximum number of EPS bearers reached", and the Back-off timer value IE is included, the UE shall behave as follows depending on the timer value received in the Back-off timer value IE (if the UE is a UE configured to use AC11 – 15 in selected PLMN, exceptions are specified in subclause 6.3.6):

- if the timer value indicates neither zero nor deactivated, the UE shall start the back-off timer with the value provided in the Back-off timer value IE for the bearer resource allocation procedure and PLMN and APN combination and not send another BEARER RESOURCE ALLOCATION REQUEST message in the PLMN for the same APN until the back-off timer expires, the UE is switched off or the USIM is removed;

- if the timer value indicates that this timer is deactivated, the UE shall not send another BEARER RESOURCE ALLOCATION REQUEST message in the PLMN for the same APN until the UE is switched off or the USIM is removed; and

- if the timer value indicates zero, the UE may send another BEARER RESOURCE ALLOCATION REQUEST message in the PLMN for the same APN.

If the Back-off timer value IE is not included, then the UE shall ignore the Re-attempt Indicator IE provided by the network, if any.

1) Additionally, if the ESM cause value is #32 "service option not supported", or #33 "requested service option not subscribed", the UE shall proceed as follows:

   - if the UE is registered in the HPLMN or in a PLMN that is within the EHPLMN list, the UE shall behave as described above in the present subclause, using the configured SM_RetryWaitTime value as specified in 3GPP TS 24.368 [15A] or in USIM file NAS_{CONFIG} as specified in 3GPP TS 31.102 [17], if available, as back-off timer value; and

   - otherwise, if the UE is not registered in its HPLMN or a PLMN that is within the EHPLMN list or the SM_RetryWaitTime value is not configured, the UE shall behave as described above in the present subclause, using the default value of 12 minutes for the back-off timer.

2) For ESM cause values different from #32 "service option not supported", or #33 "requested service option not subscribed", the UE behaviour regarding the start of a back-off timer is unspecified.

The UE shall not stop any back-off timer upon a PLMN change or inter-system change. If the network indicates that a back-off timer for the bearer resource allocation procedure and PLMN and APN combination is deactivated, then it remains deactivated upon a PLMN change or inter-system change.

NOTE 1: This means the back-off timer can still be running or be deactivated for the given ESM procedure and PLMN and APN combination when the UE returns to the PLMN or when it performs inter-system change back from A/Gb or Iu mode to S1 mode. Thus the UE can still be prevented from sending another BEARER RESOURCE ALLOCATION REQUEST message in the PLMN for the same APN.

If the back-off timer is started upon receipt of BEARER RESOURCE ALLOCATION REJECT (i.e. the timer value was provided by the network, a configured value is available or the default value is used as explained above) or the back-off timer is deactivated, the UE behaves as follows:

1) after a PLMN change the UE may send a BEARER RESOURCE ALLOCATION REQUEST message for the same APN in the new PLMN, if the back-off timer is not running and is not deactivated for the bearer resource allocation procedure and the combination of new PLMN and APN;

   Furthermore as an implementation option, for the ESM cause values #32 "service option not supported" or #33 "requested service option not subscribed", if the network does not include a Re-attempt indicator IE, the UE may decide not to automatically send another BEARER RESOURCE ALLOCATION REQUEST message for the same APN that was sent by the UE, if the UE is registered to a new PLMN which is in the list of equivalent PLMNs.

2) if the network does not include the Re-attempt indicator IE to indicate whether re-attempt in A/Gb or Iu mode is allowed, or the UE ignores the Re-attempt indicator IE, e.g. because the Back-off timer value IE is not included, then:

   - if the UE is registered in its HPLMN or in a PLMN that is within the EHPLMN list, the UE shall apply the configured SM_RetryAtRATChange value as specified in 3GPP TS 24.368 [15A] or in USIM file NAS_{CONFIG} as specified in 3GPP TS 31.102 [17], if available, to determine whether the UE may attempt a secondary PDP context activation procedure for the same PLMN and APN combination in A/Gb or Iu mode; and

   - if the UE is not registered in its HPLMN or in a PLMN that is within the EHPLMN list, or if the NAS configuration MO as specified in 3GPP TS 24.368 [15A] is not available and the value for inter-system change is not configured in the USIM file NAS_{CONFIG}, then the UE behaviour regarding a secondary PDP context activation procedure for the same PLMN and APN combination in A/Gb or Iu mode is unspecified; and

3) if the network includes the Re-attempt indicator IE indicating that re-attempt in an equivalent PLMN is not allowed, then depending on the timer value received in the Back-off timer value IE, for each combination of a PLMN from the equivalent PLMN list and the APN the UE shall start a back-off timer for the bearer resource allocation procedure with the value provided by the network, or deactivate the respective back-off timer as follows:

   - If the Re-attempt indicator IE additionally indicates that re-attempt in A/Gb or Iu mode is allowed, the UE shall start or deactivate the back-off timer for S1 mode only; and

   - otherwise the UE shall start or deactivate the back-off timer for A/Gb, Iu, and S1 mode.

If the back-off timer for a PLMN and APN combination was started or deactivated in A/Gb or Iu mode upon receipt of an ACTIVATE SECONDARY PDP CONTEXT REJECT message (see 3GPP TS 24.008 [13]) and the network indicated that re-attempt in S1 mode is allowed, then this back-off timer does not prevent the UE from sending a BEARER RESOURCE ALLOCATION REQUEST message in this PLMN for the same APN after inter-system change to S1 mode. If the network indicated that re-attempt in S1 mode is not allowed, the UE shall not send any BEARER RESOURCE ALLOCATION REQUEST message in this PLMN for the same APN after inter-system change to S1 mode until the timer expires, the UE is switched off or the USIM is removed.

NOTE 2: The back-off timer is used to describe a logical model of the required UE behaviour. This model does not imply any specific implementation, e.g. as a timer or timestamp.

NOTE 3: Reference to back-off timer in this section can either refer to use of timer T3396 or to use of a different packet system specific timer within the UE. Whether the UE uses T3396 as a back-off timer or it uses different packet system specific timers as back-off timers is left up to UE implementation. This back-off timer is stopped when the UE is switched off or the USIM is removed.

If the ESM cause value is #65 "maximum number of EPS bearers reached", the UE shall determine the PLMN's maximum number of EPS bearer contexts in S1 mode (see subclause 6.5.0) as the number of active EPS bearer contexts it has. The UE shall ignore the Back-off timer value IE and Re-attempt indicator IE provided by the network, if any.

NOTE 5: In some situations, when attempting to establish multiple EPS bearer contexts, the number of active EPS bearer contexts in the UE when cause #65 is received is not equal to the maximum number of EPS bearer contexts reached in the network.

The PLMN's maximum number of EPS bearer contexts in S1 mode applies to the PLMN in which the ESM cause #65 "maximum number of EPS bearers reached" is received. When the UE is switched off or when the USIM is removed, the UE shall clear all previous determinations representing any PLMN's maximum number of EPS bearer contexts in S1 mode. Upon successful registration with a new PLMN, the UE may clear previous determinations representing any PLMN's maximum number of EPS bearer contexts in S1 mode.

The further actions to be performed by the UE are implementation dependent as part of upper layers responsibility.

6.5.3.4A Handling the maximum number of active EPS bearer contexts

If the UE requests allocation of additional bearer resources, and the network has reached its maximum number of active EPS bearer contexts, then the network can:

- reject the request if the network decides that it is necessary to allocate a dedicated EPS bearer context; or
- accept the request by sending a MODIFY EPS BEARER CONTEXT REQUEST message.

NOTE: An example of where the network will reject the request for allocation of additional bearer resources is when the request includes a GBR requirement while all existing bearers are non-GBR bearers, and the maximum number of active EPS bearer contexts has been reached at the network.

If the maximum number of active EPS bearer contexts is reached at the UE (see subclause 6.5.0) and the UE de-activates an active EPS bearer context prior to sending the request for additional bearer resources, then choosing which EPS bearer context to de-activate is a implementation specific, however the UE shall not deactivate a default EPS bearer context for emergency.

6.5.3.5 Abnormal cases in the UE

The following abnormal cases can be identified:

a) Expiry of timer T3480:

On the first expiry of the timer T3480, the UE shall resend the BEARER RESOURCE ALLOCATION REQUEST and shall reset and restart timer T3480. This retransmission is repeated four times, i.e. on the fifth expiry of timer T3480, the UE shall abort the procedure, release the PTI allocated for this activation and enter the state PROCEDURE TRANSACTION INACTIVE.

b) Unknown EPS bearer context

Upon receipt of the BEARER RESOURCE ALLOCATION REJECT message including ESM cause #43 "invalid EPS bearer identity", the UE shall deactivate the existing default EPS bearer context locally without peer-to-peer signalling between the UE and the MME.

c) Collision of a UE requested bearer resource allocation procedure and an EPS bearer context deactivation procedure.

When the UE receives a DEACTIVATE EPS BEARER CONTEXT REQUEST message for the default EPS bearer context related to the UE requested bearer resource allocation procedure, the UE shall abort the UE requested bearer resource allocation procedure and proceed with the EPS bearer context deactivation procedure.

6.5.3.6 Abnormal cases on the network side

The following abnormal case can be identified:

a) No PDN connection with the linked EPS bearer identity activated:

   If the linked EPS bearer identity included in the BEARER RESOURCE ALLOCATION REQUEST message does not belong to the default EPS bearer context of an established PDN connection, the MME shall reply with a BEARER RESOURCE ALLOCATION REJECT message with ESM cause #43 "invalid EPS bearer identity".

b) BEARER RESOURCE ALLOCATION REQUEST message received for a PDN connection established for emergency bearer services:

   The MME shall reply with a BEARER RESOURCE ALLOCATION REJECT message with ESM cause #31 "request rejected, unspecified".

6.5.4 UE requested bearer resource modification procedure

6.5.4.1 General

The purpose of the UE requested bearer resource modification procedure is for a UE to request a modification, or release of bearer resources for a traffic flow aggregate, or modification of a traffic flow aggregate by replacing packet filters or adding packet filters, or re-negotiate header compression configuration associated to an EPS bearer context, or to indicate a change of 3GPP PS data off UE status for a PDN connection. When requesting a modification of bearer resources for a traffic flow aggregate or a modification of a traffic flow aggregate, the UE can modify the existing GBR. If accepted by the network, this procedure invokes a dedicated EPS bearer context activation procedure (see subclause 6.4.2), an EPS bearer context modification procedure (see subclause 6.4.3), or an EPS bearer context deactivation procedure (see subclause 6.4.4).

If there is a PDN connection for emergency bearer services established, the UE shall not request a modification of bearer resources for this PDN connection.

6.5.4.2 UE requested bearer resource modification procedure initiation

In order to request the modification of bearer resources for one traffic flow aggregate, the UE shall send a BEARER RESOURCE MODIFICATION REQUEST message to the MME, start timer T3481 and enter the state PROCEDURE TRANSACTION PENDING (see example in figure 6.5.4.2.1).

The UE shall include the EPS bearer identity of the EPS bearer associated with the traffic flow aggregate in the EPS bearer identity for packet filter IE.

To request a change of the GBR without changing the packet filter(s), the UE shall set the TFT operation code in the Traffic flow aggregate IE to "no TFT operation" and include the packet filter identifier(s) to which the change of the GBR applies in the Packet filter identifier parameter in the parameters list. The UE shall indicate the new GBR requested for the EPS bearer context in the Required traffic flow QoS IE.

To request a modification of a traffic flow aggregate, the UE shall set the TFT operation code in the Traffic flow aggregate IE to "Replace packet filters in existing TFT" or "Add packet filters to existing TFT". If the TFT operation code is set to "Add packet filters to existing TFT", the UE shall include in the parameter list one existing packet filter identifier to which the newly added packet filter(s) is linked. If the EPS bearer is a GBR bearer and the UE also wishes to request a change of GBR, the UE shall indicate the new GBR requested for the EPS bearer context in the Required traffic flow QoS IE.

To request a release of bearer resources, the UE shall set the TFT operation code in the Traffic flow aggregate IE to "Delete packet filters from existing TFT". If the EPS bearer is a GBR bearer and the UE does not request the release of all bearer resources, the UE shall indicate the new GBR requested for the EPS bearer context in the Required traffic flow QoS IE.

To request re-negotiation of header compression configuration associated to an EPS bearer context, the UE shall include the Header compression configuration IE in the BEARER RESOURCE MODIFICATION REQUEST message if the network indicated "Control plane CIoT EPS optimization supported" and "Header compression for control plane CIoT EPS optimization supported" in the EPS network feature support IE.

To indicate a change of 3GPP PS data off UE status associated to a PDN connection, the UE shall include the protocol configuration options IE in the BEARER RESOURCE MODIFICATION REQUEST message and set the 3GPP PS data off UE status only if the network included the 3GPP PS data off support indication in the protocol configuration options IE in the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message when the PDN connection was established. The UE behaves as described in subclause 6.3.10.

If the UE requests the modification of a traffic flow aggregate, which is assigned to a dedicated EPS bearer context, it shall ensure that at least one packet filter applicable for the uplink direction remains among the packet filters created on request from the UE in that TFT, or no own packet filters.

NOTE: If the UE requests the release of all bearer resources of a GBR bearer and includes a Required traffic flow QoS IE in the BEARER RESOURCE MODIFICATION REQUEST message, the network ignores the Required traffic flow QoS IE.

If the UE includes the Required traffic flow QoS IE, the UE shall set the QCI to the current QCI value of the EPS bearer context.

If the UE requests the release of bearer resources, the ESM cause value typically indicates one of the following:

#36: regular deactivation.

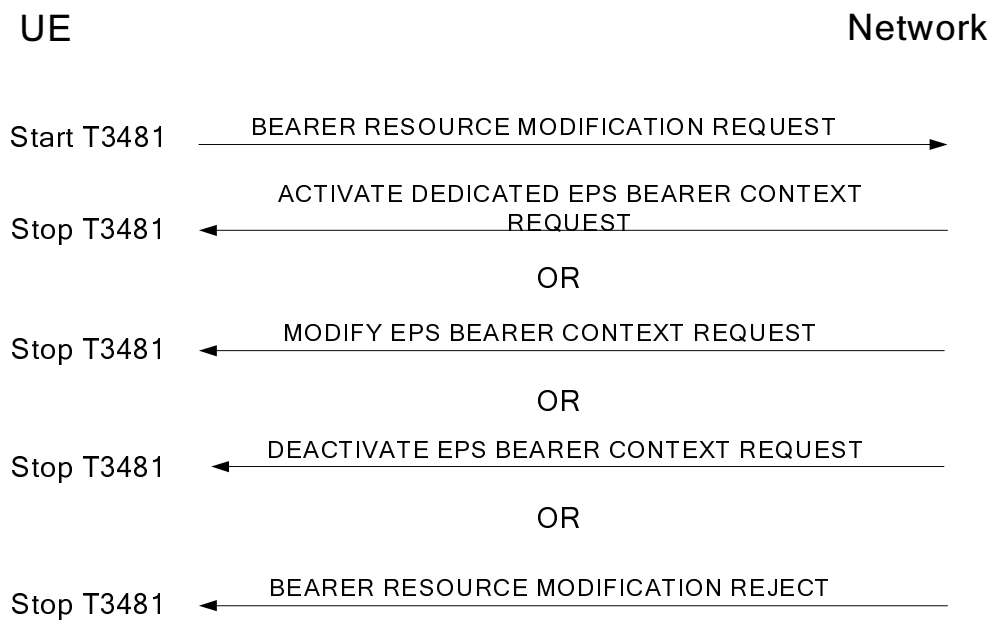


Figure 6.5.4.2.1: UE requested bearer resource modification procedure

For the NBIFOM procedures as defined in 3GPP TS 24.161 [36], the UE may send a BEARER RESOURCE MODIFICATION REQUEST message to the MME. If the traffic flow aggregate IE is not needed in those procedures, the UE shall set:

- the length indicator of the Traffic flow aggregate IE to the value 1;
- the TFT operation code to "000";
- the E bit to zero; and
- the number of packet filters to zero.

6.5.4.3 UE requested bearer resource modification procedure accepted by the network

Upon receipt of the BEARER RESOURCE MODIFICATION REQUEST message, the MME checks whether the resources requested by the UE can be established, modified or released by verifying the EPS bearer identity given in the EPS bearer identity for packet filter IE.

If the bearer resource modification requested is accepted by the network, the MME shall initiate either a dedicated EPS bearer context activation procedure, an EPS bearer context modification procedure or an EPS bearer context deactivation procedure.

If the request to re-negotiate header compression configuration associated to an EPS bearer context is accepted by the network, the MME shall initiate an EPS bearer context modification procedure.

If the bearer resource modification requests a release of bearer resources that results in the TFT of the EPS bearer context containing only packet filters applicable to the uplink direction, the network may initiate the EPS bearer context deactivation procedure.

Upon receipt of an ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST, MODIFY EPS BEARER CONTEXT REQUEST or DEACTIVATE EPS BEARER CONTEXT REQUEST message with a PTI which matches the value used for the BEARER RESOURCE MODIFICATION REQUEST message, the UE shall stop timer T3481 and enter the state PROCEDURE TRANSACTION INACTIVE. The UE should ensure that the procedure transaction identity (PTI) assigned to this procedure is not released immediately. The way to achieve this is implementation dependent. While the PTI value is not released, the UE regards any received ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST or MODIFY EPS BEARER CONTEXT REQUEST or DEACTIVATE EPS BEARER CONTEXT REQUEST message with the same PTI value as a network retransmission (see subclause 7.3.1).

i) If the ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST message is received, the UE shall verify that the EPS bearer identity given in the EPS bearer identity IE is not already used by any EPS bearer context. The UE shall then proceed as described in subclause 6.4.2.3 or subclause 6.4.2.4.

ii) If the MODIFY EPS BEARER CONTEXT REQUEST message is received, the UE verifies that the EPS bearer identity given in the EPS bearer identity IE is any of the active EPS bearer contexts. The UE shall then proceed as described in subclause 6.4.3.3 or subclause 6.4.3.4.

iii) If the DEACTIVATE EPS BEARER CONTEXT REQUEST message is received, the UE verifies that the EPS bearer identity given in the EPS bearer identity IE is one of the active EPS bearer contexts. The UE shall then proceed as described in subclause 6.4.4.3.

In case i, after successful completion of the dedicated EPS bearer context activation procedure, the network may initiate an EPS bearer context modification procedure to delete the packet filters which have packet filter identifiers indicated by the UE in the Traffic flow aggregate IE in the BEARER RESOURCE MODIFICATION REQUEST message and for which the network created new packet filters during the dedicated EPS bearer context activation procedure. In this case the MME shall set the procedure transaction identity value in the MODIFY EPS BEARER CONTEXT REQUEST message to "no procedure transaction identity assigned".

6.5.4.4 UE requested bearer resource modification procedure not accepted by the network

6.5.4.4.1 General

If the bearer resource modification requested cannot be accepted by the network, the MME shall send a BEARER RESOURCE MODIFICATION REJECT message to the UE. The message shall contain the PTI and an ESM cause value indicating the reason for rejecting the UE requested bearer resource modification.

The ESM cause value typically indicates one of the following:

#26: insufficient resources;

#30: request rejected by Serving GW or PDN GW;

#31: request rejected, unspecified;

#32: service option not supported;

#33: requested service option not subscribed;

#34: service option temporarily out of order;

#35: PTI already in use;

#37: EPS QoS not accepted;

#41: semantic error in the TFT operation;

#42: syntactical error in the TFT operation;

#43: invalid EPS bearer identity;

#44: semantic error(s) in packet filter(s);

#45: syntactical error(s) in packet filter(s);

#56: collision with network initiated request;

#59: unsupported QCI value;

#60: bearer handling not supported; or

#95 – 111: protocol errors.

If the bearer resource modification requested is for an established LIPA PDN connection or SIPTO at the local network PDN connection, then the network shall reply with a BEARER RESOURCE MODIFICATION REJECT message with ESM cause #60 "bearer handling not supported".

If the requested new TFT is not available, then the BEARER RESOURCE MODIFICATION REJECT message shall be sent.

The TFT in the request message is checked by the network for different types of TFT IE errors as follows:

a) Semantic errors in TFT operations:

1) When the *TFT operation* is an operation other than "Replace packet filters in existing TFT", "Add packet filters to existing TFT", "Delete packet filters from existing TFT" or "No TFT operation".

2) When the *TFT operation* is "Replace packet filters in existing TFT", "Add packet filters to existing TFT" or "Delete packet filters from existing TFT" and there is no TFT for the default EPS bearer context.

3) *TFT operation* = "Delete packet filters from existing TFT" when it would render the TFT empty.

In case 1 the network shall reject the modification request with ESM cause #41 "semantic error in the TFT operation".

In case 2, if the TFT operation is "Delete packet filters from existing TFT", the network shall further process the new request and, if no error according to items b, c, and d was detected, shall perform an EPS bearer context modification procedure including the value of EPS bearer identity for packet filter IE in the EPS bearer identity IE and a TFT IE with *TFT operation* = "Delete existing TFT" in the MODIFY EPS BEARER CONTEXT REQUEST message.

In case 2, if the TFT operation is "Replace packet filters in existing TFT" or "Add packet filters to existing TFT", the network shall process the new request as a request with TFT operation = "Create a new TFT".

In case 3, if the packet filters belong to a dedicated EPS bearer context, the network shall process the new deletion request and, if no error according to items b, c, and d was detected, delete the existing TFT. After successful deletion of the TFT, the network shall perform an EPS bearer context deactivation request procedure to deactivate the dedicated EPS bearer context between the UE and the network.

In case 3, if the packet filters belong to the default EPS bearer context, the network shall process the new deletion request and if no error according to items b, c, and d was detected then perform an EPS bearer context modification procedure to remove the existing TFT of the default EPS bearer context, this corresponds to using match-all packet filter for the default EPS bearer context.

b) Syntactical errors in TFT operations:

1) When the *TFT operation* = "Replace packet filters in existing TFT", "Add packet filters to existing TFT" or "Delete packet filters from existing TFT", and the packet filter list in the TFT IE is empty.

2) *TFT operation* = "No TFT operation" with a non-empty packet filter list in the TFT IE.

3) *TFT operation* = "Replace packet filters in existing TFT" when the packet filter to be replaced does not exist in the original TFT.

4) *TFT operation* = "Delete packet filters from existing TFT" when the packet filter to be deleted does not exist in the original TFT.

5) *TFT operation* = "Delete packet filters from existing TFT" with a packet filter list also including packet filters in addition to the packet filter identifiers.

6) When there are other types of syntactical errors in the coding of the TFT IE, such as a mismatch between the number of packet filters subfield, and the number of packet filters in the packet filter list.

7) *TFT operation* = "No TFT operation" with an empty parameters list.

In case 3 the network shall not diagnose an error, shall further process the replace request and, if no error according to items c and d was detected, shall perform an EPS bearer context modification procedure using *TFT operation* = "Add packet filters to existing TFT" to include the packet filters received to the existing TFT.

In case 4 the network shall not diagnose an error, shall further process the deletion request and, if no error according to items c and d was detected, shall perform an EPS bearer context modification procedure including the value of EPS bearer identity for packet filter IE in the EPS bearer identity IE and a TFT IE with *TFT operation* = "Delete packet filters from existing TFT" and the received packet filter identifier(s) in the MODIFY EPS BEARER CONTEXT REQUEST message.

Otherwise the network shall reject the modification request with ESM cause #42 "syntactical error in the TFT operation".

c) Semantic errors in packet filters:

1) When a packet filter consists of conflicting packet filter components which would render the packet filter ineffective, i.e. no IP packet will ever fit this packet filter. How the network determines a semantic error in a packet filter is outside the scope of the present document.

2) When the resulting TFT, which is assigned to a dedicated EPS bearer context, does not contain any packet filter applicable for the uplink direction.

The network shall reject the modification request with ESM cause #44 "semantic errors in packet filter(s)".

d) Syntactical errors in packet filters:

1) When the *TFT operation* = "Replace packet filters in existing TFT" and two or more packet filters in all TFTs associated with the PDN connection would have identical packet filter precedence values.

2) When there are other types of syntactical errors in the coding of packet filters, such as the use of a reserved value for a packet filter component identifier.

In case 1, if the old packet filters do not belong to the default EPS bearer context, the network shall not diagnose an error, shall further process the new request and, if it was processed successfully, shall delete the old packet filters which have identical filter precedence values. Furthermore, the network shall perform an EPS bearer context deactivation procedure to deactivate the dedicated EPS bearer context(s) for which it has deleted the packet filters.

In case 1, if one or more old packet filters belong to the default EPS bearer context, the network shall release the relevant PDN connection using the EPS bearer context deactivation procedure. If the relevant PDN connection is the last one and EMM-REGISTERED without PDN connection is not supported by the UE or the MME, the network shall detach the UE using detach type "re-attach required".

Otherwise the network shall reject the modification request with ESM cause #45 "syntactical errors in packet filter(s)".

The network may include a Back-off timer value IE in the BEARER RESOURCE MODIFICATION REJECT message.

If the Back-off timer value IE is included and the ESM cause value is not #26 "insufficient resources", the network may include the Re-attempt indicator IE to indicate whether the UE is allowed to attempt a PDP context modification procedure in the PLMN for the same APN in A/Gb or Iu mode, and whether another attempt in A/Gb and Iu mode or in S1 mode is allowed in an equivalent PLMN.

Upon receipt of a BEARER RESOURCE MODIFICATION REJECT message, the UE shall stop the timer T3481, release the traffic flow aggregate description associated to the PTI value, and enter the state PROCEDURE TRANSACTION INACTIVE. If the ESM cause included in the BEARER RESOURCE MODIFICATION REJECT message is #43 "invalid EPS bearer identity", the UE locally deactivates the EPS bearer context(s) without peer-to-peer ESM signalling.

6.5.4.4.2 Handling of network rejection due to ESM cause #26

If the ESM cause value is #26 "insufficient resources" and the Back-off timer value IE is included, the UE shall ignore the Re-attempt indicator IE provided by the network, if any, and take different actions depending on the timer value received for timer T3396 in the Back-off timer value IE (if the UE is configured for dual priority, exceptions are specified in subclause 6.5.5; if the UE is a UE configured to use AC11 – 15 in selected PLMN, exceptions are specified in subclause 6.3.5):

i) if the timer value indicates neither zero nor deactivated, the UE shall stop timer T3396 associated with the corresponding APN, if it is running. The UE shall then start T3396 with the value provided in the Back-off timer value IE and not send another PDN CONNECTIVITY REQUEST, BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message for the same APN until timer T3396 expires or timer T3396 is stopped. If the UE did not provide an APN for the establishment of the PDN connection and the request type was different from "emergency" and from "handover of emergency bearer services", the UE shall stop the timer T3396 associated with no APN if it is running. The UE shall start timer T3396 with the received value and not send another PDN CONNECTIVITY REQUEST message without an APN and with request type different from "emergency" and from "handover of emergency bearer services", or another BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message for a non-emergency PDN connection established without an APN provided by the UE, until timer T3396 expires or timer T3396 is stopped. The UE shall not stop timer T3396 upon a PLMN change or inter-system change;

ii) if the timer value indicates that this timer is deactivated, the UE shall not send another PDN CONNECTIVITY REQUEST, BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message for the same APN until the UE is switched off or the USIM is removed or the UE receives an ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST, ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST or MODIFY EPS BEARER CONTEXT REQUEST message for the same APN from the network or a DEACTIVATE EPS BEARER CONTEXT REQUEST message including ESM cause #39 "reactivation requested" for a default EPS bearer context for the same APN from the network. If the UE did not provide an APN for the establishment of the PDN connection and the request type was different from "emergency" and from "handover of emergency bearer services", the UE shall not send another PDN CONNECTIVITY REQUEST message without an APN and with request type different from "emergency" and from "handover of emergency bearer services", or another BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message for a non-emergency PDN connection established without APN provided by the UE, until the UE is switched off or the USIM is removed, or the UE receives an ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST, ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST or MODIFY EPS BEARER CONTEXT REQUEST message for a non-emergency PDN connection established without an APN provided by the UE, or a DEACTIVATE EPS BEARER CONTEXT REQUEST message including ESM cause #39 "reactivation requested" for a default EPS bearer context of a non-emergency PDN connection established without an APN provided by the UE. The timer T3396 remains deactivated upon a PLMN change or inter-system change; or

iii) if the timer value indicates zero, the UE:

- shall stop timer T3396 associated with the corresponding APN, if running, and may send another PDN CONNECTIVITY REQUEST, BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message for the same APN; and

- if the UE did not provide an APN for the establishment of the PDN connection and the request type was different from "emergency" and from "handover of emergency bearer services", the UE shall stop timer T3396 associated with no APN, if running, and may send another PDN CONNECTIVITY REQUEST message without an APN, or another BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message for a non-emergency PDN connection established without an APN provided by the UE.

If the Back-off timer value IE is not included, the UE may send a PDN CONNECTIVITY REQUEST, BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST messages for the same APN.

The further actions to be performed by the UE are implementation dependent as part of upper layers responsibility.

If the timer T3396 is running when the UE enters state EMM-DEREGISTERED, the UE remains switched on, and the USIM in the UE remains the same, then timer T3396 is kept running until it expires or it is stopped.

If the UE is switched off when the timer T3396 is running, and if the USIM in the UE remains the same when the UE is switched on, the UE behaves as follows:

- let t1 be the time remaining for T3396 timeout at switch off and let t be the time elapsed between switch off and switch on. If t1 is greater than t, then the timer shall be restarted with the value t1 – t. If t1 is equal to or less than t, then the timer need not be restarted. If the UE is not capable of determining t, then the UE shall restart the timer with the value t1;

- if prior to switch off, timer T3396 was running for a specific APN, because a PDN CONNECTIVITY REQUEST, BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message containing the low priority indicator set to "MS is configured for NAS signalling low priority" was rejected with a timer value for timer T3396, and if timer T3396 is restarted at switch on, then the UE configured for dual priority shall handle session management requests as indicated in subclause 6.5.5; and

- if prior to switch off timer T3396 was running because a PDN CONNECTIVITY REQUEST without APN sent together with an ATTACH REQUEST message containing the low priority indicator set to "MS is configured for NAS signalling low priority" was rejected with a timer value for timer T3396, and if timer T3396 is restarted at switch on, then the UE configured for dual priority shall handle session management requests as indicated in subclause 6.5.5.

6.5.4.4.3 Handling of network rejection due to ESM cause other than ESM cause #26

If the ESM cause value is not #26 "insufficient resources", and the Back-off timer value IE is included, the UE shall behave as follows depending on the timer value received in the Back-off timer value IE (if the UE is a UE configured to use AC11 – 15 in selected PLMN, exceptions are specified in subclause 6.3.6):

- if the timer value indicates neither zero nor deactivated, the UE shall start the back-off timer with the value provided in the Back-off timer value IE for the bearer resource modification procedure and PLMN and APN combination and not send another BEARER RESOURCE MODIFICATION REQUEST message in the PLMN for the same APN until the back-off timer expires, the UE is switched off or the USIM is removed;

- if the timer value indicates that this timer is deactivated, the UE shall not send another BEARER RESOURCE MODIFICATION REQUEST message in the PLMN for the same APN until the UE is switched off or the USIM is removed; and

- if the timer value indicates zero, the UE may send another BEARER RESOURCE MODIFICATION REQUEST message in the PLMN for the same APN.

If the Back-off timer value IE is not included, then the UE shall ignore the Re-attempt indicator IE provided by the network, if any.

1) Additionally, if the ESM cause value is #32 "service option not supported", or #33 "requested service option not subscribed", the UE shall proceed as follows:

   - if the UE is registered in the HPLMN or in a PLMN that is within the EHPLMN list, the UE shall behave as described above in the present subclause, using the configured SM_RetryWaitTime value as specified in 3GPP TS 24.368 [15A] or in USIM file NAS_{CONFIG} as specified in 3GPP TS 31.102 [17], if available, as back-off timer value; and

   - otherwise, if the UE is not registered in its HPLMN or a PLMN that is within the EHPLMN list or the SM_RetryWaitTime value is not configured, the UE shall behave as described above in the present subclause, using the default value of 12 minutes for the back-off timer.

2) For ESM cause values different from #32 "service option not supported", or #33 "requested service option not subscribed", the UE behaviour regarding the start of a back-off timer is unspecified.

The UE shall not stop any back-off timer upon a PLMN change or inter-system change. If the network indicates that a back-off timer for the bearer resource allocation procedure and PLMN and APN combination is deactivated, then it remains deactivated upon a PLMN change or inter-system change.

NOTE 1: This means the back-off timer can still be running or be deactivated for the given ESM procedure and PLMN and APN combination when the UE returns to the PLMN or when it performs inter-system change back from A/Gb or Iu mode to S1 mode. Thus the UE can still be prevented from sending another BEARER RESOURCE MODIFICATION REQUEST message in the PLMN for the same APN.

If the back-off timer is started upon receipt of BEARER RESOURCE MODIFICATION REJECT (i.e. the timer value was provided by the network, a configured value is available or the default value is used as explained above) or the back-off timer is deactivated, the UE behaves as follows:

1) after a PLMN change the UE may send a BEARER RESOURCE MODIFICATION REQUEST message for the same APN in the new PLMN, if the back-off timer is not running and is not deactivated for the bearer resource modification procedure and the combination of new PLMN and APN;

   Furthermore as an implementation option, for the ESM cause values #32 "service option not supported" or #33 "requested service option not subscribed", if the network does not include a Re-attempt indicator IE, the UE may decide not to automatically send another BEARER RESOURCE MODIFICATION REQUEST message for the same APN that was sent by the UE, if the UE is registered to a new PLMN which is in the list of equivalent PLMNs.

2) if the network does not include the Re-attempt indicator IE to indicate whether re-attempt in A/Gb or Iu mode is allowed, or the UE ignores the Re-attempt indicator IE, e.g. because the Back-off timer value IE is not included, then:

   - if the UE is registered in its HPLMN or in a PLMN that is within the EHPLMN list, the UE shall apply the configured SM_RetryAtRATChange value as specified in 3GPP TS 24.368 [15A] or in USIM file NAS_{CONFIG} as specified in 3GPP TS 31.102 [17], if available, to determine whether the UE may attempt a PDP context modification procedure for the same PLMN and APN combination in A/Gb or Iu mode; and

   - if the UE is not registered in its HPLMN or in a PLMN that is within the EHPLMN list, or if the NAS configuration MO as specified in 3GPP TS 24.368 [15A] is not available and the value for inter-system change is not configured in the USIM file NAS_{CONFIG}, then the UE behaviour regarding a PDP context modification procedure for the same PLMN and APN combination in A/Gb or Iu mode is unspecified; and

3) if the network includes the Re-attempt indicator IE indicating that re-attempt in an equivalent PLMN is not allowed, then depending on the timer value received in the Back-off timer value IE, for each combination of a PLMN from the equivalent PLMN list and the APN the UE shall start a back-off timer for the bearer resource modification procedure with the value provided by the network, or deactivate the respective back-off timer as follows:

   - If the Re-attempt indicator IE additionally indicates that re-attempt in A/Gb or Iu mode is allowed, the UE shall start or deactivate the back-off timer for A/Gb and Iu mode only; and

   - otherwise the UE shall start or deactivate the back-off timer for A/Gb, Iu, and S1 mode.

If the back-off timer for a PLMN and APN combination was started or deactivated upon receipt of an MODIFY PDP CONTEXT REJECT message (see 3GPP TS 24.008 [13]) and the network indicated that re-attempt in S1 mode is allowed, then this back-off timer does not prevent the UE from sending a BEARER RESOURCE MODIFICATION REQUEST message in this PLMN for the same APN after inter-system change to S1 mode. If the network indicated that re-attempt in S1 mode is not allowed, the UE shall not send any BEARER RESOURCE MODIFICATION REQUEST message in this PLMN for the same APN after inter-system change to S1 mode until the timer expires, the UE is switched off or the USIM is removed.

NOTE 2: The back-off timer is used to describe a logical model of the required UE behaviour. This model does not imply any specific implementation, e.g. as a timer or timestamp.

NOTE 3: Reference to back-off timer in this section can either refer to use of timer T3396 or to use of a different packet system specific timer within the UE. Whether the UE uses T3396 as a back-off timer or it uses different packet system specific timers as back-off timers is left up to UE implementation. This back-off timer is stopped when the UE is switched off or the USIM is removed.

The further actions to be performed by the UE are implementation dependent as part of upper layers responsibility.

6.5.4.5 Abnormal cases in the UE

The following abnormal cases can be identified:

a) Expiry of timer T3481:

On the first expiry of the timer T3481, the UE shall resend the BEARER RESOURCE MODIFICATION REQUEST and shall reset and restart timer T3481. This retransmission is repeated four times, i.e. on the fifth expiry of timer T3481, the UE shall abort the procedure, release the PTI allocated for this activation and enter the state PROCEDURE TRANSACTION INACTIVE. In addition, if the UE had initiated resource release for all the traffic flows for the bearer, it shall deactivate the EPS bearer context locally without peer-to-peer signalling between the UE and the MME. In order to synchronize the EPS bearer context status with the MME, on indication of "back to E-UTRAN coverage" from the lower layers, the UE shall send a TRACKING AREA UPDATE REQUEST message that includes the EPS bearer context status IE to the MME.

b) Unknown EPS bearer context

Upon receipt of the BEARER RESOURCE MODIFICATION REJECT message including ESM cause #43 "invalid EPS bearer identity", the UE shall deactivate the existing EPS bearer context locally without peer-to-peer signalling between the UE and the MME.

c) Collision of a UE requested bearer resource modification procedure and an EPS bearer context deactivation procedure.

When the UE receives a DEACTIVATE EPS BEARER CONTEXT REQUEST message during the bearer resource modification procedure, and the EPS bearer identity indicated in the DEACTIVATE EPS BEARER CONTEXT REQUEST message is a EPS bearer context the UE indicated in the UE requested bearer resource modification procedure, then the UE shall abort the UE requested bearer resource modification procedure and proceed with the EPS bearer context deactivation procedure.

d) Rejection of a UE requested bearer resource modification procedure when the UE has initiated the procedure to release all traffic flows for the bearer

Upon receipt of a BEARER RESOURCE MODIFICATION REJECT message with ESM cause value #31 "request rejected, unspecified", if the UE had initiated resource release for all the traffic flows for the bearer, it shall deactivate the EPS bearer context locally without peer-to-peer signalling between the UE and the MME. In order to synchronize the EPS bearer context status with the MME, the UE may send a TRACKING AREA UPDATE REQUEST message that includes the EPS bearer context status IE to the MME.

6.5.4.6 Abnormal cases on the network side

The following abnormal cases can be identified:

a) Unknown EPS bearer context

If the EPS bearer identity provided in the EPS bearer identity for packet filter IE in the BEARER RESOURCE MODIFICATION REQUEST message indicates an EPS bearer identity value and this does not belong to any already activated EPS bearer context, the MME shall reply with a BEARER RESOURCE MODIFICATION REJECT message with ESM cause #43 "invalid EPS bearer identity".

b) BEARER RESOURCE MODIFICATION REQUEST message received for a PDN connection established for emergency bearer services:

The MME shall reply with a BEARER RESOURCE MODIFICATION REJECT message with ESM cause #30 "request rejected by Serving GW or PDN GW".

6.5.5 Handling session management request for UE configured for dual priority

If timer T3396 is running for a specific APN due to one of the following reasons:

- a PDN CONNECTIVITY REQUEST, BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message containing the low priority indicator set to "MS is configured

for NAS signalling low priority" was rejected with a timer value for timer T3396 and ESM cause value #26 "insufficient resources";

- a DEACTIVATE EPS BEARER CONTEXT REQUEST message was received with a timer value for timer T3396 and ESM cause value #26 "insufficient resources" for a PDN connection established with low priority indicator set to "MS is configured for NAS signalling low priority", or

- because the UE received a DEACTIVATE EPS BEARER CONTEXT REQUEST message containing a timer value for timer T3396 and ESM cause value #26 "insufficient resources" for a PDN connection established with low priority indicator set to "MS is configured for NAS signalling low priority",

upon request of the upper layers the UE can:

- send a PDN CONNECTIVITY REQUEST message to the same APN, with low priority indicator set to "MS is not configured for NAS signalling low priority"; or,

- send a BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message, with low priority indicator set to "MS is not configured for NAS signalling low priority", for a PDN connection established with low priority indicator set to "MS is not configured for NAS signalling low priority" exists.

If timer T3396 is running, because any of the following messages containing the low priority indicator set to "MS is configured for NAS signalling low priority" was rejected with a timer value for timer T3396 and ESM cause value #26 "insufficient resources":

- a PDN CONNECTIVITY REQUEST without APN and with request type different from "emergency" and from "handover of emergency bearer services", sent together with an ATTACH REQUEST message;

- a stand-alone PDN CONNECTIVITY REQUEST message without APN and with request type different from "emergency" and from "handover of emergency bearer services"; or

- a BEARER RESOURCE MODIFICATION REQUEST or BEARER RESOURCE ALLOCATION REQUEST message sent for a non-emergency PDN connection established without APN provided by the UE,

or because the UE received a DEACTIVATE EPS BEARER CONTEXT REQUEST message containing a timer value for timer T3396 and ESM cause value #26 "insufficient resources" for a non-emergency PDN connection established without APN provided by the UE and established with low priority indicator set to "MS is configured for NAS signalling low priority", then upon request of the upper layers the UE can initiate a new attach procedure or stand-alone PDN CONNECTIVITY REQUEST procedure without APN and with request type different from "emergency" and from "handover of emergency bearer services", with low priority indicator set to "MS is not configured for NAS signalling low priority".

For requests with low priority indicator set to "MS is configured for NAS signalling low priority", the UE shall follow the procedures specified in subclause 6.5.1.4.

6.6 Miscellaneous procedures

6.6.1 Exchange of protocol configuration options

6.6.1.1 General

The UE and the PDN GW can exchange protocol configuration options via the dedicated ESM information request procedure or via other ESM procedures.

If supported by the network and UE end-to-end for a PDN connection, protocol configuration options shall be exchanged via the extended protocol configuration options IE. Otherwise the protocol configuration options IE is used.

NOTE 1: In this version of the protocol inter-system mobility to and from NB-S1 mode is supported. During inter-system-mobility from NB-S1 mode to WB-S1 mode the end-to-end support of the extended protocol configuration options IE can be lost, e.g. if the new MME does not support the extended protocol configuration options IE.

For the UE, the extended protocol configuration options is supported by the network and the UE end-to-end for a PDN connection if

- the UE is in NB-S1 mode;
- the PDN Type requested for the PDN connection is non-IP;
- the UE supports N1 mode; or
- the network has indicated support of the extended protocol configuration options IE in the last ATTACH ACCEPT or TRACKING AREA UPDATING ACCEPT message and the network has included the extended protocol configuration options IE in at least one EPS session management message received by the UE for this PDN connection.

For the MME, the extended protocol configuration options is supported by the network and the UE end-to-end for a PDN connection if

- the UE is in NB-S1 mode;
- the PDN Type requested for the PDN connection is non-IP;
- the MME supports inter-system change with 5GS; or
- the UE has indicated support of the extended protocol configuration options IE in the last ATTACH REQUEST or TRACKING AREA UPDATING REQUEST message, and the MME has received the extended protocol configuration options IE in at least one message sent by the PDN GW towards the UE for this PDN connection (for details see 3GPP TS 29.274 [16D]).

NOTE 2: For the PDN GW, the extended protocol configuration options is supported by the network and the UE end-to-end for a PDN connection if the last support indication received from the MME or S-GW indicates that extended protocol configuration options is supported for this PDN connection (for details see 3GPP TS 29.274 [16D]).

6.6.1.2 ESM information request procedure

6.6.1.2.1 General

The ESM information request procedure is used by the network to retrieve ESM information, i.e. protocol configuration options, APN, or both from the UE during the attach procedure if the UE indicated in the PDN CONNECTIVITY REQUEST message that it has ESM information that needs to be sent security protected. The purpose of this procedure is to provide privacy for the ESM information if ciphering is enabled in the network.

6.6.1.2.2 ESM information request initiated by the network

The network intiates the ESM information request procedure by sending a ESM INFORMATION REQUEST message to the UE, starting timer T3489 and entering the state PROCEDURE TRANSACTION PENDING (see example in figure 6.6.1.2.2.1). This message shall be sent only after the security context has been setup, and if the ESM information transfer flag has been set in the PDN CONNECTIVITY REQUEST message. The MME shall set the EPS bearer identity of the ESM INFORMATION REQUEST message to the value "no EPS bearer identity assigned" and include the PTI from the associated PDN CONNECTIVITY REQUEST message.

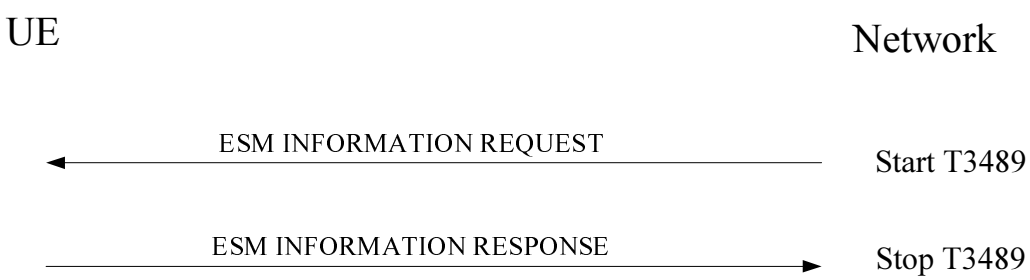


Figure 6.6.1.2.2.1: ESM information request procedure

6.6.1.2.3 ESM information request completion by the UE

Upon receipt of the ESM INFORMATION REQUEST message, the UE shall send an ESM INFORMATION RESPONSE message to the network. The UE shall include all the protocol configuration options that need to be transferred security protected, and APN if required, to the network in the ESM INFORMATION RESPONSE message. The UE shall set the EPS bearer identity of the ESM INFORMATION RESPONSE message to the value "no EPS bearer identity assigned" and include the PTI from the ESM INFORMATION REQUEST message.

6.6.1.2.4 ESM information request completion by the network

Upon receipt of the ESM INFORMATION RESPONSE message, the network shall stop timer T3489 and enter the state PROCEDURE TRANSACTION INACTIVE. A protocol configuration options IE or extended protocol configuration options IE included in the ESM INFORMATION RESPONSE message replaces any protocol configuration options IE or extended protocol configuration options IE that the network previously may have received during the attach procedure execution.

6.6.1.2.5 Abnormal cases in the UE

Apart from the case described in subclause 6.3.3, no abnormal cases have been identified.

6.6.1.2.6 Abnormal cases on the network side

The following abnormal cases can be identified:

a) Expiry of timer T3489:

   On the first expiry of the timer T3489, the MME shall resend the ESM INFORMATION REQUEST message and shall reset and restart timer T3489. This retransmission is repeated two times, i.e. on the third expiry of timer T3489, the MME shall abort the procedure, release any resources for this procedure and reject the associated PDN connectivity procedure including the ESM cause #53 "ESM information not received", in the PDN CONNECTIVITY REJECT message.

6.6.1.3 Exchange of protocol configuration options in other messages

The UE may include a protocol configuration options IE or extended protocol configuration options IE on EPS bearer context activation, EPS bearer context deactivation, EPS bearer context modification, PDN connectivity request, PDN disconnect request, bearer resource allocation request and bearer resource modification request if the UE wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the PDN GW or the SCEF. In particular, the UE may use this procedure on EPS bearer context activation to perform the MSISDN notification procedure as specified in 3GPP TS 24.008 [13], subclause 6.4.

The PDN GW or the SCEF may include a protocol configuration options IE or extended protocol configuration options IE on EPS bearer context activation, EPS bearer context deactivation, EPS bearer context modification, PDN connectivity reject, PDN disconnect reject, bearer resource allocation reject and bearer resource modification reject if the PDN GW or the SCEF wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the UE. In particular, the PDN GW may use this procedure on EPS bearer context activation to perform the MSISDN notification procedure as specified in 3GPP TS 24.008 [13], subclause 6.4.

6.6.2 Notification procedure

6.6.2.1 General

The network can use the notification procedure to inform the UE about events which are relevant for the upper layer which is using an EPS bearer context or has requested a procedure transaction.

If the UE has indicated that it supports the notification procedure, the network may initiate the procedure at any time while a PDN connection exists or a procedure transaction is ongoing.

6.6.2.2 Notification procedure initiation by the network

The network initiates the notification procedure by sending a NOTIFICATION message to the UE (see example in figure 6.6.2.2.1).

Figure 6.6.2.2.1: Notification procedure

6.6.2.3 Notification procedure in the UE

When the UE receives a NOTIFICATION message, the ESM protocol entity in the UE shall provide the notification indicator to the upper layer.

The notification indicator can have the following value:

#1: SRVCC handover cancelled, IMS session re-establishment required.

6.6.2.4 Abnormal cases on the network side

The following abnormal case can be identified:

a) Lower layer indication of non-delivered NAS PDU due to handover

If the NOTIFICATION message could not be delivered due to an intra MME handover, then upon successful completion of the intra MME handover the MME shall retransmit the NOTIFICATION message. If a failure of the handover procedure is reported by the lower layer and the S1 signalling connection exists, the MME shall retransmit the NOTIFICATION message.

6.6.3 Remote UE Report procedure

6.6.3.1 General

The purpose of the Remote UE Report procedure is for a UE acting as ProSe UE-to-network relay to notify the network that a remote UE is connected to the ProSe UE-to-network relay or disconnected from the ProSe UE-to-network relay as specified in 3GPP TS 23.303 [31].

6.6.3.2 Remote UE Report initiated by the UE

The UE initiates the Remote UE Report procedure by sending a REMOTE UE REPORT message to the network, starting timer T3493 and entering the state PROCEDURE TRANSACTION PENDING (see example in figure 6.6.3.2.1). The UE shall include information of newly connected or disconnected remote UEs to the network in the REMOTE UE REPORT message. If any encrypted IMSI remote UE identity is included in the REMOTE UE REPORT message, the UE shall include the corresponding ProSe Key Management Function address. The UE shall include the default EPS bearer identity of the PDN connection associated with the remote UE connected to the ProSe UE-to-network relay or disconnected from the ProSe UE-to-network relay.

NOTE: Encrypted IMSI remote UE identities corresponding to different ProSe Key Management Function addresses need to be reported using separate REMOTE UE REPORT messages.

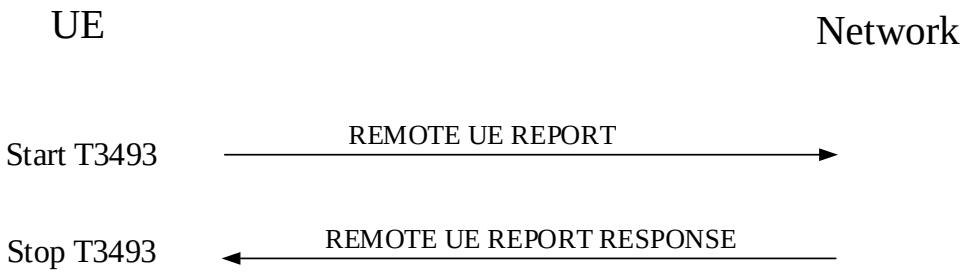


Figure 6.6.3.2.1: Remote UE Report procedure

6.6.3.3 Remote UE Report completion by the network

Upon receipt of the REMOTE UE REPORT message, the MME shall send an REMOTE UE REPORT RESPONSE message to the UE. The MME shall include the PTI from the REMOTE UE REPORT message.

6.6.3.4 Remote UE Report completion by the UE

Upon receipt of the REMOTE UE REPORT RESPONSE message, the UE shall stop timer T3493 and enter the state PROCEDURE TRANSACTION INACTIVE.

6.6.3.5 Abnormal cases in the UE

The following abnormal cases can be identified:

a) Expiry of timer T3493:

On the first expiry of the timer T3493, the UE shall resend the REMOTE UE REPORT message and shall reset and restart timer T3493. This retransmission is repeated two times, i.e. on the third expiry of timer T3493, the UE shall abort the procedure and release any resources for this procedure.

NOTE: After the abortion of the Remote UE Report procedure, the Remote UE Report procedure for the remote UE(s) can be restarted and how to restart the procedure is left to UE implementation.

6.6.3.6 Abnormal cases on the network side

No abnormal cases have been identified.

6.6.4 Transport of user data via the control plane procedure

6.6.4.1 General

The purpose of the transport of user data via the control plane procedure is to transfer user data via the control plane in an encapsulated form between the UE and the MME.

The procedure may be initiated by the UE or the network when the UE is in EMM-CONNECTED mode.

The procedure may also be initiated by the UE in EMM-IDLE mode by including the ESM DATA TRANSPORT message in a CONTROL PLANE SERVICE REQUEST message.

6.6.4.2 UE initiated transport of user data via the control plane

Upon receipt of a request to transfer user data via the control plane, if the UE is in EMM-CONNECTED mode, the UE initiates the procedure by sending the ESM DATA TRANSPORT message including the user data to be sent in the User data container IE. The length of the value part of the User data container IE should not exceed the link MTU size for the respective type of user data (IPv4, IPv6 or Non-IP).

NOTE: The recommended maximum size for link MTU is 1358 octets to prevent fragmentation in the backbone network (see 3GPP TS 23.060 [74]). Depending on the network configuration, setting link MTU size to a value larger than 1358 octets could lead to inefficient core network implementation due to fragmentation.

If the UE is in EMM-IDLE mode, the UE initiates the procedure by sending the ESM DATA TRANSPORT message included in a CONTROL PLANE SERVICE REQUEST message.

Based on information provided by the upper layers, the UE may include a Release assistance indication IE in the ESM DATA TRANSPORT message to inform the network that

1) subsequent to the current uplink data transmission no further uplink or downlink data transmission (e.g. an acknowledgement or response) is expected; i.e. the upper layers indicated that data exchanges have completed with the current UL data transfer; or

2) subsequent to the current uplink data transmission only a single downlink data transmission and no further uplink data transmission is expected; i.e. the upper layers indicated that data exchanges will have completed with the next downlink data transmission.

When receiving the ESM DATA TRANSPORT message, the MME shall identify the PDN connection to the SCEF or to the PDN GW, based on the EPS bearer identity included in message, and forward the contents of the User data container IE accordingly. If the ESM DATA TRANSPORT message includes a Release assistance indication IE, then ESM layer indicates to the EMM layer to initiate release of the NAS signalling connection,

1) if the release assistance indication indicates that no further uplink or downlink data transmission subsequent to the uplink data transmission is expected; or,

2) upon subsequent delivery of the next received downlink data transmission to the UE if the release assistance indication indicates that only a single downlink data transmission and no further uplink data transmission subsequent to the uplink data transmission is expected.

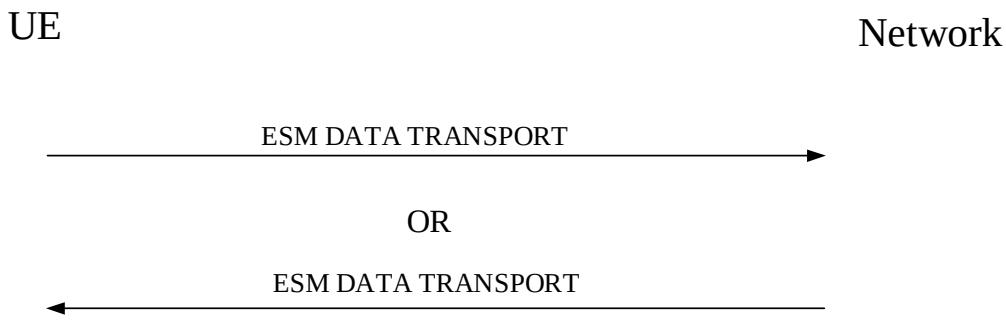


Figure 6.6.4.2.1: Transport of user data via the control plane procedure

6.6.4.3 Network initiated transport of user data via the control plane

The network initiates the procedure by sending the ESM DATA TRANSPORT message. Upon receiving the ESM DATA TRANSPORT message, the UE shall:

- forward the contents of the User data container IE to the upper layers.

6.6.4.4 Abnormal cases in the UE

The following abnormal case can be identified:

a) T3396 is running

The UE shall not send an ESM DATA TRANSPORT message unless

- the UE is a UE configured to use AC11 – 15 in selected PLMN; or

- the ESM DATA TRANSPORT message is used for an exception data reporting and the UE is allowed to use exception data reporting (see the ExceptionDataReportingAllowed leaf of the NAS configuration MO in 3GPP TS 24.368 [15A] or the USIM file $EF_{NASCONFIG}$ in 3GPP TS 31.102 [17]).

The ESM DATA TRANSPORT message can be sent, if still necessary, when timer T3396 expires or is stopped.

b) Transmission failure of the ESM DATA TRANSPORT message indication from lower layers

If lower layers indicate a TAI change and the current TAI is not in the TAI list, the transport of user data via the control plane procedure shall be aborted and re-initiated after successfully performing a tracking area updating procedure if the control plane CIoT EPS optimisation is still used and the user data exists. The "signalling active" flag shall be set in the TRACKING AREA UPDATE REQUEST message.

If lower layers indicate a TAI change, but the current TAI is still part of the TAI list, or the TAI has not changed, the transport of user data via the control plane procedure shall be re-initiated immediately if the user data still exists by including the ESM DATA TRANSPORT message in a CONTROL PLANE SERVICE REQUEST message.

NOTE: How the ESM sublayer handles the retransmission of user data via the control plane is up to the UE implementation.

6.6.4.5 Abnormal cases on the network side

Apart from the case described in subclause 6.3.4, no other abnormal cases have been identified.

6.7 Reception of an ESM STATUS message by an ESM entity

The purpose of the sending of the ESM STATUS message is to report at any time certain error conditions detected upon receipt of ESM protocol data. The ESM STATUS message can be sent by both the MME and the UE (see example in figure 6.7.1).

If the ESM entity of the UE receives an ESM STATUS message the UE shall take different actions depending on the received ESM cause value:

#43 (Invalid EPS bearer identity);

The UE shall abort any ongoing ESM procedure related to the received EPS bearer identity, stop any related timer, and deactivate the corresponding EPS bearer context locally (without peer to peer signalling between the UE and the MME).

#81 (Invalid PTI value);

The UE shall abort any ongoing ESM procedure related to the received PTI value and stop any related timer.

#97 (Message type non-existent or not implemented);

The UE shall abort any ongoing ESM procedure related to the PTI or EPS bearer identity and stop any related timer.

On receipt of an ESM STATUS message with any other ESM cause value no state transition and no specific action shall be taken as seen from the radio interface, i.e. local actions are possible.

If the ESM entity of the MME receives an ESM STATUS message the MME shall take different actions depending on the received ESM cause value:

#43 (Invalid EPS bearer identity);

The MME shall abort any ongoing ESM procedure related to the received EPS bearer identity, stop any related timer, and deactivate the corresponding EPS bearer context locally (without peer to peer signalling between the MME and the UE).

#81 (Invalid PTI value);

The MME shall abort any ongoing ESM procedure related to the received PTI value and stop any related timer.

#97 (Message type non-existent or not implemented);

The MME shall abort any ongoing ESM procedure related to the PTI or EPS bearer identity and stop any related timer.

The local actions to be taken by the MME on receipt of an ESM STATUS message with any other ESM cause value are implementation dependent.

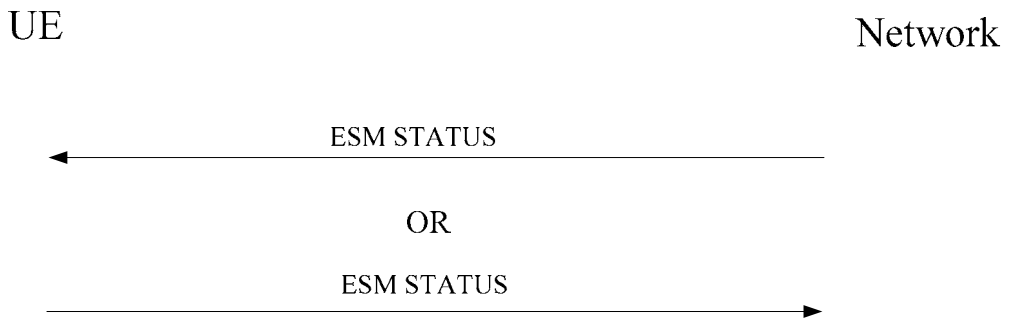


Figure 6.7.1: ESM status procedure

7 Handling of unknown, unforeseen, and erroneous protocol data

7.1 General

The procedures specified in the present document apply to those messages which pass the checks described in this subclause.

This subclause also specifies procedures for the handling of unknown, unforeseen, and erroneous protocol data by the receiving entity. These procedures are called "error handling procedures", but in addition to providing recovery mechanisms for error situations they define a compatibility mechanism for future extensions of the protocols.

Subclauses 7.1 to 7.8 shall be applied in order of precedence.

Most error handling procedures are mandatory for the UE.

Detailed error handling procedures in the network are implementation dependent and may vary from PLMN to PLMN. However, when extensions of this protocol are developed, networks will be assumed to have the error handling that is indicated in this subclause as mandatory ("shall") and that is indicated as strongly recommended ("should").

Also, the error handling of the network is only considered as mandatory or strongly recommended when certain thresholds for errors are not reached during a dedicated connection.

For definition of semantical and syntactical errors see 3GPP TS 24.007 [12], subclause 11.4.2.

7.2 Message too short

When a message is received that is too short to contain a complete message type information element, that message shall be ignored, cf. 3GPP TS 24.007 [12].

7.3 Unknown or unforeseen procedure transaction identity or EPS bearer identity

7.3.1 Procedure transaction identity

The following network procedures shall apply for handling an unknown, erroneous, or unforeseen PTI received in an ESM message:

a) If the network receives a PDN CONNECTIVITY REQUEST message with an unassigned or reserved PTI value, the network shall respond with a PDN CONNECTIVITY REJECT message including ESM cause #81 "invalid PTI value".

b) If the network receives a PDN DISCONNECT REQUEST message with an unassigned or reserved PTI value, the network shall respond with a PDN DISCONNECT REJECT message including ESM cause #81 "invalid PTI value".

c) If the network receives a BEARER RESOURCE ALLOCATION REQUEST message with an unassigned or reserved PTI value, the network shall respond with a BEARER RESOURCE ALLOCATION REJECT message including ESM cause #81 "invalid PTI value".

d) If the network receives a BEARER RESOURCE MODIFICATION REQUEST message with an unassigned or reserved PTI value, the network shall respond with a BEARER RESOURCE MODIFICATION REJECT message including ESM cause #81 "invalid PTI value".

e) If the network receives an ESM INFORMATION RESPONSE message which includes an unassigned or reserved PTI value, the network shall ignore the message. If the PTI is an assigned value that does not match the PTI in use for any ongoing transaction related procedure, the network shall respond with an ESM STATUS message including ESM cause #81 "invalid PTI value".

f) If the network receives an ESM message other than those listed in items a through e above with a reserved PTI value, the network shall ignore the message.

The following UE procedures shall apply for handling an unknown, erroneous, or unforeseen PTI received in an ESM message:

a) If the UE receives a PDN CONNECTIVITY REJECT message in which the PTI value is an unassigned or reserved value, or an assigned value that does not match any PTI in use, the UE shall ignore the message.

b) If the UE receives a PDN DISCONNECT REJECT message in which the PTI value is an unassigned or reserved value, or an assigned value that does not match any PTI in use, the UE shall ignore the message.

c) If the UE receives a BEARER RESOURCE ALLOCATION REJECT message in which the PTI value is an unassigned or reserved value, or an assigned value that does not match any PTI in use, the UE shall ignore the message.

d) If the UE receives a BEARER RESOURCE MODIFICATION REJECT message in which the PTI value is an unassigned or reserved value, or an assigned value that does not match any PTI in use, the UE shall ignore the message.

e) If the UE receives an ESM INFORMATION REQUEST message in which the PTI value is an unassigned or reserved value, the UE shall ignore the message. If the PTI is an assigned value that does not match a PTI in use for a pending UE requested PDN connectivity procedure for which the ESM information transfer flag was set in the PDN CONNECTIVITY REQUEST message, the UE shall respond with an ESM STATUS message including ESM cause #47 "PTI mismatch".

f) If the UE receives a NOTIFICATION message in which the PTI value is an unassigned value, the UE shall proceed as specified in subclause 7.3.2. If the PTI is a reserved value, the UE shall respond with an ESM STATUS message including ESM cause #81 "invalid PTI value". If the PTI is an assigned value that does not match any PTI in use, the UE shall respond with an ESM STATUS message including ESM cause #47 "PTI mismatch".

g) If the UE receives an ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message in which the PTI value is an assigned value that does not match any PTI in use, if the UE detects that this request is a network retransmission of an already accepted request (see subclause 6.5.1.3) the UE shall respond with an ACTIVATE DEFAULT EPS BEARER CONTEXT ACCEPT message. Otherwise, the UE shall respond with an ACTIVATE DEFAULT EPS BEARER CONTEXT REJECT message including ESM cause #47 "PTI mismatch".

h) If the UE receives an ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message which contains a reserved or unassigned PTI value, the UE shall respond with an ACTIVATE DEFAULT EPS BEARER CONTEXT REJECT message including ESM cause #81 "invalid PTI value".

i) If the UE receives an ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST message in which the PTI value is an assigned value that does not match any PTI in use, if the UE detects that this request is a network

retransmission of an already accepted request (see subclauses 6.5.3.3 and 6.5.4.3) the UE shall respond with an ACTIVATE DEDICATED EPS BEARER CONTEXT ACCEPT message. Otherwise, the UE shall respond with an ACTIVATE DEDICATED EPS BEARER CONTEXT REJECT message including ESM cause #47 "PTI mismatch".

j) If the UE receives an ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST message which contains a reserved PTI value, the UE shall respond with an ACTIVATE DEDICATED EPS BEARER CONTEXT REJECT message including ESM cause #81 "invalid PTI value".

k) If the UE receives a MODIFY EPS BEARER CONTEXT REQUEST message in which the PTI value is an assigned value that does not match any PTI in use, if the UE detects that this request is a network retransmission of an already accepted request (see subclauses 6.5.3.3 and 6.5.4.3) the UE shall respond with a MODIFY EPS BEARER CONTEXT ACCEPT message. Otherwise, the UE shall respond with a MODIFY EPS BEARER CONTEXT REJECT message including ESM cause #47 "PTI mismatch".

l) If the UE receives a MODIFY EPS BEARER CONTEXT REQUEST message which contains a reserved PTI value, the UE shall respond with a MODIFY EPS BEARER CONTEXT REJECT message including ESM cause #81 "invalid PTI value".

m) If the UE receives a DEACTIVATE EPS BEARER CONTEXT REQUEST message in which the PTI value is a reserved value or an assigned value that does not match any PTI in use, the UE shall ignore the message.

n) If the UE receives an ESM message other than those listed in items a through m with a reserved PTI value or an assigned value that does not match any PTI in use, the UE shall ignore the message.

7.3.2 EPS bearer identity

The following network procedures shall apply for handling an unknown, erroneous, or unforeseen EPS bearer identity received in the header of an ESM message (specified as the header of a standard L3 message, see 3GPP TS 24.007 [12]):

a) If the network receives a PDN CONNECTIVITY REQUEST message which includes an assigned or reserved EPS bearer identity value, the network shall respond with a PDN CONNECTIVITY REJECT message including ESM cause #43 "invalid EPS bearer identity".

b) If the network receives a PDN DISCONNECT REQUEST message which includes an assigned or reserved EPS bearer identity value, the network shall respond with a PDN DISCONNECT REJECT message including ESM cause #43 "invalid EPS bearer identity".

c) If the network receives a BEARER RESOURCE ALLOCATION REQUEST message which includes an assigned or reserved EPS bearer identity value, the network shall respond with a BEARER RESOURCE ALLOCATION REJECT message including ESM cause #43 "invalid EPS bearer identity".

d) If the network receives a BEARER RESOURCE MODIFICATION REQUEST message which includes an assigned or reserved EPS bearer identity value, the network shall respond with a BEARER RESOURCE MODIFICATION REJECT message including ESM cause #43 "invalid EPS bearer identity".

e) If the network receives an ESM INFORMATION RESPONSE message which includes an assigned or reserved EPS bearer identity value, the network shall ignore the message.

f) If the network receives an ESM DATA TRANSPORT message which includes a reserved EPS bearer identity value or an assigned value that does not match an existing EPS bearer context, the network shall respond with an ESM STATUS message including ESM cause #43 "invalid EPS bearer identity".

g) If the network receives an ESM message other than those listed in items a through e above in which the message includes a reserved EPS bearer identity value or an assigned value that does not match an existing EPS bearer context, the network shall ignore the message.

The following UE procedures shall apply for handling an unknown, erroneous, or unforeseen EPS bearer identity received in the header of an ESM message:

a) If the UE receives a PDN CONNECTIVITY REJECT message which includes an assigned or reserved EPS bearer identity value, the UE shall ignore the message.

b) If the UE receives a PDN DISCONNECT REJECT message which includes an assigned or reserved EPS bearer identity value, the UE shall ignore the message.

c) If the UE receives a BEARER RESOURCE ALLOCATION REJECT message which includes an assigned or reserved EPS bearer identity value, the UE shall ignore the message.

d) If the UE receives a BEARER RESOURCE MODIFICATION REJECT message which includes an assigned or reserved EPS bearer identity value, the UE shall ignore the message.

e) If the UE receives an ESM INFORMATION REQUEST message which includes an assigned or reserved EPS bearer identity value, the UE shall respond with an ESM STATUS message including ESM cause #43 "invalid EPS bearer identity".

f) If the UE receives a NOTIFICATION message which includes a reserved EPS bearer identity value, an assigned EPS bearer identity value that does not match an existing EPS bearer context, or the combination of an unassigned PTI value and an unassigned EPS bearer identity value, the UE shall respond with an ESM STATUS message including ESM cause #43 "invalid EPS bearer identity".

g) If the UE receives an ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message which includes an unassigned or reserved EPS bearer identity value, the UE shall respond with an ACTIVATE DEFAULT EPS BEARER CONTEXT REJECT message including ESM cause #43 "invalid EPS bearer identity".

h) If the UE receives an ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST message which includes an unassigned or reserved EPS bearer identity value, the UE shall respond with an ACTIVATE DEDICATED EPS BEARER CONTEXT REJECT message including ESM cause #43 "invalid EPS bearer identity".

i) If the UE receives a MODIFY EPS BEARER CONTEXT REQUEST message which includes an unassigned or reserved EPS bearer identity value or an assigned EPS bearer identity value that does not match an existing EPS bearer context, the UE shall respond with a MODIFY EPS BEARER CONTEXT REJECT message including ESM cause #43 "invalid EPS bearer identity".

j) If the UE receives a DEACTIVATE EPS BEARER CONTEXT REQUEST message which includes an unassigned or reserved EPS bearer identity value or an assigned EPS bearer identity value that does not match an existing EPS bearer context, the UE shall respond with a DEACTIVATE EPS BEARER CONTEXT ACCEPT message with the EPS bearer identity set to the received EPS bearer identity.

k) If the UE receives an ESM DATA TRANSPORT message which includes a reserved EPS bearer identity value or an assigned value that does not match an existing EPS bearer context, the UE shall respond with an ESM STATUS message including ESM cause #43 "invalid EPS bearer identity".

l) If the UE receives an ESM message other than those listed in items a through j in which the message includes an unassigned or reserved EPS bearer identity value or a value that does not match an EPS bearer context of an established PDN connection, the UE shall ignore the message.

7.4 Unknown or unforeseen message type

If UE receives an EMM message or ESM message with message type not defined for the protocol discriminator (PD) or not implemented by the receiver, it shall return a status message (EMM STATUS or ESM STATUS depending on the PD) with cause #97 "message type non-existent or not implemented".

If the network receives an EMM or ESM message with message type not defined for the PD or not implemented by the receiver in a protocol state where reception of an unsolicited message with the given PD from the UE is not foreseen in the protocol, the network actions are implementation dependent. Otherwise, if the network receives a message with message type not defined for the PD or not implemented by the receiver, it shall ignore the message except that it should return a status message (EMM STATUS or ESM STATUS depending on the PD) with cause #97 "message type non-existent or not implemented".

NOTE: A message type not defined for the PD in the given direction is regarded by the receiver as a message type not defined for the PD, see 3GPP TS 24.007 [12].

If the UE receives a message not compatible with the protocol state, the UE shall return a status message (EMM STATUS or ESM STATUS depending on the PD) with cause #98 "message type not compatible with protocol state".

If the network receives a message not compatible with the protocol state, the network actions are implementation dependent.

7.5 Non-semantical mandatory information element errors

7.5.1 Common procedures

When on receipt of a message,

- an "imperative message part" error; or
- a "missing mandatory IE" error

is diagnosed or when a message containing:

- a syntactically incorrect mandatory IE;
- an IE unknown in the message, but encoded as "comprehension required" (see 3GPP TS 24.007 [12]); or
- an out of sequence IE encoded as "comprehension required" (see 3GPP TS 24.007 [12]) is received,

the UE shall proceed as follows:

If the message is not one of the messages listed in subclause 7.5.3, item a, b, c, or d, the UE shall return a status message (EMM STATUS or ESM STATUS depending on the PD) with cause #96 "invalid mandatory information"; and

the network shall proceed as follows:

If the message is not one of the messages listed in subclause 7.5.3, item e, f, g or h, the network shall either:

- try to treat the message (the exact further actions are implementation dependent); or
- ignore the message except that it should return a status message (EMM STATUS or ESM STATUS depending on the PD) with cause #96 "invalid mandatory information".

7.5.2 EPS mobility management

No exceptional cases are described for mobility management messages.

No semantical or syntactical diagnosis other than presence and length shall be performed on the ESM message container information element in the ATTACH REQUEST, ATTACH ACCEPT, ATTACH COMPLETE and CONTROL PLANE SERVICE REQUEST messages.

7.5.3 EPS session management

The following UE procedures shall apply for handling an error encountered with a mandatory information element in an ESM message:

a) If the message is an ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST, an ACTIVATE DEFAULT EPS BEARER CONTEXT REJECT message with ESM cause #96 "invalid mandatory information", shall be returned.

b) If the message is an ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST, an ACTIVATE DEDICATED EPS BEARER CONTEXT REJECT message with ESM cause #96 "invalid mandatory information", shall be returned.

c) If the message is a MODIFY EPS BEARER CONTEXT REQUEST, a MODIFY EPS BEARER CONTEXT REJECT message with ESM cause #96 "invalid mandatory information", shall be returned.

d) If the message is a DEACTIVATE EPS BEARER CONTEXT REQUEST, a DEACTIVATE EPS BEARER CONTEXT ACCEPT message shall be returned. All resources associated with that EPS bearer shall be released.

The following network procedures shall apply for handling an error encountered with a mandatory information element in an ESM message:

e) If the message is a PDN CONNECTIVITY REQUEST, a PDN CONNECTIVITY REJECT message with ESM cause #96 "invalid mandatory information", shall be returned.

f) If the message is a PDN DISCONNECT REQUEST, a PDN DISCONNECT REJECT message with ESM cause #96 "invalid mandatory information", shall be returned.

g) If the message is a BEARER RESOURCE ALLOCATION REQUEST, a BEARER RESOURCE ALLOCATION REJECT message with ESM cause #96 "invalid mandatory information", shall be returned.

h) If the message is a BEARER RESOURCE MODIFICATION REQUEST, a BEARER RESOURCE MODIFICATION REJECT message with ESM cause #96 "invalid mandatory information", shall be returned.

7.6 Unknown and unforeseen IEs in the non-imperative message part

7.6.1 IEIs unknown in the message

The UE shall ignore all IEs unknown in a message which are not encoded as "comprehension required" (see 3GPP TS 24.007 [12]).

The network shall take the same approach.

7.6.2 Out of sequence IEs

The UE shall ignore all out of sequence IEs in a message which are not encoded as "comprehension required" (see 3GPP TS 24.007 [12]).

The network should take the same approach.

7.6.3 Repeated IEs

If an information element with format T, TV, TLV, or TLV-E is repeated in a message in which repetition of the information element is not specified in clause 8 of the present document, the UE shall handle only the contents of the information element appearing first and shall ignore all subsequent repetitions of the information element. When repetition of information elements is specified, the UE shall handle only the contents of specified repeated information elements. If the limit on repetition of information elements is exceeded, the UE shall handle the contents of information elements appearing first up to the limit of repetitions and shall ignore all subsequent repetitions of the information element.

The network should follow the same procedures.

7.7 Non-imperative message part errors

This category includes:

- syntactically incorrect optional IEs; and
- conditional IE errors.

7.7.1 Syntactically incorrect optional IEs

The UE shall treat all optional IEs that are syntactically incorrect in a message as not present in the message.

The network shall take the same approach.

7.7.2 Conditional IE errors

When upon receipt of a EMM or ESM message the UE diagnoses a "missing conditional IE" error or an "unexpected conditional IE" error, or when it receives a EMM or ESM message containing at least one syntactically incorrect conditional IE, the UE shall ignore the message and shall return a status message (EMM STATUS or ESM STATUS depending on the PD) with cause #100 "conditional IE error".

When the network receives a message and diagnoses a "missing conditional IE" error or an "unexpected conditional IE" error or when it receives a message containing at least one syntactically incorrect conditional IE, the network shall either:

- try to treat the message (the exact further actions are implementation dependent); or
- ignore the message except that it should return a status message (EMM STATUS or ESM STATUS depending on the PD) with cause #100 "conditional IE error".

7.8 Messages with semantically incorrect contents

When a message with semantically incorrect contents is received, the UE shall perform the foreseen reactions of the procedural part of the present document (i.e. of clauses 4, 5 and 6). If however no such reactions are specified, the UE shall ignore the message except that it shall return a status message (EMM STATUS or ESM STATUS depending on the PD) with cause #95 "semantically incorrect message".

The network should follow the same procedure except that a status message is not normally transmitted.

8 Message functional definitions and contents

8.1 Overview

This clause defines the structure of the messages of the Layer 3 (L3) protocols defined in the present document. These are standard L3 messages as defined in 3GPP TS 24.007 [12].

Each definition given in the present clause includes:

a) a brief description of the message direction and use, including whether the message has:

   1. Local significance, i.e. relevant only on the originating or terminating access;
   2. Access significance, i.e. relevant in the originating and terminating access, but not in the network;
   3. Dual significance, i.e. relevant in either the originating or terminating access and in the network; or
   4. Global significance, i.e. relevant in the originating and terminating access and in the network.

b) a table listing the Information Elements (IE) known in the message and the order of their appearance in the message. All IEs that may be repeated are explicitly indicated (The V, LV and LV-E formatted IEs, which compose the imperative part of the message, occur before the T, TV, TLV and TLV-E formatted IEs which compose the non-imperative part of the message, see 3GPP TS 24.007 [12]). In a (maximal) sequence of consecutive IEs with half octet length, the first IE with half octet length occupies bits 1 to 4 of octet N, the second IE bits 5 to 8 of octet N, the third IE bits 1 to 4 of octet N+1 etc. Such a sequence always has an even number of elements.

   For each information element the table indicates:

   1. The Information Element Identifier (IEI), in hexadecimal notation, if the IE has format T, TV, TLV or TLV-E. If the IEI has half octet length, it is specified by a notation representing the IEI as a hexadecimal digit followed by a "-" (example: B-).

NOTE: The same IEI can be used for different information element types in different messages of the same protocol.

   2. The name of the information element (which may give an idea of the semantics of the element). The name of the information element followed by "IE" or "information element" is used in this technical report as reference to the information element within a message.
   3. The name of the type of the information element (which indicates the coding of the value part of the IE), and generally, the referenced subclause of clause 9 of the present document describing the value part of the information element.
   4. The presence requirement indication (M, C, or O) for the IE as defined in 3GPP TS 24.007 [12].

5. The format of the information element (T, V, TV, LV, TLV, LV-E or TLV-E) as defined in 3GPP TS 24.007 [12].

6. The length of the information element (or permissible range of lengths), in octets, in the message, where "?" means that the maximum length of the IE is only constrained by link layer protocol. This indication is non-normative.

c) subclauses specifying, where appropriate, conditions for IEs with presence requirement C or O in the relevant message which together with other conditions specified in the present document define when the information elements shall be included or not, what non-presence of such IEs means, and – for IEs with presence requirement C – the static conditions for presence or non-presence of the IEs or for both cases (see 3GPP TS 24.007 [12]).

8.2 EPS mobility management messages

8.2.1 Attach accept

8.2.1.1 Message definition

This message is sent by the network to the UE to indicate that the corresponding attach request has been accepted. See table 8.2.1.1.

Message type: ATTACH ACCEPT

Significance: dual

Direction: network to UE

Table 8.2.1.1: ATTACH ACCEPT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Attach accept message identity	Message type 9.8	M	V	1
	EPS attach result	EPS attach result 9.9.3.10	M	V	1/2
	Spare half octet	Spare half octet 9.9.2.9	M	V	1/2
	T3412 value	GPRS timer 9.9.3.16	M	V	1
	TAI list	Tracking area identity list 9.9.3.33	M	LV	7-97
	ESM message container	ESM message container 9.9.3.15	M	LV-E	5-n
50	GUTI	EPS mobile identity 9.9.3.12	O	TLV	13
13	Location area identification	Location area identification 9.9.2.2	O	TV	6
23	MS identity	Mobile identity 9.9.2.3	O	TLV	7-10
53	EMM cause	EMM cause 9.9.3.9	O	TV	2
17	T3402 value	GPRS timer 9.9.3.16	O	TV	2
59	T3423 value	GPRS timer 9.9.3.16	O	TV	2
4A	Equivalent PLMNs	PLMN list 9.9.2.8	O	TLV	5-47
34	Emergency number list	Emergency number list 9.9.3.37	O	TLV	5-50
64	EPS network feature support	EPS network feature support 9.9.3.12A	O	TLV	3-4
F-	Additional update result	Additional update result 9.9.3.0A	O	TV	1
5E	T3412 extended value	GPRS timer 3 9.9.3.16B	O	TLV	3
6A	T3324 value	GPRS timer 2 9.9.3.16A	O	TLV	3
6E	Extended DRX parameters	Extended DRX parameters 9.9.3.46	O	TLV	3
65	DCN-ID	DCN-ID 9.9.3.48	O	TLV	4
E-	SMS services status	SMS services status 9.9.3.4B	O	TV	1
D-	Non-3GPP NW provided policies	Non-3GPP NW provided policies 9.9.3.49	O	TV	1
6B	T3448 value	GPRS timer 2 9.9.3.16A	O	TLV	3
C-	Network policy	Network policy 9.9.3.52	O	TV	1
6C	T3447 value	GPRS timer 3 9.9.3.16B	O	TLV	3
35	Extended emergency number list	Extended emergency number list 9.9.3.37A	O	TLV	FFS
80	Ciphering key data	Ciphering key data 9.9.3.56	O	TLV-E	35-2291

8.2.1.2 GUTI

This IE may be included to assign a GUTI to the UE during attach or combined EPS/IMSI attach.

8.2.1.3 Location area identification

This IE may be included to assign a new location area identification to a UE during a combined attach.

8.2.1.4 MS identity

This IE may be included to assign or unassign a new TMSI to a UE during a combined attach.

8.2.1.5 EMM cause

This IE shall be included when IMSI attach for non-EPS services is not successful during a combined EPS/IMSI attach procedure.

8.2.1.6 T3402 value

This IE may be included to indicate a value for timer T3402.

8.2.1.7 T3423 value

This IE may be included to indicate a value for timer T3423.

If this IE is not included, the UE shall use the default value.

8.2.1.8 Equivalent PLMNs

This IE may be included in order to assign a new equivalent PLMNs list to a UE.

8.2.1.9 Emergency number list

This IE may be sent by the network. If this IE is sent, the contents of this IE indicates a list of emergency numbers valid within the same country as in the cell on which this IE is received.

8.2.1.9A Extended emergency number list

This IE may be sent by the network. If this IE is sent, the contents of this IE indicates a list of emergency numbers (with URN information) valid within the same country as in the cell on which this IE is received.

8.2.1.10 EPS network feature support

The network may include this IE to inform the UE of the support of certain features. If this IE is not included then the UE shall interpret this as a receipt of an information element with all bits of the value part coded as zero, except for the S1-u data transfer (S1-U data) (octet 4, bit 2).

NOTE: In this exceptional case, the UE deems that the network supports S1-u data transfer.

8.2.1.11 Additional update result

The network may include this IE to provide the UE with additional information about the result of:

- a combined attach procedure if the procedure was successful for EPS services and non-EPS services, or for EPS services and "SMS only"; or
- an attach procedure requested for CIoT EPS optimizations if the procedure was successful for EPS services and "SMS only".

8.2.1.12 T3412 extended value

The network may include this IE to provide the UE with longer periodic tracking area update timer.

8.2.1.13 T3324 value

The network shall include the T3324 value IE if:

- the UE included the T3324 value IE in the ATTACH REQUEST message; and
- the network supports PSM and accepts the use of PSM.

8.2.1.14 Extended DRX parameters

The network shall include the Extended DRX parameters IE if:

- the UE included the Extended DRX parameters IE in the ATTACH REQUEST message; and
- the network supports eDRX and accepts the use of eDRX.

8.2.1.15 DCN-ID

This IE is included in the message when the network wishes to provide a DCN-ID to the UE.

8.2.1.16 SMS services status

This IE may be included when a normal attach procedure for EPS services and "SMS only" was successful for EPS services only.

8.2.1.17 Non-3GPP NW provided policies

This IE is included if the network needs to indicate whether emergency numbers provided via non-3GPP access can be used to initiate UE detected emergency calls (see 3GPP TS 24.302 [48]). If this IE is not included then the UE shall interpret this as a receipt of an information element with all bits of the value part coded as zero.

8.2.1.18 T3448 value

The network may include this IE if the congestion control for transport of user data via the control plane is active and the UE supports timer T3448.

8.2.1.19 Network policy

This IE is included if the network needs to indicate network policy information to the UE, If this IE is not included then the UE shall interpret this as a receipt of an information element with all bits of the value part coded as zero.

8.2.1.20 T3447 value

The network may include T3447 value IE if:

- the UE has indicated support for service gap control in the ATTACH REQUEST message; and
- the EMM context contains a service gap time value.

8.2.1.21 Ciphering key data

This IE is included if the network needs to send ciphering key data to the UE for ciphered broadcast assistance data.

8.2.2 Attach complete

This message is sent by the UE to the network in response to an ATTACH ACCEPT message. See table 8.2.2.1.

Message type: ATTACH COMPLETE

Significance: dual

Direction: UE to network

Table 8.2.2.1: ATTACH COMPLETE message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Attach complete message identity	Message type 9.8	M	V	1
	ESM message container	ESM message container 9.9.3.15	M	LV-E	5-n

8.2.3 Attach reject

8.2.3.1 Message definition

This message is sent by the network to the UE to indicate that the corresponding attach request has been rejected. See table 8.2.3.1.

Message type: ATTACH REJECT

Significance: dual

Direction: network to UE

Table 8.2.3.1: ATTACH REJECT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Attach reject message identity	Message type 9.8	M	V	1
	EMM cause	EMM cause 9.9.3.9	M	V	1
78	ESM message container	ESM message container 9.9.3.15	O	TLV-E	6-n
5F	T3346 value	GPRS timer 2 9.9.3.16A	O	TLV	3
16	T3402 value	GPRS timer 2 9.9.3.16A	O	TLV	3
A-	Extended EMM cause	Extended EMM cause 9.9.3.26A	O	TV	1

8.2.3.2 ESM message container

This IE is included to carry a single ESM message.

8.2.3.3 T3346 value

The MME may include this IE when the NAS level mobility management congestion control is active.

8.2.3.4 T3402 value

This IE may be included to indicate a value for timer T3402.

8.2.3.5 Extended EMM cause

This IE may be included by the network to indicate additional information associated with the EMM cause.

8.2.4 Attach request

8.2.4.1 Message definition

This message is sent by the UE to the network in order to perform an attach procedure. See table 8.2.4.1.

Message type: ATTACH REQUEST

Significance: dual

Direction: UE to network

Table 8.2.4.1: ATTACH REQUEST message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Attach request message identity	Message type 9.8	M	V	1
	EPS attach type	EPS attach type 9.9.3.11	M	V	1/2
	NAS key set identifier	NAS key set identifier 9.9.3.21	M	V	1/2
	EPS mobile identity	EPS mobile identity 9.9.3.12	M	LV	5-12
	UE network capability	UE network capability 9.9.3.34	M	LV	3-14
	ESM message container	ESM message container 9.9.3.15	M	LV-E	5-n
19	Old P-TMSI signature	P-TMSI signature 9.9.3.26	O	TV	4
50	Additional GUTI	EPS mobile identity 9.9.3.12	O	TLV	13
52	Last visited registered TAI	Tracking area identity 9.9.3.32	O	TV	6
5C	DRX parameter	DRX parameter 9.9.3.8	O	TV	3
31	MS network capability	MS network capability 9.9.3.20	O	TLV	4-10
13	Old location area identification	Location area identification 9.9.2.2	O	TV	6
9-	TMSI status	TMSI status 9.9.3.31	O	TV	1
11	Mobile station classmark 2	Mobile station classmark 2 9.9.2.4	O	TLV	5
20	Mobile station classmark 3	Mobile station classmark 3 9.9.2.5	O	TLV	2-34
40	Supported Codecs	Supported Codec List 9.9.2.10	O	TLV	5-n
F-	Additional update type	Additional update type 9.9.3.0B	O	TV	1
5D	Voice domain preference and UE's usage setting	Voice domain preference and UE's usage setting 9.9.3.44	O	TLV	3
D-	Device properties	Device properties 9.9.2.0A	O	TV	1
E-	Old GUTI type	GUTI type 9.9.3.45	O	TV	1
C-	MS network feature support	MS network feature support 9.9.3.20A	O	TV	1
10	TMSI based NRI container	Network resource identifier container 9.9.3.24A	O	TLV	4
6A	T3324 value	GPRS timer 2 9.9.3.16A	O	TLV	3
5E	T3412 extended value	GPRS timer 3 9.9.3.16B	O	TLV	3
6E	Extended DRX parameters	Extended DRX parameters 9.9.3.46	O	TLV	3
6F	UE additional security capability	UE additional security capability 9.9.3.53	O	TLV	6
6D	UE status	UE status 9.9.3.54	O	TLV	3
17	Additional information requested	Additional information requested 9.9.3.55	O	TV	2

8.2.4.2 Old P-TMSI signature

The UE shall include this IE if the UE holds a valid P-TMSI signature, P-TMSI and RAI, and the TIN either indicates "P-TMSI" or is deleted. If the UE is configured for "AttachWithIMSI" as specified in 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17] and is attaching in a new PLMN that is neither the registered PLMN nor in the list of equivalent PLMNs, the UE shall not include this IE.

8.2.4.3 Additional GUTI

The UE shall include this IE if the TIN indicates "P-TMSI" and the UE holds a valid GUTI, P-TMSI and RAI. If the UE is configured for "AttachWithIMSI" as specified in 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17] and is attaching in a new PLMN that is neither the registered PLMN nor in the list of equivalent PLMNs, the UE shall not include this IE.

8.2.4.4 Last visited registered TAI

This IE shall be included if the UE holds a valid last visited registered TAI.

8.2.4.5 DRX parameter

This IE is included if UE supports A/Gb mode or Iu mode or if the UE wants to indicate its UE specific DRX parameters to the network.

8.2.4.6 MS network capability

A UE supporting A/Gb mode or Iu mode shall include this IE to indicate its capabilities to the network.

8.2.4.7 Old location area identification

The UE shall include this IE during a combined attach procedure if it has a valid location area identification.

8.2.4.8 TMSI status

The UE shall include this IE during combined attach procedure if it has no valid TMSI available.

8.2.4.9 Mobile station classmark 2

This IE shall be included if the UE supports SRVCC to GERAN or UTRAN or supports vSRVCC to UTRAN (see 3GPP TS 23.216 [8]), or if the UE is performing a combined attach procedure.

8.2.4.10 Mobile station classmark 3

This IE shall be included if the UE supports SRVCC to GERAN.

8.2.4.11 Supported Codecs

This IE shall be included if the UE supports SRVCC to GERAN or UTRAN or supports vSRVCC to UTRAN to indicate its supported speech codecs for CS speech calls.

8.2.4.12 Additional update type

The UE shall include this IE if the UE requests "SMS only" or CIoT EPS optimizations.

8.2.4.13 Voice domain preference and UE's usage setting

This IE shall be included in WB-S1 mode if the UE supports:

- CS fallback and SMS over SGs; or
- if the UE is configured to support IMS voice, but does not support 1xCS fallback.

8.2.4.14 Device properties

This IE shall be included if the UE is configured for NAS signalling low priority.

8.2.4.15 Old GUTI type

The UE shall include this IE if the type of identity in the EPS mobile identity IE is set to "GUTI".

8.2.4.16 MS network feature support

This IE shall be included if the UE supports extended periodic timer T3412.

8.2.4.17 TMSI based NRI container

The UE shall include this IE during a combined attach procedure if it has a valid TMSI.

8.2.4.18 T3324 value

The UE may include this IE to request the use of PSM.

8.2.4.19 T3412 extended value

The UE may include this IE to request a particular T3412 value if the T3324 value IE is included.

8.2.4.20 Extended DRX parameters

The UE may include this IE to request the use of eDRX.

8.2.4.21 UE additional security capability

The UE shall include this IE if the UE supports dual connectivity with NR.

8.2.4.22 UE status

This IE shall be included if the UE wants to provide the network with information concerning aspects of the current UE registration status which is used for interworking with 5GS.

8.2.4.23 Additional information requested

The UE shall include this IE if the UE supports ciphered broadcast assistance data and the UE needs to obtain new ciphering keys for ciphered broadcast assistance data.

8.2.5 Authentication failure

8.2.5.1 Message definition

This message is sent by the UE to the network to indicate that authentication of the network has failed. See table 8.2.5.1.

Message type: AUTHENTICATION FAILURE

Significance: dual

Direction: UE to network

Table 8.2.5.1: AUTHENTICATION FAILURE message content

IEI	Information element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Authentication failure message type	Message type 9.8	M	V	1
	EMM cause	EMM cause 9.9.3.9	M	V	1
30	Authentication failure parameter	Authentication failure parameter 9.9.3.1	O	TLV	16

8.2.5.2 Authentication failure parameter

This IE shall be sent if and only if the EMM cause was #21 "synch failure". It shall include the response to the authentication challenge from the USIM, which is made up of the AUTS parameter (see 3GPP TS 33.102 [18]).

8.2.6 Authentication reject

This message is sent by the network to the UE to indicate that the authentication procedure has failed and that the UE shall abort all activities. See table 8.2.6.1.

Message type: AUTHENTICATION REJECT

Significance: dual

Direction: network to UE

Table 8.2.6.1: AUTHENTICATION REJECT message content

IEI	Information element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Authentication reject message type	Message type 9.8	M	V	1

8.2.7 Authentication request

This message is sent by the network to the UE to initiate authentication of the UE identity. See table 8.2.7.1.

Message type: AUTHENTICATION REQUEST

Significance: dual

Direction: network to UE

Table 8.2.7.1: AUTHENTICATION REQUEST message content

IEI	Information element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Authentication request message type	Message type 9.8	M	V	1
	NAS key set identifier$_{ASME}$	NAS key set identifier 9.9.3.21	M	V	1/2
	Spare half octet	Spare half octet 9.9.2.9	M	V	1/2
	Authentication parameter RAND (EPS challenge)	Authentication parameter RAND 9.9.3.3	M	V	16
	Authentication parameter AUTN (EPS challenge)	Authentication parameter AUTN 9.9.3.2	M	LV	17

8.2.8 Authentication response

This message is sent by the UE to the network to deliver a calculated authentication response to the network. See table 8.2.8.1.

Message type: AUTHENTICATION RESPONSE

Significance: dual

Direction: UE to network

Table 8.2.8.1: AUTHENTICATION RESPONSE message content

IEI	Information element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Authentication response message type	Message type 9.8	M	V	1
	Authentication response parameter	Authentication response parameter 9.9.3.4	M	LV	5-17

8.2.9 CS service notification

8.2.9.1 Message definition

This message is sent by the network when a paging request with CS call indicator was received via SGs for a UE, and a NAS signalling connection is already established for the UE. See table 8.2.9.1.

Message type: CS SERVICE NOTIFICATION

Significance: dual

Direction: network to UE

Table 8.2.9.1: CS SERVICE NOTIFICATION message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	CS service notification message identity	Message type 9.8	M	V	1
	Paging identity	Paging identity 9.9.3.25A	M	V	1
60	CLI	CLI 9.9.3.38	O	TLV	3-14
61	SS Code	SS Code 9.9.3.39	O	TV	2
62	LCS indicator	LCS indicator 9.9.3.40	O	TV	2
63	LCS client identity	LCS client identity 9.9.3.41	O	TLV	3-257

8.2.9.2 CLI

The network shall send this IE if it was received via SGs. It contains the identification of the calling line for the mobile terminating call in the CS domain, which triggered the paging via SGs.

8.2.9.3 SS Code

The network shall send this IE if it was received via SGs. It contains information on the supplementary service transaction in the CS domain, which triggered the paging via SGs.

8.2.9.4 LCS indicator

The network shall send this IE if it was received via SGs. It indicates that the paging was triggered by a terminating LCS request in the CS domain.

8.2.9.5 LCS client identity

The network shall send this IE if received via SGs. It contains information related to the requestor of the terminating LCS request in the CS domain.

8.2.10 Detach accept

8.2.10.1 Detach accept (UE originating detach)

This message is sent by the network to indicate that the detach procedure has been completed. See table 8.2.10.1.1.

Message type: DETACH ACCEPT

Significance: dual

Direction: network to UE

Table 8.2.10.1.1: DETACH ACCEPT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Detach accept message identity	Message type 9.8	M	V	1

8.2.10.2 Detach accept (UE terminated detach)

This message is sent by the UE to indicate that the detach procedure has been completed. See table 8.2.10.2.1.

Message type: DETACH ACCEPT

Significance: dual

Direction: UE to network

Table 8.2.10.2.1: DETACH ACCEPT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Detach accept message identity	Message type 9.8	M	V	1

8.2.11 Detach request

8.2.11.1 Detach request (UE originating detach)

This message is sent by the UE to request the release of an EMM context. See table 8.2.11.1.1.

Message type: DETACH REQUEST

Significance: dual

Direction: UE to network

Table 8.2.11.1.1: DETACH REQUEST message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Detach request message identity	Message type 9.8	M	V	1
	Detach type	Detach type 9.9.3.7	M	V	1/2
	NAS key set identifier	NAS key set identifier 9.9.3.21	M	V	1/2
	EPS mobile identity	EPS mobile identity 9.9.3.12	M	LV	5-12

8.2.11.2 Detach request (UE terminated detach)

8.2.11.2.1 Message definition

This message is sent by the network to request the release of an EMM context. See table 8.2.11.2.1.

Message type: DETACH REQUEST

Significance: dual

Direction: network to UE

Table 8.2.11.2.1: DETACH REQUEST message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Detach request message identity	Message type 9.8	M	V	1
	Detach type	Detach type 9.9.3.7	M	V	1/2
	Spare half octet	Spare half octet 9.9.2.9	M	V	1/2
53	EMM cause	EMM cause 9.9.3.9	O	TV	2

8.2.11.2.2 EMM cause

This information element is included if an EMM cause is provided.

8.2.12 Downlink NAS Transport

This message is sent by the network to the UE in order to carry an SMS message in encapsulated format. See table 8.2.12.1.

Message type: DOWNLINK NAS TRANSPORT

Significance: dual

Direction: network to UE

Table 8.2.12.1: DOWNLINK NAS TRANSPORT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Downlink NAS transport message identity	Message type 9.8	M	V	1
	NAS message container	NAS message container 9.9.3.22	M	LV	3-252

8.2.13 EMM information

8.2.13.1 Message definition

This message is sent by the network at any time during EMM context is established to send certain information to the UE. See table 8.2.13.1.

Message type: EMM INFORMATION

Significance: local

Direction: network to UE

Table 8.2.13.1: EMM INFORMATION message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	EMM information message identity	Message type 9.8	M	V	1
43	Full name for network	Network name 9.9.3.24	O	TLV	3-n
45	Short name for network	Network name 9.9.3.24	O	TLV	3-n
46	Local time zone	Time zone 9.9.3.29	O	TV	2
47	Universal time and local time zone	Time zone and time 9.9.3.30	O	TV	8
49	Network daylight saving time	Daylight saving time 9.9.3.6	O	TLV	3

8.2.13.2 Full name for network

This IE may be sent by the network. If this IE is sent, the contents of this IE indicate the "full length name of the network" that the network wishes the UE to associate with the MCC and MNC contained in the last visited tracking area identification.

8.2.13.3 Short name for network

This IE may be sent by the network. If this IE is sent, the contents of this IE indicate the "abbreviated name of the network" that the network wishes the UE to associate with the MCC and MNC contained in the last visited tracking area identification.

8.2.13.4 Local time zone

This IE may be sent by the network. The UE should assume that this time zone applies to the tracking area of the current cell, and also applies to the tracking area list if available in the UE.

NOTE: The time information can be inaccurate, especially when the TAI list includes tracking areas belonging to different time zones.

If the local time zone has been adjusted for daylight saving time, the network shall indicate this by including the Network daylight saving time IE.

8.2.13.5 Universal time and local time zone

This IE may be sent by the network. The UE should assume that this time zone applies to the tracking area the UE is currently in, and also applies to the tracking area list if available in the UE. The UE shall not assume that the time information is accurate.

NOTE: The time information can be inaccurate, especially when the TAI list includes tracking areas belonging to different time zones.

If the local time zone has been adjusted for daylight saving time, the network shall indicate this by including the Network daylight saving time IE.

8.2.13.6 Network daylight saving time

This IE may be sent by the network. If this IE is sent, the contents of this IE indicates the value that has been used to adjust the local time zone.

8.2.14 EMM status

This message is sent by the UE or by the network at any time to report certain error conditions listed in clause 7. See table 8.2.14.1.

Message type: EMM STATUS

Significance: local

Direction: both

Table 8.2.14.1: EMM STATUS message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	EMM status message identity	Message type 9.8	M	V	1
	EMM cause	EMM cause 9.9.3.9	M	V	1

8.2.15 Extended service request

8.2.15.1 Message definition

This message is sent by the UE to the network

- to initiate a CS fallback or 1xCS fallback call or respond to a mobile terminated CS fallback or 1xCS fallback request from the network; or
- to request the establishment of a NAS signalling connection and of the radio and S1 bearers for packet services, if the UE needs to provide additional information that cannot be provided via a SERVICE REQUEST message.

See table 8.2.15.1.

Message type: EXTENDED SERVICE REQUEST

Significance: dual

Direction: UE to network

Table 8.2.15.1: EXTENDED SERVICE REQUEST message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Extended service request message identity	Message type 9.8	M	V	1
	Service type	Service type 9.9.3.27	M	V	1/2
	NAS key set identifier	NAS key set identifier 9.9.3.21	M	V	1/2
	M-TMSI	Mobile identity 9.9.2.3	M	LV	6
B-	CSFB response	CSFB response 9.9.3.5	C	TV	1
57	EPS bearer context status	EPS bearer context status 9.9.2.1	O	TLV	4
D-	Device properties	Device properties 9.9.2.0A	O	TV	1

8.2.15.2 CSFB response

The UE shall include this IE only if the Service type information element indicates "mobile terminating CS fallback or 1xCS fallback".

NOTE: The UE does not include this IE for mobile terminating 1xCS fallback.

8.2.15.3 EPS bearer context status

This IE shall be included if the UE wants to indicate the EPS bearer contexts that are active within the UE.

8.2.15.4 Device properties

The UE shall include this IE if the UE is configured for NAS signalling low priority.

8.2.16 GUTI reallocation command

8.2.16.1 Message definition

This message is sent by the network to the UE to reallocate a GUTI and optionally to provide a new TAI list or a new DCN-ID or both. See table 8.2.16.1.

Message type: GUTI REALLOCATION COMMAND

Significance: dual

Direction: network to UE

Table 8.2.16.1: GUTI REALLOCATION COMMAND message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	GUTI reallocation command message identity	Message type 9.8	M	V	1
	GUTI	EPS mobile identity 9.9.3.12	M	LV	12
54	TAI list	Tracking area identity list 9.9.3.33	O	TLV	8-98
65	DCN-ID	DCN-ID 9.9.3.48	O	TLV	4

8.2.16.2 TAI list

This IE may be included to assign a TAI list to the UE.

8.2.16.3 DCN-ID

This IE may be included to assign a new DCN-ID to the UE.

8.2.17 GUTI reallocation complete

This message is sent by the UE to the network to indicate that reallocation of a GUTI has taken place. See table 8.2.17.1.

Message type: GUTI REALLOCATION COMPLETE

Significance: dual

Direction: UE to network

Table 8.2.17.1: GUTI REALLOCATION COMPLETE message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	GUTI reallocation complete message identity	Message type 9.8	M	V	1

8.2.18 Identity request

This message is sent by the network to the UE to request the UE to provide the specified identity. See table 8.2.18.1.

Message type: IDENTITY REQUEST

Significance: dual

Direction: network to UE

Table 8.2.18.1: IDENTITY REQUEST message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Identity request message identity	Message type 9.8	M	V	1
	Identity type	Identity type 2 9.9.3.17	M	V	1/2
	Spare half octet	Spare half octet 9.9.2.9	M	V	1/2

8.2.19 Identity response

This message is sent by the UE to the network in response to an IDENTITY REQUEST message and provides the requested identity. See table 8.2.19.1.

Message type: IDENTITY RESPONSE

Significance: dual

Direction: UE to network

Table 8.2.19.1: IDENTITY RESPONSE message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Identity response message	Message type 9.8	M	V	1
	Mobile identity	Mobile identity 9.9.2.3	M	LV	4-10

8.2.20 Security mode command

8.2.20.1 Message definition

This message is sent by the network to the UE to establish NAS signalling security. See table 8.2.20.1.

Message type: SECURITY MODE COMMAND

Significance: dual

Direction: network to UE

Table 8.2.20.1: SECURITY MODE COMMAND message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Security mode command message identity	Message type 9.8	M	V	1
	Selected NAS security algorithms	NAS security algorithms 9.9.3.23	M	V	1
	NAS key set identifier	NAS key set identifier 9.9.3.21	M	V	1/2
	Spare half octet	Spare half octet 9.9.2.9	M	V	1/2
	Replayed UE security capabilities	UE security capability 9.9.3.36	M	LV	3-6
C-	IMEISV request	IMEISV request 9.9.3.18	O	TV	1
55	Replayed $nonce_{UE}$	Nonce 9.9.3.25	O	TV	5
56	$Nonce_{MME}$	Nonce 9.9.3.25	O	TV	5
4F	$Hash_{MME}$	$Hash_{MME}$ 9.9.3.50	O	TLV	10
6F	Replayed UE additional security capability	UE additional security capability 9.9.3.53	O	TLV	6

8.2.20.2 IMEISV request

The MME may include this information element to request the UE to send its IMEISV with the corresponding SECURITY MODE COMPLETE message.

8.2.20.3 Replayed $nonce_{UE}$

The MME may include this information element to indicate to the UE to use the replayed $nonce_{UE}$.

8.2.20.4 $Nonce_{MME}$

The MME may include this information element to indicate to the UE to use the $nonce_{MME}$.

8.2.20.5 $Hash_{MME}$

The MME shall include this information element when the MME is initiating a SECURITY MODE COMMAND during an attach or tracking area updating procedure and the ATTACH REQUEST or TRACKING AREA UPDATE REQUEST message was received without integrity protection or did not successfully pass the integrity check at the MME.

8.2.20.6 Replayed UE additional security capability

The MME shall include this IE if the MME supports handling of UE additional security capabilities, the MME is initiating a SECURITY MODE COMMAND during an attach or tracking area updating procedure and the ATTACH REQUEST or TRACKING AREA UPDATE REQUEST message included a UE additional security capability IE.

8.2.21 Security mode complete

8.2.21.1 Message definition

This message is sent by the UE to the network in response to a SECURITY MODE COMMAND message. See table 8.2.21.1.

Message type: SECURITY MODE COMPLETE

Significance: dual

Direction: UE to network

Table 8.2.21.1: SECURITY MODE COMPLETE message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Security mode complete message identity	Message type 9.8	M	V	1
23	IMEISV	Mobile identity 9.9.2.3	O	TLV	11
79	Replayed NAS message container	Replayed NAS message container 9.9.3.51	O	TLV-E	3-n

8.2.21.2 IMEISV

The UE shall include this information element, if the IMEISV was requested within the corresponding SECURITY MODE COMMAND message.

8.2.21.3 Replayed NAS message container

The UE shall include this information element, if during an ongoing attach or tracking area updating procedure, the MME included $HASH_{MME}$ in the SECURITY MODE COMMAND message and $HASH_{MME}$ has a different value from the hash value locally calculated at the UE as described in 3GPP TS 33.401 [19].

8.2.22 Security mode reject

This message is sent by the UE to the network to indicate that the corresponding security mode command has been rejected. See table 8.2.22.1.

Message type: SECURITY MODE REJECT

Significance: dual

Direction: UE to network

Table 8.2.22.1: SECURITY MODE REJECT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Security mode reject message identity	Message type 9.8	M	V	1
	EMM cause	EMM cause 9.9.3.9	M	V	1

8.2.23 Security protected NAS message

This message is sent by the UE or the network to transfer a NAS message together with the sequence number and the message authentication code protecting the message. See table 8.2.23.1.

Message type: SECURITY PROTECTED NAS MESSAGE

Significance: dual

Direction: both

Table 8.2.23.1: SECURITY PROTECTED NAS MESSAGE message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Message authentication code	Message authentication code 9.5	M	V	4
	Sequence number	Sequence number 9.6	M	V	1
	NAS message	NAS message 9.7	M	V	1-n

8.2.24 Service reject

8.2.24.1 Message definition

This message is sent by the network to the UE in order to reject the service request procedure. See table 8.2.24.1.

Message type: SERVICE REJECT

Significance: dual

Direction: network to UE

Table 8.2.24.1: SERVICE REJECT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Service reject message identity	Message type 9.8	M	V	1
	EMM cause	EMM cause 9.9.3.9	M	V	1
5B	T3442 value	GPRS timer 9.9.3.16	C	TV	2
5F	T3346 value	GPRS timer 2 9.9.3.16A	O	TLV	3
6B	T3448 value	GPRS timer 2 9.9.3.16A	O	TLV	3

8.2.24.2 T3442 value

The MME shall include this IE when the EMM cause value is #39 "CS service temporarily not available".

8.2.24.3 T3346 value

The MME may include this IE when the general NAS level mobility management congestion control is active.

8.2.24.4 T3448 value

The network may include this IE if the congestion control for transport of user data via the control plane is active and the UE supports timer T3448.

8.2.25 Service request

This message is sent by the UE to the network to request the establishment of a NAS signalling connection and of the radio and S1 bearers. Its structure does not follow the structure of a standard layer 3 message. See table 8.2.25.1.

Message type: SERVICE REQUEST

Significance: dual

Direction: UE to network

Table 8.2.25.1: SERVICE REQUEST message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	KSI and sequence number	KSI and sequence number 9.9.3.19	M	V	1
	Message authentication code (short)	Short MAC 9.9.3.28	M	V	2

8.2.26 Tracking area update accept

8.2.26.1 Message definition

This message is sent by the network to the UE to provide the UE with EPS mobility management related data in response to a tracking area update request message. See table 8.2.26.1.

Message type: TRACKING AREA UPDATE ACCEPT

Significance: dual

Direction: network to UE

Table 8.2.26.1: TRACKING AREA UPDATE ACCEPT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Tracking area update accept message identity	Message type 9.8	M	V	1
	EPS update result	EPS update result 9.9.3.13	M	V	1/2
	Spare half octet	Spare half octet 9.9.2.9	M	V	1/2
5A	T3412 value	GPRS timer 9.9.3.16	O	TV	2
50	GUTI	EPS mobile identity 9.9.3.12	O	TLV	13
54	TAI list	Tracking area identity list 9.9.3.33	O	TLV	8-98
57	EPS bearer context status	EPS bearer context status 9.9.2.1	O	TLV	4
13	Location area identification	Location area identification 9.9.2.2	O	TV	6
23	MS identity	Mobile identity 9.9.2.3	O	TLV	7-10
53	EMM cause	EMM cause 9.9.3.9	O	TV	2
17	T3402 value	GPRS timer 9.9.3.16	O	TV	2
59	T3423 value	GPRS timer 9.9.3.16	O	TV	2
4A	Equivalent PLMNs	PLMN list 9.9.2.8	O	TLV	5-47
34	Emergency number list	Emergency number list 9.9.3.37	O	TLV	5-50
64	EPS network feature support	EPS network feature support 9.9.3.12A	O	TLV	3-4
F-	Additional update result	Additional update result 9.9.3.0A	O	TV	1
5E	T3412 extended value	GPRS timer 3 9.9.3.16B	O	TLV	3
6A	T3324 value	GPRS timer 2 9.9.3.16A	O	TLV	3
6E	Extended DRX parameters	Extended DRX parameters 9.9.3.46	O	TLV	3
68	Header compression configuration status	Header compression configuration status 9.9.4.27	O	TLV	4
65	DCN-ID	DCN-ID 9.9.3.48	O	TLV	4
E-	SMS services status	SMS services status 9.9.3.4B	O	TV	1
D-	Non-3GPP NW policies	Non-3GPP NW provided policies 9.9.3.49	O	TV	1
6B	T3448 value	GPRS timer 2 9.9.3.16A	O	TLV	3
C-	Network policy	Network policy 9.9.3.52	O	TV	1
6C	T3447 value	GPRS timer 3 9.9.3.16B	O	TLV	3
35	Extended emergency number list	Extended emergency number list 9.9.3.37A	O	TLV	FFS
80	Ciphering key data	Ciphering key data 9.9.3.56	O	TLV-E	35-2291

8.2.26.2 T3412 value

The MME shall include this IE during normal and combined tracking area updating procedure, and may include this IE during periodic tracking area updating procedure.

The MME shall include this IE if it includes the T3412 extended value IE.

8.2.26.3 GUTI

This IE may be included to assign a GUTI to a UE.

8.2.26.4 TAI list

This IE may be included to assign a TAI list to a UE.

8.2.26.5 EPS bearer context status

This IE shall be included if the network wants to indicate the EPS bearer contexts that are active for the UE in the network.

8.2.26.6 Location area identification

This IE may be included to assign a new location area identification to a UE during a combined TA/LA update.

8.2.26.7 MS identity

This IE may be included to assign or unassign a new TMSI to a UE during a combined TA/LA update.

8.2.26.8 EMM cause

This IE shall be included if the combined tracking area updating procedure was successful for EPS services only.

8.2.26.9 T3402 value

This IE may be included to indicate a value for timer T3402.

8.2.26.10 T3423 value

This IE may be included to indicate a value for timer T3423.

If this IE is not included, the UE shall use the default value.

8.2.26.11 Equivalent PLMNs

This IE may be included in order to assign a new equivalent PLMNs list to a UE.

8.2.26.12 Emergency number list

This IE may be sent by the network. If this IE is sent, the contents of this IE indicates a list of emergency numbers valid within the same country as in the cell on which this IE is received.

8.2.26.12A Extended emergency number list

This IE may be sent by the network. If this IE is sent, the contents of this IE indicates a list of emergency numbers (with URN information) valid within the same country as in the cell on which this IE is received.

8.2.26.13 EPS network feature support

The network may include this IE to inform the UE of the support of certain features. If this IE is not included then the UE shall interpret this as a receipt of an information element with all bits of the value part coded as zero, except for the S1-u data transfer (S1-U data) (octet 4, bit 2).

NOTE: In this exceptional case, the UE deems that the network supports S1-u data transfer.

8.2.26.14 Additional update result

The network may include this IE to provide the UE with additional information about the result of:

- a combined tracking area updating procedure if the procedure was successful for EPS services and non-EPS services, or for EPS services and "SMS only"; or
- a normal tracking area updating procedure requested for CIoT EPS optimizations if the procedure was successful for EPS services and "SMS only".

8.2.26.15 T3412 extended value

The network may include this IE to provide the UE with a longer periodic tracking area update timer.

8.2.26.16 T3324 value

The network shall include the T3324 value IE if:

- the UE included the T3324 value IE in the TRACKING AREA UPDATE REQUEST message; and
- the network supports PSM and accepts the use of PSM.

8.2.26.17 Extended DRX parameters

The network shall include the Extended DRX parameters IE if:

- the UE included the Extended DRX parameters IE in the TRACKING AREA UPDATE REQUEST message; and
- the network supports eDRX and accepts the use of eDRX.

8.2.26.18 DCN-ID

This IE is included in the message when the network wishes to provide a DCN-ID to the UE.

8.2.26.19 SMS services status

This IE may be included when a normal tracking area updating procedure for EPS services and "SMS only" was successful for EPS services only.

8.2.26.20 Non-3GPP NW provided policies

This IE is included if the network needs to indicate whether emergency numbers provided via non-3GPP access can be used to initiate UE detected emergency calls (see 3GPP TS 24.302 [48]). If this IE is not included then the UE shall interpret this as a receipt of an information element with all bits of the value part coded as zero.

8.2.26.21 T3448 value

The network may include this IE if the congestion control for transport of user data via the control plane is active and the UE supports timer T3448.

8.2.26.22 Network policy

This IE is included if the network needs to indicate network policy information to the UE, If this IE is not included then the UE shall interpret this as a receipt of an information element with all bits of the value part coded as zero.

8.2.26.23 T3447 value

The network may include T3447 value IE if:

- the UE has indicated support for service gap control in the TRACKING AREA UPDATE REQUEST messages; and
- the EMM context contains a service gap time value.

8.2.26.24 Ciphering key data

This IE is included if the network needs to send ciphering key data to the UE for ciphered broadcast assistance data.

8.2.27 Tracking area update complete

This message shall be sent by the UE to the network in response to a tracking area update accept message if a GUTI has been changed or a new TMSI has been assigned. See table 8.2.27.1.

Message type: TRACKING AREA UPDATE COMPLETE

Significance: dual

Direction: UE to network

Table 8.2.27.1: TRACKING AREA UPDATE COMPLETE message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Tracking area update complete message identity	Message type 9.8	M	V	1

8.2.28 Tracking area update reject

8.2.28.1 Message definition

This message is sent by the network to the UE in order to reject the tracking area updating procedure. See table 8.2.28.1.

Message type: TRACKING AREA UPDATE REJECT

Significance: dual

Direction: network to UE

Table 8.2.28.1: TRACKING AREA UPDATE REJECT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Tracking area update reject message identity	Message type 9.8	M	V	1
	EMM cause	EMM cause 9.9.3.9	M	V	1
5F	T3346 value	GPRS timer 2 9.9.3.16A	O	TLV	3
A-	Extended EMM cause	Extended EMM cause 9.9.3.26A	O	TV	1

8.2.28.2 T3346 value

The MME may include this IE when the general NAS level mobility management congestion control is active.

8.2.28.3 Extended EMM cause

This IE may be included by the network to indicate additional information associated with the EMM cause.

8.2.29 Tracking area update request

8.2.29.1 Message definition

The purposes of sending the tracking area update request by the UE to the network are described in subclause 5.5.3.1. See table 8.2.29.1.

Message type: TRACKING AREA UPDATE REQUEST

Significance: dual

Direction: UE to network

Table 8.2.29.1: TRACKING AREA UPDATE REQUEST message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Tracking area update request message identity	Message type 9.8	M	V	1
	EPS update type	EPS update type 9.9.3.14	M	V	1/2
	NAS key set identifier	NAS key set identifier 9.9.3.21	M	V	1/2
	Old GUTI	EPS mobile identity 9.9.3.12	M	LV	12
B-	Non-current native NAS key set identifier	NAS key set identifier 9.9.3.21	O	TV	1
8-	GPRS ciphering key sequence number	Ciphering key sequence number 9.9.3.4a	O	TV	1
19	Old P-TMSI signature	P-TMSI signature 9.9.3.26	O	TV	4
50	Additional GUTI	EPS mobile identity 9.9.3.12	O	TLV	13
55	$Nonce_{UE}$	Nonce 9.9.3.25	O	TV	5
58	UE network capability	UE network capability 9.9.3.34	O	TLV	4-15
52	Last visited registered TAI	Tracking area identity 9.9.3.32	O	TV	6
5C	DRX parameter	DRX parameter 9.9.3.8	O	TV	3
A-	UE radio capability information update needed	UE radio capability information update needed 9.9.3.35	O	TV	1
57	EPS bearer context status	EPS bearer context status 9.9.2.1	O	TLV	4
31	MS network capability	MS network capability 9.9.3.20	O	TLV	4-10
13	Old location area identification	Location area identification 9.9.2.2	O	TV	6
9-	TMSI status	TMSI status 9.9.3.31	O	TV	1
11	Mobile station classmark 2	Mobile station classmark 2 9.9.2.4	O	TLV	5
20	Mobile station classmark 3	Mobile station classmark 3 9.9.2.5	O	TLV	2-34
40	Supported Codecs	Supported Codec List 9.9.2.10	O	TLV	5-n
F-	Additional update type	Additional update type 9.9.3.0B	O	TV	1
5D	Voice domain preference and UE's usage setting	Voice domain preference and UE's usage setting 9.9.3.44	O	TLV	3
E-	Old GUTI type	GUTI type 9.9.3.45	O	TV	1
D-	Device properties	Device properties 9.9.2.0A	O	TV	1
C-	MS network feature support	MS network feature support 9.9.3.20A	O	TV	1
10	TMSI based NRI container	Network resource identifier container 9.9.3.24A	O	TLV	4
6A	T3324 value	GPRS timer 2 9.9.3.16	O	TLV	3
5E	T3412 extended value	GPRS timer 3 9.9.3.16B	O	TLV	3

6E	Extended DRX parameters	Extended DRX parameters 9.9.3.46	O	TLV	3
6F	UE additional security capability	UE additional security capability 9.9.3.53	O	TLV	6
6D	UE status	UE status 9.9.3.54	O	TLV	3
17	Additional information requested	Additional information requested 9.9.3.55	O	TV	2

8.2.29.2 Non-current native NAS key set identifier

The UE shall include this IE if the UE has a valid non-current native EPS security context when the UE performs an A/Gb mode or Iu mode to S1 mode inter-system change in EMM-CONNECTED mode and the UE uses a mapped EPS security context to protect the TRACKING AREA UPDATE REQUEST message.

8.2.29.3 GPRS ciphering key sequence number

The UE shall include this IE if the UE performs an A/Gb mode or Iu mode to S1 mode inter-system change in EMM-IDLE mode and the TIN indicates "P-TMSI".

8.2.29.4 Old P-TMSI signature

The UE shall include this IE if the TIN indicates "P-TMSI" and the UE holds a valid P-TMSI signature, P-TMSI and RAI.

8.2.29.5 Additional GUTI

The UE shall include this IE if the TIN indicates "P-TMSI" and the UE holds a valid GUTI, P-TMSI and RAI.

8.2.29.6 $Nonce_{UE}$

This IE is included if the UE performs an A/Gb mode or Iu mode to S1 mode inter-system change in idle mode and the TIN is set to "P-TMSI".

8.2.29.7 UE network capability

The UE shall include this IE, unless the UE performs a periodic tracking area updating procedure.

8.2.29.8 Last visited registered TAI

This IE shall be included if the UE holds a valid last visited registered TAI.

8.2.29.9 DRX parameter

This IE is included by the UE to indicate a change of UE specific DRX parameters to the network.

8.2.29.10 UE radio capability information update needed

The UE shall include this IE if the UE radio capability information in the network needs to be updated.

8.2.29.11 EPS bearer context status

This IE shall be included if the UE wants to indicate the EPS bearer contexts that are active within the UE.

8.2.29.12 MS network capability

A UE supporting A/Gb mode or Iu mode shall include this IE, unless the UE performs a periodic tracking area updating procedure.

8.2.29.13 Old location area identification

The UE shall include this IE during a combined tracking area updating procedure if it has a valid location area identification.

8.2.29.14 TMSI status

The UE shall include this IE during a combined tracking area updating procedure if it has no valid TMSI available.

8.2.29.15 Mobile station classmark 2

This IE shall be included if the UE supports SRVCC to GERAN or UTRAN or supports vSRVCC to UTRAN (see 3GPP TS 23.216 [8]), or if the UE is performing a combined tracking area updating procedure.

8.2.29.16 Mobile station classmark 3

This IE shall be included if the UE supports SRVCC to GERAN.

8.2.29.17 Supported Codecs

This IE shall be included if the UE supports SRVCC to GERAN or UTRAN or supports vSRVCC to UTRAN to indicate its supported speech codecs for CS speech calls.

8.2.29.18 Additional update type

The UE shall include this IE if the UE requests "SMS only" or CIoT EPS optimizations, unless the UE performs a periodic tracking area updating procedure.

8.2.29.19 Voice domain preference and UE's usage setting

This IE shall be included in WB-S1 mode if the UE supports:

- CS fallback and SMS over SGs; or
- if the UE is configured to support IMS voice, but does not support 1xCS fallback.

8.2.29.20 Old GUTI type

The UE shall include this IE.

8.2.29.21 Device properties

This IE shall be included if the UE is configured for NAS signalling low priority.

8.2.29.22 MS network feature support

This IE shall be included if the UE supports extended periodic timer T3412.

8.2.29.23 TMSI based NRI container

The UE shall include this IE if it has a valid TMSI.

8.2.29.24 T3324 value

The UE may include this IE to request the use of PSM.

8.2.29.25 T3412 extended value

The UE may include this IE to request a particular T3412 value if the T3324 value IE is included.

8.2.29.26 Extended DRX parameters

The UE may include this IE to request the use of eDRX.

8.2.29.27 UE additional security capability

The UE shall include this IE if the UE supports dual connectivity with NR.

8.2.29.28 UE status

This IE shall be included if the UE wants to provide the network with information concerning aspects of the current UE registration status which is used for interworking with 5GS.

8.2.29.29 Additional information requested

The UE shall include this IE if the UE supports ciphered broadcast assistance data and the UE needs to obtain new ciphering keys for ciphered broadcast assistance data.

8.2.30 Uplink NAS Transport

This message is sent by the UE to the network in order to carry an SMS message in encapsulated format. See table 8.2.30.1.

Message type: UPLINK NAS TRANSPORT

Significance: dual

Direction: UE to network

Table 8.2.30.1: UPLINK NAS TRANSPORT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Uplink NAS transport message identity	Message type 9.8	M	V	1
	NAS message container	NAS message container 9.9.3.22	M	LV	3-252

8.2.31 Downlink generic NAS transport

8.2.31.1 Message definition

This message is sent by the network to the UE in order to carry an application message in encapsulated format. See table 8.2.31.1.

Message type: DOWNLINK GENERIC NAS TRANSPORT

Significance: dual

Direction: network to UE

Table 8.2.31.1: DOWNLINK GENERIC NAS TRANSPORT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Downlink generic NAS transport message identity	Message type 9.8	M	V	1
	Generic message container type	Generic message container type 9.9.3.42	M	V	1
	Generic message container	Generic message container 9.9.3.43	M	LV-E	3-n
65	Additional information	Additional information 9.9.2.0	O	TLV	3-n

8.2.31.2 Additional information

The MME may include this information element if the application wants to send any additional information.

8.2.32 Uplink generic NAS transport

8.2.32.1 Message definition

This message is sent by the UE to the network in order to carry an application protocol message in encapsulated format. See table 8.2.32.1.

Message type: UPLINK GENERIC NAS TRANSPORT

Significance: dual

Direction: UE to network

Table 8.2.32.1: UPLINK GENERIC NAS TRANSPORT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Uplink generic NAS transport message identity	Message type 9.8	M	V	1
	Generic message container type	Generic message container type 9.9.3.42	M	V	1
	Generic message container	Generic message container 9.9.3.43	M	LV-E	3-n
65	Additional information	Additional information 9.9.2.0	O	TLV	3-n

8.2.32.2 Additional information

The UE may include this information element if the application wants to send any additional information.

8.2.33 CONTROL PLANE SERVICE REQUEST

8.2.33.1 Message definition

This message is sent by the UE to the network when the UE is using EPS services with control plane CIoT EPS optimization. See table 8.2.33.1.

Message type: CONTROL PLANE SERVICE REQUEST

Significance: dual

Direction: UE to network

Table 8.2.33.1: CONTROL PLANE SERVICE REQUEST message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Control plane service request message identity	Message type 9.8	M	V	1
	Control plane service type	Control plane service type 9.9.3.47	M	V	1/2
	NAS key set identifier	NAS key set identifier 9.9.3.21	M	V	1/2
78	ESM message container	ESM message container 9.9.3.15	O	TLV-E	3-n
67	NAS message container	NAS message container 9.9.3.22	O	TLV	4-253
57	EPS bearer context status	EPS bearer context status 9.9.2.1	O	TLV	4
D-	Device properties	Device properties 9.9.2.0A	O	TV	1

8.2.33.2 ESM message container

The UE shall include this IE, if it wants to send an ESM message to the network.

8.2.33.3 NAS message container

The UE shall include this IE, if it is in EMM-IDLE mode and has pending SMS messages to be sent.

8.2.33.4 EPS bearer context status

The UE shall include this IE, if it wants to indicate the EPS bearer contexts that are active within the UE.

8.2.33.5 Device properties

The UE shall include this IE if the UE is configured for NAS signalling low priority.

8.2.34 Service Accept

8.2.34.1 Message definition

This message is sent by the network in response to the SERVICE REQUEST message, the EXTENDED SERVICE REQUEST message or the CONTROL PLANE SERVICE REQUEST message. See table 8.2.34.1.

Message type: SERVICE ACCEPT

Significance: dual

Direction: network to UE

Table 8.2.34.1: SERVICE ACCEPT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	Security header type	Security header type 9.3.1	M	V	1/2
	Service accept message identity	Message type 9.8	M	V	1
57	EPS bearer context status	EPS bearer context status 9.9.2.1	O	TLV	4
6B	T3448 value	GPRS timer 2 9.9.3.16A	O	TLV	3

8.2.34.2 EPS bearer context status

This IE shall be included if the network wants to indicate the EPS bearer contexts that are active for the UE in the network.

8.2.34.3 T3448 value

The network may include this IE if the congestion control for transport of user data via the control plane is active and the UE supports timer T3448.

8.3 EPS session management messages

8.3.1 Activate dedicated EPS bearer context accept

8.3.1.1 Message definition

This message is sent by the UE to the network to acknowledge activation of a dedicated EPS bearer context associated with the same PDN address(es) and APN as an already active EPS bearer context. See table 8.3.1.1.

Message type: ACTIVATE DEDICATED EPS BEARER CONTEXT ACCEPT

Significance: dual

Direction: UE to network

Table 8.3.1.1: ACTIVATE DEDICATED EPS BEARER CONTEXT ACCEPT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	EPS bearer identity	EPS bearer identity 9.3.2	M	V	1/2
	Procedure transaction identity	Procedure transaction identity 9.4	M	V	1
	Activate dedicated EPS bearer context accept message identity	Message type 9.8	M	V	1
27	Protocol configuration options	Protocol configuration options 9.9.4.11	O	TLV	3-253
33	NBIFOM container	NBIFOM container 9.9.4.19	O	TLV	3-257
7B	Extended protocol configuration options	Extended protocol configuration options 9.9.4.26	O	TLV-E	4-65538

8.3.1.2 Protocol configuration options

This IE is included in the message when the UE wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the network and the extended protocol configuration options is not supported by the UE or the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.1.3 NBIFOM container

This information element is used to transfer information associated with network-based IP flow mobility, see 3GPP TS 24.161 [36].

8.3.1.4 Extended protocol configuration options

This IE is included in the message when the UE wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the network and the extended protocol configuration options is supported by both the UE and the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.2 Activate dedicated EPS bearer context reject

8.3.2.1 Message definition

This message is sent by UE to the network to reject activation of a dedicated EPS bearer context. See table 8.3.2.1.

Message type: ACTIVATE DEDICATED EPS BEARER CONTEXT REJECT

Significance: dual

Direction: UE to network

Table 8.3.2.1: ACTIVATE DEDICATED EPS BEARER CONTEXT REJECT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	EPS bearer identity	EPS bearer identity 9.3.2	M	V	1/2
	Procedure transaction identity	Procedure transaction identity 9.4	M	V	1
	Activate dedicated EPS bearer context reject message identity	Message type 9.8	M	V	1
	ESM cause	ESM cause 9.9.4.4	M	V	1
27	Protocol configuration options	Protocol configuration options 9.9.4.11	O	TLV	3-253
33	NBIFOM container	NBIFOM container 9.9.4.19	O	TLV	3-257
7B	Extended protocol configuration options	Extended protocol configuration options 9.9.4.26	O	TLV-E	4-65538

8.3.2.2 Protocol configuration options

This IE is included in the message when the UE wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the network and the extended protocol configuration options is not supported by the UE or the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.2.3 NBIFOM container

This information element is used to transfer information associated with network-based IP flow mobility, see 3GPP TS 24.161 [36].

8.3.2.4 Extended protocol configuration options

This IE is included in the message when the UE wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the network and the extended protocol configuration options is supported by both the UE and the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.3 Activate dedicated EPS bearer context request

8.3.3.1 Message definition

This message is sent by the network to the UE to request activation of a dedicated EPS bearer context associated with the same PDN address(es) and APN as an already active default EPS bearer context. See table 8.3.3.1.

Message type: ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST

Significance: dual

Direction: network to UE

Table 8.3.3.1: ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	EPS bearer identity	EPS bearer identity 9.3.2	M	V	1/2
	Procedure transaction identity	Procedure transaction identity 9.4	M	V	1
	Activate dedicated EPS bearer context request message identity	Message type 9.8	M	V	1
	Linked EPS bearer identity	Linked EPS bearer identity 9.9.4.6	M	V	1/2
	Spare half octet	Spare half octet 9.9.2.9	M	V	1/2
	EPS QoS	EPS quality of service 9.9.4.3	M	LV	2-14
	TFT	Traffic flow template 9.9.4.16	M	LV	2-256
5D	Transaction identifier	Transaction identifier 9.9.4.17	O	TLV	3-4
30	Negotiated QoS	Quality of service 9.9.4.12	O	TLV	14-22
32	Negotiated LLC SAPI	LLC service access point identifier 9.9.4.7	O	TV	2
8-	Radio priority	Radio priority 9.9.4.13	O	TV	1
34	Packet flow Identifier	Packet flow Identifier 9.9.4.8	O	TLV	3
27	Protocol configuration options	Protocol configuration options 9.9.4.11	O	TLV	3-253
C-	WLAN offload indication	WLAN offload acceptability 9.9.4.18	O	TV	1
33	NBIFOM container	NBIFOM container 9.9.4.19	O	TLV	3-257
7B	Extended protocol configuration options	Extended protocol configuration options 9.9.4.26	O	TLV-E	4-65538
5C	Extended EPS QoS	Extended quality of service 9.9.4.30	O	TLV	12

8.3.3.2 Transaction identifier

If the UE supports A/Gb mode or Iu mode or both, a network supporting mobility from S1 mode to A/Gb mode or Iu mode or both shall include this IE

8.3.3.3 Negotiated QoS

If the UE supports A/Gb mode or Iu mode or both, a network supporting mobility from S1 mode to A/Gb mode or Iu mode or both shall include the corresponding R99 QoS parameter values of a PDP context.

8.3.3.4 Negotiated LLC SAPI

If the UE supports A/Gb mode, a network supporting mobility from S1 mode to A/Gb mode shall include this IE.

8.3.3.5 Radio priority

If the UE supports A/Gb mode, a network supporting mobility from S1 mode to A/Gb mode shall include this IE.

8.3.3.6 Packet flow identifier

If the UE supports A/Gb mode and BSS packet flow procedures, a network supporting mobility from S1 mode to A/Gb mode shall include this IE.

8.3.3.7 Protocol configuration options

This IE is included in the message when the network wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the UE and the extended protocol configuration options is not supported by the UE or the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.3.8 WLAN offload indication

This IE shall be included in the message when the network wishes to indicate if the UE is allowed to offload the traffic of the associated PDN connection to WLAN(s), as specified in subclause 9.9.4.18.

8.3.3.9 NBIFOM container

This information element is used to transfer information associated with network-based IP flow mobility, see 3GPP TS 24.161 [36].

8.3.3.10 Extended protocol configuration options

This IE is included in the message when the network wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the UE and the extended protocol configuration options is supported by both the UE and the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.3.11 Extended EPS QoS

This IE shall be included in the message only if the network wishes to transmit the maximum and guaranteed bit rate values to the UE and at least one of the values to be transmitted exceeds the maximum value specified in the EPS quality of service information element in subclause 9.9.4.3.

8.3.4 Activate default EPS bearer context accept

8.3.4.1 Message definition

This message is sent by the UE to the network to acknowledge activation of a default EPS bearer context. See table 8.3.4.1.

Message type: ACTIVATE DEFAULT EPS BEARER CONTEXT ACCEPT

Significance: dual

Direction: UE to network

Table 8.3.4.1: ACTIVATE DEFAULT EPS BEARER CONTEXT ACCEPT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	EPS bearer identity	EPS bearer identity 9.3.2	M	V	1/2
	Procedure transaction identity	Procedure transaction identity 9.4	M	V	1
	Activate default EPS bearer context accept message identity	Message type 9.8	M	V	1
27	Protocol configuration options	Protocol configuration options 9.9.4.11	O	TLV	3-253
7B	Extended protocol configuration options	Extended protocol configuration options 9.9.4.26	O	TLV-E	4-65538

8.3.4.2 Protocol configuration options

This IE is included in the message when the UE wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the network and the extended protocol configuration options is not supported by the UE or the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.4.3 Extended protocol configuration options

This IE is included in the message when the UE wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the network and the extended protocol configuration options is supported by both the UE and the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.5 Activate default EPS bearer context reject

8.3.5.1 Message definition

This message is sent by UE to the network to reject activation of a default EPS bearer context. See table 8.3.5.1.

Message type: ACTIVATE DEFAULT EPS BEARER CONTEXT REJECT

Significance: dual

Direction: UE to network

Table 8.3.5.1: ACTIVATE DEFAULT EPS BEARER CONTEXT REJECT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	EPS bearer identity	EPS bearer identity 9.3.2	M	V	1/2
	Procedure transaction identity	Procedure transaction identity 9.4	M	V	1
	Activate default EPS bearer context reject message identity	Message type 9.8	M	V	1
	ESM cause	ESM cause 9.9.4.4	M	V	1
27	Protocol configuration options	Protocol configuration options 9.9.4.11	O	TLV	3-253
7B	Extended protocol configuration options	Extended protocol configuration options 9.9.4.26	O	TLV-E	4-65538

8.3.5.2 Protocol configuration options

This IE is included in the message when the UE wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the network and the extended protocol configuration options is not supported by the UE or the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.5.3 Extended protocol configuration options

This IE is included in the message when the UE wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the network and the extended protocol configuration options is supported by both the UE and the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.6 Activate default EPS bearer context request

8.3.6.1 Message definition

This message is sent by the network to the UE to request activation of a default EPS bearer context. See table 8.3.6.1.

Message type: ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST

Significance: dual

Direction: network to UE

Table 8.3.6.1: ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	EPS bearer identity	EPS bearer identity 9.3.2	M	V	1/2
	Procedure transaction identity	Procedure transaction identity 9.4	M	V	1
	Activate default EPS bearer context request message identity	Message type 9.8	M	V	1
	EPS QoS	EPS quality of service 9.9.4.3	M	LV	2-14
	Access point name	Access point name 9.9.4.1	M	LV	2-101
	PDN address	PDN address 9.9.4.9	M	LV	6-14
5D	Transaction identifier	Transaction identifier 9.9.4.17	O	TLV	3-4
30	Negotiated QoS	Quality of service 9.9.4.12	O	TLV	14-22
32	Negotiated LLC SAPI	LLC service access point identifier 9.9.4.7	O	TV	2
8-	Radio priority	Radio priority 9.9.4.13	O	TV	1
34	Packet flow Identifier	Packet flow Identifier 9.9.4.8	O	TLV	3
5E	APN-AMBR	APN aggregate maximum bit rate 9.9.4.2	O	TLV	4-8
58	ESM cause	ESM cause 9.9.4.4	O	TV	2
27	Protocol configuration options	Protocol configuration options 9.9.4.11	O	TLV	3-253
B-	Connectivity type	Connectivity type 9.9.4.2A	O	TV	1
C-	WLAN offload indication	WLAN offload acceptability 9.9.4.18	O	TV	1
33	NBIFOM container	NBIFOM container 9.9.4.19	O	TLV	3-257
66	Header compression configuration	Header compression configuration 9.9.4.22	O	TLV	5-257
9-	Control plane only indication	Control plane only indication 9.9.4.23	O	TV	1
7B	Extended protocol configuration options	Extended protocol configuration options 9.9.4.26	O	TLV-E	4-65538
6E	Serving PLMN rate control	Serving PLMN rate control 9.9.4.28	O	TLV	4
5F	Extended APN-AMBR	Extended APN aggregate maximum bit rate 9.9.4.29	O	TLV	8

8.3.6.2 Transaction identifier

If the UE supports A/Gb mode or Iu mode or both, a network supporting mobility from S1 mode to A/Gb mode or Iu mode or both shall include this IE.

8.3.6.3 Negotiated QoS

If the UE supports A/Gb mode or Iu mode or both, a network supporting mobility from S1 mode to A/Gb mode or Iu mode or both shall include the corresponding R99 QoS parameter values of a PDP context.

8.3.6.4 Negotiated LLC SAPI

If the UE supports A/Gb mode, a network supporting mobility from S1 mode to A/Gb mode shall include this IE.

8.3.6.5 Radio priority

If the UE supports A/Gb mode, a network supporting mobility from S1 mode to A/Gb mode shall include this IE.

8.3.6.6 Packet flow identifier

If the UE supports A/Gb mode and BSS packet flow procedures, a network supporting mobility from S1 mode to A/Gb mode shall include this IE.

8.3.6.7 APN-AMBR

This IE is included in the message when the network wishes to transmit the APN-AMBR to the UE for possible uplink policy enforcement.

8.3.6.8 ESM cause

The network shall include this IE, if the network allocated a PDN address of a PDN type which is different from the PDN type requested by the UE.

8.3.6.9 Protocol configuration options

This IE is included in the message when the network wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the UE and the extended protocol configuration options is not supported by the UE or the network end-to-end for the PDN connection (see subclause 6.6.1.1).

This IE shall be included if the network supports Local IP address in the traffic flow aggregate description and TFT filter, the PDN Type is different from Non-IP, and the extended protocol configuration options is not supported by the UE or the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.6.10 Connectivity type

The network shall include the Connectivity type IE if:

- the network is configured to indicate when a PDN connection is a LIPA PDN connection; and
- the present PDN connection is a LIPA PDN connection.

8.3.6.11 WLAN offload indication

This IE shall be included in the message when the network wishes to indicate if the UE is allowed to offload the traffic of the associated PDN connection to WLAN(s), as specified in subclause 9.9.4.18.

8.3.6.12 NBIFOM container

This information element is used to transfer information associated with network-based IP flow mobility, see 3GPP TS 24.161 [36].

8.3.6.13 Header compression configuration

The network may include the Header compression configuration IE if:

- the network accepts an IP PDN type; and
- control plane CIoT EPS optimization is selected.

8.3.6.14 Control plane only indication

The network shall include the Control plane only indication IE if the associated PDN connection is only for control plane CIoT EPS optimization.

8.3.6.15 Extended protocol configuration options

This IE is included in the message when the network wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the UE and the extended protocol configuration options is supported by both the UE and the network end-to-end for the PDN connection (see subclause 6.6.1.1).

This IE shall be included if the network supports Local IP address in the traffic flow aggregate description and TFT filter, the PDN Type is different from Non-IP, and the extended protocol configuration options is supported by both the UE and the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.6.16 Serving PLMN rate control

This IE shall be included when the network wishes to indicate the maximum number of uplink ESM DATA TRANSPORT messages including User data container IEs the UE is allowed to send per 6 minute interval.

8.3.6.17 Extended APN aggregate maximum bit rate

This IE shall be included in the message only if the network wishes to transmit the APN-AMBR values to the UE for possible uplink policy enforcement and at least one of the values to be transmitted exceeds the maximum value specified in the APN aggregate maximum bit rate information element in subclause 9.9.4.2.

8.3.7 Bearer resource allocation reject

8.3.7.1 Message definition

This message is sent by the network to the UE to reject the allocation of a dedicated bearer resource. See table 8.3.7.1.

Message type: BEARER RESOURCE ALLOCATION REJECT

Significance: dual

Direction: network to UE

Table 8.3.7.1: BEARER RESOURCE ALLOCATION REJECT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	EPS bearer identity	EPS bearer identity 9.3.2	M	V	1/2
	Procedure transaction identity	Procedure transaction identity 9.4	M	V	1
	Bearer resource allocation reject message identity	Message type 9.8	M	V	1
	ESM cause	ESM cause 9.9.4.4	M	V	1
27	Protocol configuration options	Protocol configuration options 9.9.4.11	O	TLV	3-253
37	Back-off timer value	GPRS timer 3 9.9.3.16B	O	TLV	3
6B	Re-attempt indicator	Re-attempt indicator 9.9.4.13A	O	TLV	3
33	NBIFOM container	NBIFOM container 9.9.4.19	O	TLV	3-257
7B	Extended protocol configuration options	Extended protocol configuration options 9.9.4.26	O	TLV-E	4-65538

8.3.7.2 Protocol configuration options

This IE is included in the message when the network wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the UE and the extended protocol configuration options is not supported by the UE or the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.7.3 Back-off timer value

The network may include this IE if the ESM cause is not #65 "maximum number of EPS bearers reached", to request a minimum time interval before procedure retry is allowed.

8.3.7.4 Re-attempt indicator

The network may include this IE only if it includes the Back-off timer value IE and the ESM cause value is not #26 "insufficient resources".

8.3.7.5 NBIFOM container

This information element is used to transfer information associated with network-based IP flow mobility, see 3GPP TS 24.161 [36].

8.3.7.6 Extended protocol configuration options

This IE is included in the message when the network wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the UE and the extended protocol configuration options is supported by both the UE and the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.8 Bearer resource allocation request

8.3.8.1 Message definition

This message is sent by the UE to the network to request the allocation of a dedicated bearer resource. See table 8.3.8.1.

Message type: BEARER RESOURCE ALLOCATION REQUEST

Significance: dual

Direction: UE to network

Table 8.3.8.1: BEARER RESOURCE ALLOCATION REQUEST message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	EPS bearer identity	EPS bearer identity 9.3.2	M	V	1/2
	Procedure transaction identity	Procedure transaction identity 9.4	M	V	1
	Bearer resource allocation request message identity	Message type 9.8	M	V	1
	Linked EPS bearer identity	Linked EPS bearer identity 9.9.4.6	M	V	1/2
	Spare half octet	Spare half octet 9.9.2.9	M	V	1/2
	Traffic flow aggregate	Traffic flow aggregate description 9.9.4.15	M	LV	2-256
	Required traffic flow QoS	EPS quality of service 9.9.4.3	M	LV	2-14
27	Protocol configuration options	Protocol configuration options 9.9.4.11	O	TLV	3-253
C-	Device properties	Device properties 9.9.2.0A	O	TV	1
33	NBIFOM container	NBIFOM container 9.9.4.19	O	TLV	3-257
7B	Extended protocol configuration options	Extended protocol configuration options 9.9.4.26	O	TLV-E	4-65538
5C	Extended EPS QoS	Extended quality of service 9.9.4.30	O	TLV	12

8.3.8.2 Protocol configuration options

This IE is included in the message when the UE wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the network and the extended protocol configuration options is not supported by the UE or the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.8.3 Device properties

The UE shall include this IE if the UE is configured for NAS signalling low priority.

8.3.8.4 NBIFOM container

This information element is used to transfer information associated with network-based IP flow mobility, see 3GPP TS 24.161 [36].

8.3.8.5 Extended protocol configuration options

This IE is included in the message when the UE wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the network and the extended protocol configuration options is supported by both the UE and the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.8.6 Extended EPS QoS

This IE shall be included in the message only if the UE wishes to transmit the maximum and guaranteed bit rate values to the network and at least one of the values to be transmitted exceeds the maximum value specified in the EPS quality of service information element in subclause 9.9.4.3.

8.3.9 Bearer resource modification reject

8.3.9.1 Message definition

This message is sent by the network to the UE to reject the modification of a dedicated bearer resource. See table 8.3.9.1.

Message type: BEARER RESOURCE MODIFICATION REJECT

Significance: dual

Direction: network to UE

Table 8.3.9.1: BEARER RESOURCE MODIFICATION REJECT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	EPS bearer identity	EPS bearer identity 9.3.2	M	V	1/2
	Procedure transaction identity	Procedure transaction identity 9.4	M	V	1
	Bearer resource modification reject message identity	Message type 9.8	M	V	1
	ESM cause	ESM cause 9.9.4.4	M	V	1
27	Protocol configuration options	Protocol configuration options 9.9.4.11	O	TLV	3-253
37	Back-off timer value	GPRS timer 3 9.9.3.16B	O	TLV	3
6B	Re-attempt indicator	Re-attempt indicator 9.9.4.13A	O	TLV	3
33	NBIFOM container	NBIFOM container 9.9.4.19	O	TLV	3-257
7B	Extended protocol configuration options	Extended protocol configuration options 9.9.4.26	O	TLV-E	4-65538

8.3.9.2 Protocol configuration options

This IE is included in the message when the network wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the UE and the extended protocol configuration options is not supported by the UE or the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.9.3 Back-off timer value

The network may include this IE to request a minimum time interval before procedure retry is allowed.

8.3.9.4 Re-attempt indicator

The network may include this IE only if it includes the Back-off timer value IE and the ESM cause value is not #26 "insufficient resources".

8.3.9.5 NBIFOM container

This information element is used to transfer information associated with network-based IP flow mobility, see 3GPP TS 24.161 [36].

8.3.9.6 Extended protocol configuration options

This IE is included in the message when the network wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the UE and the extended protocol configuration options is supported by both the UE and the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.10 Bearer resource modification request

8.3.10.1 Message definition

This message is sent by the UE to the network to request the modification of a dedicated bearer resource, or to request re-negotiation of header compression configuration associated to an EPS bearer context if the network has previously indicated support of Control plane CIoT EPS optimization and Header compression for control plane CIoT EPS optimization. See table 8.3.10.1.

Message type: BEARER RESOURCE MODIFICATION REQUEST

Significance: dual

Direction: UE to network

Table 8.3.10.1: BEARER RESOURCE MODIFICATION REQUEST message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	EPS bearer identity	EPS bearer identity 9.3.2	M	V	1/2
	Procedure transaction identity	Procedure transaction identity 9.4	M	V	1
	Bearer resource modification request message identity	Message type 9.8	M	V	1
	EPS bearer identity for packet filter	Linked EPS bearer identity 9.9.4.6	M	V	1/2
	Spare half octet	Spare half octet 9.9.2.9	M	V	1/2
	Traffic flow aggregate	Traffic flow aggregate description 9.9.4.15	M	LV	2-256
5B	Required traffic flow QoS	EPS quality of service 9.9.4.3	O	TLV	3-15
58	ESM cause	ESM cause 9.9.4.4	O	TV	2
27	Protocol configuration options	Protocol configuration options 9.9.4.11	O	TLV	3-253
C-	Device properties	Device properties 9.9.2.0A	O	TV	1
33	NBIFOM container	NBIFOM container 9.9.4.19	O	TLV	3-257
66	Header compression configuration	Header compression configuration 9.9.4.22	O	TLV	5-257
7B	Extended protocol configuration options	Extended protocol configuration options 9.9.4.26	O	TLV-E	4-65538
5C	Extended EPS QoS	Extended quality of service 9.9.4.30	O	TLV	12

8.3.10.2 Required traffic flow QoS

This IE is included in the message when the UE requests a change of QoS for the indicated traffic flows and does not request to release all bearer resources for the EPS bearer context.

8.3.10.3 ESM cause

This IE is included in the message when the UE requests the release of a dedicated bearer resource.

8.3.10.4 Protocol configuration options

This IE is included in the message when the UE wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the network and the extended protocol configuration options is not supported by the UE or the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.10.5 Device properties

The UE shall include this IE if the UE is configured for NAS signalling low priority.

8.3.10.6 NBIFOM container

This information element is used to transfer information associated with network-based IP flow mobility, see 3GPP TS 24.161 [36].

8.3.10.7 Header compression configuration

This IE is included in the message if the UE wishes to re-negotiate header compression configuration associated to an EPS bearer context and both the UE and the network supports Control plane CIoT EPS optimization and header compression.

8.3.10.8 Extended protocol configuration options

This IE is included in the message when the UE wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the network and the extended protocol configuration options is supported by both the UE and the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.10.9 Extended EPS QoS

This IE shall be included in the message only if the UE wishes to transmit the maximum and guaranteed bit rate values to the network and at least one of the values to be transmitted exceeds the maximum value specified in the EPS quality of service information element in subclause 9.9.4.3.

8.3.11 Deactivate EPS bearer context accept

8.3.11.1 Message definition

This message is sent by the UE to acknowledge deactivation of the EPS bearer context requested in the corresponding Deactivate EPS bearer context request message. See table 8.3.11.1.

Message type: DEACTIVATE EPS BEARER CONTEXT ACCEPT

Significance: dual

Direction: UE to network

Table 8.3.11.1: DEACTIVATE EPS BEARER CONTEXT ACCEPT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	EPS bearer identity	EPS bearer identity 9.3.2	M	V	1/2
	Procedure transaction identity	Procedure transaction identity 9.4	M	V	1
	Deactivate EPS bearer context accept message identity	Message type 9.8	M	V	1
27	Protocol configuration options	Protocol configuration options 9.9.4.11	O	TLV	3-253
7B	Extended protocol configuration options	Extended protocol configuration options 9.9.4.26	O	TLV-E	4-65538

8.3.11.2 Protocol configuration options

This IE is included in the message when the UE wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the network and the extended protocol configuration options is not supported by the UE or the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.11.3 Void

8.3.11.4 Extended protocol configuration options

This IE is included in the message when the UE wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the network and the extended protocol configuration options is supported by both the UE and the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.12 Deactivate EPS bearer context request

8.3.12.1 Message definition

This message is sent by the network to request deactivation of an active EPS bearer context. See table 8.3.12.1.

Message type: DEACTIVATE EPS BEARER CONTEXT REQUEST

Significance: dual

Direction: network to UE

Table 8.3.12.1: DEACTIVATE EPS BEARER CONTEXT REQUEST message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	EPS bearer identity	EPS bearer identity 9.3.2	M	V	1/2
	Procedure transaction identity	Procedure transaction identity 9.4	M	V	1
	Deactivate EPS bearer context request message identity	Message type 9.8	M	V	1
	ESM cause	ESM cause 9.9.4.4	M	V	1
27	Protocol configuration options	Protocol configuration options 9.9.4.11	O	TLV	3-253
37	T3396 value	GPRS timer 3 9.9.3.16B	O	TLV	3
C-	WLAN offload indication	WLAN offload acceptability 9.9.4.18	O	TV	1
33	NBIFOM container	NBIFOM container 9.9.4.19	O	TLV	3-257
7B	Extended protocol configuration options	Extended protocol configuration options 9.9.4.26	O	TLV-E	4-65538

8.3.12.2 Protocol configuration options

This IE is included in the message when the network wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the UE and the extended protocol configuration options is not supported by the UE or the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.12.3 T3396 value

The network may include this IE if the ESM cause is #26 "insufficient resources".

8.3.12.4 WLAN offload indication

This IE shall be included in the message when the network wishes to indicate if the UE is allowed to offload the traffic of the associated PDN connection to WLAN(s), as specified in subclause 9.9.4.18. If the MME wishes to deactivate all EPS bearer contexts of a PDN connection, MME shall not include this IE.

8.3.12.5 NBIFOM container

This information element is used to transfer information associated with network-based IP flow mobility, see 3GPP TS 24.161 [36].

8.3.12.6 Extended protocol configuration options

This IE is included in the message when the network wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the UE and the extended protocol configuration options is supported by both the UE and the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.12A ESM dummy message

This message is sent by the UE or the network included in an ESM message container information element during an attach procedure, if the UE does not request for PDN connection. See table 8.3.12A.1.

Message type: ESM DUMMY MESSAGE

Significance: dual

Direction: both

Table 8.3.12A.1: ESM DUMMY MESSAGE message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	EPS bearer identity	EPS bearer identity 9.3.2	M	V	1/2
	Procedure transaction identity	Procedure transaction identity 9.4	M	V	1
	ESM dummy message message identity	Message type 9.8	M	V	1

8.3.13 ESM information request

This message is sent by the network to the UE to request the UE to provide ESM information, i.e. protocol configuration options or APN or both. See table 8.3.13.1.

Message type: ESM INFORMATION REQUEST

Significance: dual

Direction: network to UE

Table 8.3.13.1: ESM INFORMATION REQUEST message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	EPS bearer identity	EPS bearer identity 9.3.2	M	V	1/2
	Procedure transaction identity	Procedure transaction identity 9.4	M	V	1
	ESM information request message identity	Message type 9.8	M	V	1

8.3.14 ESM information response

8.3.14.1 Message definition

This message is sent by the UE to the network in response to an ESM INFORMATION REQUEST message and provides the requested ESM information. See table 8.3.14.1.

Message type: ESM INFORMATION RESPONSE

Significance: dual

Direction: UE to network

Table 8.3.14.1: ESM INFORMATION RESPONSE message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	EPS bearer identity	EPS bearer identity 9.3.2	M	V	1/2
	Procedure transaction identity	Procedure transaction identity 9.4	M	V	1
	ESM information response message identity	Message type 9.8	M	V	1
28	Access point name	Access point name 9.9.4.1	O	TLV	3-102
27	Protocol configuration options	Protocol configuration options 9.9.4.11	O	TLV	3-253
7B	Extended protocol configuration options	Extended protocol configuration options 9.9.4.26	O	TLV-E	4-65538

8.3.14.2 Access point name

This IE is included in the message when the UE wishes to request network connectivity as defined by a certain access point name during the attach procedure.

8.3.14.3 Protocol configuration options

This IE is included in the message when, during the attach procedure, the UE wishes to transmit security protected (protocol) data (e.g. configuration parameters, error codes or messages/events) to the network, the UE is in WB-S1 mode and the PDN Type requested is different from Non-IP.

This IE shall be included if the UE supports local IP address in traffic flow aggregate description and TFT filter, the UE is in WB-S1 mode and the PDN Type requested is different from Non-IP.

This IE shall not be included if the Extended protocol configuration options IE is included in the message.

8.3.14.4 Extended protocol configuration options

This IE is included in the message when, during the attach procedure, the UE wishes to transmit security protected (protocol) data (e.g. configuration parameters, error codes or messages/events) to the network, and the UE is in NB-S1 mode or Non-IP PDN Type is requested.

This IE shall be included if the UE supports local IP address in traffic flow aggregate description and TFT filter, the UE is in NB-S1 mode and the PDN Type requested is different from Non-IP.

This IE shall not be included if the Protocol configuration options IE is included in the message.

8.3.15 ESM status

This message is sent by the network or the UE to pass information on the status of the indicated EPS bearer context and report certain error conditions (e.g. as listed in clause 7). See table 8.3.15.1.

Message type: ESM STATUS

Significance: dual

Direction: both

Table 8.3.15.1: ESM STATUS message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	EPS bearer identity	EPS bearer identity 9.3.2	M	V	1/2
	Procedure transaction identity	Procedure transaction identity 9.4	M	V	1
	ESM status message identity	Message type 9.8	M	V	1
	ESM cause	ESM cause 9.9.4.4	M	V	1

8.3.16 Modify EPS bearer context accept

8.3.16.1 Message definition

This message is sent by the UE to the network to acknowledge the modification of an active EPS bearer context. See table 8.3.16.1.

Message type: MODIFY EPS BEARER CONTEXT ACCEPT

Significance: dual

Direction: UE to network

Table 8.3.16.1: MODIFY EPS BEARER CONTEXT ACCEPT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	EPS bearer identity	EPS bearer identity 9.3.2	M	V	1/2
	Procedure transaction identity	Procedure transaction identity 9.4	M	V	1
	Modify EPS bearer context accept message identity	Message type 9.8	M	V	1
27	Protocol configuration options	Protocol configuration options 9.9.4.11	O	TLV	3-253
33	NBIFOM container	NBIFOM container 9.9.4.19	O	TLV	3-257
7B	Extended protocol configuration options	Extended protocol configuration options 9.9.4.26	O	TLV-E	4-65538

8.3.16.2 Protocol configuration options

This IE is included in the message when the UE wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the network and the extended protocol configuration options is not supported by the UE or the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.16.3 NBIFOM container

This information element is used to transfer information associated with network-based IP flow mobility, see 3GPP TS 24.161 [36].

8.3.16.4 Extended protocol configuration options

This IE is included in the message when the UE wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the network and the extended protocol configuration options is supported by both the UE and the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.17 Modify EPS bearer context reject

8.3.17.1 Message definition

This message is sent by the UE or the network to reject a modification of an active EPS bearer context. See table 8.3.17.1.

Message type: MODIFY EPS BEARER CONTEXT REJECT

Significance: dual

Direction: UE to network

Table 8.3.17.1: MODIFY EPS BEARER CONTEXT REJECT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	EPS bearer identity	EPS bearer identity 9.3.2	M	V	1/2
	Procedure transaction identity	Procedure transaction identity 9.4	M	V	1
	Modify EPS bearer context reject message identity	Message type 9.8	M	V	1
	ESM cause	ESM cause 9.9.4.4	M	V	1
27	Protocol configuration options	Protocol configuration options 9.9.4.11	O	TLV	3-253
33	NBIFOM container	NBIFOM container 9.9.4.19	O	TLV	3-257
7B	Extended protocol configuration options	Extended protocol configuration options 9.9.4.26	O	TLV-E	4-65538

8.3.17.2 Protocol configuration options

This IE is included in the message when the UE wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the network and the extended protocol configuration options is not supported by the UE or the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.17.3 NBIFOM container

This information element is used to transfer information associated with network-based IP flow mobility, see 3GPP TS 24.161 [36].

8.3.17.4 Extended protocol configuration options

This IE is included in the message when the UE wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the network and the extended protocol configuration options is supported by both the UE and the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.18 Modify EPS bearer context request

8.3.18.1 Message definition

This message is sent by the network to the UE to request modification of an active EPS bearer context, or to request re-negotiation of header compression configuration associated to an EPS bearer context if the UE has previously indicated support of Control plane CIoT EPS optimization and Header compression for control plane CIoT EPS optimization. See table 8.3.18.1.

Message type: MODIFY EPS BEARER CONTEXT REQUEST

Significance: dual

Direction: network to UE

Table 8.3.18.1: MODIFY EPS BEARER CONTEXT REQUEST message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	EPS bearer identity	EPS bearer identity 9.3.2	M	V	1/2
	Procedure transaction identity	Procedure transaction identity 9.4	M	V	1
	Modify EPS bearer context request message identity	Message type 9.8	M	V	1
5B	New EPS QoS	EPS quality of service 9.9.4.3	O	TLV	3-15
36	TFT	Traffic flow template 9.9.4.16	O	TLV	3-257
30	New QoS	Quality of service 9.9.4.12	O	TLV	14-22
32	Negotiated LLC SAPI	LLC service access point identifier 9.9.4.7	O	TV	2
8-	Radio priority	Radio priority 9.9.4.13	O	TV	1
34	Packet flow Identifier	Packet flow Identifier 9.9.4.8	O	TLV	3
5E	APN-AMBR	APN aggregate maximum bit rate 9.9.4.2	O	TLV	4-8
27	Protocol configuration options	Protocol configuration options 9.9.4.11	O	TLV	3-253
C-	WLAN offload indication	WLAN offload acceptability 9.9.4.18	O	TV	1
33	NBIFOM container	NBIFOM container 9.9.4.19	O	TLV	3-257
66	Header compression configuration	Header compression configuration 9.9.4.22	O	TLV	5-257
7B	Extended protocol configuration options	Extended protocol configuration options 9.9.4.26	O	TLV-E	4-65538
5F	Extended APN-AMBR	Extended APN aggregate maximum bit rate 9.9.4.29	O	TLV	8
5C	Extended EPS QoS	Extended quality of service 9.9.4.30	O	TLV	12

8.3.18.2 New EPS QoS

When the EPS QoS of the EPS bearer context is modified, the network shall include the modified EPS QoS assigned to the EPS bearer context.

8.3.18.3 TFT

This IE provides the UE with packet filters.

8.3.18.4 New QoS

If the UE supports A/Gb mode or Iu mode or both and when the corresponding R99 QoS of the EPS bearer context is modified, a network supporting mobility from S1 mode to A/Gb mode or Iu mode or both shall include the corresponding R99 QoS parameter values of a PDP context.

8.3.18.5 Negotiated LLC SAPI

If the UE supports A/Gb mode and when the negotiated LLC SAPI is modified, a network supporting mobility from S1 mode to A/Gb mode shall include this IE.

8.3.18.6 Radio priority

If the UE supports A/Gb mode and when the radio priority is modified, a network supporting mobility from S1 mode to A/Gb mode shall include this IE.

8.3.18.7 Packet flow identifier

If the UE supports A/Gb mode and BSS packet flow procedures, a network supporting mobility from S1 mode to A/Gb mode shall include this IE.

8.3.18.8 APN-AMBR

This IE is included when the APN-AMBR has been changed by the network.

8.3.18.9 Protocol configuration options

This IE is included in the message when the network wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the UE and the extended protocol configuration options is not supported by the UE or the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.18.10 WLAN offload indication

This IE shall be included in the message when the network wishes to indicate if the UE is allowed to offload the traffic of the associated PDN connection to WLAN(s), as specified in subclause 9.9.4.18.

8.3.18.11 NBIFOM container

This information element is used to transfer information associated with network-based IP flow mobility, see 3GPP TS 24.161 [36].

8.3.18.12 Header compression configuration

This IE is included in the message if the network wishes to re-negotiate header compression configuration associated to an EPS bearer context and both the UE and the network support Control plane CIoT EPS optimization and header compression.

8.3.18.13 Extended protocol configuration options

This IE is included in the message when the network wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the UE and the extended protocol configuration options is supported by both the UE and the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.18.14 Extended APN-AMBR

This IE shall be included in the message only if at least one of the APN-AMBR values has been changed by the network and at least one of the values to be transmitted exceeds the maximum value specified in the APN aggregate maximum bit rate information element in subclause 9.9.4.2.

8.3.18.15 Extended EPS QoS

This IE shall be included in the message only if the network wishes to transmit the maximum and guaranteed bit rate values to the UE and at least one of the values to be transmitted exceeds the maximum value specified in the EPS quality of service information element in subclause 9.9.4.3.

8.3.18A Notification

This message is sent by the network to inform the UE about events which are relevant for the upper layer using an EPS bearer context or having requested a procedure transaction. See table 8.3.18A.1.

Message type: NOTIFICATION

Significance: local

Direction: network to UE

Table 8.3.18A.1: NOTIFICATION message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	EPS bearer identity	EPS bearer identity 9.3.2	M	V	1/2
	Procedure transaction identity	Procedure transaction identity 9.4	M	V	1
	Notification message identity	Message type 9.8	M	V	1
	Notification indicator	Notification indicator 9.9.4.7A	M	LV	2

8.3.19 PDN connectivity reject

8.3.19.1 Message definition

This message is sent by the network to the UE to reject establishment of a PDN connection. See table 8.3.19.1.

Message type: PDN CONNECTIVITY REJECT

Significance: dual

Direction: network to UE

Table 8.3.19.1: PDN CONNECTIVITY REJECT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	EPS bearer identity	EPS bearer identity 9.3.2	M	V	1/2
	Procedure transaction identity	Procedure transaction identity 9.4	M	V	1
	PDN connectivity reject message identity	Message type 9.8	M	V	1
	ESM cause	ESM cause 9.9.4.4	M	V	1
27	Protocol configuration options	Protocol configuration options 9.9.4.11	O	TLV	3-253
37	Back-off timer value	GPRS timer 3 9.9.3.16B	O	TLV	3
6B	Re-attempt indicator	Re-attempt indicator 9.9.4.13A	O	TLV	3
33	NBIFOM container	NBIFOM container 9.9.4.19	O	TLV	3-257
7B	Extended protocol configuration options	Extended protocol configuration options 9.9.4.26	O	TLV-E	4-65538

8.3.19.2 Protocol configuration options

This IE is included in the message when the network wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the UE and the extended protocol configuration options is not supported by the UE or the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.19.3 Back-off timer value

The network may include this IE if the ESM cause is not #50 "PDN type IPv4 only allowed", #51 "PDN type IPv6 only allowed", #54 "PDN connection does not exist", #57 "PDN type IPv4v6 only allowed", #58 "PDN type non IP only allowed", nor #65 "maximum number of EPS bearers reached", to request a minimum time interval before procedure retry is allowed.

8.3.19.4 Re-attempt indicator

The network may include this IE only if the ESM cause value is #50 "PDN type IPv4 only allowed", #51 "PDN type IPv6 only allowed", #57 "PDN type IPv4v6 only allowed", #58 "PDN type non IP only allowed", or #66 "requested APN not supported in current RAT and PLMN combination", or if the network includes the Back-off timer value IE and the ESM cause value is not #26 "insufficient resources".

8.3.19.5 Extended protocol configuration options

This IE is included in the message when the network wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the UE and the extended protocol configuration options is supported by both the UE and the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.20 PDN connectivity request

8.3.20.1 Message definition

This message is sent by the UE to the network to initiate establishment of a PDN connection. See table 8.3.20.1.

Message type: PDN CONNECTIVITY REQUEST

Significance: dual

Direction: UE to network

Table 8.3.20.1: PDN CONNECTIVITY REQUEST message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	EPS bearer identity	EPS bearer identity 9.3.2	M	V	1/2
	Procedure transaction identity	Procedure transaction identity 9.4	M	V	1
	PDN connectivity request message identity	Message type 9.8	M	V	1
	Request type	Request type 9.9.4.14	M	V	1/2
	PDN type	PDN type 9.9.4.10	M	V	1/2
D-	ESM information transfer flag	ESM information transfer flag 9.9.4.5	O	TV	1
28	Access point name	Access point name 9.9.4.1	O	TLV	3-102
27	Protocol configuration options	Protocol configuration options 9.9.4.11	O	TLV	3-253
C-	Device properties	Device properties 9.9.2.0A	O	TV	1
33	NBIFOM container	NBIFOM container 9.9.4.19	O	TLV	3-257
66	Header compression configuration	Header compression configuration 9.9.4.22	O	TLV	5-257
7B	Extended protocol configuration options	Extended protocol configuration options 9.9.4.26	O	TLV-E	4-65538

8.3.20.2 ESM information transfer flag

The UE shall include this IE in the PDN CONNECTIVITY REQUEST message sent during the attach procedure if the UE has protocol configuration options that need to be transferred security protected or wishes to provide an access point name for the PDN connection to be established during the attach procedure.

8.3.20.3 Access point name

This IE is included in the message when the UE wishes to request network connectivity as defined by a certain access point name. This IE shall not be included when the PDN CONNECTIVITY REQUEST message is included in an ATTACH REQUEST message or if the request type indicates "emergency" or "handover of emergency bearer services".

8.3.20.4 Protocol configuration options

This IE is included in the message when the UE wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the network, the UE is in WB-S1 mode and the PDN Type requested is different from Non-IP.

This IE shall be included if the UE supports local IP address in traffic flow aggregate description and TFT filter, the UE is in WB-S1 mode and the PDN Type requested is different from Non-IP.

This IE shall not be included if the Extended protocol configuration options IE is included in the message.

8.3.20.5 Device properties

The UE shall include this IE if the UE is configured for NAS signalling low priority.

8.3.20.6 NBIFOM container

This information element is used to transfer information associated with network-based IP flow mobility, see 3GPP TS 24.161 [36].

8.3.20.7 Header compression configuration

The UE shall include the Header compression configuration IE if:

- the PDN type value of the PDN type IE is set to IPv4 or IPv6 or IPv4v6;
- the UE indicates "Control Plane CIoT EPS optimization supported" in the UE network capability IE of the ATTACH REQUEST message; and
- the UE supports header compression.

8.3.20.8 Extended protocol configuration options

This IE is included in the message when the UE wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the network, and the UE is in NB-S1 mode or Non-IP PDN Type is requested.

This IE shall be included if the UE supports local IP address in traffic flow aggregate description and TFT filter, the UE is in NB-S1 mode and the PDN Type requested is different from Non-IP.

This IE shall not be included if the Protocol configuration options IE is included in the message.

8.3.21 PDN disconnect reject

8.3.21.1 Message definition

This message is sent by the network to the UE to reject release of a PDN connection. See table 8.3.21.1.

Message type: PDN DISCONNECT REJECT

Significance: dual

Direction: network to UE

Table 8.3.21.1: PDN DISCONNECT REJECT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	EPS bearer identity	EPS bearer identity 9.3.2	M	V	1/2
	Procedure transaction identity	Procedure transaction identity 9.4	M	V	1
	PDN disconnect reject message identity	Message type 9.8	M	V	1
	ESM cause	ESM cause 9.9.4.4	M	V	1
27	Protocol configuration options	Protocol configuration options 9.9.4.11	O	TLV	3-253
7B	Extended protocol configuration options	Extended protocol configuration options 9.9.4.26	O	TLV-E	4-65538

8.3.21.2 Protocol configuration options

This IE is included in the message when the network wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the UE and the extended protocol configuration options is not supported by the UE or the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.21.3 Extended protocol configuration options

This IE is included in the message when the network wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the UE and the extended protocol configuration options is supported by both the UE and the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.22 PDN disconnect request

8.3.22.1 Message definition

This message is sent by the UE to the network to initiate release of a PDN connection. See table 8.3.22.1.

Message type: PDN DISCONNECT REQUEST

Significance: dual

Direction: UE to network

Table 8.3.22.1: PDN DISCONNECT REQUEST message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	EPS bearer identity	EPS bearer identity 9.3.2	M	V	1/2
	Procedure transaction identity	Procedure transaction identity 9.4	M	V	1
	PDN disconnect request message identity	Message type 9.8	M	V	1
	Linked EPS bearer identity	Linked EPS bearer identity 9.9.4.6	M	V	1/2
	Spare half octet	Spare half octet 9.9.2.9	M	V	1/2
27	Protocol configuration options	Protocol configuration options 9.9.4.11	O	TLV	3-253
7B	Extended protocol configuration options	Extended protocol configuration options 9.9.4.26	O	TLV-E	4-65538

8.3.22.2 Protocol configuration options

This IE is included in the message when the UE wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the network and the extended protocol configuration options is not supported by the UE or the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.22.3 Extended protocol configuration options

This IE is included in the message when the UE wishes to transmit (protocol) data (e.g. configuration parameters, error codes or messages/events) to the network and the extended protocol configuration options is supported by both the UE and the network end-to-end for the PDN connection (see subclause 6.6.1.1).

8.3.23 Remote UE report

8.3.23.1 Message definition

This message is sent by the UE to the network to report connection or disconnection of remote UE(s). See table 8.3.23.1.

Message type: REMOTE UE REPORT

Significance: dual

Direction: UE to network

Table 8.3.23.1: REMOTE UE REPORT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	EPS bearer identity	EPS bearer identity 9.3.2	M	V	1/2
	Procedure transaction identity	Procedure transaction identity 9.4	M	V	1
	Remote UE report message identity	Message type 9.8	M	V	1
79	Remote UE Context Connected	Remote UE context list IE 9.9.4.20	O	TLV-E	3-65538
7A	Remote UE Context Disconnected	Remote UE context list IE 9.9.4.20	O	TLV-E	3-65538
6F	ProSe Key Management Function address	PKMF address IE 9.9.4.21	O	TLV	3-19

8.3.23.2 Remote UE Context Connected

This IE is included in the message by the UE acting as ProSe UE-to-network relay to provide the network with newly connected remote UE information as specified in 3GPP TS 23.303 [31].

8.3.23.3 Remote UE Context Disconnected

This IE is included in the message by the UE acting as ProSe UE-to-Network Relay to provide the network with disconnected remote UE information as specified in 3GPP TS 23.303 [31].

8.3.23.4 ProSe Key Management Function Address

This IE is included in the message by the UE acting as ProSe UE-to-network relay to provide the network with the address of the ProSe Key Management Function associated with the remote UEs connected to or disconnected from the ProSe UE-to-network relay.

8.3.24 Remote UE report response

8.3.24.1 Message definition

This message is sent by the network to the UE to acknowledge receipt of a Remote UE report message. See table 8.3.24.1.

Message type: REMOTE UE REPORT RESPONSE

Significance: dual

Direction: network to UE

Table 8.3.24.1: REMOTE UE REPORT RESPONSE message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	EPS bearer identity	EPS bearer identity 9.3.2	M	V	1/2
	Procedure transaction identity	Procedure transaction identity 9.4	M	V	1
	Remote UE report response message identity	Message type 9.8	M	V	1

8.3.25 ESM DATA TRANSPORT

8.3.25.1 Message definition

This message is sent by the UE or the network in order to carry user data in an encapsulated format. See table 8.3.25.1.

Message type: ESM DATA TRANSPORT

Significance: dual

Direction: both

Table 8.3.25.1: ESM DATA TRANSPORT message content

IEI	Information Element	Type/Reference	Presence	Format	Length
	Protocol discriminator	Protocol discriminator 9.2	M	V	1/2
	EPS bearer identity	EPS bearer identity 9.3.2	M	V	1/2
	Procedure transaction identity	Procedure transaction identity 9.4	M	V	1
	ESM data transport message identity	Message type 9.8	M	V	1
	User data container	User data container 9.9.4.24	M	LV-E	2-n
F-	Release assistance indication	Release assistance indication 9.9.4.25	O	TV	1

8.3.25.2 Release assistance indication

The UE may include this IE to inform the network whether

- no further uplink or downlink data transmission is expected; or
- only a single downlink data transmission (e.g. acknowledgement or response to uplink data) and no further uplink data transmission subsequent to the uplink data transmission is expected.

9 General message format and information elements coding

9.1 Overview

Within the protocols defined in the present document, every message, except the SERVICE REQUEST message, is a standard L3 message as defined in 3GPP TS 24.007 [12]. This means that the message consists of the following parts:

1) if the message is a plain NAS message:
   a) protocol discriminator;
   b) EPS bearer identity or security header type;
   c) procedure transaction identity;
   d) message type;
   e) other information elements, as required.
2) if the message is a security protected NAS message:
   a) protocol discriminator;
   b) security header type;
   c) message authentication code;
   d) sequence number;
   e) plain NAS message, as defined in item 1.

The organization of a plain NAS message is illustrated in the example shown in figure 9.1.1.

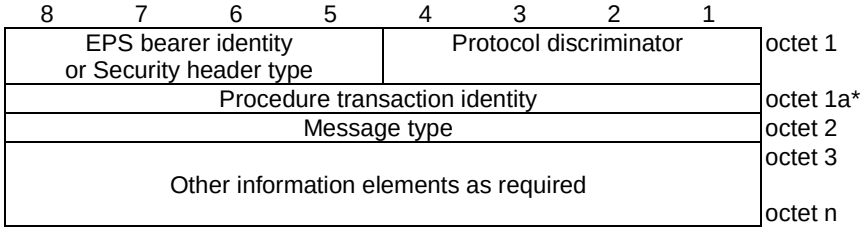


Figure 9.1.1: General message organization example for a plain NAS message

The organization of a security protected NAS message is illustrated in the example shown in figure 9.1.2.

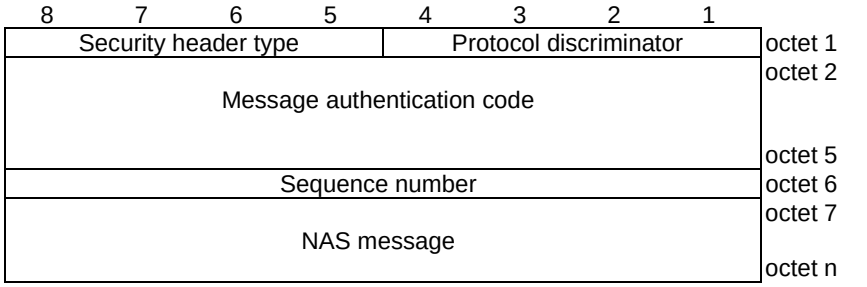


Figure 9.1.2: General message organization example for a security protected NAS message

The EPS bearer identity and the procedure transaction identity are only used in messages with protocol discriminator EPS session management. Octet 1a with the procedure transaction identity shall only be included in these messages.

Unless specified otherwise in the message descriptions of clause 8, a particular information element shall not be present more than once in a given message.

When a field extends over more than one octet, the order of bit values progressively decreases as the octet number increases. The most significant bit of the field is represented by the highest numbered bit of the lowest numbered octet of the field. The least significant bit of the field is represented by the lowest numbered bit of the highest numbered octet of the field.

9.2 Protocol discriminator

The Protocol Discriminator (PD) and its use are defined in 3GPP TS 24.007 [12]. The protocol discriminator in the header (see 3GPP TS 24.007 [12]) of a security protected NAS message is encoded as "EPS mobility management messages".

9.3 Security header type and EPS bearer identity

9.3.1 Security header type

Bits 5 to 8 of the first octet of every EPS Mobility Management (EMM) message contain the Security header type IE. This IE includes control information related to the security protection of a NAS message. The total size of the Security header type IE is 4 bits.

The Security header type IE can take the values shown in table 9.3.1.

Table 9.3.1: Security header type

Security header type (octet 1)				
8	**7**	**6**	**5**	
0	0	0	0	Plain NAS message, not security protected
				Security protected NAS message:
0	0	0	1	Integrity protected
0	0	1	0	Integrity protected and ciphered
0	0	1	1	Integrity protected with new EPS security context (NOTE 1)
0	1	0	0	Integrity protected and ciphered with new EPS security context (NOTE 2)
0	1	0	1	Integrity protected and partially ciphered NAS message (NOTE 4)
				Non-standard L3 message:
1	1	0	0	Security header for the SERVICE REQUEST message
1	1	0	1	These values are not used in this version of the protocol.
	to			If received they shall be interpreted as '1100'. (NOTE 3)
1	1	1	1	
All other values are reserved.				

NOTE 1:	This codepoint may be used only for a SECURITY MODE COMMAND message.
NOTE 2:	This codepoint may be used only for a SECURITY MODE COMPLETE message.
NOTE 3:	When bits 7 and 8 are set to '11', bits 5 and 6 can be used for future extensions of the SERVICE REQUEST message.
NOTE 4:	This codepoint may be used only for a CONTROL PLANE SERVICE REQUEST message.

An EMM message received with the security header type encoded as 0000 shall be treated as not security protected, plain NAS message. A protocol entity sending a not security protected EMM message shall send the message as plain NAS message and encode the security header type as 0000.

9.3.2 EPS bearer identity

Bits 5 to 8 of the first octet of every EPS Session Management (ESM) message contain the EPS bearer identity. The EPS bearer identity and its use to identify a message flow are defined in 3GPP TS 24.007 [12].

If the UE or the MME or both do not support signalling for a maximum number of 15 EPS bearer contexts, the MME shall select the EPS bearer identity from the value range 5 to 15, or select the value 0 when it needs to indicate that no EPS bearer identity is assigned.

NOTE: When assigning EPS bearer identities from the range 1 to 4, the MME can take into account that these EPS bearer contexts will be subject to local deactivation if the UE performs inter-system change to A/Gb mode or Iu mode or if it performs a change to an MME not supporting signalling for a maximum number of 15 EPS bearer contexts.

9.4 Procedure transaction identity

Bits 1 to 8 of the second octet (octet 1a) of every EPS Session Management (ESM) message contain the procedure transaction identity. The procedure transaction identity and its use are defined in 3GPP TS 24.007 [12].

9.5 Message authentication code

The Message authentication code (MAC) information element contains the integrity protection information for the message. The MAC IE shall be included in the security protected NAS message if a valid EPS security context exists and security functions are started. The usage of MAC is specified in subclause 4.4.3.3.

9.6 Sequence number

This IE includes the NAS message sequence number (SN) which consists of the eight least significant bits of the NAS COUNT for a security protected NAS message The usage of SN is specified in subclause 4.4.3.

9.7 NAS message

This IE includes a complete plain NAS message as specified in subclause 8.2 and 8.3. The SECURITY PROTECTED NAS MESSAGE and the SERVICE REQUEST message are not plain NAS messages and shall not be included in this IE.

9.8 Message type

The message type IE and its use are defined in 3GPP TS 24.007 [12]. Tables 9.8.1 and 9.8.2 define the value part of the message type IE used in the EPS mobility management protocol and EPS session management protocol.

Table 9.8.1: Message types for EPS mobility management

Bits 8	7	6	5	4	3	2	1	
0	1	-	-	-	-	-	-	EPS mobility management messages
0	1	0	0	0	0	0	1	Attach request
0	1	0	0	0	0	1	0	Attach accept
0	1	0	0	0	0	1	1	Attach complete
0	1	0	0	0	1	0	0	Attach reject
0	1	0	0	0	1	0	1	Detach request
0	1	0	0	0	1	1	0	Detach accept
0	1	0	0	1	0	0	0	Tracking area update request
0	1	0	0	1	0	0	1	Tracking area update accept
0	1	0	0	1	0	1	0	Tracking area update complete
0	1	0	0	1	0	1	1	Tracking area update reject
0	1	0	0	1	1	0	0	Extended service request
0	1	0	0	1	1	0	1	Control plane service request
0	1	0	0	1	1	1	0	Service reject
0	1	0	0	1	1	1	1	Service accept
0	1	0	1	0	0	0	0	GUTI reallocation command
0	1	0	1	0	0	0	1	GUTI reallocation complete
0	1	0	1	0	0	1	0	Authentication request
0	1	0	1	0	0	1	1	Authentication response
0	1	0	1	0	1	0	0	Authentication reject
0	1	0	1	1	1	0	0	Authentication failure
0	1	0	1	0	1	0	1	Identity request
0	1	0	1	0	1	1	0	Identity response
0	1	0	1	1	1	0	1	Security mode command
0	1	0	1	1	1	1	0	Security mode complete
0	1	0	1	1	1	1	1	Security mode reject
0	1	1	0	0	0	0	0	EMM status
0	1	1	0	0	0	0	1	EMM information
0	1	1	0	0	0	1	0	Downlink NAS transport
0	1	1	0	0	0	1	1	Uplink NAS transport
0	1	1	0	0	1	0	0	CS Service notification
0	1	1	0	1	0	0	0	Downlink generic NAS transport
0	1	1	0	1	0	0	1	Uplink generic NAS transport

Table 9.8.2: Message types for EPS session management

Bits 8	7	6	5	4	3	2	1	
1	1	-	-	-	-	-	-	EPS session management messages
1	1	0	0	0	0	0	1	Activate default EPS bearer context request
1	1	0	0	0	0	1	0	Activate default EPS bearer context accept
1	1	0	0	0	0	1	1	Activate default EPS bearer context reject
1	1	0	0	0	1	0	1	Activate dedicated EPS bearer context request
1	1	0	0	0	1	1	0	Activate dedicated EPS bearer context accept
1	1	0	0	0	1	1	1	Activate dedicated EPS bearer context reject
1	1	0	0	1	0	0	1	Modify EPS bearer context request
1	1	0	0	1	0	1	0	Modify EPS bearer context accept
1	1	0	0	1	0	1	1	Modify EPS bearer context reject
1	1	0	0	1	1	0	1	Deactivate EPS bearer context request
1	1	0	0	1	1	1	0	Deactivate EPS bearer context accept
1	1	0	1	0	0	0	0	PDN connectivity request
1	1	0	1	0	0	0	1	PDN connectivity reject
1	1	0	1	0	0	1	0	PDN disconnect request
1	1	0	1	0	0	1	1	PDN disconnect reject
1	1	0	1	0	1	0	0	Bearer resource allocation request
1	1	0	1	0	1	0	1	Bearer resource allocation reject
1	1	0	1	0	1	1	0	Bearer resource modification request
1	1	0	1	0	1	1	1	Bearer resource modification reject
1	1	0	1	1	0	0	1	ESM information request
1	1	0	1	1	0	1	0	ESM information response
1	1	0	1	1	0	1	1	Notification
1	1	0	1	1	1	0	0	ESM dummy message
1	1	1	0	1	0	0	0	ESM status
1	1	1	0	1	0	0	1	Remote UE report
1	1	1	0	1	0	1	0	Remote UE report response
1	1	1	0	1	0	1	1	ESM data transport

9.9 Other information elements

9.9.1 General

The different formats (V, LV, T, TV, TLV, LV-E, TLV-E) and the five categories of information elements (type 1, 2, 3, 4 and 6) are defined in 3GPP TS 24.007 [12].

The first octet of an information element in the non-imperative part contains the IEI of the information element. If this octet does not correspond to an IEI known in the message, the receiver shall determine whether this IE is of type 1 or 2 (i.e. it is an information element of one octet length) or an IE of type 4 (i.e. that the next octet is the length indicator indicating the length of the remaining of the information element) (see 3GPP TS 24.007 [12]).

This allows the receiver to jump over unknown information elements and to analyse any following information elements.

The definitions of information elements which are common for the EMM and ESM protocols or which are used by access stratum protocols are described in subclause 9.9.2.

The information elements of the EMM or ESM protocols can be defined by reference to an appropriate specification, e.g., "see subclause 10.5.6.3 in 3GPP TS 24.008 [13]".

9.9.2 Common information elements

9.9.2.0 Additional information

The purpose of the Additional information information element is to provide additional information to upper layers in relation to the generic NAS message transport mechanism.

The Additional information information element is coded as shown in figure 9.9.2.0.1 and table 9.9.2.0.1.

The Additional information is a type 4 information element with a minimum length of 3 octets.

8	7	6	5	4	3	2	1	
Additional information IEI								octet 1
Additional information length								octet 2
Additional information value								octets 3-n

Figure 9.9.2.0.1: Additional information information element

Table 9.9.2.0.1: Additional information information element

Additional information value (octet 3 to octet n) The coding of the additional information value is dependent on the generic message container type.

9.9.2.0A Device properties

See subclause 10.5.7.8 in 3GPP TS 24.008 [13].

9.9.2.1 EPS bearer context status

The purpose of the EPS bearer context status information element is to indicate the state of each EPS bearer context that can be identified by an EPS bearer identity.

The EPS bearer context status information element is coded as shown in figure 9.9.2.1.1 and table 9.9.2.1.1.

The EPS bearer context status information element is a type 4 information element with 4 octets length.

8	7	6	5	4	3	2	1	
EPS bearer context status IEI								octet 1
Length of EPS bearer context status contents								octet 2
EBI (7)	EBI (6)	EBI (5)	EBI (4)	EBI (3)	EBI (2)	EBI (1)	EBI (0)	octet 3
EBI (15)	EBI (14)	EBI (13)	EBI (12)	EBI (11)	EBI (10)	EBI (9)	EBI (8)	octet 4

Figure 9.9.2.1.1: EPS bearer context status information element

Table 9.9.2.1.1: EPS bearer context status information element

EBI(x) shall be coded as follows: EBI(0): Bit 1 of octet 3 is spare and shall be coded as zero. EBI(1) – EBI(15): 0 indicates that the ESM state of the corresponding EPS bearer context is BEARER CONTEXT-INACTIVE. 1 indicates that the ESM state of the corresponding EPS bearer context is not BEARER CONTEXT-INACTIVE

9.9.2.2 Location area identification

See subclause 10.5.1.3 in 3GPP TS 24.008 [13].

9.9.2.3 Mobile identity

See subclause 10.5.1.4 in 3GPP TS 24.008 [13].

9.9.2.4 Mobile station classmark 2

See subclause 10.5.1.6 in 3GPP TS 24.008 [13].

9.9.2.5 Mobile station classmark 3

See subclause 10.5.1.7 in 3GPP TS 24.008 [13].

9.9.2.6 NAS security parameters from E-UTRA

The purpose of the NAS security parameters from E-UTRA information element is to provide the UE with information that enables the UE to create a mapped UMTS security context.

The NAS security parameters from E-UTRA information element is coded as shown in figure 9.9.2.6.1 and table 9.9.2.6.1.

The NAS security parameters from E-UTRA is a type 3 information element with a length of 2 octets.

The value part of the NAS security parameters from E-UTRA information element is included in specific information elements within some RRC messages sent to the UE; see 3GPP TS 36.331 [22]. For these cases the coding of the information element identifier and length information is defined in 3GPP TS 36.331 [22].

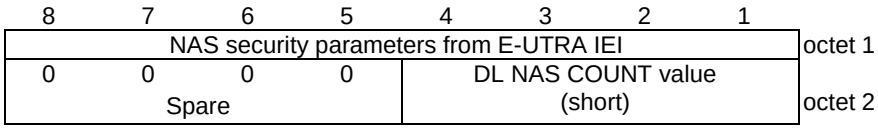


Figure 9.9.2.6.1: NAS security parameters from E-UTRA information element

Table 9.9.2.6.1: NAS security parameters from E-UTRA information element

DL NAS COUNT value (short) (octet 2, bit 1 to 4) This field contains the 4 least significant bits of the binary representation of the downlink NAS COUNT value applicable when this information element is sent. Bit 5 to 8 of octet 2 are spare and shall be coded as zero.

9.9.2.7 NAS security parameters to E-UTRA

The purpose of the NAS security parameters to E-UTRA information element is to provide the UE with parameters that enable the UE to create a mapped EPS security context and take this context into use after inter-system handover to S1 mode.

The NAS security parameters to E-UTRA information element is coded as shown in figure 9.9.2.7.1 and table 9.9.2.7.1.

The NAS security parameters to E-UTRA is a type 3 information element with a length of 7 octets.

The value part of the NAS security parameters to E-UTRA information element is included in specific information elements within some RRC messages sent to the UE; see 3GPP TS 36.331 [22]. For these cases the coding of the information element identifier and length information is defined in 3GPP TS 36.331 [22].

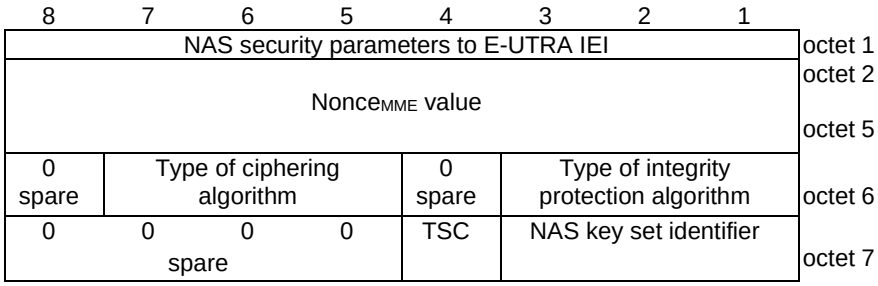


Figure 9.9.2.7.1: NAS security parameters to E-UTRA information element

Table 9.9.2.7.1: NAS security parameters to E-UTRA information element

Nonce$_{MME}$ value (octet 2 to 5) This field is coded as the nonce value in the Nonce information element (see subclause 9.9.3.25). Type of integrity protection algorithm (octet 6, bit 1 to 3) and type of ciphering algorithm (octet 6, bit 5 to 7) These fields are coded as the type of integrity protection algorithm and type of ciphering algorithm in the NAS security algorithms information element (see subclause 9.9.3.23). Bit 4 and 8 of octet 6 are spare and shall be coded as zero. NAS key set identifier (octet 7, bit 1 to 3) and type of security context flag (TSC) (octet 7, bit 4) These fields are coded as the NAS key set identifier and type of security context flag in the NAS key set identifier information element (see subclause 9.9.3.21). Bit 5 to 8 of octet 7 are spare and shall be coded as zero.

9.9.2.8 PLMN list

See subclause 10.5.1.13 in 3GPP TS 24.008 [13].

9.9.2.9 Spare half octet

This element is used in the description of EMM and ESM messages when an odd number of half octet type 1 information elements are used. This element is filled with spare bits set to zero and is placed in bits 5 to 8 of the octet unless otherwise specified.

9.9.2.10 Supported codec list

See subclause 10.5.4.32 in 3GPP TS 24.008 [13].

9.9.3 EPS Mobility Management (EMM) information elements

9.9.3.0A Additional update result

The purpose of the Additional update result information element is to provide additional information about the result of a combined attach procedure or a combined tracking area updating procedure.

The Additional update result information element is coded as shown in figure 9.9.3.0A.1 and table 9.9.3.0A.1.

The Additional update result is a type 1 information element.

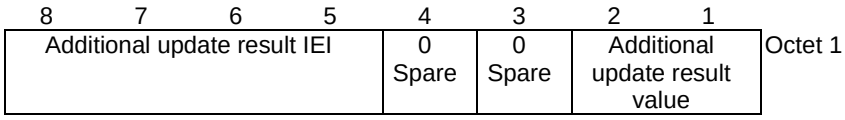


Figure 9.9.3.0A.1: Additional update result information element

Table 9.9.3.0A.1: Additional update result information element

Additional update result value (octet 1) Bits **2 1** 0 0 no additional information 0 1 CS Fallback not preferred 1 0 SMS only 1 1 reserved Bits 4 and 3 of octet 1 are spare and shall all be coded as zero.
NOTE: Bits 4 and 3 of octet 1 were used in earlier versions of this release of this specification.

9.9.3.0B Additional update type

The purpose of the Additional update type information element is to provide additional information about the type of request for an attach or a tracking area updating procedure.

The Additional update type information element is coded as shown in figure 9.9.3.0B.1 and table 9.9.3.0B.1.

The Additional update type is a type 1 information element.

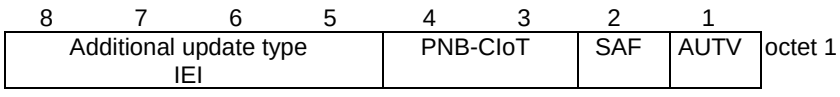


Figure 9.9.3.0B.1: Additional update type information element

Table 9.9.3.0B.1: Additional update type information element

Additional update type value (AUTV) (octet 1)

Bit
1
0 no additional information. If received it shall be interpreted as request for combined attach or combined tracking area updating.
1 SMS only

"Signalling active" flag (SAF) (octet 1)

Bit
2
0 keeping the NAS signalling connection is not required after the completion of the tracking area updating procedure
1 keeping the NAS signalling connection is required after the completion of the tracking area updating procedure

Preferred CIoT network behaviour (PNB-CIoT) (octet 1)

Bit **4**	**3**	
0	0	no additional information
0	1	control plane CIoT EPS optimization
1	0	user plane CIoT EPS optimization
1	1	reserved

9.9.3.1 Authentication failure parameter

See subclause 10.5.3.2.2 in 3GPP TS 24.008 [13].

9.9.3.2 Authentication parameter AUTN

See subclause 10.5.3.1.1 in 3GPP TS 24.008 [13].

9.9.3.3 Authentication parameter RAND

See subclause 10.5.3.1 in 3GPP TS 24.008 [13].

9.9.3.4 Authentication response parameter

The purpose of the Authentication response parameter information element is to provide the network with the authentication response calculated in the USIM.

The Authentication response parameter information element is coded as shown in figure 9.9.3.4.1 and table 9.9.3.4.1.

The Authentication response parameter is a type 4 information element with a minimum length of 6 octets and a maximum length of 18 octets.

In an EPS authentication challenge, the response calculated in the USIM (RES) is minimum 4 octets and may be up to 16 octets in length.

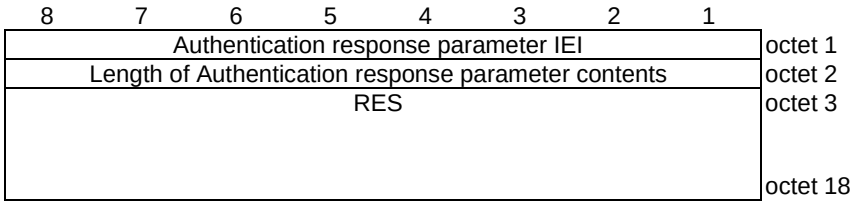


Figure 9.9.3.4.1: Authentication response parameter information element

Table 9.9.3.4.1: Authentication response parameter information element

RES value (octet 3 to 18) This contains the RES.

9.9.3.4A Ciphering key sequence number

See subclause 10.5.1.2 in 3GPP TS 24.008 [13].

9.9.3.4B SMS services status

The purpose of the SMS services status information element is to indicate the status of availability for SMS services requested by the UE during the normal attach procedure or tracking area updating procedure.

The SMS services status information element is coded as shown in figure 9.9.3.4B.1 and table 9.9.3.4B.1.

The SMS services status is a type 1 information element.

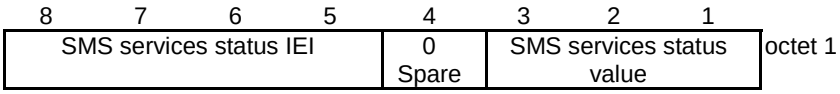


Figure 9.9.3.4B.1: SMS services status information element

Table 9.9.3.4B.1: SMS services status information element

SMS services status value (octet 1, bit 1 to 3) Bits **3 2 1** 0 0 0 SMS services not available 0 0 1 SMS services not available in this PLMN 0 1 0 Network failure 0 1 1 Congestion All other values are unused and shall be treated as abnormal case, if received by the UE. Bit 4 of octet 1 is spare and shall be coded as zero.

9.9.3.5 CSFB response

The purpose of the CSFB response information element is to indicate whether the UE accepts or rejects a paging for CS fallback.

The CSFB response information element is coded as shown in figure 9.9.3.5.1 and table 9.9.3.5.1.

The CSFB response is a type 1 information element.

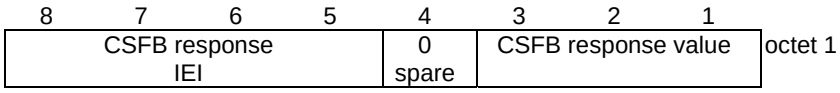


Figure 9.9.3.5.1: CSFB response information element

Table 9.9.3.5.1: CSFB response information element

CSFB response value (octet 1)			
Bits			
3	**2**	**1**	
0	0	0	CS fallback rejected by the UE
0	0	1	CS fallback accepted by the UE
All other values are reserved.			

9.9.3.6 Daylight saving time

See subclause 10.5.3.12 in 3GPP TS 24.008 [13].

9.9.3.7 Detach type

The purpose of the Detach type information element is to indicate the type of detach.

The Detach type information element is coded as shown in figure 9.9.3.7.1 and table 9.9.3.7.1.

The Detach type is a type 1 information element.

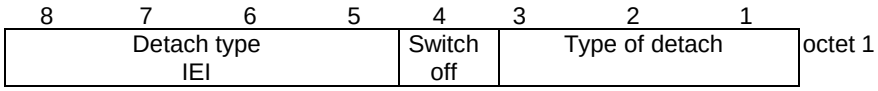


Figure 9.9.3.7.1: Detach type information element

Table 9.9.3.7.1: Detach type information element

Type of detach (octet 1)

In the UE to network direction:
Bits

3	2	1	
0	0	1	EPS detach
0	1	0	IMSI detach
0	1	1	combined EPS/IMSI detach
1	1	0	reserved
1	1	1	reserved

All other values are interpreted as "combined EPS/IMSI detach" in this version of the protocol.

In the network to UE direction:
Bits

3	2	1	
0	0	1	re-attach required
0	1	0	re-attach not required
0	1	1	IMSI detach
1	1	0	reserved
1	1	1	reserved

All other values are interpreted as "re-attach not required" in this version of the protocol.

Switch off (octet 1)

In the UE to network direction:
Bit

4	
0	normal detach
1	switch off

In the network to UE direction bit 4 is spare. The network shall set this bit to zero.

9.9.3.8 DRX parameter

See subclause 10.5.5.6 in 3GPP TS 24.008 [13].

9.9.3.9 EMM cause

The purpose of the EMM cause information element is to indicate the reason why an EMM request from the UE is rejected by the network.

The EMM cause information element is coded as shown in figure 9.9.3.9.1 and table 9.9.3.9.1.

The EMM cause is a type 3 information element with 2 octets length.

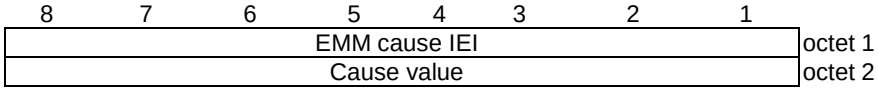


Figure 9.9.3.9.1: EMM cause information element

Table 9.9.3.9.1: EMM cause information element

Cause value (octet 2)

Bits

8	7	6	5	4	3	2	1	
0	0	0	0	0	0	1	0	IMSI unknown in HSS
0	0	0	0	0	0	1	1	Illegal UE
0	0	0	0	0	1	0	1	IMEI not accepted
0	0	0	0	0	1	1	0	Illegal ME
0	0	0	0	0	1	1	1	EPS services not allowed
0	0	0	0	1	0	0	0	EPS services and non-EPS services not allowed
0	0	0	0	1	0	0	1	UE identity cannot be derived by the network
0	0	0	0	1	0	1	0	Implicitly detached
0	0	0	0	1	0	1	1	PLMN not allowed
0	0	0	0	1	1	0	0	Tracking Area not allowed
0	0	0	0	1	1	0	1	Roaming not allowed in this tracking area
0	0	0	0	1	1	1	0	EPS services not allowed in this PLMN
0	0	0	0	1	1	1	1	No Suitable Cells In tracking area
0	0	0	1	0	0	0	0	MSC temporarily not reachable
0	0	0	1	0	0	0	1	Network failure
0	0	0	1	0	0	1	0	CS domain not available
0	0	0	1	0	0	1	1	ESM failure
0	0	0	1	0	1	0	0	MAC failure
0	0	0	1	0	1	0	1	Synch failure
0	0	0	1	0	1	1	0	Congestion
0	0	0	1	0	1	1	1	UE security capabilities mismatch
0	0	0	1	1	0	0	0	Security mode rejected, unspecified
0	0	0	1	1	0	0	1	Not authorized for this CSG
0	0	0	1	1	0	1	0	Non-EPS authentication unacceptable
0	0	1	0	0	0	1	1	Requested service option not authorized in this PLMN
0	0	1	0	0	1	1	1	CS service temporarily not available
0	0	1	0	1	0	0	0	No EPS bearer context activated
0	0	1	0	1	0	1	0	Severe network failure
0	1	0	1	1	1	1	1	Semantically incorrect message
0	1	1	0	0	0	0	0	Invalid mandatory information
0	1	1	0	0	0	0	1	Message type non-existent or not implemented
0	1	1	0	0	0	1	0	Message type not compatible with the protocol state
0	1	1	0	0	0	1	1	Information element non-existent or not implemented
0	1	1	0	0	1	0	0	Conditional IE error
0	1	1	0	0	1	0	1	Message not compatible with the protocol state
0	1	1	0	1	1	1	1	Protocol error, unspecified

Any other value received by the mobile station shall be treated as 0110 1111, "protocol error, unspecified". Any other value received by the network shall be treated as 0110 1111, "protocol error, unspecified".

9.9.3.10 EPS attach result

The purpose of the EPS attach result information element is to specify the result of an attach procedure.

The EPS attach result information element is coded as shown in figure 9.9.3.10.1 and table 9.9.3.10.1.

The EPS attach result is a type 1 information element.

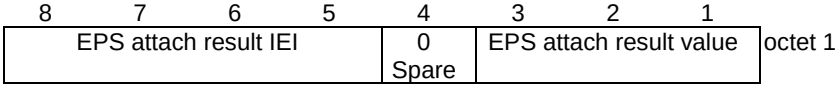


Figure 9.9.3.10.1: EPS attach result information element

Table 9.9.3.10.1: EPS attach result information element

EPS attach result value (octet 1) Bits **3 2 1**	
0 0 1	EPS only
0 1 0	combined EPS/IMSI attach
All other values are reserved.	
Bit 4 of octet 1 is spare and shall be coded as zero.	

9.9.3.11 EPS attach type

The purpose of the EPS attach type information element is to indicate the type of the requested attach.

The EPS attach type information element is coded as shown in figure 9.9.3.11.1 and table 9.9.3.11.1.

The EPS attach type is a type 1 information element.

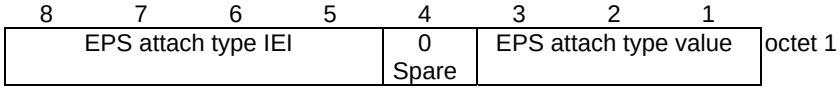


Figure 9.9.3.11.1: EPS attach type information element

Table 9.9.3.11.1: EPS attach type information element

EPS attach type value (octet 1) Bits **3 2 1**	
0 0 1	EPS attach
0 1 0	combined EPS/IMSI attach
1 1 0	EPS emergency attach
1 1 1	reserved
All other values are unused and shall be interpreted as "EPS attach", if received by the network.	
Bit 4 of octet 1 is spare and shall be coded as zero.	

9.9.3.12 EPS mobile identity

The purpose of the EPS mobile identity information element is to provide either the IMSI, the GUTI or the IMEI.

The EPS mobile identity information element is coded as shown in figures 9.9.3.12.1 and 9.9.3.12.2 and table 9.9.3.12.1.

The EPS mobile identity is a type 4 information element with a minimum length of 3 octets and a maximum length of 13 octets.

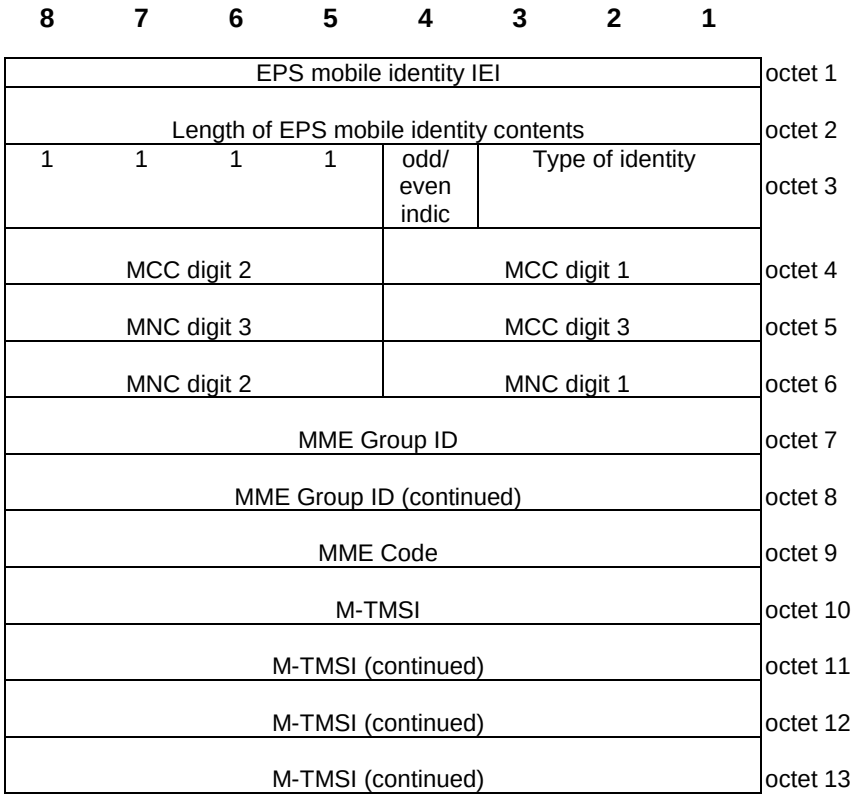


Figure 9.9.3.12.1: EPS mobile identity information element for type of identity "GUTI"

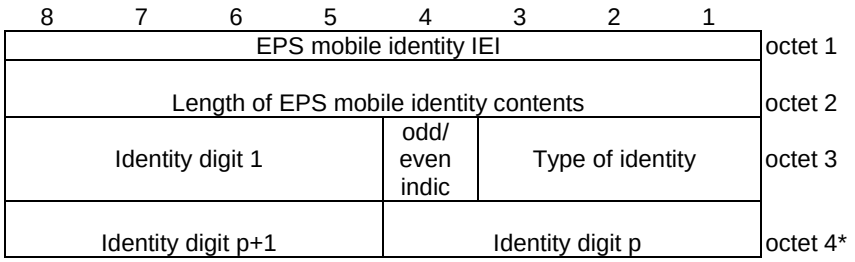


Figure 9.9.3.12.2: EPS mobile identity information element for type of identity "IMSI" or "IMEI"

Table 9.9.3.12.1: EPS mobile identity information element

Type of identity (octet 3)
Bits

3	**2**	**1**	
0	0	1	IMSI
1	1	0	GUTI
0	1	1	IMEI

All other values are reserved.

Odd/even indication (octet 3)
Bit

4	
0	even number of identity digits and also when the GUTI is used
1	odd number of identity digits

Identity digits (octet 4 etc)

For the IMSI, this field is coded using BCD coding. If the number of identity digits is even then bits 5 to 8 of the last octet shall be filled with an end mark coded as "1111".

For the GUTI, then bits 5 to 8 of octet 3 are coded as "1111", octet 4 through 6 contain the MCC and MNC values as specified below, and bit 8 of octet 7 is the most significant bit and bit 1 of the last octet the least significant bit for the subsequent fields. The required fields for the GUTI are as defined in 3GPP TS 23.003 [2].

MCC, Mobile country code (octet 4, octet 5 bits 1 to 4)

The MCC field is coded as in ITU-T Recommendation E.212 [30], annex A.

MNC, Mobile network code (octet 5 bits 5 to 8, octet 6)

The coding of this field is the responsibility of each administration but BCD coding shall be used. The MNC shall consist of 2 or 3 digits. If a network operator decides to use only two digits in the MNC, bits 5 to 8 of octet 5 shall be coded as "1111".

The contents of the MCC and MNC digits are coded as octets 6 to 8 of the Temporary Mobile Group Identity IE in figure 10.5.154 of 3GPP TS 24.008 [13].

For the IMEI, this field is coded using BCD coding. The format of the IMEI is described in 3GPP TS 23.003 [2].

9.9.3.12A EPS network feature support

The purpose of the EPS network feature support information element is to indicate whether certain features are supported by the network.

The EPS network feature support information element is coded as shown in figure 9.9.3.12A.1 and table 9.9.3.12A.1.

The EPS network feature support is a type 4 information element with a minimum length of 3 octets and a maximum length of 4 octets.

If the network does not include octet 4 as defined below in the present version of the protocol, then the UE shall interpret this as a receipt of an information element with all bits of octet 4 coded as zero.

8	7	6	5	4	3	2	1	
EPS network feature support IEI								octet 1
Length of EPS network feature support contents								octet 2
CP CIoT	ERw/o PDN	ESR PS	CS-LCS		EPC-LCS	EMC BS	IMS VoPS	octet 3
15 bearers	IWKN26	RestrictDCNR	RestrictEC	ePCO	HC-CP CIoT	S1-U data	UP CIoT	octet 4*

Figure 9.9.3.12A.1: EPS network feature support information element

Table 9.9.3.12A.1: EPS network feature support information element

IMS voice over PS session indicator (IMS VoPS) (octet 3, bit 1)

Bit
1
0 IMS voice over PS session in S1 mode not supported
1 IMS voice over PS session in S1 mode supported

Emergency bearer services indicator (EMC BS) (octet 3, bit 2)

Bit
2
0 emergency bearer services in S1 mode not supported
1 emergency bearer services in S1 mode supported

Location services indicator in EPC (EPC-LCS) (octet 3, bit 3)

Bit
3
0 location services via EPC not supported
1 location services via EPC supported

Location services indicator in CS (CS-LCS) (octet 3, bit 4 to 5)

Bit

5	**4**	
0	0	no information about support of location services via CS domain is available
0	1	location services via CS domain supported
1	0	location services via CS domain not supported
1	1	reserved

Support of EXTENDED SERVICE REQUEST for packet services (ESRPS)
(octet 3, bit 6)

Bit
6
0 network does not support use of EXTENDED SERVICE REQUEST to request for packet services
1 network supports use of EXTENDED SERVICE REQUEST to request for packet services

EMM REGISTERED without PDN connectivity (ERw/oPDN)
(octet 3, bit 7)
This bit indicates the capability for EMM-REGISTERED without PDN connection
Bit
7
0 EMM-REGISTERED without PDN connection not supported
1 EMM-REGISTERED without PDN connectionsupported

Control plane CIoT EPS optimization (CP CIoT)
(octet 3, bit 8)
This bit indicates the capability for control plane CIoT EPS optimization
Bit
8
0 Control plane CIoT EPS optimization not supported
1 Control plane CIoT EPS optimization supported

User plane CIoT EPS optimization (UP CIoT)
(octet 4, bit 1)
This bit indicates the capability for user plane CIoT EPS optimization
Bit
1
0 User plane CIoT EPS optimization not supported
1 User plane CIoT EPS optimization supported

S1-u data transfer (S1-U data)
(octet 4, bit 2)

This bit indicates the capability for S1-u data transfer. This bit shall be considered only if the Control plane CIoT EPS optimization (CP CIoT) bit (octet 3, bit 8) is set to 1.
Bit
2
0 S1-u data transfer not supported
1 S1-u data transfer supported

Header compression for control plane CIoT EPS optimization (HC-CP CIoT) (octet 4, bit 3)
This bit indicates the capability for header compression for control plane CIoT EPS optimization
Bit
3
0 Header compression for control plane CIoT EPS optimization not supported
1 Header compression for control plane CIoT EPS optimization supported

Extended protocol configuration options (ePCO) (octet 4, bit 4)
This bit indicates the support of the extended protocol configuration options IE.
Bit
4
0 Extended protocol configuration options IE not supported
1 Extended protocol configuration options IE supported

Restriction on enhanced coverage (RestrictEC) (octet 4, bit 5)
This bit indicates if the use of enhanced coverage is restricted or not.
Bit
5
0 Use of enhanced coverage is not restricted
1 Use of enhanced coverage is restricted

Restriction on the use of dual connectivity with NR (RestrictDCNR) (octet 4, bit 6)
This bit indicates if the use of dual connectivity with NR is restricted or not.
Bit
6
0 Use of dual connectivity with NR is not restricted
1 Use of dual connectivity with NR is restricted

Interworking without N26 interface indicator (IWK N26) (octet 4, bit 7)
This bit indicates whether the network supports interworking procedure without N26 interface.
Bit
7
0 Interworking without N26 not supported
1 Interworking without N26 supported

Signalling for a maximum number of 15 EPS bearer contexts (15 bearers) (octet 4, bit 8)
This bit indicates the support of signalling for a maximum number of 15 EPS bearer contexts.
Bit
8
0 Signalling for a maximum number of 15 EPS bearer contexts not supported
1 Signalling for a maximum number of 15 EPS bearer contexts supported

9.9.3.13 EPS update result

The purpose of the EPS update result information element is to specify the result of the associated updating procedure.

The EPS update result information element is coded as shown in figure 9.9.3.13.1 and table 9.9.3.13.1.

The EPS update result is a type 1 information element.

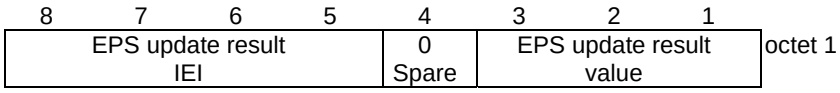


Figure 9.9.3.13.1: EPS update result information element

Table 9.9.3.13.1: EPS update result information element

EPS update result value (octet 1, bit 1 to 3) Bits **3 2 1** 0 0 0 TA updated 0 0 1 combined TA/LA updated 1 0 0 TA updated and ISR activated (NOTE) 1 0 1 combined TA/LA updated and ISR activated (NOTE) All other values are reserved. Bit 4 of octet 1 is spare and shall be coded as zero.
NOTE: Values "TA updated and ISR activated" and "combined TA/LA updated and ISR activated" are used only for a UE supporting also A/Gb or Iu mode.

9.9.3.14 EPS update type

The purpose of the EPS update type information element is to specify the area the updating procedure is associated with.

The EPS update type information element is coded as shown in figure 9.9.3.14.1 and table 9.9.3.14.1.

The EPS update type is a type 1 information element.

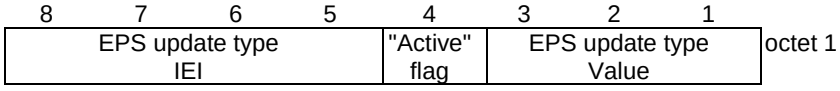


Figure 9.9.3.14.1: EPS update type information element

Table 9.9.3.14.1: EPS update type information element

EPS update type value (octet 1, bit 1 to 3)			
Bits			
3	**2**	**1**	
0	0	0	TA updating
0	0	1	combined TA/LA updating
0	1	0	combined TA/LA updating with IMSI attach
0	1	1	periodic updating
1	0	0	unused; shall be interpreted as "TA updating", if received by the network.
1	0	1	unused; shall be interpreted as "TA updating", if received by the network.
All other values are reserved.			
"Active" flag (octet 1, bit 4)			
Bit			
4			
0			No bearer establishment requested
1			Bearer establishment requested

9.9.3.15 ESM message container

The purpose of the ESM message container information element is to enable piggybacked transfer of a single ESM message within an EMM message. The ESM message included in this IE shall be coded as specified in subclause 8.3, i.e. without NAS security header.

The ESM message container information element is coded as shown in figure 9.9.3.15.1 and table 9.9.3.15.1.

The ESM message container is a type 6 information element.

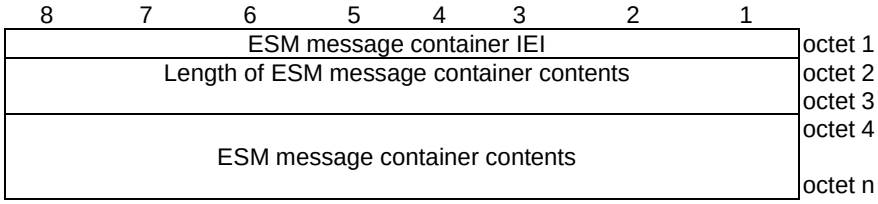


Figure 9.9.3.15.1: ESM message container information element

Table 9.9.3.15.1: ESM message container information element

ESM message container contents (octet 4 to octet n); Max value of 65535 octets
This IE can contain any ESM PDU as defined in subclause 8.3.

9.9.3.16 GPRS timer

See subclause 10.5.7.3 in 3GPP TS 24.008 [13].

9.9.3.16A GPRS timer 2

See subclause 10.5.7.4 in 3GPP TS 24.008 [13].

9.9.3.16B GPRS timer 3

See subclause 10.5.7.4a in 3GPP TS 24.008 [13].

9.9.3.17 Identity type 2

See subclause 10.5.5.9 in 3GPP TS 24.008 [13].

9.9.3.18 IMEISV request

See subclause 10.5.5.10 in 3GPP TS 24.008 [13].

9.9.3.19 KSI and sequence number

The purpose of the KSI and sequence number information element is to provide the network with the key set identifier (KSI) value of the current EPS security context and the 5 least significant bits of the NAS COUNT value applicable for the message including this information element.

The KSI and sequence number information element is coded as shown in figure 9.9.3.19.1 and table 9.9.3.19.1.

The KSI and sequence number is a type 3 information element with a length of 2 octets.

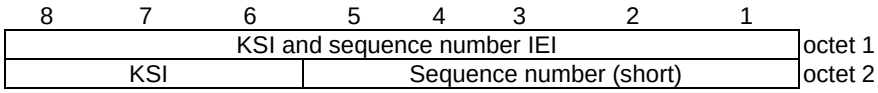


Figure 9.9.3.19.1: KSI and sequence number information element

Table 9.9.3.19.1: KSI and sequence number information element

Sequence number (short) (octet 2, bit 1 to 5) This field contains the 5 least significant bits of the NAS COUNT value applicable when this message is sent. KSI (octet 2, bit 6 to 8) This field contains the key set identifier value, as specified in bit 1 to 3 of octet 1 of the NAS key set identifier information element. (see subclause 9.9.3.21.)

9.9.3.20 MS network capability

See subclause 10.5.5.12 in 3GPP TS 24.008 [13].

9.9.3.20A MS network feature support

See subclause 10.5.1.15 in 3GPP TS 24.008 [13].

9.9.3.21 NAS key set identifier

The NAS key set identifier is allocated by the network.

The NAS key set identifier information element is coded as shown in figure 9.9.3.21.1 and table 9.9.3.21.1.

The NAS key set identifier is a type 1 information element.

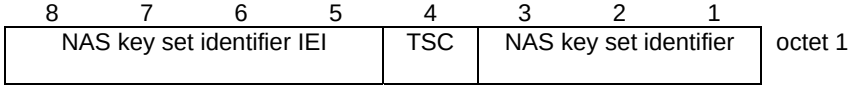


Figure 9.9.3.21.1: NAS key set identifier information element

Table 9.9.3.21.1: NAS key set identifier information element

Type of security context flag (TSC) (octet 1) Bit **4** 0 native security context (for KSI_{ASME}) 1 mapped security context (for KSI_{SGSN}) TSC does not apply for NAS key set identifier value "111". NAS key set identifier (octet 1) Bits **3 2 1** 0 0 0 through possible values for the NAS key set identifier 1 1 0 1 1 1 no key is available (UE to network); reserved (network to UE)

9.9.3.22 NAS message container

This information element is used to encapsulate the SMS messages transferred between the UE and the network.The NAS message container information element is coded as shown in figure 9.9.3.22.1 and table 9.9.3.22.1.

The NAS message container is a type 4 information element with a minimum length of 4 octets and a maximum length of 253 octets.

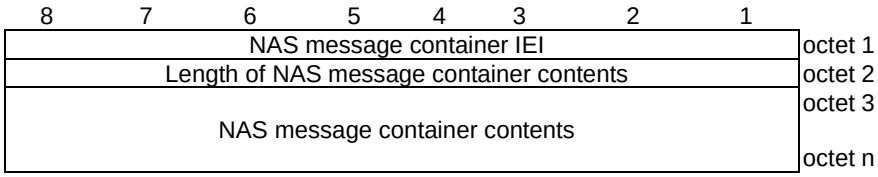


Figure 9.9.3.22.1: NAS message container information element

Table 9.9.3.22.1: NAS message container information element

NAS message container contents (octet 3 to octet n) This IE can contain an SMS message (i.e. CP-DATA, CP-ACK or CP-ERROR) as defined in subclause 7.2 in 3GPP TS 24.011 [13A].

9.9.3.23 NAS security algorithms

The purpose of the NAS security algorithms information element is to indicate the algorithms to be used for ciphering and integrity protection.

The NAS security algorithms information element is coded as shown in figure 9.9.3.23.1 and table 9.9.3.23.1.

The NAS security algorithms is a type 3 information element with a length of 2 octets.

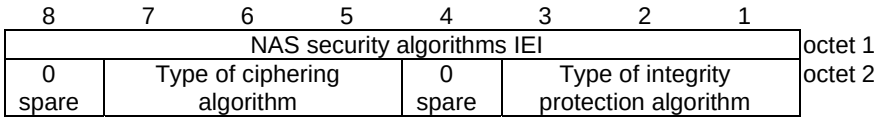


Figure 9.9.3.23.1: NAS security algorithms information element

Table 9.9.3.23.1: NAS security algorithms information element

Type of integrity protection algorithm (octet 2, bit 1 to 3)

Bits 3	2	1	
0	0	0	EPS integrity algorithm EIA0 (null integrity protection algorithm)
0	0	1	EPS integrity algorithm 128-EIA1
0	1	0	EPS integrity algorithm 128-EIA2
0	1	1	EPS integrity algorithm 128-EIA3
1	0	0	EPS integrity algorithm EIA4
1	0	1	EPS integrity algorithm EIA5
1	1	0	EPS integrity algorithm EIA6
1	1	1	EPS integrity algorithm EIA7

Type of ciphering algorithm (octet 2, bit 5 to 7)

Bits 7	6	5	
0	0	0	EPS encryption algorithm EEA0 (null ciphering algorithm)
0	0	1	EPS encryption algorithm 128-EEA1
0	1	0	EPS encryption algorithm 128-EEA2
0	1	1	EPS encryption algorithm 128-EEA3
1	0	0	EPS encryption algorithm EEA4
1	0	1	EPS encryption algorithm EEA5
1	1	0	EPS encryption algorithm EEA6
1	1	1	EPS encryption algorithm EEA7

Bit 4 and 8 of octet 2 are spare and shall be coded as zero.

9.9.3.24 Network name

See subclause 10.5.3.5a in 3GPP TS 24.008 [13].

9.9.3.24A Network resource identifier container

See subclause 10.5.5.31 in 3GPP TS 24.008 [13].

9.9.3.25 Nonce

The purpose of the Nonce information element is to transfer a 32-bit nonce value to support deriving a new mapped EPS security context.

The Nonce information element is coded as shown in figure 9.9.3.25.1 and table 9.9.3.25.1.

The Nonce is a type 3 information element with a length of 5 octets.

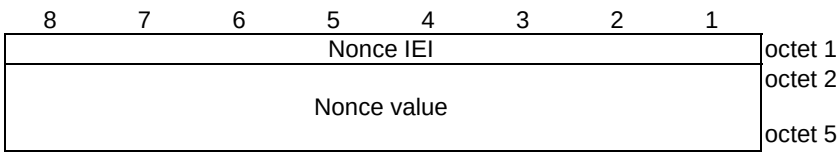


Figure 9.9.3.25.1: Nonce information element

Table 9.9.3.25.1: Nonce information element

Nonce value (octet 2 to 5) This field contains the binary representation of the nonce. Bit 8 of octet 2 represents the most significant bit of the nonce and bit 1 of octet 5 the least significant bit.

9.9.3.25A Paging identity

The purpose of the Paging identity information element is to indicate the identity used for paging for non-EPS services.

The Paging identity information element is coded as shown in figure 9.9.3.25A.1 and table 9.9.3.25A.1.

The Paging identity is a type 3 information element with 2 octets length.

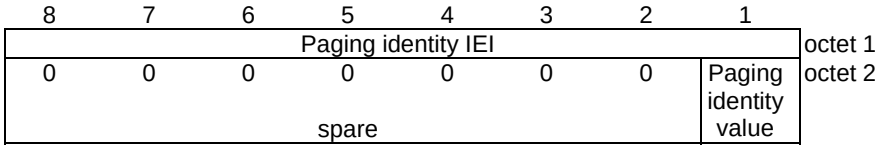


Figure 9.9.3.25A.1: Paging identity information element

Table 9.9.3.25A.1: Paging identity information element

Paging identity value (octet 2) Bit **1** 0 IMSI 1 TMSI

9.9.3.26 P-TMSI signature

See subclause 10.5.5.8 in 3GPP TS 24.008 [13].

9.9.3.26A Extended EMM cause

The purpose of the extended EMM cause information element is to indicate additional information associated with the EMM cause.

The Extended EMM cause information element is coded as shown in figure 9.9.3.26A.1 and table 9.9.3.26A.1.

The Extended EMM cause is a type 1 information element.

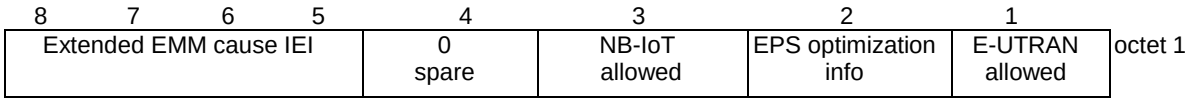


Figure 9.9.3.26A.1: Extended EMM cause information element

Table 9.9.3.26A.1: Extended EMM cause information element

E-UTRAN allowed value (octet 1, bit 1) Bit **1** 0 E-UTRAN allowed 1 E-UTRAN not allowed EPS optimization info (octet 1, bit 2) Bit **2** 0 No EPS optimization information 1 requested EPS optimization not supported Bit 4 of octet 1 is spare and shall be coded as zero.

9.9.3.27 Service type

The purpose of the Service type information element is to specify the purpose of the service request procedure.

The Service type information element is coded as shown in figure 9.9.3.27.1 and table 9.9.3.27.1.

The Service type is a type 1 information element.

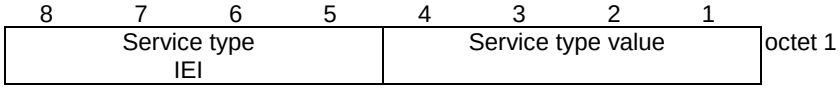


Figure 9.9.3.27.1: Service type information element

Table 9.9.3.27.1: Service type information element

Service type value (octet 1) Service type value Bits				
4	**3**	**2**	**1**	
0	0	0	0	mobile originating CS fallback or 1xCS fallback
0	0	0	1	mobile terminating CS fallback or 1xCS fallback
0	0	1	0	mobile originating CS fallback emergency call or 1xCS fallback emergency call
0	0	1	1	unused; shall be interpreted as "mobile originating CS fallback or 1xCS fallback", if received by the network
0	1	0	0	unused; shall be interpreted as "mobile originating CS fallback or 1xCS fallback", if received by the network
1	0	0	0	packet services via S1
1	0	0	1	unused; shall be interpreted as "packet services via S1", if received by the network
1	0	1	0	unused; shall be interpreted as "packet services via S1", if received by the network
1	0	1	1	unused; shall be interpreted as "packet services via S1", if received by the network
All other values are reserved.				

9.9.3.28 Short MAC

The purpose of the Short MAC information element is to protect the integrity of a SERVICE REQUEST message.

The integrity protection shall include octet 1 and 2 of the SERVICE REQUEST message. For the used algorithm and other input parameters to the algorithm see subclause 9.5. Only the 2 least significant octets of the resulting message authentication code are included in the information element.

The Short MAC information element is coded as shown in figure 9.9.3.28.1 and table 9.9.3.28.1.

The Short MAC is a type 3 information element with a length of 3 octets.

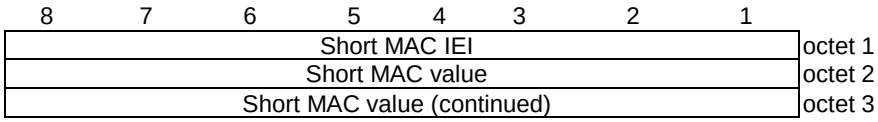


Figure 9.9.3.28.1: Short MAC information element

Table 9.9.3.28.1: Short MAC information element

Short MAC value (octet 2 and 3) This field contains the 2 least significant octets of the message authentication code calculated for the SERVICE REQUEST message. Bit 1 of octet 3 contains the least significant bit, and bit 8 of octet 2 the most significant bit of these 2 octets.

9.9.3.29 Time zone

See subclause 10.5.3.8 in 3GPP TS 24.008 [13].

9.9.3.30 Time zone and time

See subclause 10.5.3.9 in 3GPP TS 24.008 [13].

9.9.3.31 TMSI status

See subclause 10.5.5.4 in 3GPP TS 24.008 [13].

9.9.3.32 Tracking area identity

The purpose of the Tracking area identity information element is to provide an unambiguous identification of tracking areas within the area covered by the 3GPP system.

The Tracking area identity information element is coded as shown in figure 9.9.3.32.1 and table 9.9.3.32.1.

The Tracking area identity is a type 3 information element with a length of 6 octets.

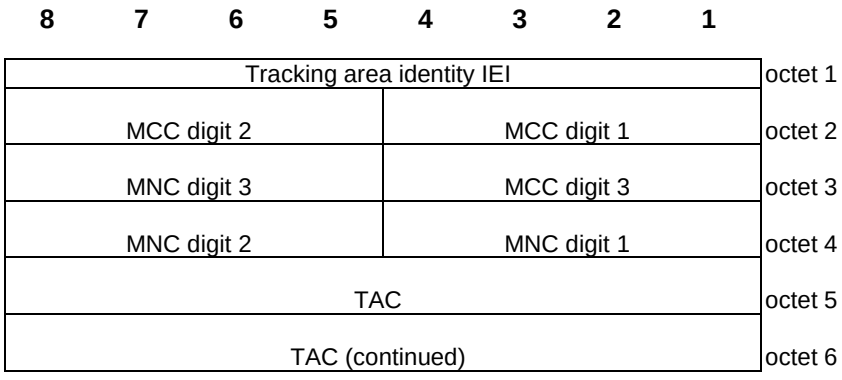


Figure 9.9.3.32.1: Tracking area identity information element

Table 9.9.3.32.1: Tracking area identity information element

MCC, Mobile country code (octet 2 and 3)
The MCC field is coded as in ITU-T Rec. E212 [30], annex A.

If the TAI is deleted the MCC and MNC shall take the value from the deleted TAI.

In abnormal cases, the MCC stored in the UE can contain elements not in the set {0, 1 ... 9}. In such cases the UE should transmit the stored values using full hexadecimal encoding. When receiving such an MCC, the network shall treat the TAI as deleted.

MNC, Mobile network code (octet 3 bits 5 to 8, octet 4)
The coding of this field is the responsibility of each administration, but BCD coding shall be used. The MNC shall consist of 2 or 3 digits. For PCS 1900 for NA, Federal regulation mandates that a 3-digit MNC shall be used. However a network operator may decide to use only two digits in the MNC in the TAI over the radio interface. In this case, bits 5 to 8 of octet 3 shall be coded as "1111". Mobile equipment shall accept a TAI coded in such a way.

In abnormal cases, the MNC stored in the UE can have:
- digit 1 or 2 not in the set {0, 1 ... 9}, or
- digit 3 not in the set {0, 1 ... 9, F} hex.

In such cases the UE shall transmit the stored values using full hexadecimal encoding. When receiving such an MNC, the network shall treat the TAI as deleted.

The same handling shall apply for the network, if a 3-digit MNC is sent by the UE to a network using only a 2-digit MNC.

TAC, Tracking area code (octet 5 and 6)
In the TAC field bit 8 of octet 5 is the most significant bit and bit 1 of octet 6 the least significant bit.
The coding of the tracking area code is the responsibility of each administration except that two values are used to mark the TAC, and hence the TAI, as deleted. Coding using full hexadecimal representation may be used. The tracking area code consists of 2 octets.
If a TAI has to be deleted then all bits of the tracking area code shall be set to one with the exception of the least significant bit which shall be set to zero. If a USIM is inserted in a mobile equipment with the tracking area code containing all zeros, then the mobile equipment shall recognise this TAC as part of a deleted TAI.

9.9.3.33 Tracking area identity list

The purpose of the Tracking area identity list information element is to transfer a list of tracking areas from the network to the UE.

The coding of the information element allows combining different types of lists. The lists of type "00" and "01" allow a more compact encoding, when the different TAIs are sharing the PLMN identity.

The Tracking area identity list information element is coded as shown in figure 9.9.3.33.1, figure 9.9.3.33.2, figure 9.9.3.33.3, figure 9.9.3.33.4 and table 9.9.3.33.1.

The Tracking area identity list is a type 4 information element, with a minimum length of 8 octets and a maximum length of 98 octets. The list can contain a maximum of 16 different tracking area identities.

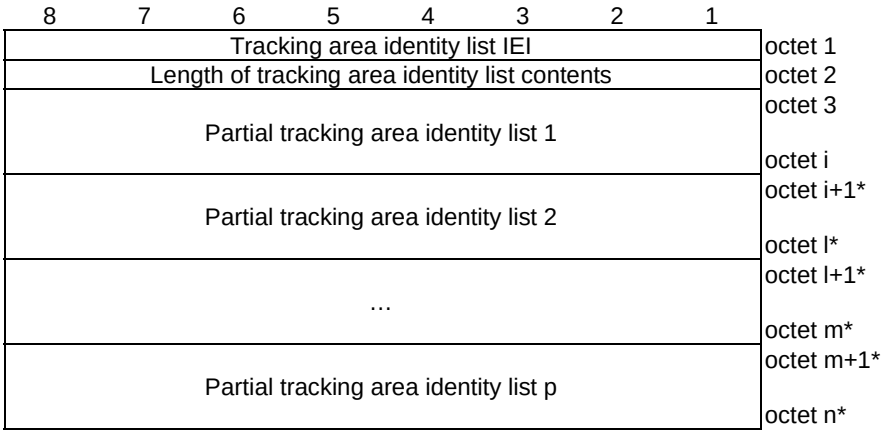


Figure 9.9.3.33.1: Tracking area identity list information element

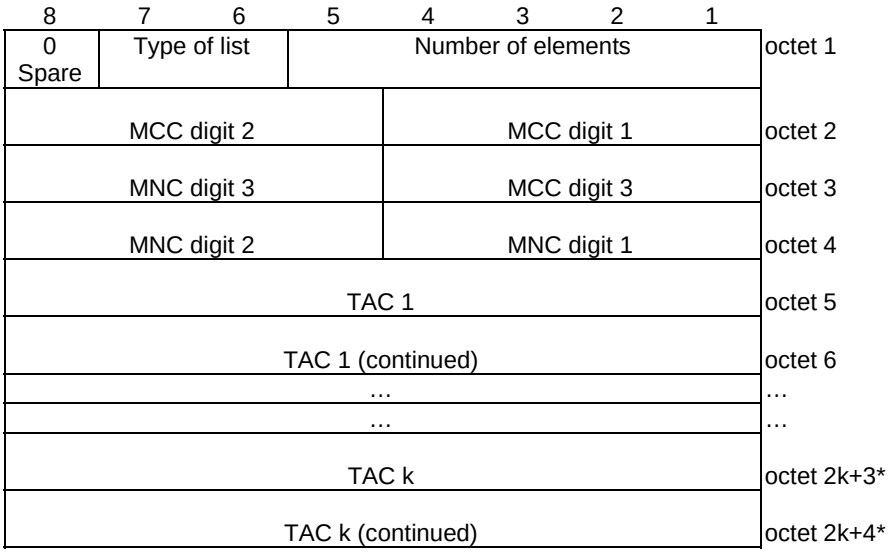


Figure 9.9.3.33.2: Partial tracking area identity list – type of list = "00"

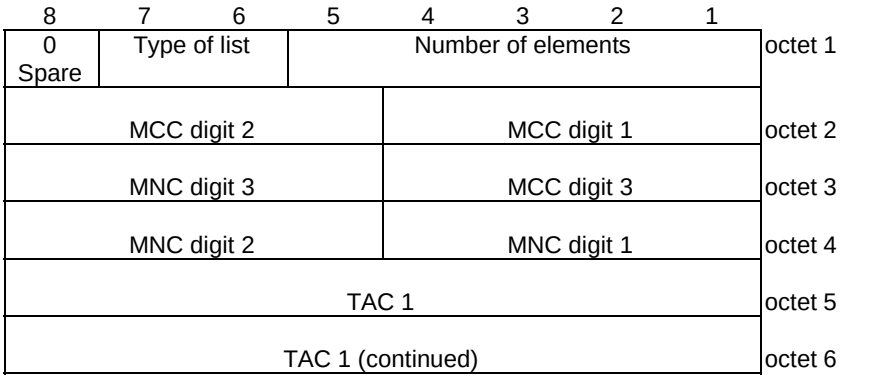


Figure 9.9.3.33.3: Partial tracking area identity list – type of list = "01"

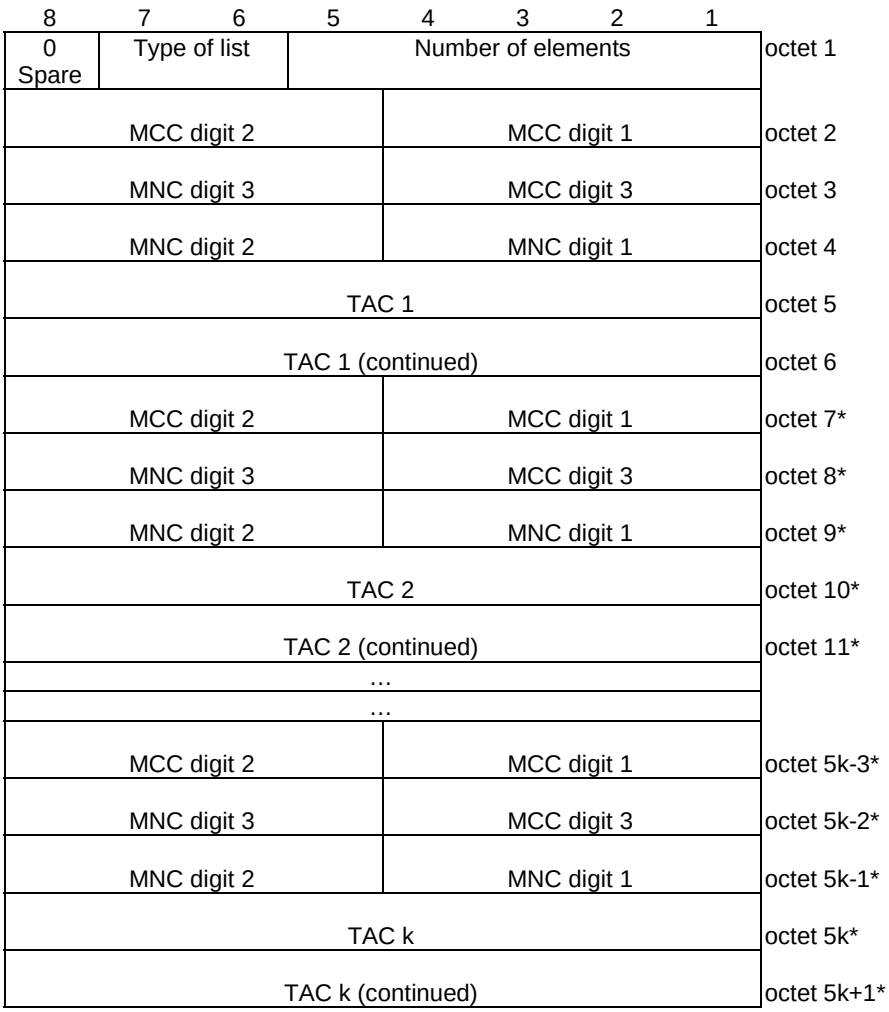


Figure 9.9.3.33.4: Partial tracking area identity list – type of list = "10"

Table 9.9.3.33.1: Tracking area identity list information element

Value part of the Tracking area identity list information element (octet 3 to n)

The value part of the Tracking area identity list information element consists of one or several partial tracking area identity lists. The length of each partial tracking area identity list can be determined from the 'type of list' field and the 'number of elements' field in the first octet of the partial tracking area identity list.
The UE shall store the complete list received. If more than 16 TAIs are included in this information element, the UE shall store the first 16 TAIs and ignore the remaining octets of the information element.

Partial tracking area identity list:

Type of list (octet 1)
Bits

7	**6**	
0	0	list of TACs belonging to one PLMN, with non-consecutive TAC values
0	1	list of TACs belonging to one PLMN, with consecutive TAC values
1	0	list of TAIs belonging to different PLMNs (see NOTE)

All other values are reserved.

Number of elements (octet 1)
Bits

5	**4**	**3**	**2**	**1**	
0	0	0	0	0	1 element
0	0	0	0	1	2 elements
0	0	0	1	0	3 elements
		…			
0	1	1	0	1	14 elements
0	1	1	1	0	15 elements
0	1	1	1	1	16 elements

All other values are unused and shall be interpreted as 16, if received by the UE.

Bit 8 of octet 1 is spare and shall be coded as zero.

For type of list = "00" and number of elements = k:

octet 2 to 4 contain the MCC+MNC, and
for j = 1, k:
octet 2j+3 and 2j+4 contain the TAC of the j-th TAI belonging to the partial list,

For type of list = "01" and number of elements = k:

octet 2 to 4 contain the MCC+MNC, and
octet 5 and 6 contain the TAC of the first TAI belonging to the partial list.
The TAC values of the other k-1 TAIs are TAC+1, TAC+2, …, TAC+k-1.

For type of list = "10" and number of elements = k:

for j = 1, k.
octet 5j-3 to 5j-1 contain the MCC+MNC, and
octet 5j and 5j+1 contain the TAC of the j-th TAI belonging to the partial list.

MCC, Mobile country code

The MCC field is coded as in ITU-T Recommendation E.212 [30], annex A.

MNC, Mobile network code

The coding of this field is the responsibility of each administration but BCD coding shall be used. The MNC shall consist of 2 or 3 digits. If a network operator decides to use only two digits in the MNC, MNC digit 3 shall be coded as "1111".

TAC, Tracking area code

In the TAC field bit 8 of the first octet is the most significant bit and bit 1 of second octet the least significant bit. The coding of the tracking area code is the responsibility of each administration. Coding using full hexadecimal representation may be used. The tracking area code consists of 2 octets.
NOTE: If the "list of TAIs belonging to different PLMNs" is used, the PLMNs included in the list need to be present in the list of "equivalent PLMNs".

9.9.3.34 UE network capability

The purpose of the UE network capability information element is to provide the network with information concerning aspects of the UE related to EPS or interworking with GPRS. The contents might affect the manner in which the network handles the operation of the UE. The UE network capability information indicates general UE characteristics and it shall therefore, except for fields explicitly indicated, be independent of the frequency band of the channel it is sent on.

The UE network capability information element is coded as shown in figure 9.9.3.34.1 and table 9.9.3.34.1.

The UE network capability is a type 4 information element with a minimum length of 4 octets and a maximum length of 15 octets.

NOTE: The requirements for the support of UMTS security algorithms in the UE are specified in 3GPP TS 33.102 [18], and the requirements for the support of EPS security algorithms in 3GPP TS 33.401 [19].

8	7	6	5	4	3	2	1	
UE network capability IEI								octet 1
Length of UE network capability contents								octet 2
EEA0	128-EEA1	128-EEA2	128-EEA3	EEA4	EEA5	EEA6	EEA7	octet 3
EIA0	128-EIA1	128-EIA2	128-EIA3	EIA4	EIA5	EIA6	EIA7	octet 4
UEA0	UEA1	UEA2	UEA3	UEA4	UEA5	UEA6	UEA7	octet 5*
UCS2	UIA1	UIA2	UIA3	UIA4	UIA5	UIA6	UIA7	octet 6*
ProSe-dd	ProSe	H.245-ASH	ACC-CSFB	LPP	LCS	1xSRVCC	NF	octet 7*
ePCO	HC-CP CIoT	ERw/o PDN	S1-U data	UP CIoT	CP CIoT	Prose-relay	ProSe-dc	octet 8*
15 bearers	SGC	N1mode	DCNR	CP backoff	RestrictEC	V2X PC5	multiplDRB	octet 9*
0	0	0	0	0	0	0	0	octet 10* - 15*
Spare								

Figure 9.9.3.34.1: UE network capability information element

Table 9.9.3.34.1: UE network capability information element

EPS encryption algorithms supported (octet 3)

EPS encryption algorithm EEA0 supported (octet 3, bit 8)
0 EPS encryption algorithm EEA0 not supported
1 EPS encryption algorithm EEA0 supported

EPS encryption algorithm 128-EEA1 supported (octet 3, bit 7)
0 EPS encryption algorithm 128-EEA1 not supported
1 EPS encryption algorithm 128-EEA1 supported

EPS encryption algorithm 128-EEA2 supported (octet 3, bit 6)
0 EPS encryption algorithm 128-EEA2 not supported
1 EPS encryption algorithm 128-EEA2 supported

EPS encryption algorithm 128-EEA3 supported (octet 3, bit 5)
0 EPS encryption algorithm 128-EEA3 not supported
1 EPS encryption algorithm 128-EEA3 supported

EPS encryption algorithm EEA4 supported (octet 3, bit 4)
0 EPS encryption algorithm EEA4 not supported
1 EPS encryption algorithm EEA4 supported

EPS encryption algorithm EEA5 supported (octet 3, bit 3)
0 EPS encryption algorithm EEA5 not supported
1 EPS encryption algorithm EEA5 supported

EPS encryption algorithm EEA6 supported (octet 3, bit 2)
0 EPS encryption algorithm EEA6 not supported
1 EPS encryption algorithm EEA6 supported

EPS encryption algorithm EEA7 supported (octet 3, bit 1)
0 EPS encryption algorithm EEA7 not supported
1 EPS encryption algorithm EEA7 supported

EPS integrity algorithms supported (octet 4)

EPS integrity algorithm EIA0 supported (octet 4, bit 8)
0 EPS integrity algorithm EIA0 not supported
1 EPS integrity algorithm EIA0 supported

EPS integrity algorithm 128-EIA1 supported (octet 4, bit 7)
0 EPS integrity algorithm 128-EIA1 not supported
1 EPS integrity algorithm 128-EIA1 supported

EPS integrity algorithm 128-EIA2 supported (octet 4, bit 6)
0 EPS integrity algorithm 128-EIA2 not supported
1 EPS integrity algorithm 128-EIA2 supported

EPS integrity algorithm 128-EIA3 supported (octet 4, bit 5)
0 EPS integrity algorithm 128-EIA3 not supported
1 EPS integrity algorithm 128-EIA3 supported

EPS integrity algorithm EIA4 supported (octet 4, bit 4)
0 EPS integrity algorithm EIA4 not supported
1 EPS integrity algorithm EIA4 supported

EPS integrity algorithm EIA5 supported (octet 4, bit 3)
0 EPS integrity algorithm EIA5 not supported
1 EPS integrity algorithm EIA5 supported

EPS integrity algorithm EIA6 supported (octet 4, bit 2)
0 EPS integrity algorithm EIA6 not supported
1 EPS integrity algorithm EIA6 supported

EPS integrity algorithm EIA7 supported (octet 4, bit 1)
0 EPS integrity algorithm EIA7 not supported
1 EPS integrity algorithm EIA7 supported

UMTS encryption algorithms supported (octet 5)

UMTS encryption algorithm UEA0 supported (octet 5, bit 8)
0 UMTS encryption algorithm UEA0 not supported
1 UMTS encryption algorithm UEA0 supported

UMTS encryption algorithm UEA1 supported (octet 5, bit 7)
0 UMTS encryption algorithm UEA1 not supported
1 UMTS encryption algorithm UEA1 supported

UMTS encryption algorithm UEA2 supported (octet 5, bit 6)
0 UMTS encryption algorithm UEA2 not supported
1 UMTS encryption algorithm UEA2 supported

UMTS encryption algorithm UEA3 supported (octet 5, bit 5)
0 UMTS encryption algorithm UEA3 not supported
1 UMTS encryption algorithm UEA3 supported

UMTS encryption algorithm UEA4 supported (octet 5, bit 4)
0 UMTS encryption algorithm UEA4 not supported
1 UMTS encryption algorithm UEA4 supported

UMTS encryption algorithm UEA5 supported (octet 5, bit 3)
0 UMTS encryption algorithm UEA5 not supported
1 UMTS encryption algorithm UEA5 supported

UMTS encryption algorithm UEA6 supported (octet 5, bit 2)
0 UMTS encryption algorithm UEA6 not supported
1 UMTS encryption algorithm UEA6 supported

UMTS encryption algorithm UEA7 supported (octet 5, bit 1)
0 UMTS encryption algorithm UEA7 not supported
1 UMTS encryption algorithm UEA7 supported

UCS2 support (UCS2) (octet 6, bit 8)
This information field indicates the likely treatment of UCS2 encoded character strings by the UE.

0 The UE has a preference for the default alphabet (defined in 3GPP TS 23.038 [3]) over UCS2 (see ISO/IEC 10646 [29]).
1 The UE has no preference between the use of the default alphabet and the use of UCS2.

UMTS integrity algorithms supported (octet 6)

UMTS integrity algorithm UIA1 supported (octet 6, bit 7)
0 UMTS integrity algorithm UIA1 not supported
1 UMTS integrity algorithm UIA1 supported

UMTS integrity algorithm UIA2 supported (octet 6, bit 6)
0 UMTS integrity algorithm UIA2 not supported
1 UMTS integrity algorithm UIA2 supported

UMTS integrity algorithm UIA3 supported (octet 6, bit 5)
0 UMTS integrity algorithm UIA3 not supported
1 UMTS integrity algorithm UIA3 supported

UMTS integrity algorithm UIA4 supported (octet 6, bit 4)
0 UMTS integrity algorithm UIA4 not supported
1 UMTS integrity algorithm UIA4 supported

UMTS integrity algorithm UIA5 supported (octet 6, bit 3)
0 UMTS integrity algorithm UIA5 not supported
1 UMTS integrity algorithm UIA5 supported

UMTS integrity algorithm UIA6 supported (octet 6, bit 2)
0 UMTS integrity algorithm UIA6 not supported
1 UMTS integrity algorithm UIA6 supported

UMTS integrity algorithm UIA7 supported (octet 6, bit 1)
0 UMTS integrity algorithm UIA7 not supported
1 UMTS integrity algorithm UIA7 supported

NF capability (octet 7, bit 1)
0 notification procedure not supported
1 notification procedure supported

1xSRVCC capability (octet 7, bit 2)
0 SRVCC from E-UTRAN to cdma2000® 1x CS not supported
1 SRVCC from E-UTRAN to cdma2000® 1x CS supported
(see 3GPP TS 23.216 [8])

Location services (LCS) notification mechanisms capability (octet 7, bit 3)
0 LCS notification mechanisms not supported
1 LCS notification mechanisms supported (see 3GPP TS 24.171 [13C])

LTE Positioning Protocol (LPP) capability (octet 7, bit 4)
0 LPP not supported
1 LPP supported (see 3GPP TS 36.355 [22A])

Access class control for CSFB (ACC-CSFB) capability (octet 7, bit 5)
0 eNodeB-based access class control for CSFB not supported
1 eNodeB-based access class control for CSFB supported
(see 3GPP TS 22.011 [1A])

H.245 After SRVCC Handover capability (H.245-ASH) (octet 7, bit 6)
This bit indicates the capability for H.245 with support and use of pre-defined codecs, and if needed, H.245 codec negotiation after SRVCC handover.
0 H.245 after SRVCC handover capability not supported
1 H.245 after SRVCC handover capability supported
(see 3GPP TS 23.216 [8])

ProSe (octet 7, bit 7)
This bit indicates the capability for ProSe.
0 ProSe not supported
1 ProSe supported

ProSe direct discovery (ProSe-dd) (octet 7, bit 8)
This bit indicates the capability for ProSe direct discovery.
0 ProSe direct discovery not supported
1 ProSe direct discovery supported

ProSe direct communication (ProSe-dc) (octet 8, bit 1)
This bit indicates the capability for ProSe direct communication.
0 ProSe direct communication not supported
1 ProSe direct communication supported

ProSe UE-to-network-relay (ProSe-relay) (octet 8, bit 2)
This bit indicates the capability to act as a ProSe UE-to-network relay
0 Acting as a ProSe UE-to-network relay not supported
1 Acting as a ProSe UE-to-network relay supported

Control plane CIoT EPS optimization (CP CIoT) (octet 8, bit 3)
This bit indicates the capability for control plane CIoT EPS optimization.
0 Control plane CIoT EPS optimization not supported
1 Control plane CIoT EPS optimization supported

User plane CIoT EPS optimization (UP CIoT) (octet 8, bit 4)
This bit indicates the capability for user plane CIoT EPS optimization.
0 User plane CIoT EPS optimization not supported
1 User plane CIoT EPS optimization supported

S1-u data transfer (S1-U data) (octet 8, bit 5)
This bit indicates the capability for S1-u data transfer.
0 S1-U data transfer not supported
1 S1-U data transfer supported

EMM-REGISTERED without PDN connection (ERw/oPDN) (octet 8, bit 6)
This bit indicates the capability for EMM REGISTERED without PDN connectivity.
0 EMM-REGISTERED without PDN connection not supported
1 EMM-REGISTERED without PDN connection supported

Header compression for control plane CIoT EPS optimization (HC-CP CIoT) (octet 8, bit 7)
This bit indicates the capability for header compression for control plane CIoT EPS optimization.
0 Header compression for control plane CIoT EPS optimization not supported
1 Header compression for control plane CIoT EPS optimization supported

Extended protocol configuration options (ePCO) (octet 8, bit 8)
This bit indicates the support of the extended protocol configuration options IE.
0 Extended protocol configuration options IE not supported
1 Extended protocol configuration options IE supported

Multiple DRB support (multipleDRB) (octet 9, bit 1)
This bit indicates the capability to support multiple user plane radio bearers (see 3GPP TS 36.306 [44], 3GPP TS 36.331 [22]) in NB-S1 mode.
0 Multiple DRB not supported
1 Multiple DRB supported

V2X communication over PC5 (V2X PC5) (octet 9, bit 2)
This bit indicates the capability for V2X communication over PC5.
0 V2X communication over PC5 not supported
1 V2X communication over PC5 supported

Restriction on use of enhanced coverage support (RestrictEC) (octet 9, bit 3)
This bit indicates the capability to support restriction on use of enhanced coverage.
0 Restriction on use of enhanced coverage not supported
1 Restriction on use of enhanced coverage supported

Control plane data backoff support (CP backoff) (octet 9, bit 4)
This bit indicates the support of back-off timer for transport of user data via the control plane..
0 back-off timer for transport of user data via the control plane not supported
1 back-off timer for transport of user data via the control plane supported

Dual connectivity with NR (DCNR) (octet 9, bit 5)
This bit indicates the capability for dual connecitivity with NR.
0 dual connectivity with NR not supported
1 dual connectivity with NR supported

N1 mode supported (N1mode) (octet 9, bit 6)
This bit indicates the capability for N1 mode.
0 N1 mode not supported
1 N1 mode supported

Service gap control (SGC) (octet 9, bit 7)
This bit indicates the capability for service gap control
0 service gap control not supported
1 service gap control supported

Signalling for a maximum number of 15 EPS bearer contexts (15 bearers) (octet 9, bit 8)
This bit indicates the support of signalling for a maximum number of 15 EPS bearer contexts
0 Signalling for a maximum number of 15 EPS bearer contexts not supported
1 Signalling for a maximum number of 15 EPS bearer contexts supported

All other bits in octet 10 to 15 are spare and shall be coded as zero, if the respective octet is included in the information element.

NOTE 1: For a UE supporting dual connectivity with NR, if the UE supports one of the encryption algorithms for E-UTRAN (bits 8 to 5 of octet 3), it shall support the same algorithm for NR-PDCP as specified in 3GPP TS 33.401 [19]. The NR-PDCP is specified in 3GPP TS 38.323 [53].

NOTE 2: For a UE supporting dual connectivity with NR, if the UE supports one of the integrity algorithms for E-UTRAN (bits 8 to 5 of octet 4), it shall support the same algorithm for NR-PDCP as specified in 3GPP TS 33.401 [19].

9.9.3.35 UE radio capability information update needed

The purpose of the UE radio capability information update needed information element is to indicate whether the MME shall delete the stored UE radio capability information, if any.

The UE radio capability information update needed information element is coded as shown in figure 9.9.3.35.1and table 9.9.3.35.1.

The UE radio capability information update needed is a type 1 information element.

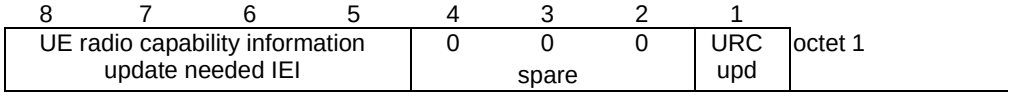


Figure 9.9.3.35.1: UE radio capability information update needed information element

Table 9.9.3.35.1: UE radio capability information update needed information element

UE radio capability information update needed flag (URC upd) (octet 1)	
Bit	
1	
0	UE radio capability information update not needed
1	UE radio capability information update needed

9.9.3.36 UE security capability

The UE security capability information element is used by the network to indicate which security algorithms are supported by the UE in S1 mode, Iu mode and Gb mode. Security algorithms supported in S1 mode are supported both for NAS and for AS security. If the UE supports S101 mode, then these security algorithms are also supported for NAS security in S101 mode.

The UE security capability information element is coded as shown in figure 9.9.3.36.1 and table 9.9.3.36.1.

The UE security capability is a type 4 information element with a minimum length of 4 octets and a maximum length of 7 octets.

Octets 5, 6, and 7 are optional. If octet 5 is included, then also octet 6 shall be included and octet 7 may be included.

If a UE did not indicate support of any security algorithm for Gb mode, octet 7 shall not be included. If the UE did not indicate support of any security algorithm for Iu mode and Gb mode, octets 5, 6, and 7 shall not be included.

If the UE did not indicate support of any security algorithm for Iu mode but indicated support of a security algorithm for Gb mode, octets 5, 6, and 7 shall be included. In this case octets 5 and 6 are filled with the value of zeroes.

8	7	6	5	4	3	2	1	
UE security capability IEI								octet 1
Length of UE security capability contents								octet 2
EEA0	128-EEA1	128-EEA2	128-EEA3	EEA4	EEA5	EEA6	EEA7	octet 3
EIA0	128-EIA1	128-EIA2	128-EIA3	EIA4	EIA5	EIA6	EIA7	octet 4
UEA0	UEA1	UEA2	UEA3	UEA4	UEA5	UEA6	UEA7	octet 5*
0 spare	UIA1	UIA2	UIA3	UIA4	UIA5	UIA6	UIA7	octet 6*
0 spare	GEA1	GEA2	GEA3	GEA4	GEA5	GEA6	GEA7	octet 7*

Figure 9.9.3.36.1: UE security capability information element

Table 9.9.3.36.1: UE security capability information element

EPS encryption algorithms supported (octet 3)

EPS encryption algorithm EEA0 supported (octet 3, bit 8)
0 EPS encryption algorithm EEA0 not supported
1 EPS encryption algorithm EEA0 supported

EPS encryption algorithm 128-EEA1 supported (octet 3, bit 7)
0 EPS encryption algorithm 128-EEA1 not supported
1 EPS encryption algorithm 128-EEA1 supported

EPS encryption algorithm 128-EEA2 supported (octet 3, bit 6)
0 EPS encryption algorithm 128-EEA2 not supported
1 EPS encryption algorithm 128-EEA2 supported

EPS encryption algorithm 128-EEA3 supported (octet 3, bit 5)
0 EPS encryption algorithm 128-EEA3 not supported
1 EPS encryption algorithm 128-EEA3 supported

EPS encryption algorithm EEA4 supported (octet 3, bit 4)
0 EPS encryption algorithm EEA4 not supported
1 EPS encryption algorithm EEA4 supported

EPS encryption algorithm EEA5 supported (octet 3, bit 3)
0 EPS encryption algorithm EEA5 not supported
1 EPS encryption algorithm EEA5 supported

EPS encryption algorithm EEA6 supported (octet 3, bit 2)
0 EPS encryption algorithm EEA6 not supported
1 EPS encryption algorithm EEA6 supported

EPS encryption algorithm EEA7 supported (octet 3, bit 1)
0 EPS encryption algorithm EEA7 not supported
1 EPS encryption algorithm EEA7 supported

EPS integrity algorithms supported (octet 4)

EPS integrity algorithm EIA0 supported (octet 4, bit 8)
0 EPS integrity algorithm EIA0 not supported
1 EPS integrity algorithm EIA0 supported

EPS integrity algorithm 128-EIA1 supported (octet 4, bit 7)
0 EPS integrity algorithm 128-EIA1 not supported
1 EPS integrity algorithm 128-EIA1 supported

EPS integrity algorithm 128-EIA2 supported (octet 4, bit 6)
0 EPS integrity algorithm 128-EIA2 not supported
1 EPS integrity algorithm 128-EIA2 supported

EPS integrity algorithm 128-EIA3 supported (octet 4, bit 5)
0 EPS integrity algorithm 128-EIA3 not supported
1 EPS integrity algorithm 128-EIA3 supported

EPS integrity algorithm EIA4 supported (octet 4, bit 4)
0 EPS integrity algorithm EIA4 not supported
1 EPS integrity algorithm EIA4 supported

EPS integrity algorithm EIA5 supported (octet 4, bit 3)
0 EPS integrity algorithm EIA5 not supported
1 EPS integrity algorithm EIA5 supported

EPS integrity algorithm EIA6 supported (octet 4, bit 2)
0 EPS integrity algorithm EIA6 not supported
1 EPS integrity algorithm EIA6 supported

EPS integrity algorithm EIA7 supported (octet 4, bit 1)
0 EPS integrity algorithm EIA7 not supported
1 EPS integrity algorithm EIA7 supported

UMTS encryption algorithms supported (octet 5)

UMTS encryption algorithm UEA0 supported (octet 5, bit 8)
0 UMTS encryption algorithm UEA0 not supported
1 UMTS encryption algorithm UEA0 supported

UMTS encryption algorithm UEA1 supported (octet 5, bit 7)
0 UMTS encryption algorithm UEA1 not supported
1 UMTS encryption algorithm UEA1 supported

UMTS encryption algorithm UEA2 supported (octet 5, bit 6)
0 UMTS encryption algorithm UEA2 not supported
1 UMTS encryption algorithm UEA2 supported

UMTS encryption algorithm UEA3 supported (octet 5, bit 5)
0 UMTS encryption algorithm UEA3 not supported
1 UMTS encryption algorithm UEA3 supported

UMTS encryption algorithm UEA4 supported (octet 5, bit 4)
0 UMTS encryption algorithm UEA4 not supported
1 UMTS encryption algorithm UEA4 supported

UMTS encryption algorithm UEA5 supported (octet 5, bit 3)
0 UMTS encryption algorithm UEA5 not supported
1 UMTS encryption algorithm UEA5 supported

UMTS encryption algorithm UEA6 supported (octet 5, bit 2)
0 UMTS encryption algorithm UEA6 not supported
1 UMTS encryption algorithm UEA6 supported

UMTS encryption algorithm UEA7 supported (octet 5, bit 1)
0 UMTS encryption algorithm UEA7 not supported
1 UMTS encryption algorithm UEA7 supported

UMTS integrity algorithms supported (octet 6)

Bit 8 of octet 6 is spare and shall be coded as zero.

UMTS integrity algorithm UIA1 supported (octet 6, bit 7)
0 UMTS integrity algorithm UIA1 not supported
1 UMTS integrity algorithm UIA1 supported

UMTS integrity algorithm UIA2 supported (octet 6, bit 6)
0 UMTS integrity algorithm UIA2 not supported
1 UMTS integrity algorithm UIA2 supported

UMTS integrity algorithm UIA3 supported (octet 6, bit 5)
0 UMTS integrity algorithm UIA3 not supported
1 UMTS integrity algorithm UIA3 supported

UMTS integrity algorithm UIA4 supported (octet 6, bit 4)
0 UMTS integrity algorithm UIA4 not supported
1 UMTS integrity algorithm UIA4 supported

UMTS integrity algorithm UIA5 supported (octet 6, bit 3)
0 UMTS integrity algorithm UIA5 not supported
1 UMTS integrity algorithm UIA5 supported

UMTS integrity algorithm UIA6 supported (octet 6, bit 2)
0 UMTS integrity algorithm UIA6 not supported
1 UMTS integrity algorithm UIA6 supported

UMTS integrity algorithm UIA7 supported (octet 6, bit 1)
0 UMTS integrity algorithm UIA7 not supported
1 UMTS integrity algorithm UIA7 supported

GPRS encryption algorithms supported (octet 7)

Bit 8 of octet 7 is spare and shall be coded as zero.

GPRS encryption algorithm GEA1 supported (octet 7, bit 7)
0 GPRS encryption algorithm GEA1 not supported
1 GPRS encryption algorithm GEA1 supported

GPRS encryption algorithm GEA2 supported (octet 7, bit 6)
0 GPRS encryption algorithm GEA2 not supported
1 GPRS encryption algorithm GEA2 supported

GPRS encryption algorithm GEA3 supported (octet 7, bit 5)
0 GPRS encryption algorithm GEA3 not supported
1 GPRS encryption algorithm GEA3 supported

GPRS encryption algorithm GEA4 supported (octet 7, bit 4)
0 GPRS encryption algorithm GEA4 not supported
1 GPRS encryption algorithm GEA4 supported

GPRS encryption algorithm GEA5 supported (octet 7, bit 3)
0 GPRS encryption algorithm GEA5 not supported
1 GPRS encryption algorithm GEA5 supported

GPRS encryption algorithm GEA6 supported (octet 7, bit 2)
0 GPRS encryption algorithm GEA6 not supported
1 GPRS encryption algorithm GEA6 supported

GPRS encryption algorithm GEA7 supported (octet 7, bit 1)
0 GPRS encryption algorithm GEA7 not supported
1 GPRS encryption algorithm GEA7 supported

NOTE 1: For a UE supporting dual connectivity with NR. if the UE supports one of the encryption algorithms for E-UTRAN (bits 8 to 5 of octet 3), it shall support the same algorithm for NR-PDCP as specified in 3GPP TS 33.401 [19].

NOTE 2: For a UE supporting dual connectivity with NR, if the UE supports one of the integrity algorithms for E-UTRAN (bits 8 to 5 of octet 4), it shall support the same algorithm for NR-PDCP as specified in 3GPP TS 33.401 [19].

9.9.3.37 Emergency Number List

See subclause 10.5.3.13 in 3GPP TS 24.008 [13].

9.9.3.37A Extended Emergency Number List

The purpose of this information element is to encode one or more local emergency number(s) together with a sub-services field containing zero ore more sub-services of the associated emergency service URN. An emergency service URN is a service URN with top level service type of "sos" as specified in IETF RFC 5031 [55].

EXAMPLE 1: If the associated emergency service URN is "urn:service:sos.gas", there is only one sub-service provided in the sub-services field which is "gas".

EXAMPLE 2: If the associated emergency service URN is "urn:service:sos", there is no sub-services provided in the sub-services field and the length of the sub-services field is "0".

NOTE: The associated emergency service URN can be a country-specific emergency service URN as defined in 3GPP TS 24.229 [13D].

The Extended Emergency Number List information element is coded as shown in figure 9.9.3.37A.1.

The Extended Emergency Number List IE is a type 6 information element with a minimum length of 6 octets and a maximum length of 65536 octets.

8	7	6	5	4	3	2	1	
Extended Emergency Number List IE								octet 1
Length of Extended Emergency Number List IE contents								octet 2 octet 3
Length of 1st Emergency Number information (Note 1)								octet 4
Number digit 2				Number digit 1				octet 5 (Note 2)
Number digit 4				Number digit 3				octet 6*
:				:				:
(Note 3)								octet j-1*
Length of 1st sub-services field (Note 4)								octet j
sub-services field								octet j+1* (Note 5) octet k-1*
Length of 2nd Emergency Number information (Note 1)								octet k*
Number digit 2				Number digit 1				octet k+1* (Note 2)
Number digit 4				Number digit 3				octet k+2*
:				:				:
(Note 3)				:				octet l-1*
Length of 2nd sub-services field (Note 4)								octet l*
sub-services field								octet l+1* (Note 5) octet m-1*
Length of 3rd Emergency Number information (Note 1)								octet m*
Number digit 2				Number digit 1				octet m+1* (Note 2)
Number digit 4				Number digit 3				octet m+2*
:				:				:
(Note 3)				:				octet n-1*
Length of 3rd sub-services field (Note 4)								octet n*
sub-services field								octet n+1* (Note 5) octet o*

NOTE 1: The length shall contain the number of octets used to encode the number digits.
NOTE 2: The number digit(s) in octet 5 precedes the digit(s) in octet 6 etc. The number digit, which would be entered first, is located in octet 6, bits 1 to 4. The contents of the number digits are coded as shown in table 10.5.118/3GPP TS 24.008 [13].
NOTE 3: If the emergency number contains an odd number of digits, bits 5 to 8 of the last octet of the respective emergency number shall be filled with an end mark coded as "1111".
NOTE 4: The length shall contain the number of octets used to encode the sub-services field.
NOTE 5: The characters of the sub-services of the associated emergency service URN shall be coded in accordance to 3GPP TS 23.038 [3] and the first character starts in octet j+1, l+1 or n+1.

Figure 9.9.3.37A.1 Extended Emergency Number List IE

EXAMPLE 3: If the associated emergency service URN is "urn:service:sos.police.municipal", the sub-services field contains "police.municipal" and the first character is "p".

9.9.3.38 CLI

The purpose of the CLI information element is to convey information about the calling line for a terminated call to a CS fallback capable UE.

The CLI information element is coded as shown in figure 9.9.3.38.1 and table 9.9.3.38.1.

The CLI is a type 4 information element with a minimum length of 3 octets and a maximum length of 14 octets.

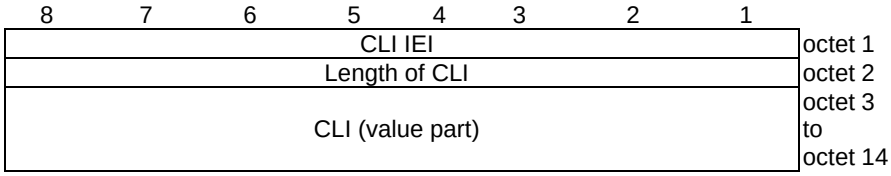


Figure 9.9.3.38.1: CLI information element

Table 9.9.3.38.1: CLI information element

CLI (value part) The coding of the CLI value part is the same as for octets 3 to 14 of the Calling party BCD number information element defined in subclause 10.5.4.9 of 3GPP TS 24.008 [13].

9.9.3.39 SS Code

The purpose of the SS code information element is to convey information related to a network initiated supplementary service request to a CS fallback capable UE.

The SS Code information element is coded as shown in figure 9.9.3.39.1 and table 9.9.3.39.1.

The SS Code is a type 3 information element with 2 octets length.

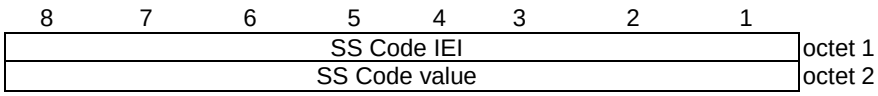


Figure 9.9.3.39.1: SS Code information element

Table 9.9.3.39.1: SS Code information element

SS Code value The coding of the SS Code value is given in subclause 17.7.5 of 3GPP TS 29.002 [15C].

9.9.3.40 LCS indicator

The purpose of the LCS indicator information element is to indicate that the origin of the message is due to a LCS request and the type of this request to a CS fallback capable UE.

The LCS indicator information element is coded as shown in figure 9.9.3.40.1 and table 9.9.3.40.1.

The LCS indicator is a type 3 information element with 2 octets length.

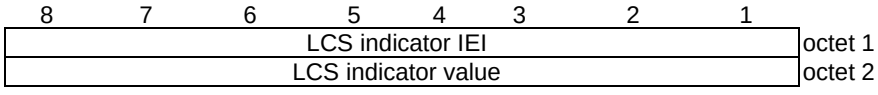


Figure 9.9.3.40.1: LCS indicator information element

Table 9.9.3.40.1: LCS indicator information element

LCS indicator value Bits 8 7 6 5 4 3 2 1	
0 0 0 0 0 0 0 0	Normal, unspecified in this version of the protocol.
0 0 0 0 0 0 0 1	MT-LR
0 0 0 0 0 0 1 0 to 1 1 1 1 1 1 1 1	Normal, unspecified in this version of the protocol

9.9.3.41 LCS client identity

The purpose of the LCS client identity information element is to convey information related to the client of a LCS request for a CS fallback capable UE.

The LCS client identity information element is coded as shown in figure 9.9.3.41.1 and table 9.9.3.41.1.

The LCI client identity is a type 4 information element with a minimum length of 3 octets and a maximum length of 257 octets.

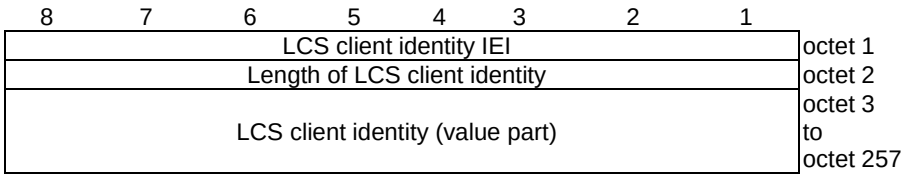


Figure 9.9.3.41.1: LCS client identity information element

Table 9.9.3.41.1: LCS client identity information element

LCS client identity (value part) The coding of the value part of the LCS client identity is given in subclause 17.7.13 of 3GPP TS 29.002 [15C].

9.9.3.42 Generic message container type

The purpose of the generic message container type information element is to specify the type of message contained in the generic message container IE.

The generic message container type information element is coded as shown in table 9.9.3.42.1.

Table 9.9.3.42.1: Generic message container type information element

Bits 8	7	6	5	4	3	2	1	
0	0	0	0	0	0	0	0	Reserved
0	0	0	0	0	0	0	1	LTE Positioning Protocol (LPP) message container (see 3GPP TS 36.355 [22A])
0	0	0	0	0	0	1	0	Location services message container (see 3GPP TS 24.171 [13C])
0	0	0	0	0	0	1	1	
			to					Unused
0	1	1	1	1	1	1	1	
1	0	0	0	0	0	0	0	
			to					Reserved
1	1	1	1	1	1	1	1	

9.9.3.43 Generic message container

This information element is used to encapsulate the application message transferred between the UE and the network.The generic message container information element is coded as shown in figure 9.9.3.43.1 and table 9.9.3.43.1.

The generic message container is a type 6 information element.

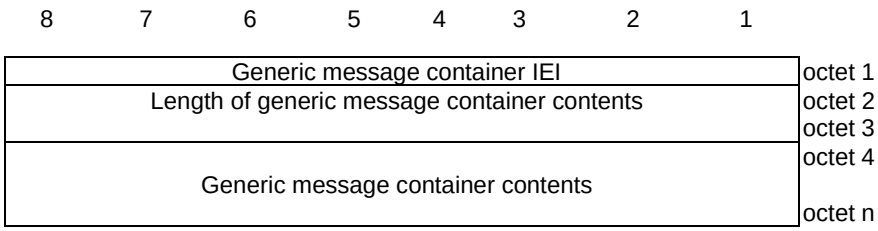


Figure 9.9.3.43.1: Generic message container information element

Table 9.9.3.43.1: Generic message container information element

Generic message container contents (octet 4 to octet n); Max value of 65535 octets The coding of the contents of the generic message container is dependent on the particular application.

9.9.3.44 Voice domain preference and UE's usage setting

See subclause 10.5.5.28 in 3GPP TS 24.008 [13].

9.9.3.45 GUTI type

The purpose of the GUTI type information element is to indicate whether the GUTI included in the same message in an information element of type EPS mobile identity represents a native GUTI or a mapped GUTI.

The GUTI type information element information element is coded as shown in figure 9.9.3.45.1 and table 9.9.3.45.1.

The GUTI type is a type 1 information element.

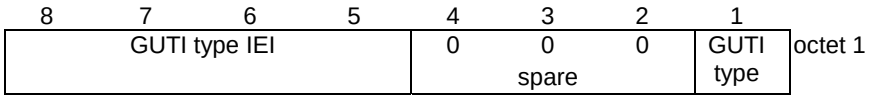


Figure 9.9.3.45.1: GUTI type information element

Table 9.9.3.45.1: GUTI type information element

GUTI type (octet 1) Bit **1** 0 Native GUTI 1 Mapped GUTI Bits 2 to 4 of octet 1 are spare and shall be coded as zero.

9.9.3.46 Extended DRX parameters

See subclause 10.5.5.32 in 3GPP TS 24.008 [13].

9.9.3.47 Control plane service type

The purpose of the Control plane service type information element is to specify the purpose of the CONTROL PLANE SERVICE REQUEST message.

TheControl plane service type information element is coded as shown in figure 9.9.3.47.1 and table 9.9.3.47.1.

The Control plane service type is a type 1 information element.

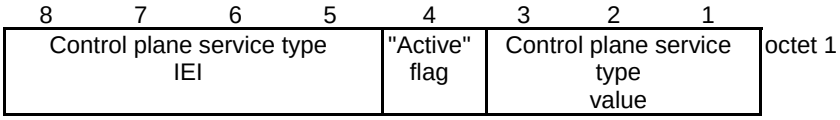


Figure 9.9.3.47.1: Control plane service type information element

Table 9.9.3.47.1: Control plane service type information element

Control plane service type value (octet 1, bit 1 to 3) Bits **3 2 1** 0 0 0 mobile originating request 0 0 1 mobile terminating request 0 1 0 to unused; shall be interpreted as " mobile originating request", if received

1 1 1 by the network. All other values are reserved. "Active" flag (octet 1, bit 4) Bit **4** 0 No radio bearer establishment requested 1 Radio bearer establishment requested

9.9.3.48 DCN-ID

See subclause 10.5.5.35 in 3GPP TS 24.008 [13].

9.9.3.49 Non-3GPP NW provided policies

See subclause 10.5.5.37 in 3GPP TS 24.008 [13].

9.9.3.50 $Hash_{MME}$

The purpose of the $Hash_{MME}$ information element is to transfer a 64-bit hash value to the UE so the UE can check the MME calculated value against the value locally calculated by the UE to determine whether the ATTACH REQUEST or TRACKING AREA UPDATE REQUEST message sent by the UE has been modified.

The $Hash_{MME}$ information element is coded as shown in figure 9.9.3.50.1 and table 9.9.3.50.1.

The $Hash_{MME}$ is a type 4 information element with a length of 10 octets.

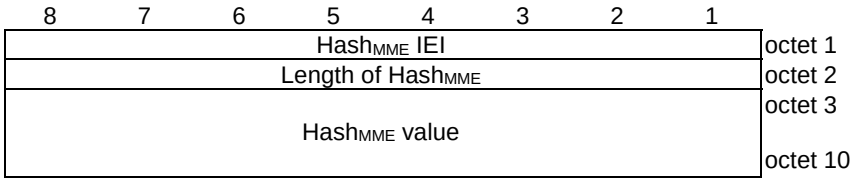


Figure 9.9.3.50.1: $Hash_{MME}$ information element

Table 9.9.3.50.1: $Hash_{MME}$ information element

$Hash_{MME}$ value (octet 3 to 10) This field contains the binary representation of the $Hash_{MME}$. Bit 8 of octet 3 represents the most significant bit of the $Hash_{MME}$ and bit 1 of octet 10 the least significant bit.

9.9.3.51 Replayed NAS message container

The purpose of the Replayed NAS message containerIE is to, during an ongoing attach or tracking area updating procedure, re-send the ATTACH REQUEST or TRACKING AREA UPDATE REQUEST message with which the UE had initiated the procedure, if the MME has included a $HASH_{MME}$ in the SECURITY MODE COMMAND message and the $HASH_{MME}$ is different from the hash value locally calculated at the UE as described in 3GPP TS 33.401 [19]. If an ATTACH REQUEST message is included in this IE, the ATTACH REQUEST message shall be coded as specified in subclause 8.2.4, i.e. without NAS security header. If a TRACKING AREA UPDATE REQUEST message is included in this IE, the TRACKING AREA UPDATE REQUEST message shall be coded as specified in subclause 8.2.29, i.e. without NAS security header

The Replayed NAS message container information element is coded as shown in figure 9.9.3.51.1 and table 9.9.3.51.1.

The Replayed NAS message container is a type 6 information element.

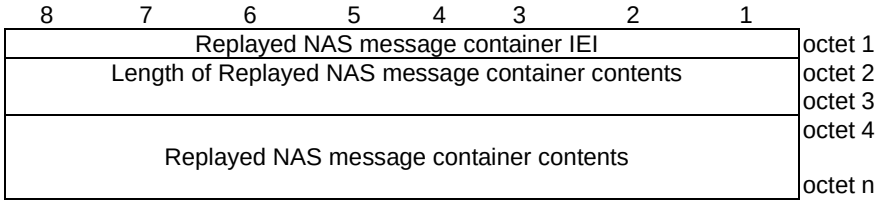


Figure 9.9.3.51.1: Replayed NAS message container information element

Table 9.9.3.51.1: Replayed NAS message container information element

Replayed NAS message container contents (octet 4 to octet n); Max value of 65535 octets This IE can contain an ATTACH REQUEST message as defined in subclause 8.2.4, or a TRACKING AREA UPDATE REQUEST message as defined in subclause 8.2.29.

9.9.3.52 Network policy

The purpose of the Network policy information element is to provide network policy information to the UE during attach or tracking area updating procedure via the ATTACH ACCEPT message or TRACKING AREA UPDATE ACCEPT message.

The Network policy information element is coded as shown in figure 9.9.3.52.1 and table 9.9.3.52.1.

The Network policy is a type 1 information element.

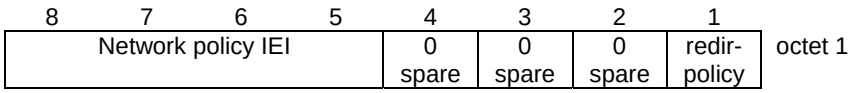


Figure 9.9.3.52.1: Network policy information element

Table 9.9.3.52.1: Network policy information element

Network policy value Redirection to GERAN security policy (redir-policy) (octet 1, bit 1) 0 Unsecured redirection to GERAN allowed 1 Unsecured redirection to GERAN not allowed Bits 2 to 4 are spare and shall be set to "0".

9.9.3.53 UE additional security capability

The UE additional security capability information element is used by the UE to indicate which additional security algorithms are supported by the UE.

The UE additional security capability information element is coded as shown in figure 9.9.3.53.1 and table 9.9.3.53.1.

The UE additional security capability is a type 4 information element with a length of 6 octets.

8	7	6	5	4	3	2	1	
UE additional security capability IEI								octet 1
Length of UE additional security capability contents								octet 2
5G-EA0	128-5G-EA1	128-5G-EA2	128-5G-EA3	5G-EA4	5G-EA5	5G-EA6	5G-EA7	octet 3
5G-EA8	5G-EA9	5G-EA10	5G-EA11	5G-EA12	5G-EA13	5G-EA14	5G-EA15	octet 4
5G-IA0	128-5G-IA1	128-5G-IA2	128-5G-IA3	5G-IA4	5G-IA5	5G-IA6	5G-IA7	octet 5
5G-IA8	5G-IA9	5G-IA10	5G-IA11	5G-IA12	5G-IA13	5G-IA14	5G-IA15	octet 6

Figure 9.9.3.53.1: UE additional security capability information element

Table 9.9.3.53.1: UE additional security capability information element

5GS encryption algorithms supported (octet 3) (NOTE 1)

5GS encryption algorithm 5G-EA0 supported (octet 3, bit 8)
0 5GS encryption algorithm 5G-EA0 not supported
1 5GS encryption algorithm 5G-EA0 supported

5GS encryption algorithm 128-5G-EA1 supported (octet 3, bit 7)
0 5GS encryption algorithm 128-5G-EA1 not supported
1 5GS encryption algorithm 128-5G-EA1 supported

5GS encryption algorithm 128-5G-EA2 supported (octet 3, bit 6)
0 5GS encryption algorithm 128-5G-EA2 not supported
1 5GS encryption algorithm 128-5G-EA2 supported

5GS encryption algorithm 128-5G-EA3 supported (octet 3, bit 5)
0 5GS encryption algorithm 128-5G-EA3 not supported
1 5GS encryption algorithm 128-5G-EA3 supported

5GS encryption algorithm 5G-EA4 supported (octet 3, bit 4)
0 5GS encryption algorithm 5G-EA4 not supported
1 5GS encryption algorithm 5G-EA4 supported

5GS encryption algorithm 5G-EA5 supported (octet 3, bit 3)
0 5GS encryption algorithm 5G-EA5 not supported
1 5GS encryption algorithm 5G-EA5 supported

5GS encryption algorithm 5G-EA6 supported (octet 3, bit 2)
0 5GS encryption algorithm 5G-EA6 not supported
1 5GS encryption algorithm 5G-EA6 supported

5GS encryption algorithm 5G-EA7 supported (octet 3, bit 1)
0 5GS encryption algorithm 5G-EA7 not supported
1 5GS encryption algorithm 5G-EA7 supported

5GS encryption algorithms supported (octet 4)

5GS encryption algorithm 5G-EA8 supported (octet 4, bit 8)
0 5GS encryption algorithm 5G-EA8 not supported
1 5GS encryption algorithm 5G-EA8 supported

5GS encryption algorithm 5G-EA9 supported (octet 4, bit 7)
0 5GS encryption algorithm 5G-EA9 not supported
1 5GS encryption algorithm 5G-EA9 supported

5GS encryption algorithm 5G-EA10 supported (octet 4, bit 6)
0 5GS encryption algorithm 5G-EA10 not supported
1 5GS encryption algorithm 5G-EA10 supported

5GS encryption algorithm 5G-EA11 supported (octet 4, bit 5)
0 5GS encryption algorithm 5G-EA11 not supported
1 5GS encryption algorithm 5G-EA11 supported

5GS encryption algorithm 5G-EA12 supported (octet 4, bit 4)
0 5GS encryption algorithm 5G-EA12 not supported
1 5GS encryption algorithm 5G-EA12 supported

5GS encryption algorithm 5G-EA13 supported (octet 4, bit 3)
0 5GS encryption algorithm 5G-EA13 not supported
1 5GS encryption algorithm 5G-EA13 supported

5GS encryption algorithm 5G-EA14 supported (octet 4, bit 2)
0 5GS encryption algorithm 5G-EA14 not supported
1 5GS encryption algorithm 5G-EA14 supported

5GS encryption algorithm 5G-EA15 supported (octet 4, bit 1)
0 5GS encryption algorithm 5G-EA15 not supported
1 5GS encryption algorithm 5G-EA15 supported

5GS integrity algorithms supported (octet 5) (NOTE 2)

5GS integrity algorithm 5G-IA0 supported (octet 5, bit 8)
0 5GS integrity algorithm 5G-IA0 not supported
1 5GS integrity algorithm 5G-IA0 supported

5GS integrity algorithm 128-5G-IA1 supported (octet 5, bit 7)
0 5GS integrity algorithm 128-5G-IA1 not supported
1 5GS integrity algorithm 128-5G-IA1 supported

5GS integrity algorithm 128-5G-IA2 supported (octet 5, bit 6)
0 5GS integrity algorithm 128-5G-IA2 not supported
1 5GS integrity algorithm 128-5G-IA2 supported

5GS integrity algorithm 128-5G-IA3 supported (octet 5, bit 5)
0 5GS integrity algorithm 128-5G-IA3 not supported
1 5GS integrity algorithm 128-5G-IA3 supported

5GS integrity algorithm 5G-IA4 supported (octet 5, bit 4)
0 5GS integrity algorithm 5G-IA4 not supported
1 5GS integrity algorithm 5G-IA4 supported

5GS integrity algorithm 5G-IA5 supported (octet 5, bit 3)
0 5GS integrity algorithm 5G-IA5 not supported
1 5GS integrity algorithm 5G-IA5 supported

5GS integrity algorithm 5G-IA6 supported (octet 5, bit 2)
0 5GS integrity algorithm 5G-IA6 not supported
1 5GS integrity algorithm 5G-IA6 supported

5GS integrity algorithm 5G-IA7 supported (octet 5, bit 1)
0 5GS integrity algorithm 5G-IA7 not supported
1 5GS integrity algorithm 5G-IA7 supported

5GS integrity algorithms supported (octet 6)

5GS integrity algorithm 5G-IA8 supported (octet 6, bit 8)
0 5GS integrity algorithm 5G-IA8 not supported
1 5GS integrity algorithm 5G-IA8 supported

5GS integrity algorithm 5G-IA9 supported (octet 6, bit 7)
0 5GS integrity algorithm 5G-IA9 not supported
1 5GS integrity algorithm 5G-IA9 supported

5GS integrity algorithm 5G-IA10 supported (octet 6, bit 6)
0 5GS integrity algorithm 5G-IA10 not supported
1 5GS integrity algorithm 5G-IA10 supported

5GS integrity algorithm 5G-IA11 supported (octet 6, bit 5)
0 5GS integrity algorithm 5G-IA11 not supported
1 5GS integrity algorithm 5G-IA11 supported

5GS integrity algorithm 5G-IA12 supported (octet 6, bit 4)
0 5GS integrity algorithm 5G-IA12 not supported
1 5GS integrity algorithm 5G-IA12 supported

5GS integrity algorithm 5G-IA13 supported (octet 6, bit 3)
0 5GS integrity algorithm 5G-IA13 not supported
1 5GS integrity algorithm 5G-IA13 supported

5GS integrity algorithm 5G-IA14 supported (octet 6, bit 2)
0 5GS integrity algorithm 5G-IA14 not supported
1 5GS integrity algorithm 5G-IA14 supported

5GS integrity algorithm 5G-IA15 supported (octet 6, bit 1)
0 5GS integrity algorithm 5G-IA15 not supported
1 5GS integrity algorithm 5G-IA15 supported

NOTE 1: For a UE supporting dual connectivity with NR. if the UE supports one of the encryption algorithms for 5GS in bits 8 to 5 of octet 3, it shall support the same algorithms for E-UTRAN as specified in 3GPP TS 33.401 [19]. NOTE 2: For a UE supporting dual connectivity with NR. if the UE supports one of the integrity protection algorithms for 5GS in bits 8 to 5 of octet 5, it shall support the same algorithms for E-UTRAN as specified in 3GPP TS 33.401 [19].

9.9.3.54 UE status

See subclause 9.8.3.49 in 3GPP TS 24.501 [54].

9.9.3.55 Additional information requested

The purpose of the Additional information requested information element is to enable the UE to request ciphering keys for deciphering of ciphered broadcast assistance data.

The Additional information requested information element is coded as shown in figure 9.9.3.55.1 and table 9.9.3.55.1.

The Additional information requested is a type 3 information element with a length of 2 octets.

8	7	6	5	4	3	2	1	
Ciphered broadcast assistance data IEI								octet 1
0	0	0	0	0	0	0	Cipher Key	octet 2
Spare								

Figure 9.9.3.55.1: Additional information requested information element

Table 9.9.3.55.1: Additional information requested information element

Ciphering keys for ciphered broadcast assistance data (CipherKey) (octet 2, bit 1)
Bit
1
0 ciphering keys for ciphered broadcast assistance data not requested
1 ciphering keys for ciphered broadcast assistance data requested
Bits 8 to 2 of octet 2 are spare and shall be coded as zero.

9.9.3.56 Ciphering key data

The purpose of the Ciphering key data information element is to transfer a list of ciphering data sets from the network to the UE for deciphering of ciphered assistance data.

The Ciphering key data information element is coded as shown in figure 9.9.3.56.1, figure 9.9.3.56.2 and table 9.9.3.56.1.

The Ciphering key data is a type 6 information element, with a minimum length of 35 octets and a maximum length of 2291 octets. The list can contain a maximum of 16 ciphering data sets.

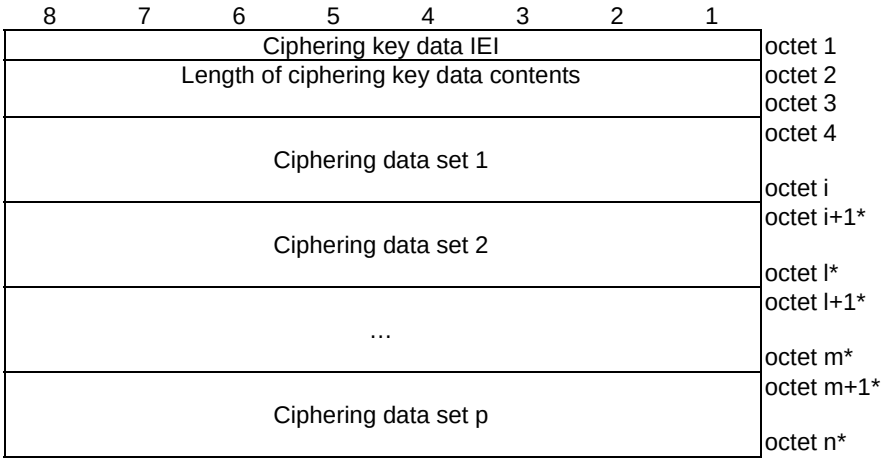


Figure 9.9.3.56.1: Ciphering key data information element

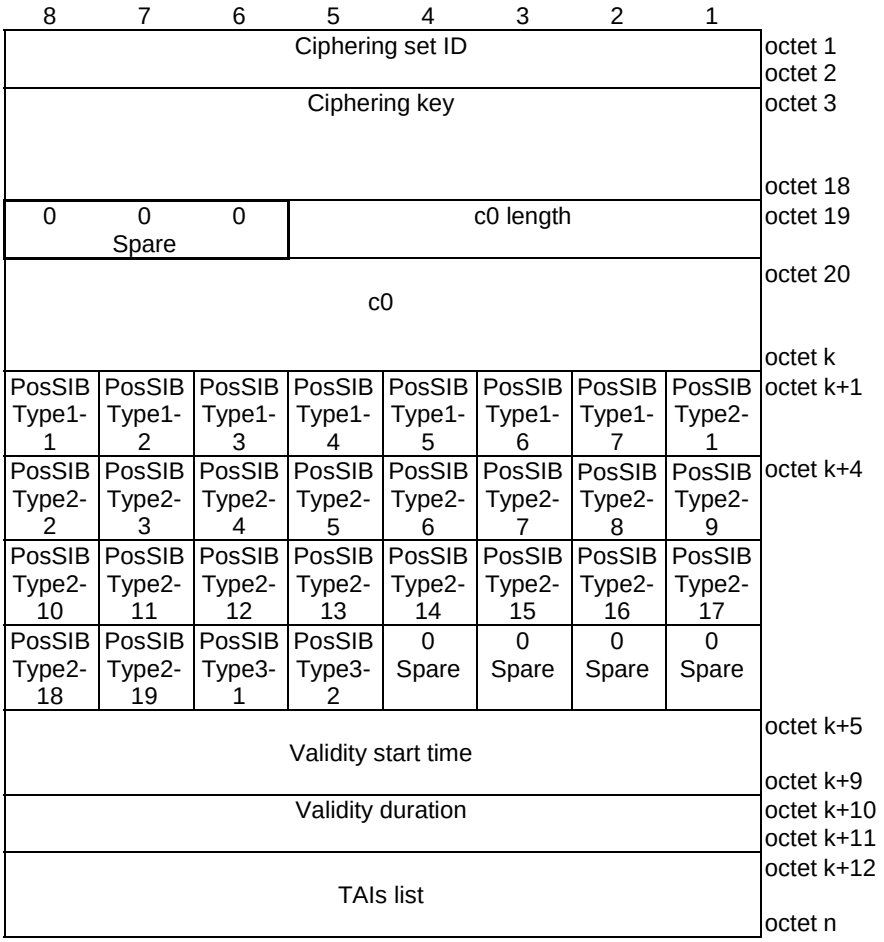


Figure 9.9.3.56.2: Ciphering data set

Table 9.9.3.56.1: Ciphering key data information element

Value part of the Ciphering key data information element (octets 4 to n)

The value part of the Ciphering key data information element consists of one or several ciphering data sets.
The UE shall store the complete list received. If more than 16 ciphering data sets are included in this information element, the UE shall store the first 16 ciphering data sets and ignore the remaining octets of the information element.

Ciphering data set:

Ciphering set ID (octets 1 to 2)

This field contains the binary encoding of the ID identifying the ciphering set.

Ciphering key (octets 3 to octet 18)

This field contains the 128 bit ciphering key.

c0 length (octet 19, bits 5 to 1)

This field contains the binary encoding of the length, in octets, of the c0 counter. The maximum value for the length of the c0 counter is 16 octets.

Bits 8 to 6 of octect 19 are spare and shall be coded as zero.

c0 (octets 20 to k)

This field contains the binary encoding of the c0 counter.

Positioning SIB types for which the ciphering data set is applicable (octets k+1 to k+4)

Ciphering data set applicable for positioning SIB type 1-1 (octet k+1, bit 8)
0 Ciphering data set not applicable to positioning SIB type 1-1
1 Ciphering data set applicable to positioning SIB type 1-1

Ciphering data set applicable for positioning SIB type 1-2 (octet k+1, bit 7)
0 Ciphering data set not applicable to positioning SIB type 1-2
1 Ciphering data set applicable to positioning SIB type 1-2

Ciphering data set applicable for positioning SIB type 1-3 (octet k+1, bit 6)
0 Ciphering data set not applicable to positioning SIB type 1-3
1 Ciphering data set applicable to positioning SIB type 1-3

Ciphering data set applicable for positioning SIB type 1-4 (octet k+1, bit 5)
0 Ciphering data set not applicable to positioning SIB type 1-4
1 Ciphering data set applicable to positioning SIB type 1-4

Ciphering data set applicable for positioning SIB type 1-5 (octet k+1, bit 4)
0 Ciphering data set not applicable to positioning SIB type 1-5
1 Ciphering data set applicable to positioning SIB type 1-5

Ciphering data set applicable for positioning SIB type 1-6 (octet k+1, bit 3)
0 Ciphering data set not applicable to positioning SIB type 1-6
1 Ciphering data set applicable to positioning SIB type 1-6

Ciphering data set applicable for positioning SIB type 1-7 (octet k+1, bit 2)
0 Ciphering data set not applicable to positioning SIB type 1-7
1 Ciphering data set applicable to positioning SIB type 1-7

Ciphering data set applicable for positioning SIB type 2-1 (octet k+1, bit 1)
0 Ciphering data set not applicable to positioning SIB type 2-1
1 Ciphering data set applicable to positioning SIB type 2-1

Ciphering data set applicable for positioning SIB type 2-2 (octet k+2, bit 8)

0 Ciphering data set not applicable to positioning SIB type 2-2 1 Ciphering data set applicable to positioning SIB type 2-2
Ciphering data set applicable for positioning SIB type 2-3 (octet k+2, bit 7) 0 Ciphering data set not applicable to positioning SIB type 2-3 1 Ciphering data set applicable to positioning SIB type 2-3
Ciphering data set applicable for positioning SIB type 2-4 (octet k+2, bit 6) 0 Ciphering data set not applicable to positioning SIB type 2-4 1 Ciphering data set applicable to positioning SIB type 2-4
Ciphering data set applicable for positioning SIB type 2-5 (octet k+2, bit 5) 0 Ciphering data set not applicable to positioning SIB type 2-5 1 Ciphering data set applicable to positioning SIB type 2-5
Ciphering data set applicable for positioning SIB type 2-6 (octet k+2, bit 4) 0 Ciphering data set not applicable to positioning SIB type 2-6 1 Ciphering data set applicable to positioning SIB type 2-6
Ciphering data set applicable for positioning SIB type 2-7 (octet k+2, bit 3) 0 Ciphering data set not applicable to positioning SIB type 2-7 1 Ciphering data set applicable to positioning SIB type 2-7
Ciphering data set applicable for positioning SIB type 2-8 (octet k+2, bit 2) 0 Ciphering data set not applicable to positioning SIB type 2-8 1 Ciphering data set applicable to positioning SIB type 2-8
Ciphering data set applicable for positioning SIB type 2-9 (octet k+2, bit 1) 0 Ciphering data set not applicable to positioning SIB type 2-9 1 Ciphering data set applicable to positioning SIB type 2-9
Ciphering data set applicable for positioning SIB type 2-10 (octet k+3, bit 8) 0 Ciphering data set not applicable to positioning SIB type 2-10 1 Ciphering data set applicable to positioning SIB type 2-10
Ciphering data set applicable for positioning SIB type 2-11 (octet k+3, bit 7) 0 Ciphering data set not applicable to positioning SIB type 2-11 1 Ciphering data set applicable to positioning SIB type 2-11
Ciphering data set applicable for positioning SIB type 2-12 (octet k+3, bit 6) 0 Ciphering data set not applicable to positioning SIB type 2-12 1 Ciphering data set applicable to positioning SIB type 2-12
Ciphering data set applicable for positioning SIB type 2-13 (octet k+3, bit 5) 0 Ciphering data set not applicable to positioning SIB type 2-13 1 Ciphering data set applicable to positioning SIB type 2-13
Ciphering data set applicable for positioning SIB type 2-14 (octet k+3, bit 4) 0 Ciphering data set not applicable to positioning SIB type 2-14 1 Ciphering data set applicable to positioning SIB type 2-14
Ciphering data set applicable for positioning SIB type 2-15 (octet k+3, bit 3) 0 Ciphering data set not applicable to positioning SIB type 2-15 1 Ciphering data set applicable to positioning SIB type 2-15
Ciphering data set applicable for positioning SIB type 2-16 (octet k+3, bit 2) 0 Ciphering data set not applicable to positioning SIB type 2-16 1 Ciphering data set applicable to positioning SIB type 2-16
Ciphering data set applicable for positioning SIB type 2-17 (octet k+3, bit 1) 0 Ciphering data set not applicable to positioning SIB type 2-17 1 Ciphering data set applicable to positioning SIB type 2-17
Ciphering data set applicable for positioning SIB type 2-18 (octet k+4, bit 8) 0 Ciphering data set not applicable to positioning SIB type 2-18 1 Ciphering data set applicable to positioning SIB type 2-18
Ciphering data set applicable for positioning SIB type 2-19 (octet k+4, bit 7)

0 Ciphering data set not applicable to positioning SIB type 2-19 1 Ciphering data set applicable to positioning SIB type 2-19 Ciphering data set applicable for positioning SIB type 3-1 (octet k+4, bit 6) 0 Ciphering data set not applicable to positioning SIB type 3-1 1 Ciphering data set applicable to positioning SIB type 3-1 Ciphering data set applicable for positioning SIB type 3-2 (octet k+4, bit 5) 0 Ciphering data set not applicable to positioning SIB type 3-2 1 Ciphering data set applicable to positioning SIB type 3-2 Bits 4 to 1 of octet k+4 are spare and shall be coded as zero. Validity start time (octets k+5 to k+9) This field contains the UTC time when the ciphering data set becomes valid, encoded as octets 2 to 6 of the Time zone and time IE specified in 3GPP TS 24.008 [13]. Validity duration (octets k+10 to k+11) This field contains the duration for which the ciphering data set is valid after the validity start time, in units of minutes. TAIs list (octets k+12 to n) This field contains the list of tracking areas for which the ciphering data set is applicable, encoded as octets 2 to n of the Tracking area identity list IE as specified in subclause 9.9.3.33. If the TAIs list is empty (as indicated by a zero length), the ciphering data set is applicable to the entire serving PLMN.

9.9.4 EPS Session Management (ESM) information elements

9.9.4.1 Access point name

See subclause 10.5.6.1 in 3GPP TS 24.008 [13].

9.9.4.2 APN aggregate maximum bit rate

The purpose of the APN aggregate maximum bit rate information element is to indicate the initial subscribed APN-AMBR when the UE establishes a PDN connection or to indicate the new APN-AMBR if it is changed by the network.

The APN aggregate maximum bit rate information element is coded as shown in figure 9.9.4.2.1 and table 9.9.4.2.1.

The APN aggregate maximum bit rate is a type 4 information element with a minimum length of 4 octets and a maximum length of 8 octets. Octets 5-8 are optional. If octet 5 is included, then octet 6 shall also be included, and octets 7-8 may be included. If octet 7 is included, then octet 8 shall also be included. The length of the APN-AMBR IE can be either 4 octets, 6 octets or 8 octets.

8	7	6	5	4	3	2	1	
APN aggregate maximum bit rate IEI								octet 1
Length of APN aggregate maximum bit rate contents								octet 2
APN-AMBR for downlink								octet 3
APN-AMBR for uplink								octet 4
APN-AMBR for downlink (extended)								octet 5*
APN-AMBR for uplink (extended)								octet 6*
APN-AMBR for downlink (extended-2)								octet 7*
APN-AMBR for uplink (extended-2)								octet 8*

Figure 9.9.4.2.1: APN aggregate maximum bit rate information element

Table 9.9.4.2.1: APN aggregate maximum bit rate information element

APN-AMBR for downlink, octet 3

Bits
8 7 6 5 4 3 2 1
0 0 0 0 0 0 0 0 Reserved

0 0 0 0 0 0 0 1 The APN-AMBR is binary coded in 8 bits, using a granularity of 1 kbps
to giving a range of values from 1 kbps to 63 kbps in 1 kbps increments.
0 0 1 1 1 1 1 1

0 1 0 0 0 0 0 0 The APN-AMBR is 64 kbps + ((the binary coded value in 8 bits –01000000) * 8 kbps)
to giving a range of values from 64 kbps to 568 kbps in 8 kbps increments.
0 1 1 1 1 1 1 1

1 0 0 0 0 0 0 0 The APN-AMBR is 576 kbps + ((the binary coded value in 8 bits –10000000) * 64 kbps)
to giving a range of values from 576 kbps to 8640 kbps in 64 kbps increments.
1 1 1 1 1 1 1 0

1 1 1 1 1 1 1 1 0kbps

If the network wants to indicate an APN-AMBR for downlink higher than 8640 kbps, it shall set octet 3 to "11111110", i.e. 8640 kbps, and shall encode the value for the APN-AMBR in octet 5.

APN-AMBR for uplink, octet 4

Coding is identical to that of APN-AMBR for downlink.

APN-AMBR for downlink (extended), octet 5

Bits
8 7 6 5 4 3 2 1
0 0 0 0 0 0 0 0 Use the value indicated by the APN-AMBR for downlink in octet 3.

For all other values: Ignore the value indicated by the APN-AMBR for downlink in octet 3 and use the following value:
0 0 0 0 0 0 0 1 The APN-AMBR is 8600 kbps + ((the binary coded value in 8 bits) * 100 kbps),
to giving a range of values from 8700 kbps to 16000 kbps in 100 kbps increments.
0 1 0 0 1 0 1 0

0 1 0 0 1 0 1 1 The APN-AMBR is 16 Mbps + ((the binary coded value in 8 bits - 01001010) * 1 Mbps),
to giving a range of values from 17 Mbps to 128 Mbps in 1 Mbps increments.
1 0 1 1 1 0 1 0

1 0 1 1 1 0 1 1 The APN-AMBR is 128 Mbps + ((the binary coded value in 8 bits - 10111010) * 2 Mbps),
to giving a range of values from 130 Mbps to 256 Mbps in 2 Mbps increments.
1 1 1 1 1 0 1 0

All other values shall be interpreted as '1 1 1 1 1 0 1 0'

APN-AMBR for uplink (extended), octet 6

This field is an extension of the APN-AMBR for uplink in octet 4. The coding is identical to that of the APN-AMBR for downlink (extended).

APN-AMBR for downlink (extended-2), octet 7

Bits
8 7 6 5 4 3 2 1
0 0 0 0 0 0 0 0 Use the value indicated by the APN-AMBR for downlink and APN-AMBR for downlink (extended) in octets 3 and 5.

0 0 0 0 0 0 0 1 The APN-AMBR is (the binary coded value in 8 bits) * 256 Mbps + (the value indicated by

to the APN-AMBR for downlink and APN-AMBR for downlink (extended) in octets 3 and 5),
1 1 1 1 1 1 1 0 giving a range of 264,64 Mbps to 65280 Mbps.

1 1 1 1 1 1 1 1 This value shall be interpreted as '0 0 0 0 0 0 0 0' in this version of the specification.

If the network wants to indicate an APN-AMBR value for downlink higher than 65280 Mbps, it shall set octet 5 to "11111010" and octet 7 to "11111110", i.e. 65280 Mbps, and shall encode the higher value for the APN-AMBR in the extended APN aggregate maximum bit rate information element specified in subclause 9.9.4.29.

APN-AMBR for uplink (extended-2), octet 8

This field is an extension of the APN-AMBR for uplink and APN-AMBR for uplink (extended) in octets 4 and 6. The coding is identical to that of the APN-AMBR for downlink (extended-2).

If the UE or the network wants to indicate an APN-AMBR value for uplink higher than 65280 Mbps, it shall set octet 8 to "11111110", i.e. 65280 Mbps, and shall encode the higher value for the APN-AMBR in the extended APN aggregate maximum bit rate information element specified in subclause 9.9.4.29.

9.9.4.2A Connectivity type

See subclause 10.5.6.19 in 3GPP TS 24.008 [13].

9.9.4.3 EPS quality of service

The purpose of the EPS quality of service information element is to specify the QoS parameters for an EPS bearer context.

The EPS quality of service information element is coded as shown in figure 9.9.4.3.1 and table 9.9.4.3.1.

The EPS quality of service is a type 4 information element with a minimum length of 3 octets and a maximum length of 15 octets. Octets 4-15 are optional. If octet 4 is included, then octets 5-7 shall also be included, and octets 8-15 may be included. If octet 8 is included, then octets 4-11 shall also be included, and octets 12-15 may be included. If octet 12 is included, then octets 4-15 shall also be included. The length of the EPS QoS IE can be either 3 octets, 7 octets, 11 octets or 15 octets.

Refer to 3GPP TS 23.203 [7] for a detailed description of the QoS Class Identifier (QCI).

8	7	6	5	4	3	2	1	
EPS quality of service IEI								octet 1
Length of EPS quality of service contents								octet 2
QCI								octet 3
Maximum bit rate for uplink								octet 4*
Maximum bit rate for downlink								octet 5*
Guaranteed bit rate for uplink								octet 6*
Guaranteed bit rate for downlink								octet 7*
Maximum bit rate for uplink (extended)								octet 8*
Maximum bit rate for downlink (extended)								octet 9*
Guaranteed bit rate for uplink (extended)								octet 10*
Guaranteed bit rate for downlink (extended)								octet 11*
Maximum bit rate for uplink (extended-2)								octet 12*
Maximum bit rate for downlink (extended-2)								octet 13*
Guaranteed bit rate for uplink (extended-2)								octet 14*
Guaranteed bit rate for downlink (extended-2)								octet 15*

Figure 9.9.4.3.1: EPS quality of service information element

Table 9.9.4.3.1: EPS quality of service information element

Quality of Service Class Identifier (QCI), octet 3 (see 3GPP TS 23.203 [7] and 3GPP TS 29.212 [16B])
Bits
8 7 6 5 4 3 2 1

In UE to network direction:
0 0 0 0 0 0 0 0 no QCI requested (NOTE)

In network to UE direction:
0 0 0 0 0 0 0 0 Reserved

In UE to network direction and in network to UE direction:
0 0 0 0 0 0 0 1 QCI 1
0 0 0 0 0 0 1 0 QCI 2
0 0 0 0 0 0 1 1 QCI 3
0 0 0 0 0 1 0 0 QCI 4
0 0 0 0 0 1 0 1 QCI 5
0 0 0 0 0 1 1 0 QCI 6
0 0 0 0 0 1 1 1 QCI 7
0 0 0 0 1 0 0 0 QCI 8
0 0 0 0 1 0 0 1 QCI 9

0 0 0 0 1 0 1 0
to Spare
0 1 0 0 0 0 0 0
0 1 0 0 0 0 0 1 QCI 65
0 1 0 0 0 0 1 0 QCI 66

0 1 0 0 0 0 1 1
to Spare
0 1 0 0 0 1 0 0
0 1 0 0 0 1 0 1 QCI 69
0 1 0 0 0 1 1 0 QCI 70

0 1 0 0 0 1 1 1
to Spare
0 1 0 0 1 0 1 0
0 1 0 0 1 0 1 1 QCI 75

0 1 0 0 1 1 0 0
to Spare
0 1 0 0 1 1 1 0
0 1 0 0 1 1 1 1 QCI 79
0 1 0 1 0 0 0 0 QCI 80
0 1 0 1 0 0 0 1 Spare
0 1 0 1 0 0 1 0 QCI 82
0 1 0 1 0 0 1 1 QCI 83

0 1 0 1 0 1 0 0
to Spare
0 1 1 1 1 1 1 1
1 0 0 0 0 0 0 0
to Operator-specific QCIs
1 1 1 1 1 1 1 0
1 1 1 1 1 1 1 1 Reserved

The network shall consider all other values not explicitly defined in this version of the protocol as unsupported.

NOTE: The UE shall use this value, if the information element has presence requirement "M" in a message, but the information element does not serve any useful purpose in the specific procedure for which the message is sent (see subclause 6.5.3.2).

QCI values 10-127 were reserved in earlier versions of the protocol.

If the UE receives a QCI value (excluding the reserved QCI values) that it does not understand, the UE shall choose a QCI value from the set of QCI values defined in this version of the protocol (see 3GPP TS 23.203 [7] and 3GPP TS 29.212 [16B]) and associated with:

- GBR bearers if the IE includes a guaranteed bit rate value; and

- non-GBR bearers if the IE does not include a guaranteed bit rate value.

The UE shall use this chosen QCI value for internal operations only. The UE shall use the received QCI value in subsequent NAS signalling procedures.

For all non-GBR QCIs, the maximum and guaranteed bit rates shall be ignored.

Maximum bit rate for uplink, octet 4 (see 3GPP TS 23.107 [5])
Bits
8 7 6 5 4 3 2 1

In UE to network direction:
0 0 0 0 0 0 0 0 Subscribed maximum bit rate for uplink

In network to UE direction:
0 0 0 0 0 0 0 0 Reserved

In UE to network direction and in network to UE direction:
0 0 0 0 0 0 0 1 The maximum bit rate is binary coded in 8 bits, using a granularity of 1 kbps
to giving a range of values from 1 kbps to 63 kbps in 1 kbps increments.
0 0 1 1 1 1 1 1

0 1 0 0 0 0 0 0 The maximum bit rate is 64 kbps + ((the binary coded value in 8 bits – 01000000) * 8 kbps)
to giving a range of values from 64 kbps to 568 kbps in 8 kbps increments.
0 1 1 1 1 1 1 1

1 0 0 0 0 0 0 0 The maximum bit rate is 576 kbps + ((the binary coded value in 8 bits – 10000000) * 64 kbps)
to giving a range of values from 576 kbps to 8640 kbps in 64 kbps increments.
1 1 1 1 1 1 1 0

1 1 1 1 1 1 1 1 0kbps

If the sending entity wants to indicate a maximum bit rate for uplink higher than 8640 kbps, it shall set octet 4 to "11111110", i.e. 8640 kbps, and shall encode the value for the maximum bit rate in octet 8.

The network shall map all other values not explicitly defined onto one of the values defined in this version of the protocol. The network shall return a negotiated value which is explicitly defined in this version of the protocol.

Maximum bit rate for downlink, octet 5 (see 3GPP TS 23.107 [5])

Coding is identical to that of maximum bit rate for uplink.

If the sending entity wants to indicate a maximum bit rate for downlink higher than 8640 kbps, it shall set octet 5 to "11111110", i.e. 8640 kbps, and shall encode the value for the maximum bit rate in octet 9.

The network shall map all other values not explicitly defined onto one of the values defined in this version of the protocol. The network shall return a negotiated value which is explicitly defined in this version of the protocol.

In this version of the protocol, for messages specified in the present document, the sending entity shall not request 0 kbps for both the maximum bit rate for downlink and the maximum bit rate for uplink at the same time. Any entity receiving a request for 0 kbps in both the maximum bit rate for downlink and the maximum bit rate for uplink shall consider that as a syntactical error (see clause 8 of 3GPP TS 24.008 [13]).

Guaranteed bit rate for uplink, octet 6 (see 3GPP TS 23.107 [5])

Coding is identical to that of maximum bit rate for uplink.

If the sending entity wants to indicate a guaranteed bit rate for uplink higher than 8640 kbps, it shall set octet 6 to "11111110", i.e. 8640 kbps, and shall encode the value for the guaranteed bit rate in octet 10.

The network shall map all other values not explicitly defined onto one of the values defined in this version of the protocol. The network shall return a negotiated value which is explicitly defined in this version of the protocol.

Guaranteed bit rate for downlink, octet 7 (see 3GPP TS 23.107 [5])

Coding is identical to that of maximum bit rate for uplink.

If the sending entity wants to indicate a guaranteed bit rate for downlink higher than 8640 kbps, it shall set octet 7 to "11111110", i.e. 8640 kbps, and shall encode the value for the guaranteed bit rate in octet 11.

The network shall map all other values not explicitly defined onto one of the values defined in this version of the protocol. The network shall return a negotiated value which is explicitly defined in this version of the protocol.

Maximum bit rate for uplink (extended), octet 8
Bits
8 7 6 5 4 3 2 1

In UE to network direction and in network to UE direction:
0 0 0 0 0 0 0 0 Use the value indicated by the maximum bit rate for uplink in octet 4.

For all other values: ignore the value indicated by the maximum bit rate for uplink in octet 4 and use the following value:
0 0 0 0 0 0 0 1 The maximum bit rate is 8600 kbps + ((the binary coded value in 8 bits) * 100 kbps),
to giving a range of values from 8700 kbps to 16000 kbps in 100 kbps increments.
0 1 0 0 1 0 1 0

0 1 0 0 1 0 1 1 The maximum bit rate is 16 Mbps + ((the binary coded value in 8 bits - 01001010) * 1 Mbps),
to giving a range of values from 17 Mbps to 128 Mbps in 1 Mbps increments.
1 0 1 1 1 0 1 0

1 0 1 1 1 0 1 1 The maximum bit rate is 128 Mbps + ((the binary coded value in 8 bits - 10111010) * 2 Mbps),
to giving a range of values from 130 Mbps to 256 Mbps in 2 Mbps increments.
1 1 1 1 1 0 1 0

If the sending entity wants to indicate a Maximum bit rate for uplink higher than 256 Mbps, it shall set octet 8 to "11111010", i.e. 256 Mbps, and shall encode the value for the Maximum bit rate in octet 12.

The network shall map all other values not explicitly defined onto one of the values defined in this version of the protocol. The network shall return a negotiated value which is explicitly defined in this version of the protocol.

Maximum bit rate for downlink (extended), octet 9

This field is an extension of the maximum bit rate for downlink in octet 5. The coding is identical to that of the maximum bit rate for uplink (extended).

If the sending entity wants to indicate a Maximum bit rate for downlink higher than 256 Mbps, it shall set octet 9 to "11111010", i.e. 256 Mbps, and shall encode the value for the Maximum bit rate in octet 13.

The network shall map all other values not explicitly defined onto one of the values defined in this version of the protocol. The network shall return a negotiated value which is explicitly defined in this version of the protocol.

Guaranteed bit rate for uplink (extended), octet 10
Bits
8 7 6 5 4 3 2 1

In UE to network direction and in network to UE direction:
0 0 0 0 0 0 0 0 Use the value indicated by the guaranteed bit rate for uplink in octet 6.

For all other values: ignore the value indicated by the guaranteed bit rate for uplink in octet 6 and use the following value:
0 0 0 0 0 0 0 1 The guaranteed bit rate is 8600 kbps + ((the binary coded value in 8 bits) * 100 kbps),
to giving a range of values from 8700 kbps to 16000 kbps in 100 kbps increments.
0 1 0 0 1 0 1 0

0 1 0 0 1 0 1 1 The guaranteed bit rate is 16 Mbps + ((the binary coded value in 8 bits - 01001010) * 1 Mbps),
to giving a range of values from 17 Mbps to 128 Mbps in 1 Mbps increments.
1 0 1 1 1 0 1 0

1 0 1 1 1 0 1 1 The guaranteed bit rate is 128 Mbps + ((the binary coded value in 8 bits - 10111010) * 2 Mbps),
to giving a range of values from 130 Mbps to 256 Mbps in 2 Mbps increments.
1 1 1 1 1 0 1 0

If the sending entity wants to indicate a Guaranteed bit rate for uplink higher than 256 Mbps, it shall set octet 10 to "11111010", i.e. 256 Mbps, and shall encode the value for the Maximum bit rate in octet 14.

The network shall map all other values not explicitly defined onto one of the values defined in this version of the protocol. The network shall return a negotiated value which is explicitly defined in this version of the protocol.

Guaranteed bit rate for downlink (extended), octet 11

This field is an extension of the guaranteed bit rate for downlink in octet 7. The coding is identical to that of guaranteed bit rate for uplink (extended).

If the sending entity wants to indicate a Guaranteed bit rate for downlink higher than 256 Mbps, it shall set octet 11 to "11111010", i.e. 256 Mbps, and shall encode the value for the Maximum bit rate in octet 15.

The network shall map all other values not explicitly defined onto one of the values defined in this version of the protocol. The network shall return a negotiated value which is explicitly defined in this version of the protocol.

Maximum bit rate for uplink (extended-2), octet 12
Bits
8 7 6 5 4 3 2 1
In UE to network direction and in network to UE direction:
0 0 0 0 0 0 0 0 Use the value indicated by the Maximum bit rate for uplink in octet 4 and octet 8.

For all other values: Ignore the value indicated by the Maximum bit rate for upink in octet 4 and octet 8 and use the following value:
0 0 0 0 0 0 0 1 The maximum bit rate is 256 Mbps + ((the binary coded value in 8 bits) * 4 Mbps),
0 0 1 1 1 1 0 1 giving a range of values from 260 Mbps to 500 Mbps in 4 Mbps increments.

0 0 1 1 1 1 1 0 The maximum bit rate is 500 Mbps + ((the binary coded value in 8 bits - 00111101) * 10 Mbps),
1 0 1 0 0 0 0 1 giving a range of values from 510 Mbps to 1500 Mbps in 10 Mbps increments.

1 0 1 0 0 0 1 0 The maximum bit rate is 1500 Mbps + ((the binary coded value in 8 bits - 10100001) * 100 Mbps),
1 1 1 1 0 1 1 0 giving a range of values from 1600 Mbps to 10 Gbps in 100 Mbps increments.

If the sending entity wants to indicate a Maximum bit rate for uplink higher than 10 Gbps, it shall set octet 12 to "11110110", i.e. 10 Gbps, and shall encode the value for the maximum bit rate in the Extended quality of service information element specified in subclause 9.9.4.30.

The network shall map all other values not explicitly defined onto one of the values defined in this version of the protocol. The network shall return a negotiated value which is explicitly defined in this version of the protocol.

The UE shall map all other values not explicitly defined onto the maximum value defined in this version of the protocol.

Maximum bit rate for downlink (extended-2), octet 13

This field is an extension of the Maximum bit rate for downlink in octet 9. The coding is identical to that of the Maximum bit rate for uplink (extended-2).

If the sending entity wants to indicate a Maximum bit rate for downlink higher than 10 Gbps, it shall set octet 13 to "11110110", i.e. 10 Gbps, and shall encode the value for the maximum bit rate in the Extended quality of service information element specified in subclause 9.9.4.30.

The network shall map all other values not explicitly defined onto one of the values defined in this version of the protocol. The network shall return a negotiated value which is explicitly defined in this version of the protocol.

The UE shall map all other values not explicitly defined onto the maximum value defined in this version of the protocol.

Guaranteed bit rate for uplink (extended-2), octet 14
Bits
8 7 6 5 4 3 2 1
In UE to network direction and in network to UE direction:

0 0 0 0 0 0 0 0 Use the value indicated by the Guaranteed bit rate for uplink in octet 6 and octet 10.

For all other values: Ignore the value indicated by the Guaranteed bit rate for uplink in octet 6 and octet 10 and use the following value:

0 0 0 0 0 0 0 1 The guaranteed bit rate is 256 Mbps + ((the binary coded value in 8 bits) * 4 Mbps),
0 0 1 1 1 1 0 1 giving a range of values from 260 Mbps to 500 Mbps in 4 Mbps increments.

0 0 1 1 1 1 1 0 The guaranteed bit rate is 500 Mbps + ((the binary coded value in 8 bits - 00111101) * 10 Mbps),
1 0 1 0 0 0 0 1 giving a range of values from 510 Mbps to 1500 Mbps in 10 Mbps increments.

1 0 1 0 0 0 1 0 The guaranteed bit rate is 1500 Mbps + ((the binary coded value in 8 bits - 10100001) * 100 Mbps),
1 1 1 1 0 1 1 0 giving a range of values from 1600 Mbps to 10 Gbps in 100 Mbps increments.

If the sending entity wants to indicate a Guaranteed bit rate for uplink higher than 10 Gbps, it shall set octet 14 to "11110110", i.e. 10 Gbps, and shall encode the value for the guaranteed bit rate in the Extended quality of service information element specified in subclause 9.9.4.30.

The network shall map all other values not explicitly defined onto one of the values defined in this version of the protocol. The network shall return a negotiated value which is explicitly defined in this version of the protocol.

The UE shall map all other values not explicitly defined onto the maximum value defined in this version of the protocol.

Guaranteed bit rate for downlink (extended-2), octet 15

This field is an extension of the Guaranteed bit rate for downlink in octet 11. The coding is identical to that of the Guaranteed bit rate for uplink (extended-2).

If the sending entity wants to indicate a Guaranteed bit rate for downlink higher than 10 Gbps, it shall set octet 15 to "11110110", i.e. 10 Gbps, and shall encode the value for the guaranteed bit rate in the Extended quality of service information element specified in subclause 9.9.4.30.

The network shall map all other values not explicitly defined onto one of the values defined in this version of the protocol. The network shall return a negotiated value which is explicitly defined in this version of the protocol.

The UE shall map all other values not explicitly defined onto the maximum value defined in this version of the protocol.

9.9.4.4 ESM cause

The purpose of the ESM cause information element is to indicate the reason why a session management request is rejected.

The ESM cause information element is coded as shown in figure 9.9.4.4.1 and table 9.9.4.4.1.

The ESM cause is a type 3 information element with 2 octets length.

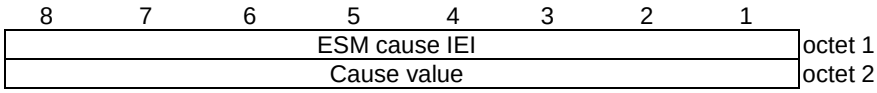


Figure 9.9.4.4.1: ESM cause information element

Table 9.9.4.4.1: ESM cause information element

Cause value (octet 2)

Bits

8	7	6	5	4	3	2	1	
0	0	0	0	1	0	0	0	Operator Determined Barring
0	0	0	1	1	0	1	0	Insufficient resources
0	0	0	1	1	0	1	1	Missing or unknown APN
0	0	0	1	1	1	0	0	Unknown PDN type
0	0	0	1	1	1	0	1	User authentication failed
0	0	0	1	1	1	1	0	Request rejected by Serving GW or PDN GW
0	0	0	1	1	1	1	1	Request rejected, unspecified
0	0	1	0	0	0	0	0	Service option not supported
0	0	1	0	0	0	0	1	Requested service option not subscribed
0	0	1	0	0	0	1	0	Service option temporarily out of order
0	0	1	0	0	0	1	1	PTI already in use
0	0	1	0	0	1	0	0	Regular deactivation
0	0	1	0	0	1	0	1	EPS QoS not accepted
0	0	1	0	0	1	1	0	Network failure
0	0	1	0	0	1	1	1	Reactivation requested
0	0	1	0	1	0	0	1	Semantic error in the TFT operation
0	0	1	0	1	0	1	0	Syntactical error in the TFT operation
0	0	1	0	1	0	1	1	Invalid EPS bearer identity
0	0	1	0	1	1	0	0	Semantic errors in packet filter(s)
0	0	1	0	1	1	0	1	Syntactical errors in packet filter(s)
0	0	1	0	1	1	1	0	Unused (see NOTE 2)
0	0	1	0	1	1	1	1	PTI mismatch
0	0	1	1	0	0	0	1	Last PDN disconnection not allowed
0	0	1	1	0	0	1	0	PDN type IPv4 only allowed
0	0	1	1	0	0	1	1	PDN type IPv6 only allowed
0	0	1	1	1	0	0	1	PDN type IPv4v6 only allowed
0	0	1	1	1	0	1	0	PDN type non IP only allowed
0	0	1	1	0	1	0	0	Single address bearers only allowed
0	0	1	1	0	1	0	1	ESM information not received
0	0	1	1	0	1	1	0	PDN connection does not exist
0	0	1	1	0	1	1	1	Multiple PDN connections for a given APN not allowed
0	0	1	1	1	0	0	0	Collision with network initiated request
0	0	1	1	1	0	1	1	Unsupported QCI value
0	0	1	1	1	1	0	0	Bearer handling not supported
0	1	0	0	0	0	0	1	Maximum number of EPS bearers reached
0	1	0	0	0	0	1	0	Requested APN not supported in current RAT and PLMN combination
0	1	0	1	0	0	0	1	Invalid PTI value
0	1	0	1	1	1	1	1	Semantically incorrect message
0	1	1	0	0	0	0	0	Invalid mandatory information
0	1	1	0	0	0	0	1	Message type non-existent or not implemented
0	1	1	0	0	0	1	0	Message type not compatible with the protocol state
0	1	1	0	0	0	1	1	Information element non-existent or not implemented
0	1	1	0	0	1	0	0	Conditional IE error
0	1	1	0	0	1	0	1	Message not compatible with the protocol state
0	1	1	0	1	1	1	1	Protocol error, unspecified
0	1	1	1	0	0	0	0	APN restriction value incompatible with active EPS bearer context
0	1	1	1	0	0	0	1	Multiple accesses to a PDN connection not allowed

Any other value received by the UE shall be treated as 0010 0010, "service option temporarily out of order". Any other value received by the network shall be treated as 0110 1111, "protocol error, unspecified".

NOTE 1: The listed cause values are defined in annex B.
NOTE 2: This value was allocated in earlier versions of this protocol, but there is no situation where this value can be used. If received by the network, it shall be treated as 0110 1111, "protocol error, unspecified".

9.9.4.5 ESM information transfer flag

The purpose of the ESM information transfer flag information element is to indicate whether ESM information, i.e. protocol configuration options or APN or both, is to be transferred security protected.

The ESM information transfer flag information element is coded as shown in figure 9.9.4.5.1 and table 9.9.4.5.1.

The ESM information transfer flag is a type 1 information element.

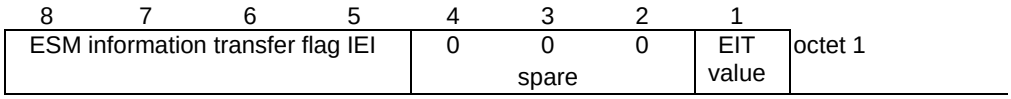


Figure 9.9.4.5.1: ESM information transfer flag information element

Table 9.9.4.5.1: ESM information transfer flag information element

EIT (ESM information transfer)	
Bit	
1	
0	security protected ESM information transfer not required
1	security protected ESM information transfer required

9.9.4.6 Linked EPS bearer identity

The purpose of the Linked EPS bearer identity IE is to identify the default bearer that is associated with a dedicated EPS bearer or to identify the EPS bearer (default or dedicated) with which one or more packet filters specified in a traffic flow aggregate are associated.

The Linked EPS bearer identity information element is coded as shown in figure 9.9.4.6.1 and table 9.9.4.6.1.

The Linked EPS bearer identity is a type 1 information element.

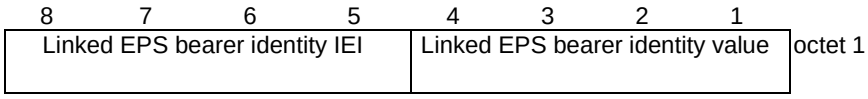


Figure 9.9.4.6.1: Linked EPS bearer identity information element

Table 9.9.4.6.1: Linked EPS bearer identity information element

Linked EPS bearer identity (bits 1-4)				
4	**3**	**2**	**1**	
0	0	0	0	Reserved
0	0	0	1	EPS bearer identity value 1
0	0	1	0	EPS bearer identity value 2
0	0	1	1	EPS bearer identity value 3
0	1	0	0	EPS bearer identity value 4
0	1	0	1	EPS bearer identity value 5
0	1	1	0	EPS bearer identity value 6
0	1	1	1	EPS bearer identity value 7
1	0	0	0	EPS bearer identity value 8
1	0	0	1	EPS bearer identity value 9
1	0	1	0	EPS bearer identity value 10
1	0	1	1	EPS bearer identity value 11
1	1	0	0	EPS bearer identity value 12
1	1	0	1	EPS bearer identity value 13
1	1	1	0	EPS bearer identity value 14
1	1	1	1	EPS bearer identity value 15

9.9.4.7 LLC service access point identifier

See subclause 10.5.6.9 in 3GPP TS 24.008 [13].

9.9.4.7A Notification indicator

The purpose of the Notification indicator information element is to inform the UE about an event which is relevant for the upper layer using an EPS bearer context or having requested a procedure transaction.

The Notification indicator information element is coded as shown in figure 9.9.4.7A.1 and table 9.9.4.7A.1.

The Notification indicator is a type 4 information element with 3 octets length.

8	7	6	5	4	3	2	1	
Notification indicator IEI								octet 1
Length of notification indicator contents								octet 2
Notification indicator value								octet 3

Figure 9.9.4.7A.1: Notification indicator information element

Table 9.9.4.7A.1: Notification indicator information element

Notification indicator value (octet 3)								
Bits								
8	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
0	0	0	0	0	0	0	1	SRVCC handover cancelled, IMS session re-establishment required (see 3GPP TS 23.216 [8])
0	0	0	0	0	0	1	0	Unused, shall be ignored if received by the UE
				to				
0	1	1	1	1	1	1	1	
All other values are reserved.								

9.9.4.8 Packet flow identifier

See subclause 10.5.6.11 in 3GPP TS 24.008 [13].

9.9.4.9 PDN address

The PDN address information element can assign an IPv4 address to the UE associated with a packet data network and provide the UE with an interface identifier to be used to build the IPv6 link local address.

The PDN address information element is coded as shown in figure 9.9.4.9.1 and table 9.9.4.9.1.

The PDN address is a type 4 information element with minimum length of 7 octets and a maximum length of 15 octets.

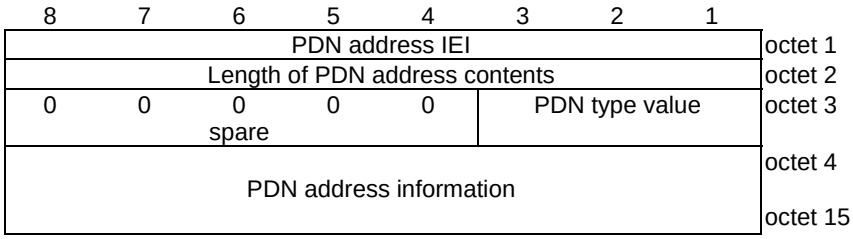


Figure 9.9.4.9.1: PDN address information element

Table 9.9.4.9.1: PDN address information element

PDN type value (octet 3)
Bits

3	**2**	**1**	
0	0	1	IPv4
0	1	0	IPv6
0	1	1	IPv4v6
1	0	1	non IP

All other values are reserved.

Bit 4 to 8 of octet 3 are spare and shall be coded as zero.

PDN address information (octet 4 to 15)

If PDN type value indicates IPv4, the PDN address information in octet 4 to octet 7 contains an IPv4 address. Bit 8 of octet 4 represents the most significant bit of the IPv4 address and bit 1 of octet 7 the least significant bit.

If PDN type value indicates IPv6, the PDN address information in octet 4 to octet 11 contains an IPv6 interface identifier. Bit 8 of octet 4 represents the most significant bit of the IPv6 interface identifier and bit 1 of octet 11 the least significant bit.

If PDN type value indicates IPv4v6, the PDN address information in octet 4 to octet 15 contains an IPv6 interface identifier and an IPv4 address. Bit 8 of octet 4 represents the most significant bit of the IPv6 interface identifier and bit 1 of octet 11 the least significant bit. Bit 8 of octet 12 represents the most significant bit of the IPv4 address and bit 1 of octet 15 the least significant bit.

If PDN type value indicates IPv4 or IPv4v6 and DHCPv4 is to be used to allocate the IPv4 address, the IPv4 address shall be coded as 0.0.0.0.

If PDN type value indicates non IP, the PDN address information in octet 4 to octet 7 are spare and shall be coded as zero.

9.9.4.10 PDN type

The purpose of the PDN type information element is to indicate:

- the IP version capability of the IP stack associated with the UE; or

- non IP.

The PDN type information element is coded as shown in figure 9.9.4.10.1 and table 9.9.4.10.1.

The PDN type is a type 1 information element.

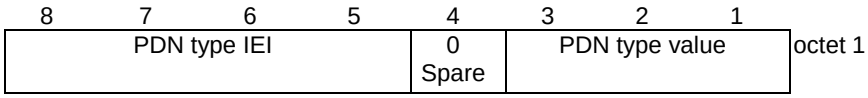


Figure 9.9.4.10.1: PDN type information element

Table 9.9.4.10.1: PDN type information element

PDN type value (octet 1)			
Bits			
3	**2**	**1**	
0	0	1	IPv4
0	1	0	IPv6
0	1	1	IPv4v6
1	0	0	unused; shall be interpreted as "IPv6" if received by the network
1	0	1	non IP
All other values are reserved.			
Bit 4 of octet 1 is spare and shall be coded as zero.			

9.9.4.11 Protocol configuration options

See subclause 10.5.6.3 in 3GPP TS 24.008 [13].

9.9.4.12 Quality of service

See subclause 10.5.6.5 in 3GPP TS 24.008 [13].

9.9.4.13 Radio priority

See subclause 10.5.7.2 in 3GPP TS 24.008 [13].

9.9.4.13A Re-attempt indicator

The purpose of the *Re-attempt indicator* information element is to indicate a condition under which the UE is allowed, in the current PLMN for the same APN, to re-attempt a session management procedure (see 3GPP TS 24.008 [13]) corresponding to the EPS session management procedure which was rejected by the network.

The *Re-attempt indicator* information element is coded as shown in figure 9.9.4.13A/3GPP TS 24.301 and table 9.9.4.13A/3GPP TS 24.301.

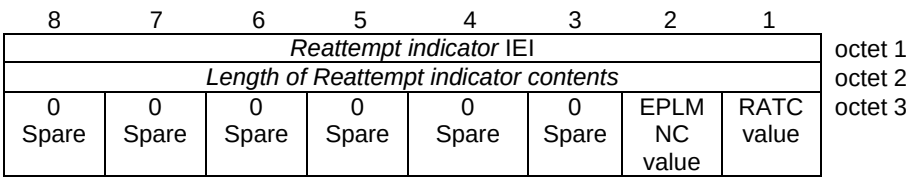


Figure 9.9.4.13A: Re-attempt indicator information element

Table 9.9.4.13A: Re-attempt indicator information element

Re-attempt indicator RATC (octet 3, bit 1) 0 UE is allowed to re-attempt the procedure in A/Gb mode or Iu mode 1 UE is not allowed to re-attempt the procedure in A/Gb mode or Iu mode EPLMNC (octet 3, bit 2) 0 UE is allowed to re-attempt the procedure in an equivalent PLMN 1 UE is not allowed to re-attempt the procedure in an equivalent PLMN Bits 3 to 8 of octet 3 are spare and shall be encoded as zero.

9.9.4.14 Request type

See subclause 10.5.6.17 in 3GPP TS 24.008 [13].

9.9.4.15 Traffic flow aggregate description

The purpose of the Traffic flow aggregate description information element is to specify the aggregate of one of more packet filters and their related parameters and operations. The traffic flow aggregate description may contain the aggregate of packet filters for the downlink direction, the uplink direction or packet filters that apply for both directions. The packet filters determine the traffic mapping to EPS bearer contexts. The downlink packet filters shall be applied by the network, and the uplink packet filters shall be applied by the UE. A packet filter that applies for both directions shall be applied by the network as a downlink packet filter and by the UE as an uplink packet filter.

When the traffic flow aggregate description is used in the UE requested bearer resource allocation procedure or the UE requested bearer resource modification procedure, it is associated to a particular procedure identified by a procedure transaction identity (PTI). Therefore, the UE shall release the traffic flow aggregate description when the UE requested bearer resource allocation procedure or the UE requested bearer resource modification procedure is completed. The UE shall not include the packet filters of a particular traffic flow aggregate description in any other traffic flow aggregate description when multiple UE requested bearer resource allocation procedures and/or UE requested bearer resource modification procedures are ongoing in parallel.

The Traffic flow aggregate description information element is encoded using the same format as the Traffic flow template (TFT) information element (see subclause 10.5.6.12 in 3GPP TS 24.008 [13]). When sending this IE in the BEARER RESOURCE ALLOCATION REQUEST message or the BEARER RESOURCE MODIFICATION REQUEST message, the UE shall set the packet filter identifier values to 0 if the packet filters are newly created; otherwise, the UE shall set the packet filter identifier values from those of already assigned packet filter identifiers of the existing EPS bearer, so that they are unique across all packet filters for the EPS bearer context indicated by the EPS bearer identity IE.

9.9.4.16 Traffic flow template

See subclause 10.5.6.12 in 3GPP TS 24.008 [13].

9.9.4.17 Transaction identifier

The purpose of the Transaction identifier information element is to represent the corresponding PDP context in A/Gb mode or Iu mode which is mapped from the EPS bearer context.

The Transaction identifier information element is coded as the Linked TI information element in 3GPP TS 24.008 [13], subclause 10.5.6.7.

9.9.4.18 WLAN offload acceptability

See subclause 10.5.6.20 in 3GPP TS 24.008 [13].

9.9.4.19 NBIFOM container

See subclause 10.5.6.21 in 3GPP TS 24.008 [4].

9.9.4.20 Remote UE context list

The purpose of the Remote UE context list information element is to provide identity and optionally IP address of a remote UE connected to, or disconnected from, a UE acting as a ProSe UE-to-network relay.

The Remote UE context list information element is coded as shown in figure 9.9.4.20.1 and table 9.9.4.20.1.

The Remote UE context list is a type 6 information element with a minimum length of 5 octets and a maximum length of 65538 octets.

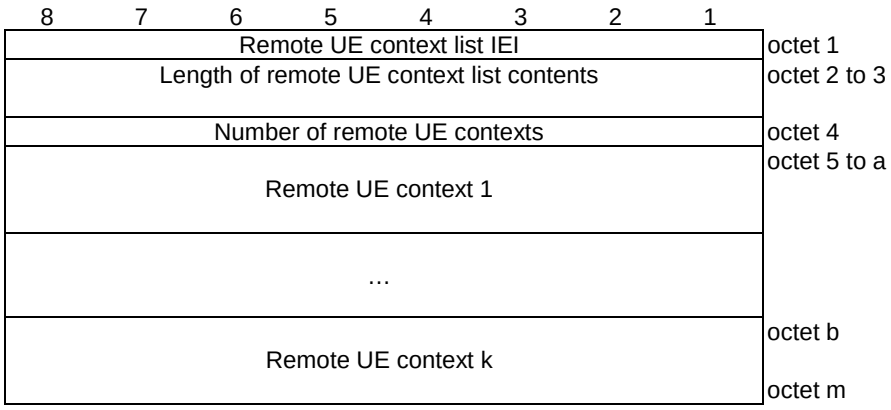


Figure 9.9.4.20.1: Remote UE context list

Table 9.9.4.20.1: Remote UE context list

Remote UE context (octet 5 etc) The contents of remote UE context are applicable for one individual UE and are coded as shown in figure 9.9.4.20.2 and table 9.9.4.20.2.

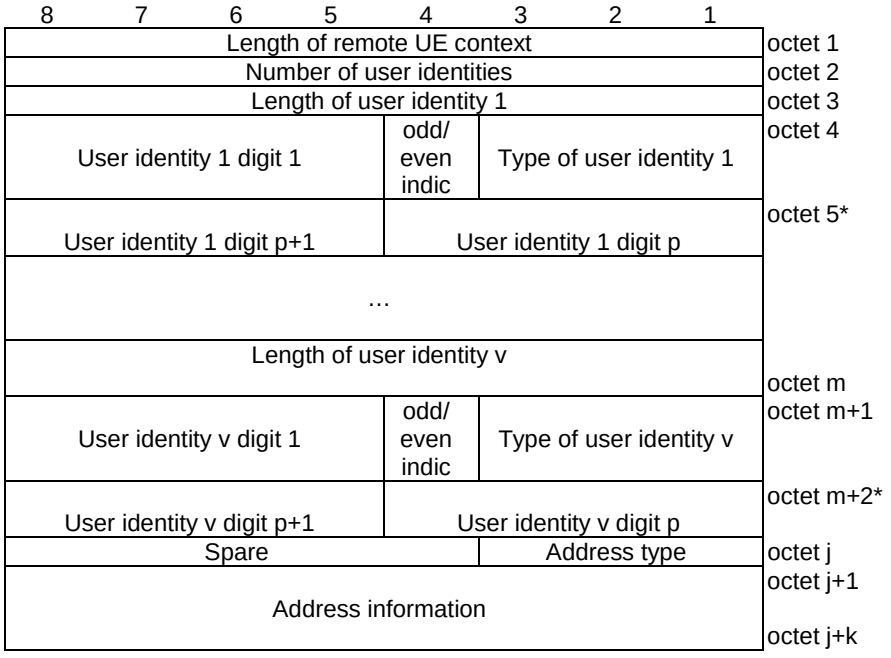


Figure 9.9.4.20.2: Remote UE context

Table 9.9.4.20.2: Remote UE context list information element

Odd/even indication (octet 4)
Bit
4
0 even number of identity digits
1 odd number of identity digits

Type of user identity (octet 4)
Bits

3	**2**	**1**	
0	0	1	Encrypted IMSI
0	1	0	IMSI
0	1	1	MSISDN
1	0	0	IMEI
1	0	1	IMEISV

All other values are reserved.

Identity digits (octet 4 etc)

For the Encrypted IMSI, this field is coded as a 128-bit string. Bits 5 to 8 of octet 4 are not part of the encrypted IMSI and shall be coded as zero. Bit 8 of octet 5 represents the most significant bit of the encrypted IMSI and bit 1 of octet 21 the least significant bit.

For the IMSI, this field is coded using BCD coding. If the number of identity digits is even then bits 5 to 8 of the last octet shall be filled with an end mark coded as "1111". The format of IMSI is described in 3GPP TS 23.003 [2].

For the MSISDN, this field is coded using BCD coding. The format of MSISDN is described in 3GPP TS 23.003 [2].

For the IMEI, this field is coded using BCD coding. The format of the IMEI is described in 3GPP TS 23.003 [2].

For the IMEISV, this field is coded using BCD coding. Bits 5 to 8 of the last octet shall be filled with an end mark coded as "1111". The format of the IMEISV is described in 3GPP TS 23.003 [2].

Bits 4 to 8 of octet j are spare and shall be coded as zero.

Address type (octet j)
Bits

3	**2**	**1**	
0	0	0	No IP Info
0	0	1	IPv4
0	1	0	IPv6

All other values are reserved.

If Address type indicates IPv4, the Address information in octet j+1 to octet j+6 contains the IPv4 address and port number. Bit 8 of octet j+1 represents the most significant bit of the IP address and bit 1 of octet j+4 the least significant bit. Bit 8 of octet j+5 represents the most significant bit of the port number and bit 1 of octet j+6 the least significant bit.

If Address type indicates IPv6, the Address information in octet j+1 to octet j+8 contains the /64 IPv6 prefix of a remote UE. Bit 8 of octet j+1 represents the most significant bit of the /64 IPv6 prefix and bit 1 of octet j+8 the least significant bit.

If Address type indicates No IP info, the Address information octets are not included.

9.9.4.21 PKMF address

The purpose of the PKMF address information element is to provide IP address of a ProSe Key Management Function associated with remote UEs connected to or disconnected from a UE acting as a ProSe UE-to-network relay.

The PKMF address information element is coded as shown in figure 9.9.4.21.1 and table 9.9.4.21.1.

The PKMF address is a type 4 information element with a minimum length of 3 octets and a maximum length of 19 octets.

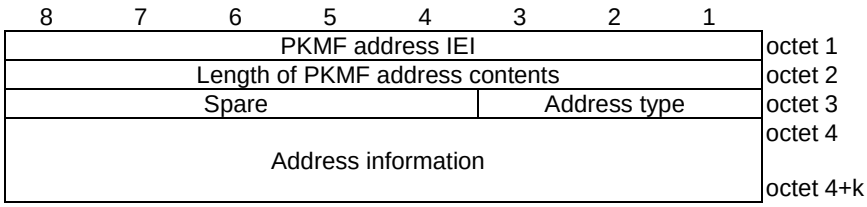


Figure 9.9.4.21.1: PKMF Address

Table 9.9.4.21.1: PKMF Address information element

Bits 4 to 8 of octet 1 are spare and shall be coded as zero. Address type (octet 1) Bits **3 2 1** 0 0 1 IPv4 0 1 0 IPv6 All other values are reserved.

If Address type indicates IPv4, the Address information in octet 4 to octet 7 contains the IPv4 address. Bit 8 of octet 4 represents the most significant bit of the IP address and bit 1 of octet 7 the least significant bit.

If Address type indicates IPv6, the Address information in octet 4 to octet 19 contains the IPv6 address. Bit 8 of octet 4 represents the most significant bit of the IP address and bit 1 of octet 19 the least significant bit.

9.9.4.22 Header compression configuration

The purpose of the Header compression configuration information element is to negotiate ROHC channel setup parameters specified in IETF RFC 5795 [37] and, optionally, provide additional header compression context setup parameters.

The Header compression configuration information element is coded as shown in figure 9.9.4.22.1 and table 9.9.4.22.1.

The Header compression configuration is a type 4 information element with a minimum length of 5 octets and a maximum length of 257 octets.

The optional Additional header compression parameters container field conveys the additional header compression context setup parameters as specified in 3GPP TS 23.401 [10] in a generic container. This field corresponds to the profile-specific information in the header of the ROHC IR packet type in IETF RFC 5795 [37].

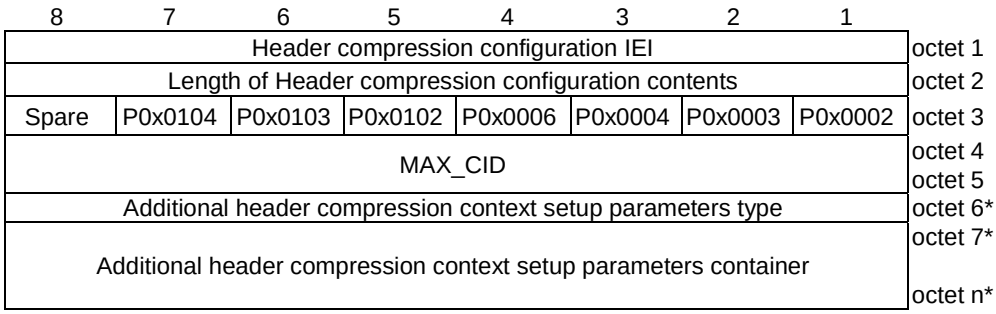


Figure 9.9.4.22.1: Header compression configuration information element

Table 9.9.4.22.1: Header compression configuration information element

ROHC Profiles (octet 3)

The ROHC Profiles shall indicate which of the ROHC profiles is supported. When a particular bit is set to 1, this indicates that the corresponding profile is supported. The No Compression profile 0x0000 (see IETF RFC 5795 [37]) shall always be supported. When all the bits are set to 0, this indicates that only the No Compression profile 0x0000 is supported.

Profile 0x0002 support indicator (see IETF RFC 3095 [40] and IETF RFC 4815 [42]) (octet 3 bit 1)

0 RoHC profile 0x0002 (UDP/IP) is not supported
1 RoHC profile 0x0002 (UDP/IP) is supported

Profile 0x0003 support indicator (see IETF RFC 3095 [40] and IETF RFC 4815 [42]) (octet 3 bit 2)

0 RoHC profile 0x0003 (ESP/IP) is not supported
1 RoHC profile 0x0003 (ESP/IP) is supported

Profile 0x0004 support indicator (see IETF RFC 3843 [41] and IETF RFC 4815 [42]) (octet 3 bit 3)

0 RoHC profile 0x0004 (IP) is not supported
1 RoHC profile 0x0004 (IP) is supported

Profile 0x0006 support indicator (see IETF RFC 6846 [39]) (octet 3 bit 4)

0 RoHC profile 0x0006 (TCP/IP) is not supported
1 RoHC profile 0x0006 (TCP/IP) is supported

Profile 0x0102 support indicator (see IETF RFC 5225 [43]) (octet 3 bit 5)

0 RoHC profile 0x0102 (UDP/IP) is not supported
1 RoHC profile 0x0102 (UDP/IP) is supported

Profile 0x0103 support indicator (see IETF RFC 5225 [43]) (octet 3 bit 6)

0 RoHC profile 0x0103 (ESP/IP) is not supported
1 RoHC profile 0x0103 (ESP/IP) is supported

Profile 0x0104 support indicator (see IETF RFC 5225 [43]) (octet 3 bit 7)

0 RoHC profile 0x0104 (IP) is not supported
1 RoHC profile 0x0104 (IP) is supported

Bits 8 is spare and shall be set to 0.

MAX_CID (octet 4 and octet 5)

This is the MAX_CID value as specified in 3GPP TS 36.323 [38]. It is encoded in binary coding with a value in the range from 1 to 16383.

Additional header compression context parameters type (octet 6).

The Additional header compression context parameters type octet indicates the profile associated with the profile-specific information in the Additional header compression context parameters container.

Bits
8 7 6 5 4 3 2 1 Type

0 0 0 0 0 0 0 0 0x0000 (No Compression)
0 0 0 0 0 0 0 1 0x0002 (UDP/IP)
0 0 0 0 0 0 1 0 0x0003 (ESP/IP)
0 0 0 0 0 0 1 1 0x0004 (IP)
0 0 0 0 0 1 0 0 0x0006 (TCP/IP)
0 0 0 0 0 1 0 1 0x0102 (UDP/IP)
0 0 0 0 0 1 1 0 0x0103 (ESP/IP)
0 0 0 0 0 1 1 1 0x0104 (IP)
0 0 0 0 1 0 0 0 Other

0 0 0 0 1 0 0 1 to 1 1 1 1 1 1 1 1 Spare Additional header compression context parameters container (octets 7 to n). Additional header compression context parameters container carries the profile-specific information (see IETF RFC 5795 [37]). The maximum size is 251 octets.

9.9.4.23 Control plane only indication

The purpose of the Control plane only indication information element is to indicate that a PDN connection is only for control plane CIoT EPS optimization, e.g. the PDN connection is with an SCEF (see 3GPP TS 23.401 [10]).

The Control plane only indication information element is coded as shown in figure 9.9.4.23.1.

The Control plane only indication is a type 1 information element.

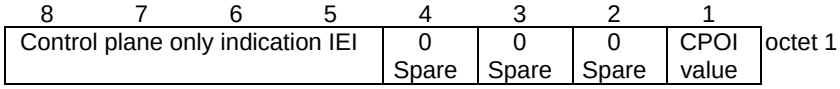


Figure 9.9.4.23.1: Control plane only indication information element

Table 9.9.4.23.1: Control plane only indication information element

Control plane only indication value (CPOI) (octet 1) Bit **1** 0 reserved 1 PDN connection can be used for control plane CIoT EPS optimization only The value 0 is reserved. If received, it shall be interpreted as if the Control plane indication IE was not included in the message. Bits 4 to 2 of octet 1 are spare and shall be all encoded as zero.

9.9.4.24 User data container

This information element is used to encapsulate the user data transferred between the UE and the MME. The User data container information element is coded as shown in figure 9.9.4.24.1 and table 9.9.4.24.1.

The User data container is a type 6 information element.

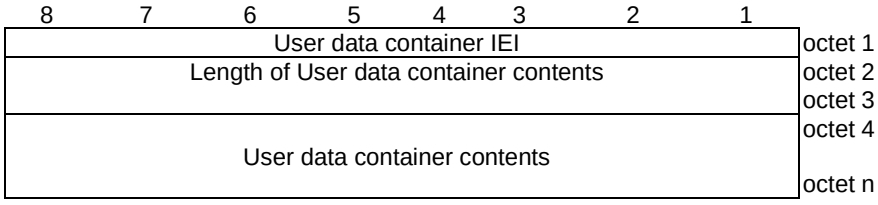


Figure 9.9.4.24.1: User data container information element

Table 9.9.4.24.1: User data container information element

User data container contents (octet 4 to octet n) These octets include user data to be delivered between UE and MME.

9.9.4.25 Release assistance indication

The purpose of the Release assistance indication IE is to inform the network whether

- no further uplink or downlink data transmission is expected; or
- only a single downlink data transmission (e.g. acknowledgement or response to uplink data) and no further uplink data transmission subsequent to the uplink data transmission is expected.

The Release assistance indication information element is coded as shown in figure 9.9.4.25.1 and table 9.9.4.25.1.

The Release assistance indication is a type 1 information element.

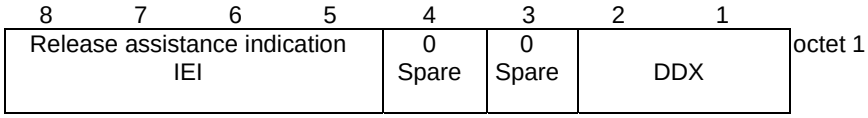


Figure 9.9.4.25.1: Release assistance indication information element

Table 9.9.4.25.1: Release assistance indication information element

Release assistance indication value Downlink data expected (DDX) Bits **2 1** 0 0 No information regarding DDX is conveyed by the information element. If received it shall be interpreted as 'neither value "01" nor "10" applies' 0 1 No further uplink or downlink data transmission subsequent to the uplink data transmission is expected 1 0 Only a single downlink data transmission and no further uplink data transmission subsequent to the uplink data transmission is expected 1 1 reserved Bits 3 and 4 of octet 1 are spare and shall be encoded as zero.

9.9.4.26 Extended protocol configuration options

See subclause 10.5.6.3A in 3GPP TS 24.008 [13].

9.9.4.27 Header compression configuration status

The purpose of the Header compression configuration status information element is to indicate the status of the Header compression configuration for each EPS bearer using Control plane CIoT EPS optimisation that can be identified by an EPS bearer identity.

The Header compression confguration status information element is a type 4 information element with 4 the length of 4 octets.

8	7	6	5	4	3	2	1	
Header compression configuration status IEI								octet 1
Length of Header compression configuration status contents								octet 2
EBI (7)	EBI (6)	EBI (5)	EBI (4)	EBI (3)	EBI (2)	EBI (1)	EBI (0)	octet 3
EBI (15)	EBI (14)	EBI (13)	EBI (12)	EBI (11)	EBI (10)	EBI (9)	EBI (8)	octet 4

Figure 9.9.4.27.1: Header compression confguration status information element

Table 9.9.4.27.1: Header compression confguration status information element

EBI(x) shall be coded as follows: EBI(0): Bit 0 of octet 3 is spare and shall be coded as zero. EBI(1) – EBI(15): 0 indicates that the header compression configuration for the corresponding EPS bearer is used. 1 indicates that the header compression configuration for the corresponding EPS bearer is not used.

9.9.4.28 Serving PLMN rate control

The purpose of the Serving PLMN rate control information element is to indicate the maximum number of uplink ESM DATA TRANSPORT messages including User data container IEs the UE is allowed to send via a PDN connection per 6 minute interval (see 3GPP TS 23.401 [10]).

The Serving PLMN rate control information element is coded as shown in figure 9.9.4.28.1.

The Serving PLMN rate control is a type 4 information element with 4 octets length.

8	7	6	5	4	3	2	1	
Serving PLMN rate control IEI								octet 1
Length of serving PLMN rate control contents								octet 2
Serving PLMN rate control value								octet 3 octet 4

Figure 9.9.4.28.1: Serving PLMN rate control information element

Serving PLMN rate control value (octet 3 to octet 4) is a binary encoded integer indicating the maximum number of uplink ESM DATA TRANSPORT messages including User data container IEs the UE is allowed to send per 6 minute interval. The Serving PLMN rate control value is an integer equal to or higher than 10. The Serving PLMN rate control value FFFFH indicates that the maximum number of uplink ESM DATA TRANSPORT messages including User data container IEs the UE is allowed to send per 6 minute interval is not restricted.

9.9.4.29 Extended APN aggregate maximum bit rate

The purpose of the extended APN aggregate maximum bit rate information element is to indicate the initial subscribed APN-AMBR with a value higher than 65280 Mbps when the UE establishes a PDN connection or to indicate the new APN-AMBR with a value higher than 65280 Mbps if it is changed by the network.

The receiving entityshall ignore the bit rate values which are included in the extended APN aggregate maximum bit rate information element and not higher than 65280 Mbps.

The extended APN aggregate maximum bit rate information element is coded as shown in figure 9.9.4.29.1 and table 9.9.4.29.1.

The extended APN aggregate maximum bit rate is a type 4 information element with a length of 8 octets.

8	7	6	5	4	3	2	1	
Extended APN aggregate maximum bit rate IEI								octet 1
Length of extended APN aggregate maximum bit rate contents								octet 2
Unit for extended APN-AMBR for downlink								octet 3
Extended APN-AMBR for downlink								octet 4
Extended APN-AMBR for downlink (continued)								octet 5
Unit for extended APN-AMBR for uplink								octet 6
Extended APN-AMBR for uplink								octet 7
Extended APN-AMBR for uplink (continued)								octet 8

Figure 9.9.4.29.1: Extended APN aggregate maximum bit rate information element

Table 9.9.4.29.1: Extended APN aggregate maximum bit rate information element

Unit for extended APN-AMBR for downlink (octet 3) 0 0 0 0 0 0 0 0 value is not used 0 0 0 0 0 0 0 1 value is not used 0 0 0 0 0 0 1 0 value is not used 0 0 0 0 0 0 1 1 value is incremented in multiples of 4 Mbps 0 0 0 0 0 1 0 0 value is incremented in multiples of 16 Mbps 0 0 0 0 0 1 0 1 value is incremented in multiples of 64 Mbps 0 0 0 0 0 1 1 0 value is incremented in multiples of 256 Mbps 0 0 0 0 0 1 1 1 value is incremented in multiples of 1 Gbps 0 0 0 0 1 0 0 0 value is incremented in multiples of 4 Gbps 0 0 0 0 1 0 0 1 value is incremented in multiples of 16 Gbps 0 0 0 0 1 0 1 0 value is incremented in multiples of 64 Gbps 0 0 0 0 1 0 1 1 value is incremented in multiples of 256 Gbps 0 0 0 0 1 1 0 0 value is incremented in multiples of 1 Tbps 0 0 0 0 1 1 0 1 value is incremented in multiples of 4 Tbps 0 0 0 0 1 1 1 0 value is incremented in multiples of 16 Tbps 0 0 0 0 1 1 1 1 value is incremented in multiples of 64 Tbps 0 0 0 1 0 0 0 0 value is incremented in multiples of 256 Tbps 0 0 0 1 0 0 0 1 value is incremented in multiples of 1 Pbps 0 0 0 1 0 0 1 0 value is incremented in multiples of 4 Pbps 0 0 0 1 0 0 1 1 value is incremented in multiples of 16 Pbps 0 0 0 1 0 1 0 0 value is incremented in multiples of 64 Pbps 0 0 0 1 0 1 0 1 value is incremented in multiples of 256 Pbps Other values shall be interpreted as multiples of 256 Pbps in this version of the protocol. Extended APN-AMBR for downlink (octets 4 and 5) Octets 4 and 5 represent the binary coded value of extended APN-AMBR for downlink in units defined by octet 3 Unit for extended APN-AMBR for uplink (octet 6) The coding is identical to that of the unit for extended APN-AMBR for downlink (octet 3) Extended APN-AMBR for uplink (octets 7 and 8) Octets 7 and 8 represent the binary coded value of extended APN-AMBR for uplink in units defined by octet 6.

9.9.4.30 Extended quality of service

The purpose of the Extended quality of service information element is to indicate for an EPS bearer context the maximum bit rates for uplink and downlink and the guaranteed bit rates for uplink and downlink, if at least one of the bit rates has a value higher than 10 Gbps.

The Extended quality of service information element is coded as shown in figure 9.9.4.30.1 and table 9.9.4.30.1. For uplink and downlink, if the sending entity only has to indicate one bit rate (i.e, with a value higher than 10 Gbps), it shall encode the other bit rate (i.e., with a value smaller or equal to 10 Gbps) as "00000000". The receiving entity shall ignore a bit rate which is included in the extended quality of service information element and has a value smaller or equal to 10 Gbps.

The Extended quality of service is a type 4 information element with a length of 12 octets.

8	7	6	5	4	3	2	1	
Extended quality of service IEI								octet 1
Length of Extended quality of service contents								octet 2
Unit for maximum bit rate								octet 3
Maximum bit rate for uplink								octet 4
Maximum bit rate for uplink (continued)								octet 5
Maximum bit rate for downlink								octet 6
Maximum bit rate for downlink (continued)								octet 7
Unit for guaranteed bit rate								octet 8
Guaranteed bit rate for uplink								octet 9
Guaranteed bit rate for uplink (continued)								octet 10
Guaranteed bit rate for downlink								octet 11
Guaranteed bit rate for downlink (continued)								octet 12

Figure 9.9.4.30.1: Extended quality of service information element

Table 9.9.4.30.1: Extended quality of service information element

Unit for maximum bit rate (octet 3)

0 0 0 0 0 0 0 0	value is not used
0 0 0 0 0 0 0 1	value is incremented in multiples of 200 kbps
0 0 0 0 0 0 1 0	value is incremented in multiples of 1 Mbps
0 0 0 0 0 0 1 1	value is incremented in multiples of 4 Mbps
0 0 0 0 0 1 0 0	value is incremented in multiples of 16 Mbps
0 0 0 0 0 1 0 1	value is incremented in multiples of 64 Mbps
0 0 0 0 0 1 1 0	value is incremented in multiples of 256 Mbps
0 0 0 0 0 1 1 1	value is incremented in multiples of 1 Gbps
0 0 0 0 1 0 0 0	value is incremented in multiples of 4 Gbps
0 0 0 0 1 0 0 1	value is incremented in multiples of 16 Gbps
0 0 0 0 1 0 1 0	value is incremented in multiples of 64 Gbps
0 0 0 0 1 0 1 1	value is incremented in multiples of 256 Gbps
0 0 0 0 1 1 0 0	value is incremented in multiples of 1 Tbps
0 0 0 0 1 1 0 1	value is incremented in multiples of 4 Tbps
0 0 0 0 1 1 1 0	value is incremented in multiples of 16 Tbps
0 0 0 0 1 1 1 1	value is incremented in multiples of 64 Tbps
0 0 0 1 0 0 0 0	value is incremented in multiples of 256 Tbps
0 0 0 1 0 0 0 1	value is incremented in multiples of 1 Pbps
0 0 0 1 0 0 1 0	value is incremented in multiples of 4 Pbps
0 0 0 1 0 0 1 1	value is incremented in multiples of 16 Pbps
0 0 0 1 0 1 0 0	value is incremented in multiples of 64 Pbps
0 0 0 1 0 1 0 1	value is incremented in multiples of 256 Pbps

Other values shall be interpreted as multiples of 256 Pbps in this version of the protocol.

Maximum bit rate for uplink (octets 4 and 5)

Octets 4 and 5 represent the binary coded value of maximum bit rate for uplink in units defined by octet 3.

Maximum bit rate for downlink (octets 6 and 7)

Octets 6 and 7 represent the binary coded value of maximum bit rate for downlink in units defined by octet 3.

Unit for guaranteed bit rate (octet 8)

The coding is identical to that of the unit for maximum bit rate (octet 3).

Guaranteed bit rate for uplink (octets 9 and 10)

Octets 9 and 10 represent the binary coded value of guaranteed bit rate for uplink in units defined by octet 8.

Guaranteed bit rate for downlink (octets 11 and 12)

Octets 11 and 12 represent the binary coded value of guaranteed bit rate for downlink in units defined by octet 8.

10 List of system parameters

10.1 General

The description of timers in the following tables should be considered a brief summary.

10.2 Timers of EPS mobility management

Table 10.2.1: EPS mobility management timers – UE side

TIMER NUM.	TIMER VALUE	STATE	CAUSE OF START	NORMAL STOP	ON EXPIRY
T3402	Default 12 min. NOTE 1	EMM-DEREGISTERED EMM-REGISTERED	At attach failure and the attempt counter is equal to 5. At tracking area updating failure and the attempt counter is equal to 5. ATTACH ACCEPT with EMM cause #16 or #17 and the attempt counter is equal to 5 for CS/PS mode 2 UE, or ATTACH ACCEPT with EMM cause #22, as described in subclause 5.5.1.3.4.3. TRACKING AREA UPDATE ACCEPT with EMM cause #16 or #17 and the attempt counter is equal to 5 for CS/PS mode 2 UE, TRACKING AREA UPDATE ACCEPT with EMM cause #16 or #17 and the attempt counter is equal to 5 for CS/PS mode 1 UE with "IMS voice not available" and with a persistent EPS bearer context, or TRACKING AREA UPDATE ACCEPT with EMM cause #22, as described in subclause 5.5.3.3.4.3. ATTACH ACCEPT and the attempt counter is equal to 5 as described in subclause 5.5.1.2.4A and 5.5.1.2.6A. TRACKING AREA UPDATE ACCEPT and the attempt counter is equal to 5 as described in subclause 5.5.3.2.4A and 5.5.3.2.6A. DETACH REQUEST with other EMM cause values than those treated in subclause 5.5.2.3.2 or no EMM cause IE and Detach type IE indicates "re-attach not required" as described in subclause 5.5.2.3.4.	ATTACH REQUEST sent TRACKING AREA UPDATE REQUEST sent NAS signalling connection released	Initiation of the attach procedure, if still required or TAU procedure
T3410	15s NOTE 7 NOTE 8 In WB-S1/CE mode, 85s	EMM-REGISTERED-INITIATED	ATTACH REQUEST sent	ATTACH ACCEPT received ATTACH REJECT received	Start T3411 or T3402 as described in subclause 5.5.1.2.6

TIMER NUM.	TIMER VALUE	STATE	CAUSE OF START	NORMAL STOP	ON EXPIRY
T3411	10s	EMM-DEREGISTERED. ATTEMPTING-TO-ATTACH EMM-REGISTERED. ATTEMPTING-TO-UPDATE EMM-REGISTERED. NORMAL-SERVICE	At attach failure due to lower layer failure, T3410 timeout or attach rejected with other EMM cause values than those treated in subclause 5.5.1.2.5. At tracking area updating failure due to lower layer failure, T3430 timeout or TAU rejected with other EMM cause values than those treated in subclause 5.5.3.2.5. ATTACH ACCEPT and the attempt counter is less than 5 as described in subclause 5.5.1.2.4A and 5.5.1.2.6A. TRACKING AREA UPDATE ACCEPT and the attempt counter is less than 5 as described in subclause 5.5.3.2.4A and 5.5.3.2.6A.	ATTACH REQUEST sent TRACKING AREA UPDATE REQUEST sent EMM-CONNECTED mode entered (NOTE 6)	Retransmission of the ATTACH REQUEST, if still required as described in subclause 5.5.1.2.6 or retransmission of TRACKING AREA UPDATE REQUEST
T3412	Default 54 min. NOTE 2 NOTE 5	EMM-REGISTERED	In EMM-REGISTERED, when EMM-CONNECTED mode is left.	When entering state EMM-DEREGISTERED or when entering EMM-CONNECTED mode.	Initiation of the periodic TAU procedure if the UE is not attached for emergency bearer services or T3423 started under the conditions as specified in subclause 5.3.5. Implicit detach from network if the UE is attached for emergency bearer services.
T3416	30s NOTE 7 NOTE 8 In WB-S1/CE mode, 48s	EMM-REGISTERED-INITIATED EMM-REGISTERED EMM-DEREGISTERED-INITIATED EMM-TRACKING-AREA-UPDATING-INITIATED EMM-SERVICE-REQUEST-INITIATED	RAND and RES stored as a result of an EPS authentication challenge	SECURITY MODE COMMAND received SERVICE REJECT received TRACKING AREA UPDATE ACCEPT received AUTHENTICATION REJECT received AUTHENTICATION FAILURE sent EMM-DEREGISTERED, EMM-NULL or EMM-IDLE mode entered	Delete the stored RAND and RES

TIMER NUM.	TIMER VALUE	STATE	CAUSE OF START	NORMAL STOP	ON EXPIRY
T3417	5s NOTE 7 NOTE 8 In WB-S1/CE mode, 51s	EMM-SERVICE-REQUEST-INITIATED	SERVICE REQUEST sent EXTENDED SERVICE REQUEST sent in case f, g, i and j in subclause 5.6.1.1 EXTENDED SERVICE REQUEST sent with service type set to "packet services via S1" in case a, b, c, h and k in subclause 5.6.1.1 CONTROL PLANE SERVICE REQUEST sent as specified in subclause 5.6.1.2.2	Bearers have been set up SERVICE REJECT received SERVICE ACCEPT received Indication of system change from lower layer received cdma2000® 1xCS fallback rejection received see subclause 5.6.1.4.2	Abort the procedure
T3417ext	10s	EMM-SERVICE-REQUEST-INITIATED	EXTENDED SERVICE REQUEST sent in case d in subclause 5.6.1.1	Inter-system change from S1 mode to A/Gb mode or Iu mode is completed Inter-system change from S1 mode to A/Gb mode or Iu mode is failed SERVICE REJECT received	Select GERAN or UTRAN
T3417ext-mt	4s	EMM-SERVICE-REQUEST-INITIATED	EXTENDED SERVICE REQUEST sent in case e in subclause 5.6.1.1 and the CSFB response was set to "CS fallback accepted by the UE"	Inter-system change from S1 mode to A/Gb mode or Iu mode is completed Inter-system change from S1 mode to A/Gb mode or Iu mode is failed SERVICE REJECT received	Select GERAN or UTRAN
T3418	20s NOTE 7 NOTE 8 In WB-S1/CE mode, 38s	EMM-REGISTERED-INITIATED EMM-REGISTERED EMM-TRACKING-AREA-UPDATING-INITIATED EMM-DEREGISTERED-INITIATED EMM-SERVICE-REQUEST-INITIATED	AUTHENTICATION FAILURE (EMM cause = #20 "MAC failure" or #26 "non-EPS authentication unacceptable") sent	AUTHENTICATION REQUEST received or AUTHENTICATION REJECT received or SECURITY MODE COMMAND received when entering EMM-IDLE mode indication of transmission failure of AUTHENTICATION FAILURE message from lower layers	On first expiry, the UE should consider the network as false and follow item f of subclause 5.4.2.7, if the UE is not attached for emergency bearer services. On first expiry, the UE will follow subclause 5.4.2.7 under "For items c, d, and e:", if the UE is attached for emergency bearer services.

TIMER NUM.	TIMER VALUE	STATE	CAUSE OF START	NORMAL STOP	ON EXPIRY
T3420	15s NOTE 7 NOTE 8 In WB-S1/CE mode, 33s	EMM-REGISTERED-INITIATED EMM-REGISTERED EMM-DEREGISTERED-INITIATED EMM-TRACKING-AREA-UPDATING-INITIATED EMM-SERVICE-REQUEST-INITIATED	AUTHENTICATION FAILURE (cause = #21 "synch failure") sent	AUTHENTICATION REQUEST received or AUTHENTICATION REJECT received or SECURITY MODE COMMAND received when entering EMM-IDLE mode indication of transmission failure of AUTHENTICATION FAILURE message from lower layers	On first expiry, the UE should consider the network as false and follow item f of subclause 5.4.2.7, if the UE is not attached for emergency bearer services. On first expiry, the UE will follow subclause 5.4.2.7 under "For items c, d, and e:", if the UE is attached for emergency bearer services.
T3421	15s NOTE 7 NOTE 8 In WB-S1/CE mode, 45s	EMM-DEREGISTERED-INITIATED EMM-REGISTERED.IMSI-DETACH-INITIATED	DETACH REQUEST sent with the Detach type IE not indicating "switch off"	DETACH ACCEPT received	Retransmission of DETACH REQUEST
T3423	NOTE 3	EMM-REGISTERED	T3412 expires while ISR is activated and either T3346 is running or the UE is in one of the following states: - EMM-REGISTERED.NO-CELL-AVAILABLE; - EMM-REGISTERED.PLMN-SEARCH; -EMM-REGISTERED.UPDATE-NEEDED; or -EMM-REGISTERED.LIMITED-SERVICE.	When entering state EMM-DEREGISTERED or when entering EMM-CONNECTED mode.	Set TIN to "P-TMSI". For A/Gb mode or Iu mode, see 3GPP TS 24.008 [13]
T3430	15s NOTE 7 NOTE 8 In WB-S1/CE mode, 77s	EMM-TRACKING-AREA-UPDATING-INITIATED	TRACKING AREA UPDATE REQUEST sent	TRACKING AREA UPDATE ACCEPT received TRACKING AREA UPDATE REJECT received	Start T3411 or T3402 as described in subclause 5.5.3.2.6

TIMER NUM.	TIMER VALUE	STATE	CAUSE OF START	NORMAL STOP	ON EXPIRY
T3440	10s	EMM-REGISTERED-INITIATED EMM-TRACKING-AREA-UPDATING-INITIATED EMM-DEREGISTERED-INITIATED EMM-SERVICE-REQUEST-INITIATED EMM-REGISTERED	ATTACH REJECT, DETACH REQUEST, TRACKING AREA UPDATE REJECT with any of the EMM cause #7, #8, #11, #12, #13, #14, #15 or #35 SERVICE REJECT received with any of the EMM cause #7, #8, #11, #12, #13, #15, 35 or #39 TRACKING AREA UPDATE ACCEPT received after the UE sent TRACKING AREA UPDATE REQUEST in EMM-IDLE mode without the "active" flag set and without the "signalling active" flag set, and the user-plane radio bearers have not been setup DETACH ACCEPT received after the UE sent DETACH REQUEST with detach type to "IMSI detach" Upon receipt of ESM DATA TRANSPORT message as described in subclause 5.3.1.2.1 (NOTE 9)	NAS signalling connection released Bearers have been set up or a request for PDN connection for emergency bearer services or a CS emergency call is started Upon receipt of ESM DATA TRANSPORT message as described in subclause 5.3.1.2.1 (NOTE 9)	Release the NAS signalling connection for the cases a), b) and c) as described in subclause 5.3.1.2
		EMM-DEREGISTERED EMM-DEREGISTERED. NORMAL-SERVICE	TRACKING AREA UPDATE REJECT, SERVICE REJECT with any of the EMM cause #9, #10 or #40	NAS signalling connection released	Release the NAS signalling connection for the cases d) and e) as described in subclause 5.3.1.2 and initiation of the attach procedure as specified in subclause 5.5.3.2.5, 5.5.3.3.5 or 5.6.1.5
T3442	NOTE 4	EMM-REGISTERED	SERVICE REJECT received with EMM cause #39 "CS service temporarily not available" with a non-zero T3442 value	TRACKING AREA UPDATE REQUEST sent	None
T3444	NOTE 11	All except EMM-NULL and 5GMM-NULL (defined in 3GPP TS 24.501 [54])	- UE configured for eCall only mode enters EMM-IDLE mode after an eCall over IMS - UE configured for eCall only mode moves from GERAN/UTRAN to E-UTRAN with timer T3242 (see 3GPP TS 24.008 [13]) running - UE configured for eCall only mode enters 5GMM-IDLE mode (defined in 3GPP TS 24.501 [54]) after an eCall over IMS	- Removal of eCall only restriction - Intersystem change from S1 mode to A/Gb or Iu mode	Perform eCall inactivity procedure in EPS as described in subclause 5.5.4. Perform eCall inactivity procedure in 5GS as described in 3GPP TS 24.501 [54].

TIMER NUM.	TIMER VALUE	STATE	CAUSE OF START	NORMAL STOP	ON EXPIRY
T3445	NOTE 12	All except EMM-NULL and 5GMM-NULL (defined in 3GPP TS 24.501 [54])	- UE configured for eCall only mode enters EMM-IDLE mode after a call to a non-emergency MSISDN or URI for test or terminal reconfiguration service - UE configured for eCall only mode moves from GERAN/UTRAN to E-UTRAN with timer T3243 (see 3GPP TS 24.008 [13]) running - UE configured for eCall only mode enters 5GMM-IDLE mode (defined in 3GPP TS 24.501 [54]) after a call to a non-emergency MSISDN or URI for test or terminal reconfiguration service	Removal of eCall only restriction - Intersystem change from S1 mode to A/Gb or Iu mode	Perform eCall inactivity procedure in EPS as described in subclause 5.5.4. Perform eCall inactivity procedure in 5GS as described in 3GPP TS 24.501 [54].
T3447	NOTE 2	All except EMM-NULL	Mobile originated requested NAS signalling connection is released.	Inter-system change from S1 mode to A/Gb mode, Iu mode or N1 mode is completed	Allowed to initiate transfer of uplink user data
T3448	NOTE 10	All except EMM-NULL	ATTACH ACCEPT message or TRACKING AREA UPDATE ACCEPT message or SERVICE ACCEPT message received with a non-zero T3448 value. SERVICE REJECT message received with EMM cause #22 "Congestion" and a non-zero T3448 value.	SERVICE ACCEPT message or TRACKING AREA UPDATE ACCEPT message received without T3448 value	Allowed to initiate transfer of user data via the control plane
T3449	5s NOTE 7 NOTE 8 In WB-S1/CE mode, 51s	EMM-REGISTERED	Bearers have been set up SECURITY MODE COMMAND message received	SERVICE ACCEPT message received Security protected ESM message or a security protected EMM message not related to an EMM common procedure received	SERVICE ACCEPT message considered as a protocol error and EMM STATUS returned

NOTE 1: The cases in which the default value of this timer is used are described in subclause 5.3.6.
NOTE 2: The value of this timer is provided by the network operator during the attach and tracking area updating procedures.
NOTE 3: The value of this timer may be provided by the network in the ATTACH ACCEPT message and TRACKING AREA UPDATE ACCEPT message. The default value of this timer is identical to the value of T3412.
NOTE 4: The value of this timer is provided by the network operator when a service request for CS fallback is rejected by the network with EMM cause #39 "CS service temporarily not available".
NOTE 5: The default value of this timer is used if the network does not indicate a value in the TRACKING AREA UPDATE ACCEPT message and the UE does not have a stored value for this timer.
NOTE 6: The conditions for which this applies are described in subclause 5.5.3.2.6.
NOTE 7: In NB-S1 mode, the timer value shall be calculated as described in subclause 4.7.
NOTE 8: In WB-S1 mode, if the UE supports CE mode B and operates in either CE mode A or CE mode B, then the timer value is as described in this table for the case of WB-S1/CE mode (see subclause 4.8).
NOTE 9: It is possible that the UE does not stop or start timer T3440 upon receipt of ESM DATA TRANSPORT message as described in subclause 5.3.1.2.1.
NOTE 10: The timer value is provided by the network in the ATTACH ACCEPT, TRACKING AREA UPDATE ACCEPT, SERVICE ACCEPT or SERVICE REJECT message, or chosen randomly from a default value range of 15 – 30 minutes.
NOTE 11: If the timer is started due to a UE configured for eCall only mode moving from GERAN/UTRAN to E-UTRAN with timer T3242 (see 3GPP TS 24.008 [13]) running, the UE starts the timer with a value set to the time left on timer T3242. Otherwise the UE starts the timer with a value set to 12 hours.
NOTE 12: If the timer is started due to a UE configured for eCall only mode moving from GERAN/UTRAN to E-UTRAN with timer T3243 (see 3GPP TS 24.008 [13]) running, the UE starts the timer with a value set to the time left on timer T3243. Otherwise the UE starts the timer with a value set to 12 hours.

Table 10.2.2: EPS mobility management timers – network side

TIMER NUM.	TIMER VALUE	STATE	CAUSE OF START	NORMAL STOP	ON THE 1st, 2nd, 3rd, 4th EXPIRY (NOTE 1)
T3413 NOTE 8 NOTE 10	NOTE 2	EMM-REGISTERED	Paging procedure for EPS services initiated	Paging procedure for EPS services completed Paging procedure is aborted	Network dependent
T3415 NOTE 8 NOTE 10	NOTE 6	EMM-REGISTERED	Paging procedure for EPS services initiated for a UE which the network accepted the request to use eDRX and the UE does not have a PDN connection for emergency bearer services	Paging procedure for EPS services completed Paging procedure is aborted	Paging procedure is aborted and the network proceeds as specified in 3GPP TS 23.401 [10]
T3422 NOTE 7 NOTE 9	6s In WB-S1/CE mode, 24s	EMM-DEREGISTERED-INITIATED	DETACH REQUEST sent	DETACH ACCEPT received	Retransmission of DETACH REQUEST
T3447	NOTE 2	All	Entering EMM-IDLE mode for a mobile originated requested NAS signalling connection	None	Allow the UE to initiate a connection for transfer of uplink user data.
T3450 NOTE 7 NOTE 9	6s In WB-S1/CE mode, 18s	EMM-COMMON-PROC-INIT	ATTACH ACCEPT sent TRACKING AREA UPDATE ACCEPT sent with GUTI TRACKING AREA UPDATE ACCEPT sent with TMSI GUTI REALLOCATION COMMAND sent	ATTACH COMPLETE received TRACKING AREA UPDATE COMPLETE received GUTI REALLOCATION COMPLETE received	Retransmission of the same message type, i.e. ATTACH ACCEPT, TRACKING AREA UPDATE ACCEPT or GUTI REALLOCATION COMMAND
T3460 NOTE 7 NOTE 9	6s In WB-S1/CE mode, 24s	EMM-COMMON-PROC-INIT	AUTHENTICATION REQUEST sent SECURITY MODE COMMAND sent	AUTHENTICATION RESPONSE received AUTHENTICATION FAILURE received SECURITY MODE COMPLETE received SECURITY MODE REJECT received	Retransmission of the same message type, i.e. AUTHENTICATION REQUEST or SECURITY MODE COMMAND
T3470 NOTE 7 NOTE 9	6s In WB-S1 mode, 24s	EMM-COMMON-PROC-INIT	IDENTITY REQUEST sent	IDENTITY RESPONSE received	Retransmission of IDENTITY REQUEST
Mobile reachable	NOTE 4	All except EMM-DEREGISTERED	Entering EMM-IDLE mode	NAS signalling connection established	Network dependent, but typically paging is halted on 1st expiry if the UE is not attached for emergency bearer services. Implicitly detach the UE which is attached for emergency bearer services.
Implicit detach timer	NOTE 3	All except EMM-DEREGISTERED	The mobile reachable timer expires while the network is in EMM-IDLE mode	NAS signalling connection established	Implicitly detach the UE on 1st expiry
active timer	NOTE 5	All except EMM-DEREGISTERED	Entering EMM-IDLE mode	NAS signalling connection established	Network dependent, but typically paging is halted on 1st expiry

NOTE 1: Typically, the procedures are aborted on the fifth expiry of the relevant timer. Exceptions are described in the corresponding procedure description.
NOTE 2: The value of this timer is network dependent.
NOTE 3: The value of this timer is network dependent. If ISR is activated, the default value of this timer is 4 minutes greater than T3423.
NOTE 4: The default value of this timer is 4 minutes greater than T3412. If T3346 is larger than T3412 and the MME includes timer T3346 in the TRACKING AREA UPDATE REJECT message or SERVICE REJECT message, the value of the mobile reachable timer and implicit detach timer is set such that the sum of the timer values is greater than T3346. If the UE is attached for emergency bearer services, the value of this timer is set equal to T3412.
NOTE 5: If the MME includes timer T3324 in the ATTACH ACCEPT message or TRACKING AREA UPDATE ACCEPT message and if the UE is not attached for emergency bearer services and has no PDN connection for emergency bearer services, the value of this timer is equal to the value of timer T3324.
NOTE 6: The value of this timer is smaller than the value of timer T3-RESPONSE (see 3GPP TS 29.274 [16D]).
NOTE 7: In NB-S1 mode, then the timer value shall be calculated as described in subclause 4.7.
NOTE 8: In NB-S1 mode, then the timer value shall be calculated by using an NAS timer value which is network dependent.
NOTE 9: In WB-S1 mode, if the UE supports CE mode B and operates in either CE mode A or CE mode B, then the timer value is as described in this table for the case of WB-S1/CE mode (see subclause 4.8).
NOTE 10: In WB-S1 mode, if the UE supports CE mode B, then the timer value shall be calculated by using an NAS timer value which value is network dependent.

10.3 Timers of EPS session management

Table 10.3.1: EPS session management timers – UE side

TIMER NUM.	TIMER VALUE	STATE	CAUSE OF START	NORMAL STOP	ON THE 1st, 2nd, 3rd, 4th EXPIRY (NOTE 1)
T3480 NOTE 2 NOTE 3	8s In WB-S1/CE mode, 16s	PROCEDURE TRANSACTION PENDING	BEARER RESOURCE ALLOCATION REQUEST sent	ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST received or MODIFY EPS BEARER CONTEXT REQUEST received or BEARER RESOURCE ALLOCATION REJECT received	Retransmission of BEARER RESOURCE ALLOCATION REQUEST
T3481 NOTE 2 NOTE 3	8s In WB-S1/CE mode, 16s	PROCEDURE TRANSACTION PENDING	BEARER RESOURCE MODIFICATION REQUEST sent	ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST received or MODIFY EPS BEARER CONTEXT REQUEST received or DEACTIVATE EPS BEARER CONTEXT REQUEST received or BEARER RESOURCE MODIFICATION REJECT received	Retransmission of BEARER RESOURCE MODIFICATION REQUEST
T3482 NOTE 2 NOTE 3	8s In WB-S1/CE mode, 16s	PROCEDURE TRANSACTION PENDING	An additional PDN connection is requested by the UE which is not combined in attach procedure	ACTIVE DEFAULT EPS BEARER CONTEXT REQUEST received or PDN CONNECTIVITY REJECT received	Retransmission of PDN CONNECTIVITY REQUEST
T3492 NOTE 2 NOTE 3	6s In WB-S1/CE mode, 14s	PROCEDURE TRANSACTION PENDING	PDN DISCONNECT REQUEST sent	DEACTIVATE EPS BEARER CONTEXT REQUEST received or PDN DISCONNECT REJECT received	Retransmission of PDN DISCONNECT REQUEST
T3493 NOTE 2	4s In WB-S1/CE mode, 12s	PROCEDURE TRANSACTION PENDING	REMOTE UE REPORT sent	REMOTE UE REPORT RESPONSE received	Retransmission of REMOTE UE REPORT
Back-off timer			defined in 3GPP TS 24.008 [13]		

NOTE 1: Typically, the procedures are aborted on the fifth expiry of the relevant timer. Exceptions are described in the corresponding procedure description.
NOTE 2: In NB-S1 mode, then the timer value shall be calculated as described in subclause 4.7.
NOTE 3: In WB-S1 mode, if the UE supports CE mode B and operates in either CE mode A or CE mode B, then the timer value is as described in this table for the case of WB-S1/CE mode (see subclause 4.8).

NOTE 1: The back-off timer is used to describe a logical model of the required UE behaviour. This model does not imply any specific implementation, e.g. as a timer or timestamp.

NOTE 2: Reference to back-off timer in this section can either refer to use of timer T3396 or to use of a different packet system specific timer within the UE. Whether the UE uses T3396 as a back-off timer or it uses different packet system specific timers as back-off timers is left up to UE implementation.

Table 10.3.2: EPS session management timers – network side

TIMER NUM.	TIMER VALUE	STATE	CAUSE OF START	NORMAL STOP	ON THE 1st, 2nd, 3rd, 4th EXPIRY (NOTE 1)
T3485 NOTE 2 NOTE 3	8s In WB-S1/CE mode, 16s	BEARER CONTEXT ACTIVE PENDING	ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST sent ACTIVATE DEDICATED EPS BEARER CONTEXT REQUEST sent	ACTIVATE DEFAULT EPS BEARER CONTEXT ACCEPT received or ACTIVATE DEFAULT EPS BEARER CONTEXT REJECT received or ACTIVATE DEDICATED EPS BEARER CONTEXT ACCEPT received or ACTIVATE DEDICATED EPS BEARER CONTEXT REJECT received	Retransmission of the same message
T3486 NOTE 2 NOTE 3	8s In WB-S1/CE mode, 16s	BEARER CONTEXT MODIFY PENDING	MODIFY EPS BEARER CONTEXT REQUEST sent	MODIFY EPS BEARER CONTEXT ACCEPT received or MODIFY EPS BEARER CONTEXT REJECT received	Retransmission of MODIFY EPS BEARER CONTEXT REQUEST
T3489 NOTE 2 NOTE 3	4s In WB-S1/CE mode, 12s	PROCEDURE TRANSACTION PENDING	ESM INFORMATION REQUEST sent	ESM INFORMATION RESPONSE received	Retransmission of ESM INFORMATION REQUEST on 1st and 2nd expiry only
T3495 NOTE 2 NOTE 3	8s In WB-S1/CE mode, 16s	BEARER CONTEXT INACTIVE PENDING	DEACTIVATE EPS BEARER CONTEXT REQUEST sent	DEACTIVATE EPS BEARER CONTEXT ACCEPT received	Retransmission of DEACTIVATE EPS BEARER CONTEXT REQUEST

NOTE 1: Typically, the procedures are aborted on the fifth expiry of the relevant timer. Exceptions are described in the corresponding procedure description.
NOTE 2: In NB-S1 mode, then the timer value shall be calculated as described in subclause 4.7.
NOTE 3: In WB-S1 mode, if the UE supports CE mode B and operates in either CE mode A or CE mode B, then the timer value is as described in this table for the case of WB-S1/CE mode (see subclause 4.8).

Annex A (informative): Cause values for EPS mobility management

A.1 Causes related to UE identification

Cause #2 – IMSI unknown in HSS

This EMM cause is sent to the UE if the UE is not known (registered) in the HSS or if the UE has packet only subscription. This EMM cause does not affect operation of the EPS service, although is may be used by an EMM procedure.

Cause #3 – Illegal UE

This EMM cause is sent to the UE when the network refuses service to the UE either because an identity of the UE is not acceptable to the network or because the UE does not pass the authentication check, i.e. the RES received from the UE is different from that generated by the network.

Cause #6 – Illegal ME

This EMM cause is sent to the UE if the ME used is not acceptable to the network, e.g. blacklisted.

Cause #9 – UE identity cannot be derived by the network.

This EMM cause is sent to the UE when the network cannot derive the UE's identity from the GUTI/S-TMSI/P-TMSI and RAI e.g. no matching identity/context in the network or failure to validate the UE's identity due to integrity check failure of the received message.

Cause #10 – Implicitly detached

This EMM cause is sent to the UE either if the network has implicitly detached the UE, e.g. after the implicit detach timer has expired, or if the EMM context data related to the subscription does not exist in the MME e.g. because of a MME restart, or because of a periodic tracking area update request routed to a new MME.

A.2 Cause related to subscription options

Cause #5 – IMEI not accepted

This cause is sent to the UE if the network does not accept an attach procedure for emergency bearer services using an IMEI.

Cause #7 – EPS services not allowed

This EMM cause is sent to the UE when it is not allowed to operate EPS services.

Cause #8 – EPS services and non-EPS services not allowed

This EMM cause is sent to the UE when it is not allowed to operate either EPS or non-EPS services.

Cause #11 – PLMN not allowed

This EMM cause is sent to the UE if it requests service, or if the network initiates a detach request, in a PLMN where the UE, by subscription or due to operator determined barring, is not allowed to operate.

Cause #12 – Tracking area not allowed

This EMM cause is sent to the UE if it requests service, or if the network initiates a detach request, in a tracking area where the HPLMN determines that the UE, by subscription, is not allowed to operate.

NOTE 1: If EMM cause #12 is sent to a roaming subscriber the subscriber is denied service even if other PLMNs are available on which registration was possible.

Cause #13 – Roaming not allowed in this tracking area

This EMM cause is sent to an UE which requests service, or if the network initiates a detach request, in a tracking area of a PLMN which by subscription offers roaming to that UE but not in that tracking area.

Cause #14 – EPS services not allowed in this PLMN

This EMM cause is sent to the UE which requests service, or if the network initiates a detach request, in a PLMN which does not offer roaming for EPS services to that UE.

NOTE 2: Since only one list of forbidden PLMNs for packet services is maintained in the UE, then the "forbidden PLMNs for GPRS service" is the maintained list and the forbidden PLMNs for EPS service is equivalent to it.

Cause #15 – No suitable cells in tracking area

This EMM cause is sent to the UE if it requests service, or if the network initiates a detach request, in a tracking area where the UE, by subscription, is not allowed to operate, but when it should find another allowed tracking area or location area in the same PLMN or an equivalent PLMN.

NOTE 3: Cause #15 and cause #12 differ in the fact that cause #12 does not trigger the UE to search for another allowed tracking area on the same PLMN.

Cause #25 – Not authorized for this CSG

This EMM cause is sent to the UE if it requests access, or if the network initiates a detach request, in a CSG cell with CSG ID where the UE either has no subscription to operate or the UE's subscription has expired and it should find another cell in the same PLMN or an equivalent PLMN.

Cause #35 – Requested service option not authorized in this PLMN

This EMM cause is sent to the UE if it requests in a PLMN a service option for which it is not authorized, e.g. if it attempts to attach for relay node operation in a PLMN with a USIM which does not belong to a relay node-specific subscription.

Cause #40 – No EPS bearer context activated

This EMM cause is sent to the UE, if during a tracking area updating procedure or a service request, the MME detects that there is no active EPS bearer context in the network.

A.3 Causes related to PLMN specific network failures and congestion/authentication failures

Cause #16 – MSC temporarily not reachable

This EMM cause is sent to the UE if it requests a combined EPS attach or tracking area updating in a PLMN where the MSC is temporarily not reachable via the EPS part of the network.

Cause #17 – Network failure

This EMM cause is sent to the UE if the MME cannot service an UE generated request because of PLMN failures.

Cause #18 – CS domain not available

This EMM cause is sent to the UE if the MME cannot service an UE generated request because CS domain is not available and SMS in MME is not supported.

Cause #19 – ESM failure

This EMM cause is sent to the UE when there is a failure in the ESM message contained in the EMM message.

Cause #20 – MAC failure

This EMM cause is sent to the network if the USIM detects that the MAC in the AUTHENTICATION REQUEST message is not fresh (see 3GPP TS 33.401 [19]).

Cause #21 – Synch failure

This EMM cause is sent to the network if the USIM detects that the SQN in the AUTHENTICATION REQUEST message is out of range (see 3GPP TS 33.401 [19]).

Cause #22 – Congestion

This EMM cause is sent to the UE because of congestion in the network (e.g. no channel, facility busy/congested etc.).

Cause #23 – UE security capabilities mismatch

This EMM cause is sent to the network if the UE detects that the UE security capability does not match the one sent back by the network.

Cause #24 – Security mode rejected, unspecified

This EMM cause is sent to the network if the security mode command is rejected by the UE if the UE detects that the $nonce_{UE}$ does not match the one sent back by the network or for unspecified reasons.

Cause #26 – Non-EPS authentication unacceptable

This EMM cause is sent to the network in S1 mode if the "separation bit" in the AMF field of AUTN is set to 0 in the AUTHENTICATION REQUEST message (see 3GPP TS 33.401 [19]).

Cause #39 – CS service temporarily not available

This EMM cause is sent to the UE when the CS fallback or 1xCS fallback request cannot be served temporarily due to O&M reasons or a mobile terminating CS fallback call is aborted by the network during call establishment (see 3GPP TS 29.118 [16A]).

Cause #42 – Severe network failure

This EMM cause is sent to the UE when the network has determined that the requested procedure cannot be completed successfully due to network failure. The failure is not expected to be temporary and repeated request is not likely to succeed in near future.

A.4 Causes related to nature of request

NOTE: This subclause has no entries in this version of the specification

A.5 Causes related to invalid messages

Cause value #95 – Semantically incorrect message.

See 3GPP TS 24.008 [13], annex H, subclause H.5.5.

Cause value #96 – Invalid mandatory information.

See 3GPP TS 24.008 [13], annex H, subclause H.6.1.

Cause value #97 – Message type non-existent or not implemented.

See 3GPP TS 24.008 [13], annex H, subclause H.6.2.

Cause value #98 – Message type not compatible with protocol state.

See 3GPP TS 24.008 [13], annex H, subclause H.6.3.

Cause value #99 – Information element non-existent or not implemented.

See 3GPP TS 24.008 [13], annex H, subclause H.6.4.

Cause value #100 – Conditional IE error.

See 3GPP TS 24.008 [13], annex H, subclause H.6.5.

Cause value #101 – Message not compatible with protocol state.

See 3GPP TS 24.008 [13], annex H, subclause H.6.6.

Cause value #111 – Protocol error, unspecified.

See 3GPP TS 24.008 [13], annex H, subclause H.6.8.

Annex B (informative): Cause values for EPS session management

B.1 Causes related to nature of request

Cause #8 – Operator Determined Barring

This ESM cause is used by the network to indicate that the requested service was rejected by the MME due to Operator Determined Barring.

Cause #26 – Insufficient resources

This ESM cause is used by the UE or by the network to indicate that the requested service cannot be provided due to insufficient resources.

Cause #27 – Missing or unknown APN

This ESM cause is used by the network to indicate that the requested service was rejected by the external packet data network because the access point name was not included although required or if the access point name could not be resolved.

Cause #28 – Unknown PDN type

This ESM cause is used by the network to indicate that the requested service was rejected by the external packet data network because the PDN type could not be recognised.

Cause #29 – User authentication or authorization failed

This ESM cause is used by the network to indicate that the requested service was rejected by the external packet data network due to a failed user authentication or revoked by the external packet data network.

Cause #30 – Request rejected by Serving GW or PDN GW

This ESM cause is used by the network to indicate that the requested service or operation or the request for a resource was rejected by the Serving GW or PDN GW.

Cause #31 – Request rejected, unspecified

This ESM cause is used by the network or by the UE to indicate that the requested service or operation or the request for a resource was rejected due to unspecified reasons.

Cause #32 – Service option not supported

This ESM cause is used by the network when the UE requests a service which is not supported by the PLMN.

Cause #33 – Requested service option not subscribed

This ESM cause is sent when the UE requests a service option for which it has no subscription.

Cause #34 – Service option temporarily out of order

This ESM cause is sent when the network cannot service the request because of temporary outage of one or more functions required for supporting the service.

Cause #35 – PTI already in use

This ESM cause is used by the network to indicate that the PTI included by the UE is already in use by another active UE requested procedure for this UE.

Cause #36 – Regular deactivation

This ESM cause is used to indicate a regular UE or network initiated release of EPS bearer resources.

Cause #37 – EPS QoS not accepted

This ESM cause is used by the network if the new EPS QoS cannot be accepted that was indicated in the UE request.

Cause #38 – Network failure

This ESM cause is used by the network to indicate that the requested service was rejected due to an error situation in the network.

Cause #39 – Reactivation requested

This ESM cause is used by the network to request a PDN connection reactivation.

Cause #41 – Semantic error in the TFT operation.

This ESM cause is used by the network or the UE to indicate that the requested service was rejected due to a semantic error in the TFT operation included in the request.

Cause #42 – Syntactical error in the TFT operation.

This ESM cause is used by the network or the UE to indicate that the requested service was rejected due to a syntactical error in the TFT operation included in the request.

Cause #43 – Invalid EPS bearer identity

This ESM cause is used by the network or the UE to indicate that the EPS bearer identity value provided to it is not a valid value for the received message or the EPS bearer context identified by the linked EPS bearer identity IE in the request is not active.

Cause #44 – Semantic errors in packet filter(s)

This ESM cause is used by the network or the UE to indicate that the requested service was rejected due to one or more semantic errors in packet filter(s) of the TFT included in the request.

Cause #45 – Syntactical error in packet filter(s)

This ESM cause is used by the network or the UE to indicate that the requested service was rejected due to one or more syntactical errors in packet filter(s) of the TFT included in the request.

Cause #47 – PTI mismatch

This ESM cause is used by the UE to indicate that the PTI value which is included in the ESM message that the UE receives does not match a PTI in use.

Cause #49 – Last PDN disconnection not allowed

This ESM cause is used by the network, in case of EMM-REGISTERED without PDN connection is not supported by the UE or the MME, to indicate that the UE requested PDN disconnection procedure on the last remaining PDN connection is not allowed.

Cause #50 – PDN type IPv4 only allowed

This ESM cause is used by the network to indicate that only PDN type IPv4 is allowed for the requested PDN connectivity.

Cause #51 – PDN type IPv6 only allowed

This ESM cause is used by the network to indicate that only PDN type IPv6 is allowed for the requested PDN connectivity.

Cause #52 – single address bearers only allowed

This ESM cause is used by the network to indicate that the requested PDN connectivity is accepted with the restriction that only single IP version bearers are allowed.

Cause #53 – ESM information not received

This ESM cause is used by the network to indicate that the PDN connectivity procedure was rejected due to the ESM information was not received.

Cause #54 – PDN connection does not exist

This ESM cause is used by the network at handover from a non-3GPP access network to indicate that the MME does not have any information about the requested PDN connection.

Cause #55 – Multiple PDN connections for a given APN not allowed

This ESM cause is used by the network to indicate that the PDN connectivity procedure was rejected due to multiple PDN connections for a given APN are not allowed.

Cause #56 – Collision with network initiated request

This ESM cause is used by the network to indicate that the network has already initiated the activation, modification or deactivation of bearer resources which was requested by the UE.

Cause #57 – PDN type IPv4v6 only allowed

This ESM cause is used by the network to indicate that only PDN types IPv4, IPv6 or IPv4v6 are allowed for the requested PDN connectivity.

Cause #58 – PDN type non IP only allowed

This ESM cause is used by the network to indicate that only PDN type non IP is allowed for the requested PDN connectivity.

Cause #59 – Unsupported QCI value

This ESM cause is used by the network if the QCI indicated in the UE request cannot be supported.

Cause #60 – Bearer handling not supported

This ESM cause is used by the network to indicate that the procedure requested by the UE was rejected because the bearer handling is not supported.

Cause #65 – Maximum number of EPS bearers reached

This ESM cause is used by the network to indicate that the procedure requested by the UE was rejected as the network has reached the maximum number of simultaneously active EPS bearer contexts for the UE.

Cause #66 – Requested APN not supported in current RAT and PLMN combination

This ESM cause is used by the network to indicate that the procedure requested by the UE was rejected as the requested APN is not supported in the current RAT and PLMN.

Cause #81 – Invalid PTI value

This ESM cause is used by the network or UE to indicate that the PTI provided to it is unassigned or reserved.

Cause #112 – APN restriction value incompatible with active EPS bearer context.

This ESM cause is used by the network to indicate that the EPS bearer context(s) have an APN restriction value that is not allowed in combination with a currently active EPS bearer context. Restriction values are defined in 3GPP TS 23.060 [4].

Cause #113 –Multiple accesses to a PDN connection not allowed

This ESM cause is used by the network to indicate that multiple accesses to a PDN connection for NBIFOM is not allowed.

B.2 Protocol errors (e.g., unknown message) class

Cause #95 – Semantically incorrect message

This ESM cause is used to report receipt of a message with semantically incorrect contents.

Cause #96 – Invalid mandatory information

This ESM cause indicates that the equipment sending this ESM cause has received a message with a non-semantical mandatory IE error.

Cause #97 – Message type non-existent or not implemented

This ESM cause indicates that the equipment sending this ESM cause has received a message with a message type it does not recognize either because this is a message not defined, or defined but not implemented by the equipment sending this ESM cause.

Cause #98 – Message type not compatible with protocol state

This ESM cause indicates that the equipment sending this ESM cause has received a message not compatible with the protocol state.

Cause #99 – Information element non-existent or not implemented

This ESM cause indicates that the equipment sending this ESM cause has received a message which includes information elements not recognized because the information element identifier is not defined or it is defined but not implemented by the equipment sending the ESM cause. However, the information element is not required to be present in the message in order for the equipment sending the ESM cause to process the message.

Cause #100 – Conditional IE error

This ESM cause indicates that the equipment sending this cause has received a message with conditional IE errors.

Cause #101 – Message not compatible with protocol state

This ESM cause indicates that a message has been received which is incompatible with the protocol state.

Cause #111 – Protocol error, unspecified

This ESM cause is used to report a protocol error event only when no other ESM cause in the protocol error class applies.

Annex C (normative): Storage of EMM information

The following EMM parameters shall be stored on the USIM if the corresponding file is present:

- GUTI;
- last visited registered TAI;
- EPS update status;
- Allowed CSG list;
- Operator CSG list; and
- EPS security context parameters from a full native EPS security context (see 3GPP TS 33.401 [19]).

The presence and format of corresponding files on the USIM is specified in 3GPP TS 31.102 [17].

If the corresponding file is not present on the USIM, these EMM parameters except allowed CSG list are stored in a non-volatile memory in the ME together with the IMSI from the USIM. The allowed CSG list is stored in a non-volatile memory in the ME if the UE supports CSG selection. These EMM parameters can only be used if the IMSI from the USIM matches the IMSI stored in the non-volatile memory; else the UE shall delete the EMM parameters.

The following EMM parameters shall be stored in a non-volatile memory in the ME together with the IMSI from the USIM:

- TIN; and
- DCN-ID list.

The TIN parameter can only be used if the IMSI from the USIM matches the IMSI stored in the non-volatile memory of the ME; else the UE shall delete the TIN parameter.

The DCN-ID list consists of DCN-IDs stored together with a PLMN identity. The list can have zero or more entries and the maximum length shall be at least 32 entries. When the maximum length is reached any new entry shall replace the oldest entry in the list. There shall be no duplicated PLMN identities in the list and any existing DCN-ID shall be deleted when a new DCN-ID is added for the same PLMN.

The DCN-ID list can only be used if the IMSI from the USIM matches the IMSI stored in the non-volatile memory of the ME; else the UE shall delete the DCN-ID list. The UE shall delete the stored DCN-ID list if the default standardized DCN-ID in the UE is changed.

If the UE is attached for emergency bearer services, the UE shall not store the EMM parameters described in this annex on the USIM or in non-volatile memory. Instead the UE shall temporarily store these parameters locally in the ME and the UE shall delete these parameters when the UE is detached.

If the UE is configured for eCall only mode as specified in 3GPP TS 31.102 [17], the UE shall not store the EMM parameters described in this annex on the USIM or in non-volatile memory. Instead the UE shall temporarily store these parameters locally in the ME and the UE shall delete these parameters when the UE enters EMM-DEREGISTERED.eCALL-INACTIVE state, the UE is switched-off or the USIM is removed.

Annex D (normative): Establishment cause (S1 mode only)

D.1 Mapping of NAS procedure to RRC establishment cause (S1 mode only)

When EMM requests the establishment of a NAS-signalling connection, or when EMM requests the lower layers to resume a NAS signalling connection, the RRC establishment cause used by the UE shall be selected according to the NAS procedure as specified in table D.1.1. The EMM shall also indicate to the lower layer for the purpose of access control, the call type associated with the RRC establishment cause as specified in table D.1.1. If the UE is configured for EAB (see the "ExtendedAccessBarring" leaf of NAS configuration MO in 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17]), the EMM shall indicate to the lower layer for the purpose of access control that EAB applies for this request except for the following cases:

- the UE is a UE configured to use AC11 – 15 in selected PLMN;
- the UE is answering to paging;
- the RRC Establishment cause is set to "Emergency call";
- the UE is configured to allow overriding EAB (see the "Override_ExtendedAccessBarring" leaf of the NAS configuration MO as specified in 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17]) and receives an indication from the upper layers to override EAB; or
- the UE is configured to allow overriding EAB (see the "Override_ExtendedAccessBarring" leaf of the NAS configuration MO as specified in 3GPP TS 24.368 [15A] or 3GPP TS 31.102 [17]) and already has a PDN connection that was established with EAB override.

Table D.1.1: Mapping of NAS procedure to establishment cause and call type

NAS procedure	RRC establishment cause (according 3GPP TS 36.331 [22])	Call type
Attach	If an ATTACH REQUEST has EPS attach type not set to "EPS emergency attach", the RRC establishment cause shall be set to MO signalling except when the UE initiates attach procedure to establish emergency bearer services. (See Note 1)	"originating signalling"
	Iif an ATTACH REQUEST contains the Device properties IE with low priority indicator set to "MS is configured for NAS signalling low priority", the RRC establishment cause shall be set to Delay tolerant. (See Note 1)	"originating signalling"
	If an ATTACH REQUEST has EPS attach type set to "EPS emergency attach", or if the ATTACH REQUEST has EPS attach type not set to "EPS emergency attach" but the UE initiates the attach procedure either on receiving request from upper layer to establish emergency bearer services or with a PDN CONNECTIVITY REQUEST that has request type set to "handover of emergency bearer services", the RRC establishment cause shall be set to Emergency call. (See Note 1, Note 4)	"emergency calls"
	If the UE is allowed to use exception data reporting (see the ExceptionDataReportingAllowed leaf of the NAS configuration MO in 3GPP TS 24.368 [15A] or the USIM file $EF_{NASCONFIG}$ in 3GPP TS 31.102 [17]) and the attach procedure has been initiated upon receiving a request from upper layers to transmit user data related to an exceptional event, the RRC establishment cause shall be set to MO exception data. (See Note 1)	"originating signalling"

Tracking Area Update	If the UE does not have a PDN connection established for emergency bearer services and is not initiating a PDN CONNECTIVITY REQUEST that has request type set to "emergency" or "handover of emergency bearer services", and MO MMTEL voice call is not started, MO MMTEL video call is not started, MO SMSoIP is not started, MO SMS over NAS or MO SMS over S102 is not requested, the RRC establishment cause shall be set to MO signalling. (See Note 1)	"originating signalling"
	If the UE does not have a PDN connection established for emergency bearer services and is not initiating a PDN CONNECTIVITY REQUEST that has request type set to "emergency" or "handover of emergency bearer services", and an MO MMTEL voice call is started, the RRC establishment cause shall be set to MO signalling. (See Note 1, Note 3)	"originating MMTEL voice"
	If the UE does not have a PDN connection established for emergency bearer services and is not initiating a PDN CONNECTIVITY REQUEST that has request type set to "emergency" or "handover of emergency bearer services", and an MO MMTEL video call is started, the RRC establishment cause shall be set to MO signalling. (See Note 1, Note 3)	"originating MMTEL video"
	If the UE does not have a PDN connection established for emergency bearer services and is not initiating a PDN CONNECTIVITY REQUEST that has request type set to "emergency" or "handover of emergency bearer services", and an MO SMSoIP is started, the RRC establishment cause shall be set to MO signalling. (See Note 1)	"originating SMSoIP"
	If the UE does not have a PDN connection established for emergency bearer services and is not initiating a PDN CONNECTIVITY REQUEST that has request type set to "emergency" or "handover of emergency bearer services", and an MO SMS over NAS or MO SMS over S102 is requested, the RRC establishment cause shall be set to MO signalling. (See Note 1)	"originating SMS"
	If the UE does not have a PDN connection established for emergency bearer services and is not initiating a PDN CONNECTIVITY REQUEST that has request type set to "emergency" or "handover of emergency bearer services", the tracking area update procedure is not triggered due to paging, a TRACKING AREA UPDATE REQUEST contains the Device properties IE with low priority indicator set to "MS is configured for NAS signalling low priority", and MO MMTEL voice call is not started, MO MMTEL video call is not started, MO SMSoIP is not started, MO SMS over NAS or MO SMS over S102 is not requested, the RRC establishment cause shall be set to Delay tolerant. (See Note 1)	"originating signalling"
	If the UE does not have a PDN connection established for emergency bearer services and is not initiating a PDN CONNECTIVITY REQUEST that has request type set to "emergency" or "handover of emergency bearer services", an MO MMTEL voice call is started, and a TRACKING AREA UPDATE REQUEST contains the Device properties IE with low priority indicator set to "MS is configured for NAS signalling low priority", the RRC establishment cause shall be set to MO signalling. (See Note 1, Note 3)	"originating MMTEL voice"

	If the UE does not have a PDN connection established for emergency bearer services and is not initiating a PDN CONNECTIVITY REQUEST that has request type set to "emergency" or "handover of emergency bearer services", an MO MMTEL video call is started, and a TRACKING AREA UPDATE REQUEST contains the Device properties IE with low priority indicator set to "MS is configured for NAS signalling low priority", the RRC establishment cause shall be set to MO signalling. (See Note 1, Note 3)	"originating MMTEL video"
	If the UE does not have a PDN connection established for emergency bearer services and is not initiating a PDN CONNECTIVITY REQUEST that has request type set to "emergency" or "handover of emergency bearer services", an MO SMSoIP is started, and a TRACKING AREA UPDATE REQUEST contains the Device properties IE with low priority indicator set to "MS is configured for NAS signalling low priority", the RRC establishment cause shall be set to MO signalling. (See Note 1)	"originating SMSoIP"
	If the UE does not have a PDN connection established for emergency bearer services and is not initiating a PDN CONNECTIVITY REQUEST that has request type set to "emergency" or "handover of emergency bearer services", an MO SMS over NAS or MO SMS over S102 is requested, and a TRACKING AREA UPDATE REQUEST contains the Device properties IE with low priority indicator set to "MS is configured for NAS signalling low priority", the RRC establishment cause shall be set to MO signalling. (See Note 1)	"originating SMS"
	If the UE does not have a PDN connection established for emergency bearer services and is not initiating a PDN CONNECTIVITY REQUEST that has request type set to "emergency" or "handover of emergency bearer services", and a TRACKING AREA UPDATE REQUEST is a response to paging where the CN domain indicator is set to "PS" or "CS", the RRC establishment cause shall be set to MT access. (See Note 1)	"terminating calls"
	If the UE has CS fallback emergency call or 1xCS fallback emergency call pending, the RRC establishment cause shall be set to Emergency call. (See Note 1)	"emergency calls"
	If the UE has a PDN connection established for emergency bearer services or is initiating a PDN CONNECTIVITY REQUEST that has request type set to "emergency" or "handover of emergency bearer services", the RRC establishment cause shall be set to Emergency call. (See Note 1)	"emergency calls"
	If the UE is allowed to use exception data reporting (see the ExceptionDataReportingAllowed leaf of the NAS configuration MO in 3GPP TS 24.368 [15A] or the USIM file $EF_{NASCONFIG}$ in 3GPP TS 31.102 [17]) and there is a pending request from upper layers to transmit user data related to an exceptional event, the RRC establishment cause shall be set to MO exception data.	"originating signalling"
	If the UE is requesting resources for V2X communication over PC5, the RRC establishment cause shall be set to MO signalling. (See Note 1)	"originating signalling"
	If the UE is requesting resources for V2X communication over PC5 and a TRACKING AREA UPDATE REQUEST contains the Device properties IE with low priority indicator set to "MS is configured for NAS signalling low priority", the RRC establishment cause shall be set to Delay tolerant. (See Note 1)	"originating signalling"

	If the UE is requesting resources for ProSe direct discovery or ProSe direct communication as specified in 3GPP TS 36.331 [22], the RRC establishment cause shall be set to MO signalling. (See Note 1)	"originating signalling"
	If the UE is requesting resources for ProSe direct discovery or ProSe direct communication as specified in 3GPP TS 36.331 [22] and a TRACKING AREA UPDATE REQUEST contains the Device properties IE with low priority indicator set to "MS is configured for NAS signalling low priority", the RRC establishment cause shall be set to Delay tolerant. (See Note 1)	"originating signalling"
Detach	MO signalling (See Note 1)	"originating signalling"
Service Request	If a SERVICE REQUEST is to request user plane radio resources and MO MMTEL voice call is not started, MO MMTEL video call is not started and MO SMSoIP is not started, the RRC establishment cause shall be set to MO data. (See Note 1)	"originating calls"
	If a SERVICE REQUEST is to request user plane radio resources and an MO MMTEL voice call is started, the RRC establishment cause shall be set to MO data. (See Note 1, Note 3)	"originating MMTEL voice"
	If a SERVICE REQUEST is to request user plane radio resources and an MO MMTEL video call is started, the RRC establishment cause shall be set to MO data. (See Note 1, Note 3)	"originating MMTEL video"
	If a SERVICE REQUEST is to request user plane radio resources and an MO SMSoIP is started, the RRC establishment cause shall be set to MO data. (See Note 1)	"originating SMSoIP"
	If a SERVICE REQUEST is to request user plane radio resources for emergency bearer services, the RRC establishment cause shall be set to Emergency call. (See Note 1)	"emergency calls"
	If a SERVICE REQUEST is to request resources for UL signalling and not for MO SMS over NAS or MO SMS over S102, the RRC establishment cause shall be set to MO data. (See Note 1)	"originating calls"
	If a SERVICE REQUEST is to request resources for UL signalling for MO SMS over NAS or MO SMS over S102, the RRC establishment cause shall be set to MO data. (See Note 1)	"originating SMS"
	If a SERVICE REQUEST is to request user plane radio resources or to request resources for UL signalling and the UE is configured for dual priority and the NAS signalling low priority indicator is overridden, the RRC establishment cause shall be set to MO data. (See Note 1)	"originating calls"
	If a SERVICE REQUEST is triggered by a PDN CONNECTIVITY REQUEST that has request type set to "emergency" or "handover of emergency bearer services", the RRC establishment cause shall be set to Emergency call. (See Note 1)	"emergency calls"
	If a SERVICE REQUEST is to request user plane radio resources or to request resources for UL signalling, the UE is configured for NAS signalling low priority, and MO MMTEL voice call is not started, MO MMTEL video call is not started and MO SMSoIP is not started, MO SMS over NAS or MO SMS over S102 is not requested, the RRC establishment cause shall be set to Delay tolerant. (See Note 1)	"originating calls"
	If a SERVICE REQUEST is to request user plane radio resources, an MO MMTEL voice call is started, and the UE is configured for NAS signalling low priority, the RRC establishment cause shall be set to MO data. (See Note 1, Note 3)	"originating MMTEL voice"

	If a SERVICE REQUEST is to request user plane radio resources, an MO MMTEL video call is started, and the UE is configured for NAS signalling low priority, the RRC establishment cause shall be set to MO data. (See Note 1, Note 3)	"originating MMTEL video"
	If a SERVICE REQUEST is to request user plane radio resources, an MO SMSoIP is started, and the UE is configured for NAS signalling low priority, the RRC establishment cause shall be set to MO data. (See Note 1)	"originating SMSoIP"
	If a SERVICE REQUEST is to request resources for UL signalling for MO SMS over NAS or MO SMS over S102 and the UE is configured for NAS signalling low priority, the RRC establishment cause shall be set to MO data. (See Note 1)	"originating SMS"
	If a SERVICE REQUEST is a response to paging where the CN domain indicator is set to "PS", the RRC establishment cause shall be set to MT access. (See Note 1)	"terminating calls"
	If a SERVICE REQUEST is triggered to request resources for ProSe direct discovery or ProSe direct communication as specified in 3GPP TS 36.331 [22], the RRC establishment cause shall be set to MO data. (See Note 1)	"originating calls"
	If a SERVICE REQUEST is triggered to request resources for ProSe direct discovery or ProSe direct communication as specified in 3GPP TS 36.331 [22] and the UE is configured for NAS signalling low priority, the RRC establishment cause shall be set to Delay tolerant. (See Note 1)	"originating calls"
	If a SERVICE REQUEST is triggered to request resources for V2X communication over PC5, the RRC establishment cause shall be set to MO data. (See Note 1)	"originating calls"
	If a SERVICE REQUEST is triggered to request resources for V2X communication over PC5 and the UE is configured for NAS signalling low priority, the RRC establishment cause shall be set to Delay tolerant. (See Note 1)	"originating calls"
	If an EXTENDED SERVICE REQUEST has service type set to "packet services via S1" and is to request user plane radio resources for emergency bearer services, the RRC establishment cause shall be set to Emergency call. (See Note 1)	"emergency calls"
	If an EXTENDED SERVICE REQUEST has service type set to "packet services via S1" and is triggered by a PDN CONNECTIVITY REQUEST that has request type set to "emergency" or "handover of emergency bearer services", the RRC establishment cause shall be set to Emergency call. (See Note 1)	"emergency calls"
	If an EXTENDED SERVICE REQUEST has service type set to "packet services via S1" and is a response to paging where the CN domain indicator is set to "PS", the RRC establishment cause shall be set to MT access. (See Note 1)	"terminating calls"

	If an EXTENDED SERVICE REQUEST has service type set to "mobile originating CS fallback or 1xCS fallback" and is to request mobile originating 1xCS fallback, or if an EXTENDED SERVICE REQUEST is a response to paging for 1xCS fallback received over cdma2000® 1xRTT and has service type set to "mobile terminating CS fallback or 1xCS fallback", the RRC establishment cause shall be set to MO data. (See Note 1).	"originating calls"
	If an EXTENDED SERVICE REQUEST has service type set to "mobile originating CS fallback or 1xCS fallback" and is to request mobile originating CS fallback, the RRC establishment cause shall be set to MO data. (See Note 1).	"mobile originating CS fallback"
	If an EXTENDED SERVICE REQUEST is a response to paging for CS fallback, service type set to "mobile terminating CS fallback or 1xCS fallback", the RRC establishment cause shall be set to MT access. (See Note1, Note 2).	"terminating calls"
	If an EXTENDED SERVICE REQUEST has service type set to "mobile originating CS fallback emergency call or 1xCS fallback emergency call", the RRC establishment cause shall be set to Emergency call. (See Note 1).	"emergency calls"
	If an EXTENDED SERVICE REQUEST contains the Device properties IE with low priority indicator set to "MS is not configured for NAS signalling low priority", and MO MMTEL voice call is not started, MO MMTEL video call is not started and MO SMSoIP is not started, MO SMS over NAS or MO SMS over S102 is not requested, the RRC establishment cause shall be set to MO data. (See Note 1)	"originating calls"
	If an EXTENDED SERVICE REQUEST contains the Device properties IE with low priority indicator set to "MS is not configured for NAS signalling low priority" and an MO MMTEL voice call is started, the RRC establishment cause shall be set to MO data. (See Note 1, Note 3)	"originating MMTEL voice"
	If an EXTENDED SERVICE REQUEST contains the Device properties IE with low priority indicator set to "MS is not configured for NAS signalling low priority" and an MO MMTEL video call is started, the RRC establishment cause shall be set to MO data. (See Note 1, Note 3)	"originating MMTEL video"
	If an EXTENDED SERVICE REQUEST contains the Device properties IE with low priority indicator set to "MS is not configured for NAS signalling low priority" and an MO SMSoIP is started, the RRC establishment cause shall be set to MO data. (See Note 1)	"originating SMSoIP"
	If an EXTENDED SERVICE REQUEST contains the Device properties IE with low priority indicator set to "MS is not configured for NAS signalling low priority" and an MO SMS over NAS or MO SMS over S102 is requested, the RRC establishment cause shall be set to MO data. (See Note 1)	"originating SMS"
	If an EXTENDED SERVICE REQUEST contains the Device properties IE with low priority indicator set to "MS is configured for NAS signalling low priority", and MO MMTEL voice call is not started, MO MMTEL video call is not started and MO SMSoIP is not started, MO SMS over NAS or MO SMS over S102 is not requested, the RRC establishment cause shall be set to Delay tolerant. (See Note 1).	"originating calls"
	If an EXTENDED SERVICE REQUEST contains the Device properties IE with low priority indicator set to "MS is configured for NAS signalling low priority" and an MO MMTEL voice call is started, the RRC establishment cause shall be set to MO data. (See Note 1, Note 3)	"originating MMTEL voice"

	If an EXTENDED SERVICE REQUEST contains the Device properties IE with low priority indicator set to "MS is configured for NAS signalling low priority" and an MO MMTEL video call is started, the RRC establishment cause shall be set to MO data. (See Note 1, Note 3)	"originating MMTEL video"
	If an EXTENDED SERVICE REQUEST contains the Device properties IE with low priority indicator set to "MS is configured for NAS signalling low priority" and an MO SMSoIP is started, the RRC establishment cause shall be set to MO data. (See Note 1)	"originating SMSoIP"

	If an EXTENDED SERVICE REQUEST contains the Device properties IE with low priority indicator set to "MS is configured for NAS signalling low priority" and an MO SMS over NAS or MO SMS over S102 is requested, the RRC establishment cause shall be set to MO data. (See Note 1)	"originating SMS"
	If an EXTENDED SERVICE REQUEST contains the Device properties IE with low priority indicator set to "MS is not configured for NAS signalling low priority" and is triggered to request resources for ProSe direct discovery or ProSe direct communication, the RRC establishment cause shall be set to MO data. (See Note 1)	"originating calls"
	If an EXTENDED SERVICE REQUEST contains the Device properties IE with low priority indicator set to "MS is configured for NAS signalling low priority" and is triggered to request resources for ProSe direct discovery or ProSe direct communication, the RRC establishment cause shall be set to Delay tolerant. (See Note 1)	"originating calls"
	If an EXTENDED SERVICE REQUEST contains the Device properties IE with low priority indicator set to "MS is not configured for NAS signalling low priority" and is triggered to request resources for V2X communication over PC5, the RRC establishment cause shall be set to MO data. (See Note 1)	"originating calls"
	If an EXTENDED SERVICE REQUEST contains the Device properties IE with low priority indicator set to "MS is configured for NAS signalling low priority" and is triggered to request resources for V2X communication over PC5, the RRC establishment cause shall be set to Delay tolerant. (See Note 1)	"originating calls"
	If a CONTROL PLANE SERVICE REQUEST is a response to paging where the Control plane service type is set to "mobile terminating request", the RRC establishment cause shall be set to MT access. (see Note 1)	"terminating calls"
	If a CONTROL PLANE SERVICE REQUEST is to transfer user data or to request resources for UL signalling , the RRC establishment cause shall be set to MO data. (see Note 1)	"originating calls"
	If a CONTROL PLANE SERVICE REQUEST is to transfer user data or to request resources for UL signalling and contains the Device properties IE with low priority indicator set to "MS is configured for NAS signalling low priority", the RRC establishment cause shall be set to Delay tolerant. (see Note 1)	"originating calls"
	In WB-S1 Mode, if a CONTROL PLANE SERVICE REQUEST is to transfer MO SMS, the RRC establishment cause shall be set to MO data. (see Note 1)	"originating SMS"
	In NB-S1 Mode, if a CONTROL PLANE SERVICE REQUEST is to transfer MO SMS, the RRC establishment cause shall be set to MO data.	"originating calls"
	In NB-S1 Mode, if a CONTROL PLANE SERVICE REQUEST is to transfer MO SMS and contains the Device properties IE with low priority indicator set to "MS is configured for NAS signalling low priority", the RRC establishment cause shall be set to Delay tolerant.	"originating calls"
	If the UE is allowed to use exception data reporting (see the ExceptionDataReportingAllowed leaf of the NAS configuration MO in 3GPP TS 24.368 [15A] or the USIM file $EF_{NASCONFIG}$ in 3GPP TS 31.102 [17]) and a CONTROL PLANE SERVICE REQUEST is to perform initial data transfer related to an exceptional event, the RRC establishment cause shall be set to MO exception data.	"originating calls"

Note 1:	For these NAS procedures in WB-S1 mode initiated by UEs of access class 12, 13 or 14 in their home country, the RRC establishment cause will be set to "High priority access AC 11 – 15". For this purpose, the home country is defined as the country to which the MCC part of the IMSI is associated, see 3GPP TS 23.122 [6] for the definition of country. For these NAS procedures in WB-S1 mode initiated by UE of access class 11 or 15 in their HPLMN (if the EHPLMN list is not present or is empty) or EHPLMN (if the EHPLMN list is present), the RRC establishment cause will be set to "High priority access AC 11 – 15".
Note 2:	This row is not applicable for mobile terminating 1xCS fallback with 1xCS paging request received over E-UTRAN.
Note 3:	For these NAS procedures, the lower layers can change the RRC establishment cause from "MO data" or from "MO Signalling" to "MO Voice Call", if the serving cell requests the UE to use the RRC establishment cause "MO voice call" (see 3GPP TS 36.331 [22]).
Note 4:	It is an implementation option to initiate attach request carrying a PDN CONNECTIVITY REQUEST with request type "handover of emergency bearer services" to support access transfer of an ongoing emergency session from non-3GPP access to 3GPP access when the UE is not already in EMM_REGISTERED state.

NOTE: The RRC establishment cause can be used by the network to prioritise the connection establishment request from the UE at high load situations in the network.

Annex E (informative): Guidelines for enhancements to MS network capability IE and UE network capability IE

The UE uses the information elements MS network capability and UE network capability to inform the core network about its network related capabilities. Both information elements can be signalled in any of the modes: A/Gb mode, Iu mode and S1 mode.

The purpose of the present annex is to give some guidelines how to select the information element(s) to be enhanced if new capabilities need to be added.

1) If a capability is related to a feature that can be used in a network supporting A/Gb mode only or Iu mode only or both, the capability will be signalled in the MS network capability IE.

2) If a capability is related to a feature that can be used in network supporting S1 mode only, the capability will be signalled in the UE network capability IE.

3) If a capability is related to a feature that can be used only in a network supporting both S1 mode and at least one of the two modes A/Gb mode and Iu mode, the capability is added only to one of the two information elements:

   a) If the information is used by the MME only, the capability will be signalled in the UE network capability IE.

   b) If the information is used by the SGSN only or both by the SGSN and by the MME, the capability will be signalled in the MS network capability IE.

NOTE: The reason for rules 1 and 2 is that a UE not supporting A/Gb mode and Iu mode will not provide the MS network capability IE to the network and a UE not supporting S1 mode will not provide the UE network capability IE. In some cases, due to rules 1 and 2 the capability indicator will be included in both information elements.

EXAMPLE 1: The support indicator for UCS2 is included in both information elements.

EXAMPLE 2: The "SRVCC to GERAN/UTRAN capability" is included in the MS network capability IE, as it is used both by the MME for SRVCC from E-UTRAN to GERAN/UTRAN and by the SGSN for SRVCC from UTRAN HSPA to GERAN/UTRAN.

Annex F (normative): Application specific Congestion control for Data Communication (ACDC)

The UE may support the procedures in this annex.

If the UE supports ACDC, the EMM layer shall determine the ACDC category applicable to the request based on the application identifier received from the upper layers and the configuration information in the "ACDCConf" leaf of ACDC MO as specified in 3GPP TS 24.105 [35] or in the USIM EF_{ACDC} as specified in 3GPP TS 31.102 [17].

NOTE 1: As an implementation option, the upper layers can determine the ACDC category and send it to the EMM layer. Then the EMM layer need not read the ACDC MO or USIM to determine the ACDC category.

The EMM sublayer shall indicate to the lower layers, for the purpose of access control:

- the ACDC category that applies to this request if only one ACDC category is applicable;
- the highest ranked ACDC category among the ACDC categories that applies to this request if multiple ACDC categories are applicable; or
- this request is for an uncategorized application if an application identifier received from the upper layers is not mapped to any ACDC category,

except for the following cases:

- the UE is a UE configured to use AC11 – 15 in selected PLMN;
- the UE is answering to paging;
- the RRC Establishment cause is set to "Emergency call"; or
- if conditions MO MMTEL voice call is started or MO MMTEL video call is started or MO SMSoIP is started, is satisfied.

NOTE 2: The request from the EMM sublayer refers to either a request to establish an initial NAS signalling connection or a request to re-establish a NAS signalling connection.

If the UE supports ACDC and access is barred because of ACDC, the EMM layer shall keep track of the ACDC category for which access is barred and it shall not send a request for the same ACDC category or a lower ACDC category until access is granted.

If the UE supports ACDC and access is barred because of ACDC, the EMM layer shall not send a request for any uncategorized application until access is granted.

Annex G (informative): Change history

Change history							
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
2008-02					Draft skeleton provided		0.0.0
2008-02	CT1#51 bis				Includes the following contributions agreed by CT1: C1-080690, C1-080743, C1-080769	0.0.0	0.1.0
2008-03	e-mail review				Correction of references that were not updated during the implementation of C1-080769	0.1.0	0.1.1
2008-04	CT1#52				Includes the following contributions agreed by CT1: C1-080943, C1-081020, C1-081037, C1-081057, C1-081058, C1-081268, C1-081269, C1-081272, C1-081273, C1-081278, C1-081280, C1-081289, C1-081290, C1-081291, C1-081292, C1-081296, C1-081301, C1-081302, C1-081387, C1-081407, C1-081409, C1-081417, C1-081418, C1-081436, C1-081437, C1-081438, C1-081439, C1-081440, C1-081442	0.1.1	0.2.0
2008-05	CT1#53				Includes the following contributions agreed by CT1: C1-081650, C1-081651, C1-081878, C1-081886, C1-081887, C1-081888, C1-081889, C1-081890, C1-081971, C1-081972, C1-081973, C1-081974, C1-081975, C1-081978, C1-081979, C1-081988, C1-081989, C1-081990, C1-081991, C1-081992, C1-081993, C1-081994, C1-081996, C1-081997, C1-081998, C1-081999, C1-082000, C1-082062, C1-082095, C1-082097, C1-082099, C1-082100, C1-082101, C1-082111	0.2.0	0.3.0
2008-07	CT1#54				Includes the following contributions agreed by CT1: C1-082125, C1-082126, C1-082282, C1-082415, C1-082432, C1-082485, C1-082487, C1-082510, C1-082572, C1-082573, C1-082574, C1-082577, C1-082578, C1-082579, C1-082580, C1-082586, C1-082588, C1-082589, C1-082633, C1-082634, C1-082635, C1-082636, C1-082701, C1-082702, C1-082703, C1-082705, C1-082719, C1-082720, C1-082722, C1-082723, C1-082724, C1-082725, C1-082726, C1-082727, C1-082728, C1-082729, C1-082791, C1-082794, C1-082795, C1-082797, C1-082802, C1-082807, C1-082811, C1-082816, C1-082819, C1-082820	0.3.0	0.4.0
2008-08	CT1#55				Includes the following contributions agreed by CT1: C1-082981, C1-082995, C1-082997, C1-083013, C1-083030, C1-083031, C1-083032, C1-083056, C1-083131, C1-083139, C1-083140, C1-083146, C1-083151, C1-083168, C1-083442, C1-083445, C1-083450, C1-083452, C1-083453, C1-083454, C1-083456, C1-083457, C1-083461, C1-083462, C1-083463, C1-083465, C1-083468, C1-083471, C1-083472, C1-083473, C1-083474, C1-083476, C1-083477, C1-083517, C1-083522, C1-083580, C1-083581, C1-083582, C1-083583, C1-083584, C1-083588, C1-083591, C1-083592, C1-083593, C1-083597, C1-083598, C1-083599, C1-083605, C1-083606, C1-083607, C1-083609, C1-083616, C1-083619, C1-083629, C1-083630, C1-083635, C1-083636, C1-083638	0.4.0	0.5.0
2008-09	-	-	-	-	Version 1.0.0 created for presentation to TSG CT#41 for information	0.5.0	1.0.0
2008-10	CT1#55 bis				Includes the following contributions agreed by CT1: C1-083788, C1-083789, C1-083948, C1-083949, C1-083953, C1-084002, C1-084012, C1-084104, C1-084143, C1-084144, C1-084146, C1-084308, C1-084310, C1-084316, C1-084329, C1-084332, C1-084333, C1-084335, C1-084337, C1-084338, C1-084340, C1-084341, C1-084343, C1-084344, C1-084346, C1-084348, C1-084349, C1-084351, C1-084352, C1-084353, C1-084355, C1-084357, C1-084358, C1-084359, C1-084360, C1-084362, C1-084381, C1-084475, C1-084478, C1-084479, C1-084480, C1-084484, C1-084490, C1-084491, C1-084492, C1-084499, C1-084551, C1-084554	1.0.0	1.1.0
2008-10	e-mail review				Correction of implementation of C1-084492	1.1.0	1.1.1
2008-10	e-mail review				Correction of implementation of C1-084353	1.1.1	1.1.2

2008-11	CT1#56				Includes the following contributions agreed by CT1: C1-084592, C1-084610, C1-084624, C1-084627, C1-084666, C1-084668, C1-084747, C1-084785, C1-084925, C1-084926, C1-084976, C1-084977, C1-085167, C1-085170, C1-085171, C1-085172, C1-085174, C1-085175, C1-085178, C1-085180, C1-085199, C1-085304, C1-085310, C1-085312, C1-085313, C1-085315, C1-085317, C1-085356, C1-085372, C1-085381, C1-085385, C1-085387, C1-085388, C1-085390, C1-085392, C1-085394, C1-085396, C1-085398, C1-085399, C1-085505, C1-085506, C1-085508, C1-085509, C1-085510, C1-085511, C1-085512, C1-085513, C1-085514, C1-085515, C1-085518, C1-085520, C1-085521, C1-085528, C1-085533, C1-085539, C1-085540, C1-085541, C1-085542, C1-085545, C1-085550, C1-085551, C1-085552, C1-085553	1.1.2	1.2.0
2008-11	review				Correction of implementation of C1-084926, C1-085180	1.2.0	1.2.1
2008-11					Version 2.0.0 created for presentation to TSG CT#42 for approval	1.2.1	2.0.0
2008-12	CT-42				Version 8.0.0 created after approval in CT#42	2.0.0	8.0.0
2009-03	CT-43	CP-090153	0003	2	Clarification of the timer T3413 in paging procedure for CSFB	8.0.0	8.1.0
2009-03	CT-43	CP-090126	0004	2	Clarification of the abnormal case in UE requested PDN connectivity procedure	8.0.0	8.1.0
2009-03	CT-43	CP-090126	0006	1	Clarification on expiration of T3417	8.0.0	8.1.0
2009-03	CT-43	CP-090126	0010	1	Clean up the unuseful definition and complete sentence	8.0.0	8.1.0
2009-03	CT-43	CP-090127	0011	1	Cleanup the definition of the TAI list	8.0.0	8.1.0
2009-03	CT-43	CP-090131	0015	1	Updating the identities of forbidden tracking areas	8.0.0	8.1.0
2009-03	CT-43	CP-090153	0017	2	the handling of the UE after the EPS detach only	8.0.0	8.1.0
2009-03	CT-43	CP-090130	0019	2	Resolve editors'notes for NAS security	8.0.0	8.1.0
2009-03	CT-43	CP-090130	0022	1	APN-AMBR Clarifications	8.0.0	8.1.0
2009-03	CT-43	CP-090130	0023	2	State change to EMM-DEREGISTERED for non-3GPP access	8.0.0	8.1.0
2009-03	CT-43	CP-090131	0025	2	Updating the APN-AMBR of the UE after inter-system handover to S1 mode	8.0.0	8.1.0
2009-03	CT-43	CP-090129	0027	2	Provision of RRC establishment cause values by EPS NAS	8.0.0	8.1.0
2009-03	CT-43	CP-090131	0034	2	Update to Paging using IMSI procedure	8.0.0	8.1.0
2009-03	CT-43	CP-090131	0035	1	Update the PDN address IE to Mandatory	8.0.0	8.1.0
2009-03	CT-43	CP-090131	0037	1	Update to the detach procedure	8.0.0	8.1.0
2009-03	CT-43	CP-090130	0039	3	Security and inter RAT mobility to E-UTRAN	8.0.0	8.1.0
2009-03	CT-43	CP-090129	0040	1	KSI inclusion in Detach Request	8.0.0	8.1.0
2009-03	CT-43	CP-090128	0044	1	Editorials on security issues	8.0.0	8.1.0
2009-03	CT-43	CP-090125	0045	2	Behaviour on Service Reject(cause#10), relationship between SM and ESM state machines, inclusion of PDP context parameters	8.0.0	8.1.0
2009-03	CT-43	CP-090126	0046	2	Clarifications on issues for bearer context states	8.0.0	8.1.0
2009-03	CT-43	CP-090130	0050		Remove Editors Note for TAI length	8.0.0	8.1.0
2009-03	CT-43	CP-090130	0051	1	Correct use of cdma terminology	8.0.0	8.1.0
2009-03	CT-43	CP-090125	0059	1	Addition of actions on receiving an ESM STATUS message	8.0.0	8.1.0
2009-03	CT-43	CP-090125	0060	1	Addition of the definition of casue value #47 (PTI mismatch)	8.0.0	8.1.0
2009-03	CT-43	CP-090128	0061	1	Editorial corrections on the definition of default bearer and the ESM message names	8.0.0	8.1.0
2009-03	CT-43	CP-090127	0062	2	Correction to error cause value #9 and integrity check failure	8.0.0	8.1.0
2009-03	CT-43	CP-090129	0064		IPv6 interface identifier coding	8.0.0	8.1.0
2009-03	CT-43	CP-090126	0066	3	Clarification for local release of bearers	8.0.0	8.1.0
2009-03	CT-43	CP-090127	0068	1	Corrections for Attach failure procedure	8.0.0	8.1.0
2009-03	CT-43	CP-090130	0069	2	Re-transmission of EMM DL NAS message handling due to handover	8.0.0	8.1.0
2009-03	CT-43	CP-090130	0070	2	Re-transmission of ESM DL NAS message handling due to handover	8.0.0	8.1.0
2009-03	CT-43	CP-090129	0071		Paging for EPS services using IMSI and DRX	8.0.0	8.1.0
2009-03	CT-43	CP-090129	0075	2	Coordination of ESM and EMM sublayers for supporting ISR	8.0.0	8.1.0
2009-03	CT-43	CP-090128	0076	1	Handling of TAI list at the UE	8.0.0	8.1.0
2009-03	CT-43	CP-090131	0078	2	UE specific DRX Parameter handling in ATTACH/TAU procedure	8.0.0	8.1.0
2009-03	CT-43	CP-090131	0081	1	Handling of security context during state transitions	8.0.0	8.1.0
2009-03	CT-43	CP-090131	0082	2	Trigger for initiating ciphering protection	8.0.0	8.1.0
2009-03	CT-43	CP-090131	0085	2	UE action related to ISR local deactivation	8.0.0	8.1.0
2009-03	CT-43	CP-090153	0088	3	Clarification on CLI usage	8.0.0	8.1.0
2009-03	CT-43	CP-090153	0092	1	Abnormal case handling for Extended Service request	8.0.0	8.1.0
2009-03	CT-43	CP-090259	0093	4	UE behaviour when UE support of CSG selection is optional	8.0.0	8.1.0
2009-03	CT-43	CP-090153	0094	2	Conditions for initiating TAU and combined TAU	8.0.0	8.1.0
2009-03	CT-43	CP-090127	0095	1	Corrections for attach and TAU attempt counters	8.0.0	8.1.0
2009-03	CT-43	CP-090129	0096	1	Network initiated detach procedure corrections	8.0.0	8.1.0
2009-03	CT-43	CP-090128	0097	1	EMM states cleanup	8.0.0	8.1.0
2009-03	CT-43	CP-090128	0099	2	Supervision timer and corrections for the extended service request procedure	8.0.0	8.1.0
2009-03	CT-43	CP-090153	0100	1	Corrections for combined attach procedure	8.0.0	8.1.0
2009-03	CT-43	CP-090153	0102	2	Definition of NAS Message Container and Removal of Editor's Note	8.0.0	8.1.0

2009-03	CT-43	CP-090125	0103	1	Adding missing procedure figure to Service Request	8.0.0	8.1.0
2009-03	CT-43	CP-090128	0104	1	Introduction of the Local Emergency Numbers List	8.0.0	8.1.0
2009-03	CT-43	CP-090129	0105	2	New cause value for separation bit failure in authentication	8.0.0	8.1.0
2009-03	CT-43	CP-090153	0106	3	Solving editor's notes in Annex A.3	8.0.0	8.1.0
2009-03	CT-43	CP-090131	0109	2	Update on security procedure section	8.0.0	8.1.0
2009-03	CT-43	CP-090126	0112	1	Clarification on Dedicated bearer setup procedure failure	8.0.0	8.1.0
2009-03	CT-43	CP-090129	0116	1	New ESM cause value for collision with network initiated request	8.0.0	8.1.0
2009-03	CT-43	CP-090129	0117	1	Populating PDN type IE value in PDN CONNECTIVITY REQUEST message	8.0.0	8.1.0
2009-03	CT-43	CP-090153	0119	2	Extended service request for 1xCSFB	8.0.0	8.1.0
2009-03	CT-43	CP-090129	0125	1	ODB Error Cause Clarification	8.0.0	8.1.0
2009-03	CT-43	CP-090129	0128		NAS recovery on/off mechanism(LTE)	8.0.0	8.1.0
2009-03	CT-43	CP-090128	0129	1	Introduce definition of EPS services and non-EPS services	8.0.0	8.1.0
2009-03	CT-43	CP-090129	0131	1	Proposal of UE GMM and MM behavior on reception of error cause #9 when UE executed TAU, combined TAU and Service Request	8.0.0	8.1.0
2009-03	CT-43	CP-090126	0135	1	Clarifications on IP address handling	8.0.0	8.1.0
2009-03	CT-43	CP-090131	0136	1	Unsuccessful cases for pre-registration	8.0.0	8.1.0
2009-03	CT-43	CP-090131	0137	2	Use of P-TMSI for the attach procedure	8.0.0	8.1.0
2009-03	CT-43	CP-090127	0138		Cleanup of editor's notes	8.0.0	8.1.0
2009-03	CT-43	CP-090127	0139	1	Correction of the paging procedure	8.0.0	8.1.0
2009-03	CT-43	CP-090127	0140	1	Cleanup of editor's notes for ESM abnormal cases	8.0.0	8.1.0
2009-03	CT-43	CP-090127	0141		Definition of ESM cause #54	8.0.0	8.1.0
2009-03	CT-43	CP-090127	0142		Definition of security related IEs for inter-system handover	8.0.0	8.1.0
2009-03	CT-43	CP-090130	0143		Removal of ISR bit from UE network capability	8.0.0	8.1.0
2009-03	CT-43	CP-090127	0144		Correction of detach procedure	8.0.0	8.1.0
2009-03	CT-43	CP-090125	0145	1	Addition of text for subclause 4.1, Overview	8.0.0	8.1.0
2009-03	CT-43	CP-090125	0146	1	Addition of text for subclause 6.1.1, General	8.0.0	8.1.0
2009-03	CT-43	CP-090125	0147	1	Addition of text for subclause 6.1.2, Types of ESM procedures	8.0.0	8.1.0
2009-03	CT-43	CP-090157	0152		Correction of cause#25 handling	8.0.0	8.1.0
2009-03	CT-43	CP-090128	0153		Description of procedure transaction states for the network	8.0.0	8.1.0
2009-03	CT-43	CP-090129	0154	1	Moving the description of the eKSI to subclause 4.4	8.0.0	8.1.0
2009-03	CT-43	CP-090129	0155	3	CS Service Notification	8.0.0	8.1.0
2009-03	CT-43	CP-090128	0158	1	E9.04, removal of Editor's note in 9.5	8.0.0	8.1.0
2009-03	CT-43	CP-090128	0159		E4.03 and E9.05, removal of Editor's notes in 4.3.3.1 and 9.6	8.0.0	8.1.0
2009-03	CT-43	CP-090128	0160	2	Inclusion of APN in PDN connectivity request	8.0.0	8.1.0
2009-03	CT-43	CP-090126	0162	2	Clarification on local EPS bearer context deactivation	8.0.0	8.1.0
2009-03	CT-43	CP-090131	0163	2	Unciphered network operation	8.0.0	8.1.0
2009-03	CT-43	CP-090128	0164		ESM cause value #53 missing in 6.5.1.4	8.0.0	8.1.0
2009-03	CT-43	CP-090130	0165	1	Reservation of "reserved" and "unused" code points	8.0.0	8.1.0
2009-03	CT-43	CP-090128	0166		Editorial modification to add a "new line" character	8.0.0	8.1.0
2009-03	CT-43	CP-090125	0167	2	Activation of dedicated bearers during attach procedure	8.0.0	8.1.0
2009-03	CT-43	CP-090125	0168	2	Additions to " EPS bearer context deactivation initiated by the network"	8.0.0	8.1.0
2009-03	CT-43	CP-090130	0170		Removal of EN for TAU reject (cause #12)	8.0.0	8.1.0
2009-03	CT-43	CP-090130	0171	2	Security Terminolgy Change to Reflect 33.401	8.0.0	8.1.0
2009-03	CT-43	CP-090125	0172	1	Alignment of cause representation	8.0.0	8.1.0
2009-03	CT-43	CP-090127	0173		Correction of fields within Detach type IE	8.0.0	8.1.0
2009-03	CT-43	CP-090128	0174		Deletion of editor's note for 2 digit MNC	8.0.0	8.1.0
2009-03	CT-43	CP-090126	0176	2	Clarification of the network behaviour on SMC rejection	8.0.0	8.1.0
2009-03	CT-43	CP-090125	0178	1	Add an abnormal case in the dedicated EPS bearer context activation procedure	8.0.0	8.1.0
2009-03	CT-43	CP-090126	0181	3	Clarify the collison between detach and service request procedure	8.0.0	8.1.0
2009-03	CT-43	CP-090127	0186	1	Correction of QCI	8.0.0	8.1.0
2009-03	CT-43	CP-090126	0187		Clarifications related to the use of "active flag"	8.0.0	8.1.0
2009-03	CT-43	CP-090153	0189	1	Corrections for CS/PS mode 1 and CS/PS mode 2 of operation	8.0.0	8.1.0
2009-03	CT-43	CP-090128	0195	1	ESM information transfer flag	8.0.0	8.1.0
2009-03	CT-43	CP-090125	0198		Attach attempt counter	8.0.0	8.1.0
2009-03	CT-43	CP-090128	0199	1	Error correction in reference for timer T3412 in TAU procedure	8.0.0	8.1.0
2009-03	CT-43	CP-090126	0201	1	Clarifications for request type	8.0.0	8.1.0
2009-03	CT-43	CP-090126	0203	1	Clarification of the use of NAS security header	8.0.0	8.1.0
2009-03	CT-43	CP-090126	0205	1	Proposal of UE GMM and MM behavior on reception of error cause #10 when UE executed TAU, combined TAU and Service Request	8.0.0	8.1.0
2009-03	CT-43	CP-090126	0206		Definition of T3480, T3485, T3486, T3495 timer duration; Corrections on EPS bearer identity checking	8.0.0	8.1.0
2009-03	CT-43	CP-090215	0207	3	Clarification of UE requested ESM procedures	8.0.0	8.1.0
2009-03	CT-43	CP-090157	0208		Corrections to CSG related NAS behavior	8.0.0	8.1.0
2009-06	CT-44	CP-090421	0190	1	Cleanup for transport of NAS messages procedure	8.1.0	8.2.0
2009-06	CT-44	CP-090410	0210	1	TAU handling	8.1.0	8.2.0
2009-06	CT-44	CP-090410	0214		NAS security parameters for inter system handovers	8.1.0	8.2.0
2009-06	CT-44	CP-090410	0216	2	Transmission failure of EMM messages	8.1.0	8.2.0

2009-06	CT-44	CP-090410	0217	1	Clarifications on protocol discriminator for security protected NAS message	8.1.0	8.2.0
2009-06	CT-44	CP-090410	0219	1	Clarifications related PDN disconnect request, ESM information request, EPS bearer context modification request and bearer resource allocation request procedures	8.1.0	8.2.0
2009-06	CT-44	CP-090410	0220		Service Reject(cause #12)	8.1.0	8.2.0
2009-06	CT-44	CP-090410	0227	1	Security context cleanup at Security Mode Reject	8.1.0	8.2.0
2009-06	CT-44	CP-090410	0228	2	Removal of KSIASME from TAU accept	8.1.0	8.2.0
2009-06	CT-44	CP-090410	0229		Add missing LV-E format	8.1.0	8.2.0
2009-06	CT-44	CP-090410	0230		New value for ESM timer T3482	8.1.0	8.2.0
2009-06	CT-44	CP-090410	0231		EPS mobile identity octet numbering	8.1.0	8.2.0
2009-06	CT-44	CP-090411	0232	2	PDN connectivity reject cause value corrections	8.1.0	8.2.0
2009-06	CT-44	CP-090411	0233	1	MME handling of lower layer failure during the attach procedure	8.1.0	8.2.0
2009-06	CT-44	CP-090411	0239	1	Null ciphering algorithm	8.1.0	8.2.0
2009-06	CT-44	CP-090411	0242	1	EPS security modification	8.1.0	8.2.0
2009-06	CT-44	CP-090411	0243	2	Clarification regarding bearer resource allocation procedure, EPS bearer identity and PTI in several ESM messages.	8.1.0	8.2.0
2009-06	CT-44	CP-090411	0244	1	Removal of default PDN	8.1.0	8.2.0
2009-06	CT-44	CP-090411	0245	2	Add description of cause #40 in Annex A	8.1.0	8.2.0
2009-06	CT-44	CP-090411	0246	2	Correct the UE behavior of handling ESM message	8.1.0	8.2.0
2009-06	CT-44	CP-090411	0247	1	Clarify the UE behavior upon reception of some reject messages	8.1.0	8.2.0
2009-06	CT-44	CP-090498	0251	5	eKSI definition in NAS messages	8.1.0	8.2.0
2009-06	CT-44	CP-090411	0252	1	eKSI in Service Request message	8.1.0	8.2.0
2009-06	CT-44	CP-090411	0257		Remove unused ESM cause value #40 – "Feature not supported"	8.1.0	8.2.0
2009-06	CT-44	CP-090421	0260	1	Abnormal case handling for Extended Service request in 1xCSFB	8.1.0	8.2.0
2009-06	CT-44	CP-090411	0269	1	Resolution of Editor's Note in subclause 5.4.4.2	8.1.0	8.2.0
2009-06	CT-44	CP-090411	0272		Update the cause of start and stop of T3413	8.1.0	8.2.0
2009-06	CT-44	CP-090421	0274		The collison handling for Extended Service Request	8.1.0	8.2.0
2009-06	CT-44	CP-090411	0275		Handling of undefined QCI values	8.1.0	8.2.0
2009-06	CT-44	CP-090411	0276	1	Relation between HNP and HA delivered through PCO	8.1.0	8.2.0
2009-06	CT-44	CP-090411	0277		Corrections on abnormal case in UE requested PDN connectivity procedure	8.1.0	8.2.0
2009-06	CT-44	CP-090411	0280	1	Correction of UE requested resource procedures	8.1.0	8.2.0
2009-06	CT-44	CP-090412	0282	1	More precise general text for UE requested PDN connectivity procedure	8.1.0	8.2.0
2009-06	CT-44	CP-090412	0283		Alignment of cause representation	8.1.0	8.2.0
2009-06	CT-44	CP-090412	0284		Text clean up in 24.301	8.1.0	8.2.0
2009-06	CT-44	CP-090412	0292	1	Correction for the main state change in the UE	8.1.0	8.2.0
2009-06	CT-44	CP-090412	0293	1	Correction for implicit detach timer	8.1.0	8.2.0
2009-06	CT-44	CP-090412	0296	1	Clarification on Local Network initiated detach procedure without EMM signalling	8.1.0	8.2.0
2009-06	CT-44	CP-090412	0300	2	Correction for the EPS mobile identity	8.1.0	8.2.0
2009-06	CT-44	CP-090421	0301		Impacts of successful combined registration on forbidden LAs lists	8.1.0	8.2.0
2009-06	CT-44	CP-090421	0302		CS/PS mode 1 UE behaviour on reception of cause #18	8.1.0	8.2.0
2009-06	CT-44	CP-090412	0303		Corrections on handling of UE network capability	8.1.0	8.2.0
2009-06	CT-44	CP-090421	0304		Cleanup for EMM procedures	8.1.0	8.2.0
2009-06	CT-44	CP-090421	0306	1	Handling of non-semantical mandatory information element errors in the PDN DISCONNNECT REQUEST message.	8.1.0	8.2.0
2009-06	CT-44	CP-090412	0309	2	Clarification on the registered PLMN for Network Sharing	8.1.0	8.2.0
2009-06	CT-44	CP-090421	0312	1	Definition of kbps	8.1.0	8.2.0
2009-06	CT-44	CP-090421	0315	2	Sending UE Id in the CS Service Notification	8.1.0	8.2.0
2009-06	CT-44	CP-090412	0318	1	Clarification of EPS QoS length	8.1.0	8.2.0
2009-06	CT-44	CP-090412	0319		Removal of unnecessary TAU procedure after abnormal bearer allocation failure	8.1.0	8.2.0
2009-06	CT-44	CP-090412	0320	1	Set of minor corrections to TS 24.301	8.1.0	8.2.0
2009-06	CT-44	CP-090412	0321	2	Clarifications to 24.301	8.1.0	8.2.0
2009-06	CT-44	CP-090412	0322	1	Set of corrections to security procedure	8.1.0	8.2.0
2009-06	CT-44	CP-090412	0328		Clarification on access class applicability	8.1.0	8.2.0
2009-06	CT-44				Correction of minor typo	8.2.0	8.2.1
2009-09	CT-45	CP-090650	0226	7	Correcting ESM and SM coordination	8.2.1	8.3.0
2009-09	CT-45	CP-090651	0255	4	Definition of valid GUTI	8.2.1	8.3.0
2009-09	CT-45	CP-090674	0266	3	Clarification of T3212	8.2.1	8.3.0
2009-09	CT-45	CP-090653	0310	6	TFT for default bearer	8.2.1	8.3.0
2009-09	CT-45	CP-090630	0329	9	Corrections in TFT checks	8.2.1	8.3.0
2009-09	CT-45	CP-090653	0330	4	Resynchronization of EPS bearer contexts on TAU without active flag	8.2.1	8.3.0
2009-09	CT-45	CP-090652	0333	2	Inclusion of GERAN/UTRAN parameters in ESM messages	8.2.1	8.3.0
2009-09	CT-45	CP-090650	0337	1	Clarifications on usage of EPS security context	8.2.1	8.3.0
2009-09	CT-45	CP-090650	0338	1	BCM mode notification for LTE UE	8.2.1	8.3.0
2009-09	CT-45	CP-090677	0340		Update to the CSG ID definition	8.2.1	8.3.0
2009-09	CT-45	CP-090653	0344		Replacing "MS" by "UE"	8.2.1	8.3.0
2009-09	CT-45	CP-090651	0345	1	Correction of error handling	8.2.1	8.3.0

2009-09	CT-45	CP-090677	0346	1	Clarifications related to manual CSG selection	8.2.1	8.3.0
2009-09	CT-45	CP-090674	0358	2	Handling of UE's usage setting, voice setting and VoIMS indicator – 24.301	8.2.1	8.3.0
2009-09	CT-45	CP-090653	0362	2	Storing EPS security parameters	8.2.1	8.3.0
2009-09	CT-45	CP-090674	0370	2	Clarification on CSFB using redirection	8.2.1	8.3.0
2009-09	CT-45	CP-090674	0372	5	Disabling E-UTRAN capability for the voice centric UE	8.2.1	8.3.0
2009-09	CT-45	CP-090651	0374	2	Detach procedure for the last PDN disconnect by the network	8.2.1	8.3.0
2009-09	CT-45	CP-090650	0375	1	Correction for network abnormal case - Attach and TAU procedures collision	8.2.1	8.3.0
2009-09	CT-45	CP-090650	0376	2	Correction for abnormal case on network side due to lower layer failure	8.2.1	8.3.0
2009-09	CT-45	CP-090650	0379	4	Inclusion of Old P-TMSI signature IE in ATTACH REQUEST and TRACKING AREA UPDATE REQUEST	8.2.1	8.3.0
2009-09	CT-45	CP-090652	0380	1	Interaction between S1 mode and A/Gb or Iu mode	8.2.1	8.3.0
2009-09	CT-45	CP-090653	0381	1	Selected PLMN identity at NAS signalling connection establishment	8.2.1	8.3.0
2009-09	CT-45	CP-090674	0382	4	Aligning UE modes of operation definition with stage 2 principles for CS domain and IM CN Subsystem selection	8.2.1	8.3.0
2009-09	CT-45	CP-090651	0388	2	Corrections for abnormal case of GUTI REALLOCATION procedure	8.2.1	8.3.0
2009-09	CT-45	CP-090677	0389	1	The abnormal case of detach for CSG	8.2.1	8.3.0
2009-09	CT-45	CP-090652	0391	2	Handling of unknown QCI in the network	8.2.1	8.3.0
2009-09	CT-45	CP-090674	0393	1	Corrections for TAU complete initiation	8.2.1	8.3.0
2009-09	CT-45	CP-090674	0395	1	Corrections for Combined TAU procedure initiation	8.2.1	8.3.0
2009-09	CT-45	CP-090652	0396	1	NAS COUNT estimation correction	8.2.1	8.3.0
2009-09	CT-45	CP-090653	0397	2	Security protection of Security mode reject	8.2.1	8.3.0
2009-09	CT-45	CP-090653	0398	1	Rename of ESM cause #30 and #31	8.2.1	8.3.0
2009-09	CT-45	CP-090650	0400	2	Abnormal case of combined default bearer and dedicated bearer	8.2.1	8.3.0
2009-09	CT-45	CP-090650	0405	1	Clarification of behavior upon reception of ESM cause #43	8.2.1	8.3.0
2009-09	CT-45	CP-090674	0407	1	Correcting service type and EPS update type	8.2.1	8.3.0
2009-09	CT-45	CP-090650	0408		Addition of missing LV-E format	8.2.1	8.3.0
2009-09	CT-45	CP-090650	0409	1	Clarification on APN-AMBR IE description	8.2.1	8.3.0
2009-09	CT-45	CP-090650	0411	2	Clarification on abnormal cases in the UE for a few ESM procedures	8.2.1	8.3.0
2009-09	CT-45	CP-090651	0413	1	Correction for the misplaced ESM message	8.2.1	8.3.0
2009-09	CT-45	CP-090733	0415	1	Additional triggers for tracking area update procedure	8.2.1	8.3.0
2009-09	CT-45	CP-090651	0417	2	Deletion of mapped context after detach	8.2.1	8.3.0
2009-09	CT-45	CP-090651	0419	1	Corrections to EPS security context handling	8.2.1	8.3.0
2009-09	CT-45	CP-090652	0425	2	Providing the MSISDN to the MS	8.2.1	8.3.0
2009-09	CT-45	CP-090651	0426		Correction QCI within EPS quality of service information	8.2.1	8.3.0
2009-09	CT-45	CP-090653	0428		Removal of inclusion of cause#46 in some ESM reject messages	8.2.1	8.3.0
2009-09	CT-45	CP-090651	0429		Correction of definition of Linked EPS bearer identity IE	8.2.1	8.3.0
2009-09	CT-45	CP-090652	0430	1	MME and network synchronisation during TAU	8.2.1	8.3.0
2009-09	CT-45	CP-090650	0439	2	Clarification to UE requested bearer modification procedure	8.2.1	8.3.0
2009-09	CT-45	CP-090674	0442		Dependency between transport of NAS messages procedure and other EMM procedures	8.2.1	8.3.0
2009-09	CT-45	CP-090650	0447	1	Correction for EPS update status change	8.2.1	8.3.0
2009-09	CT-45	CP-090653	0448	2	Security handling of TAU	8.2.1	8.3.0
2009-09	CT-45	CP-090651	0449	1	Correction for the usage of Additional GUTI IE	8.2.1	8.3.0
2009-09	CT-45	CP-090674	0452	1	Corrections for detach procedure	8.2.1	8.3.0
2009-09	CT-45	CP-090675	0459	1	Paging for SMS messages	8.2.1	8.3.0
2009-09	CT-45	CP-090650	0461	1	Clarification of the abnormal case in the attach procedure	8.2.1	8.3.0
2009-09	CT-45	CP-090652	0469	1	Miscelleneous corrections to references and incorrect aspects of the specification	8.2.1	8.3.0
2009-09	CT-45	CP-090653	0479	2	Radio capability handling	8.2.1	8.3.0
2009-09	CT-45	CP-090653	0481	3	UE handling unknown QCI value received from the network	8.2.1	8.3.0
2009-09	CT-45	CP-090652	0482	1	Local deactivation of GBR EPS bearer context at MME during RLF	8.2.1	8.3.0
2009-09	CT-45	CP-090682	0487	1	Graphs for paging procedures	8.2.1	8.3.0
2009-09	CT-45	CP-090650	0490		Clarification of bearer context deactivation procedure and correction for ESM cause name	8.2.1	8.3.0
2009-09	CT-45	CP-090675	0494	1	Parameters for SMS over SGs charging	8.2.1	8.3.0
2009-09	CT-45	CP-090682	0331	2	Clarifications related to security mode control procedure	8.3.0	9.0.0
2009-09	CT-45	CP-090694	0341	2	Paging Optimization	8.3.0	9.0.0
2009-09	CT-45	CP-090689	0342	1	Including call type "emergency calls"	8.3.0	9.0.0
2009-09	CT-45	CP-090689	0343	1	Introducing reject cause value for emergency service over EPS	8.3.0	9.0.0
2009-09	CT-45	CP-090689	0347	3	Bearer resource allocation for emergency service	8.3.0	9.0.0
2009-09	CT-45	CP-090690	0348	4	PDN Connection for emergency service	8.3.0	9.0.0
2009-09	CT-45	CP-090690	0349	3	Types of EMM procedures for emergency service	8.3.0	9.0.0
2009-09	CT-45	CP-090689	0351	3	Authentication failure for emergency service	8.3.0	9.0.0
2009-09	CT-45	CP-090689	0352	2	Limited service state attach for emergency service	8.3.0	9.0.0
2009-09	CT-45	CP-090689	0353	4	Emergency service security	8.3.0	9.0.0
2009-09	CT-45	CP-090689	0356	2	Emergency service authentication	8.3.0	9.0.0

2009-09	CT-45	CP-090682	0366	2	Clarify terminology of PTI assignment in bearer context	8.3.0	9.0.0
2009-09	CT-45	CP-090690	0422	1	Null algorithm for integrity protection	8.3.0	9.0.0
2009-09	CT-45	CP-090690	0433	2	UE states and attach for emergency services	8.3.0	9.0.0
2009-09	CT-45	CP-090690	0440	1	Update the forbidden TAI list in the limited state	8.3.0	9.0.0
2009-09	CT-45	CP-090690	0441	1	Bearer resource modification for emergency bearer	8.3.0	9.0.0
2009-09	CT-45	CP-090690	0444	1	Support indications for IMS Voice over PS session and emergency call	8.3.0	9.0.0
2009-09	CT-45	CP-090689	0456	2	Clarification about the UE handling with the TAI list in the forbidden TA	8.3.0	9.0.0
2009-09	CT-45	CP-090690	0464	1	GUTI allocation for the UE without USIM	8.3.0	9.0.0
2009-09	CT-45	CP-090689	0466	2	Handling of attach rejection for emergency service	8.3.0	9.0.0
2009-09	CT-45	CP-090689	0468	2	Deactivating non-emergency bearers	8.3.0	9.0.0
2009-09	CT-45	CP-090689	0473	3	Limited service state attach for emergency service	8.3.0	9.0.0
2009-09	CT-45	CP-090689	0474	1	Detach on timeout for emergency service	8.3.0	9.0.0
2009-09	CT-45	CP-090689	0476	1	HSS detach request and deactivate non-emergency bearers	8.3.0	9.0.0
2009-09	CT-45	CP-090694	0483	1	Update of allowed CSG list after successful manual selection of a CSG cell in a different PLMN	8.3.0	9.0.0
2009-09	CT-45	CP-090682	0493	1	Discard unencrypted NAS messages	8.3.0	9.0.0
2009-12	CT-46	CP-090922	0485	5	ESM retransmission and PTI mismatch issue	9.0.0	9.1.0
2009-12	CT-46	CP-090930	0496	2	Stop paging optimization for emergency attached UE	9.0.0	9.1.0
2009-12	CT-46	CP-090930	0497	4	RRC establishment cause for Emergency Service	9.0.0	9.1.0
2009-12	CT-46	CP-090935	0498	3	Clarification on the Closed mode CSG cell	9.0.0	9.1.0
2009-12	CT-46	CP-090922	0499	2	Corrections for description of UE behaviour in state EMM-REGISTERED	9.0.0	9.1.0
2009-12	CT-46	CP-090935	0500	3	Operator CSG List	9.0.0	9.1.0
2009-12	CT-46	CP-090899	0505	1	Mapped QCI Handling in UE	9.0.0	9.1.0
2009-12	CT-46	CP-090930	0507	1	Correction on Timer handling	9.0.0	9.1.0
2009-12	CT-46	CP-090898	0512		Correction of criterion to trigger TAU	9.0.0	9.1.0
2009-12	CT-46	CP-090930	0513	1	Specification of EPS emergency bearer services attach rules	9.0.0	9.1.0
2009-12	CT-46	CP-090930	0515	4	TAU authentication while attached for emergency services	9.0.0	9.1.0
2009-12	CT-46	CP-090915	0518	3	UE mode of operation selection corrections and additions	9.0.0	9.1.0
2009-12	CT-46	CP-090935	0521	4	Processing the reject cause code #25 for the Operator CSG List	9.0.0	9.1.0
2009-12	CT-46	CP-090930	0523		Deactivating non-emergency bearers	9.0.0	9.1.0
2009-12	CT-46	CP-090922	0524	3	Clarification for TAU trigger for NAS recovery	9.0.0	9.1.0
2009-12	CT-46	CP-090916	0526	4	Correction to the SMS paging procedure	9.0.0	9.1.0
2009-12	CT-46	CP-090922	0529	1	Correction to conditions for EMM initiating service request	9.0.0	9.1.0
2009-12	CT-46	CP-090930	0530		EMM state machine on the UE side for emergency attach	9.0.0	9.1.0
2009-12	CT-46	CP-090930	0534	4	EPS security context storage while emergency EPS security context exists	9.0.0	9.1.0
2009-12	CT-46	CP-090899	0540	2	From MBR of default PDP context to APN-AMBR of default EPS bearer	9.0.0	9.1.0
2009-12	CT-46	CP-090922	0542	1	Correction of length values for ESM message container IEIs	9.0.0	9.1.0
2009-12	CT-46	CP-090898	0546	1	Correction to SMC procedure for establishment of mapped EPS security context in EMM-IDLE	9.0.0	9.1.0
2009-12	CT-46	CP-090898	0548	1	Correction to establishment of mapped EPS security context during inter-sytem handover	9.0.0	9.1.0
2009-12	CT-46	CP-090898	0550	1	Correction to the storage of the EPS security context	9.0.0	9.1.0
2009-12	CT-46	CP-090898	0552	4	Correction to the EPS security context handling	9.0.0	9.1.0
2009-12	CT-46	CP-090898	0554	2	Correction to the EPS authentication procedure	9.0.0	9.1.0
2009-12	CT-46	CP-090899	0556	4	Transition to the EMM-DEREGISTERED state and EPS security context actions	9.0.0	9.1.0
2009-12	CT-46	CP-090898	0562	4	Clarification of local detach	9.0.0	9.1.0
2009-12	CT-46	CP-090922	0563	2	Clarifications on EPS security and minor corrections	9.0.0	9.1.0
2009-12	CT-46	CP-090916	0564	4	Combined Attach and TAU for "SMS only" and "CS fallback not preferred", and related UE behaviour	9.0.0	9.1.0
2009-12	CT-46	CP-090916	0569	2	Ignoring paging for CS fallback to A/Gb or Iu mode by an SMS only UE	9.0.0	9.1.0
2009-12	CT-46	CP-090899	0571	3	Default value for T3412	9.0.0	9.1.0
2009-12	CT-46	CP-090922	0574	2	Enhanced CS fallback to 1xRTT	9.0.0	9.1.0
2009-12	CT-46	CP-090900	0576	5	NAS count handling in idle mode inter-RAT mobility	9.0.0	9.1.0
2009-12	CT-46	CP-090900	0578	2	NAS count handling on inter-RAT mobility	9.0.0	9.1.0
2009-12	CT-46	CP-090899	0580		Integrity protection of DETACH REQUEST	9.0.0	9.1.0
2009-12	CT-46	CP-090926	0581	4	Generic Transport of NAS messages	9.0.0	9.1.0
2009-12	CT-46	CP-090915	0584	1	Clarification of disabling E-UTRAN capabilities	9.0.0	9.1.0
2009-12	CT-46	CP-090930	0585	1	Handling of only Emergency Bearers existing scenarios	9.0.0	9.1.0
2009-12	CT-46	CP-090930	0588	1	Remove Support of Emergency HO from HRPD to E-UTRAN	9.0.0	9.1.0
2009-12	CT-46	CP-090930	0589	1	EMM context handling for emergency attach	9.0.0	9.1.0
2009-12	CT-46	CP-090916	0590	2	Detach for "SMS only"	9.0.0	9.1.0
2009-12	CT-46	CP-090915	0592	1	1xCSFB triggers for RRC establishment	9.0.0	9.1.0
2009-12	CT-46	CP-090922	0593	2	Detach with re-attach required	9.0.0	9.1.0
2009-12	CT-46	CP-090922	0594		Paging cycles for EPS using S-TMSI	9.0.0	9.1.0
2009-12	CT-46	CP-090900	0598	1	Defining the value of NAS COUNTs	9.0.0	9.1.0

2009-12	CT-46	CP-090898	0602		Correcting the handling of multiple authentication failures in the UE	9.0.0	9.1.0
2009-12	CT-46	CP-090899	0604	1	Handling of missing NAS Securirty Mode Complete when generating mapped context	9.0.0	9.1.0
2009-12	CT-46	CP-090900	0606	1	Security handling when NAS COUNT wrap around	9.0.0	9.1.0
2009-12	CT-46	CP-090930	0607	2	Deactivate non-EMC bearers with CSG ID not in allowed CSG list	9.0.0	9.1.0
2009-12	CT-46	CP-090922	0611	1	Introduction of generic notification procedure	9.0.0	9.1.0
2009-12	CT-46	CP-090922	0615	1	Clarifications on security	9.0.0	9.1.0
2009-12	CT-46	CP-090930	0618	1	Rules for integrity protection with NULL algorithm	9.0.0	9.1.0
2009-12	CT-46	CP-090899	0620	1	TFT corrections	9.0.0	9.1.0
2009-12	CT-46	CP-090922	0621	2	Interpretation of GPRS timer value of 0	9.0.0	9.1.0
2009-12	CT-46	CP-090930	0625	1	Handling authentication failure during TAU	9.0.0	9.1.0
2009-12	CT-46	CP-090935	0626	1	Removal of definition of Allowed CSG list	9.0.0	9.1.0
2009-12	CT-46	CP-090916	0629	1	Abnormal cases in the UE for "SMS only" and "CS Fallback not preferred"	9.0.0	9.1.0
2009-12	CT-46	CP-090898	0633	2	Correction to the NAS security mode control procedure	9.0.0	9.1.0
2009-12	CT-46	CP-091054	0637	2	Alignment with TS23.401 caused by changing the term CSFB to "CSFB and SMS over SGs".	9.0.0	9.1.0
2009-12	CT-46	CP-090919	0567	5	Protecting the allowed CSG list	9.0.0	9.1.0
2010-03	CT-47	CP-100144	0587	3	Deactive ISR for UE attached for emergency bearer services	9.1.0	9.2.0
2010-03	CT-47	CP-100134	0624	3	EPS Bearer Context Synchronization during Extended Service Request	9.1.0	9.2.0
2010-03	CT-47	CP-100106	0639	1	Correction of MME DL NAS COUNT at handover	9.1.0	9.2.0
2010-03	CT-47	CP-100139	0640	1	Inclusion of routing identifier for generic NAS transport	9.1.0	9.2.0
2010-03	CT-47	CP-100144	0641		Tracking Area Update Procedure	9.1.0	9.2.0
2010-03	CT-47	CP-100144	0642	1	UE Initiated Detach Procedure	9.1.0	9.2.0
2010-03	CT-47	CP-100144	0643		UE Substate PLMN Search	9.1.0	9.2.0
2010-03	CT-47	CP-100106	0647	2	Security at idle mobility from E-UTRAN to UTRAN/GERAN	9.1.0	9.2.0
2010-03	CT-47	CP-100144	0657		UE behavior after EPS bearer context deactivation	9.1.0	9.2.0
2010-03	CT-47	CP-100106	0660	2	Correction of used parameter in coordination between ESM and SM	9.1.0	9.2.0
2010-03	CT-47	CP-100134	0664	1	Store EPS security context at state transition to EMM-DEREGISTERED	9.1.0	9.2.0
2010-03	CT-47	CP-100144	0665	1	Definition of attached for emergency bearer service	9.1.0	9.2.0
2010-03	CT-47	CP-100134	0667	2	Defining Selective camping capability IE	9.1.0	9.2.0
2010-03	CT-47	CP-100144	0668	1	Security handling when NAS COUNT wrap around	9.1.0	9.2.0
2010-03	CT-47	CP-100144	0670	1	Deletion of RAND and RES in the UE	9.1.0	9.2.0
2010-03	CT-47	CP-100134	0671	1	Add packet filters to existing TFT	9.1.0	9.2.0
2010-03	CT-47	CP-100144	0672	1	CSG subcription expiration and non-emergency bearer deactivation	9.1.0	9.2.0
2010-03	CT-47	CP-100144	0673		Clarification of IMEI used for EMC attach	9.1.0	9.2.0
2010-03	CT-47	CP-100134	0674	1	Correction on the security protection of the NAS message	9.1.0	9.2.0
2010-03	CT-47	CP-100144	0675	1	Handling of authentication failure in EMC cases	9.1.0	9.2.0
2010-03	CT-47	CP-100106	0677	2	EPS security context handling in detach procedure	9.1.0	9.2.0
2010-03	CT-47	CP-100106	0679	1	Re-Authentication after intergity check failure of TAU Request	9.1.0	9.2.0
2010-03	CT-47	CP-100148	0682		Use of Cause #25 when UE's subscription to CSG has expired – 24.301	9.1.0	9.2.0
2010-03	CT-47	CP-100106	0685		Correction on E-UTRAN Deactivate ISR timer	9.1.0	9.2.0
2010-03	CT-47	CP-100139	0686	1	Retransmission of non-transmistted LPP PDUs	9.1.0	9.2.0
2010-03	CT-47	CP-100106	0693	2	TAU request and ciphering in connected mode	9.1.0	9.2.0
2010-03	CT-47	CP-100139	0696	2	CS Fallback for MO-LR in Rel9	9.1.0	9.2.0
2010-03	CT-47	CP-100134	0700	1	Add reactivation requested cause code to EPS	9.1.0	9.2.0
2010-03	CT-47	CP-100106	0702	1	Deletion of mapped EPS security context when I-RAT HO fails	9.1.0	9.2.0
2010-03	CT-47	CP-100126	0704		UE behaviour corrections for 'SMS only'	9.1.0	9.2.0
2010-03	CT-47	CP-100144	0705		Definition of non-emergency EPS bearer context	9.1.0	9.2.0
2010-03	CT-47	CP-100134	0711	2	Pre Rel8 QoS mapping when this QoS is not received while on E-UTRAN	9.1.0	9.2.0
2010-03	CT-47	CP-100134	0713	1	Clarification of Integrity protection of Service Request in section 4.4.3.3	9.1.0	9.2.0
2010-03	CT-47	CP-100144	0714	1	No reset of DL NAS Count on Security Mode Command accepted by the UE	9.1.0	9.2.0
2010-03	CT-47	CP-100144	0716	2	Attach for emergency bearer services to a network not supporting EM BS	9.1.0	9.2.0
2010-03	CT-47	CP-100144	0718	1	Security Mode Command using NULL algos during TAU for normal attached UE	9.1.0	9.2.0
2010-03	CT-47	CP-100144	0720	1	Retransmission of PDN connectivity request for emergency bearer services	9.1.0	9.2.0
2010-03	CT-47	CP-100144	0724		Correction of access class bit 10 handling	9.1.0	9.2.0
2010-03	CT-47	CP-100144	0725	2	Mobility aspects of Emergency attached UEs	9.1.0	9.2.0
2010-03	CT-47	CP-100134	0726	1	Arrange definitions in alphabetical order	9.1.0	9.2.0
2010-03	CT-47	CP-100062	0708	3	Authentication Procedure after Inter PLMN Handover	9.1.0	9.2.0
2010-03	CT-47	CP-100134	0727	3	Alignment of TAI list boundary with 2G/3G LA boundary	9.1.0	9.2.0
2010-03	CT-47	CP-100210	0730	2	Correct terminating domain selection for IMS voice UEs	9.1.0	9.2.0

2010-06	CT#48	CP-100354	0722	3	Avoiding rejection of a CS fallback due to CSG subscription expiry	9.2.0	9.3.0
2010-06	CT#48	CP-100354	0735	1	eKSI value setting for no valid EPS security context	9.2.0	9.3.0
2010-06	CT#48	CP-100360	0736	4	Authentication procedure for emergency services	9.2.0	9.3.0
2010-06	CT#48	CP-100360	0746	2	Handover to EUTRAN including NULL algos	9.2.0	9.3.0
2010-06	CT#48	CP-100360	0748	1	Authentication failure by UE while it has a PDN connection for emergency bearer services	9.2.0	9.3.0
2010-06	CT#48	CP-100362	0749	3	Add HeNB name	9.2.0	9.3.0
2010-06	CT#48	CP-100354	0751	1	Correction on request type	9.2.0	9.3.0
2010-06	CT#48	CP-100354	0752	1	Correction of conditions for TAU and ISR deactivation for T-ADS	9.2.0	9.3.0
2010-06	CT#48	CP-100354	0753	2	CSFB corrections in Service request procedure	9.2.0	9.3.0
2010-06	CT#48	CP-100354	0754	1	No NAS retransmission of SMS messages	9.2.0	9.3.0
2010-06	CT#48	CP-100348	0757	1	Voice domain preference alignments	9.2.0	9.3.0
2010-06	CT#48	CP-100354	0759		Update status for cause #9 and #10	9.2.0	9.3.0
2010-06	CT#48	CP-100349	0761	1	Combined TAU trigger after SRVCC	9.2.0	9.3.0
2010-06	CT#48	CP-100354	0763	1	Cause #39	9.2.0	9.3.0
2010-06	CT#48	CP-100360	0767	3	Clarification to establishment cause used by a UE in case of EMC procedure.	9.2.0	9.3.0
2010-06	CT#48	CP-100360	0768	2	Clarifications to expirey of Periodic RAU and mobile Reachable timer in case of EMC	9.2.0	9.3.0
2010-06	CT#48	CP-100350	0770	2	Clarification to network initiated detach procedure with cause #25	9.2.0	9.3.0
2010-06	CT#48	CP-100360	0771	1	Handling EPS Security Contexts	9.2.0	9.3.0
2010-06	CT#48	CP-100348	0775	2	Correction to UE mode of operation	9.2.0	9.3.0
2010-06	CT#48	CP-100339	0777	3	Correction to mapping of EPS QoS to pre-Rel-8 QoS	9.2.0	9.3.0
2010-06	CT#48	CP-100354	0783	1	Correction of selective camping IE inclusion requirement for 1x CS fallback capable UE	9.2.0	9.3.0
2010-06	CT#48	CP-100360	0784	2	Emergency attach reject from EMM in shared networks	9.2.0	9.3.0
2010-09	CT#49	CP-100501	0739	4	Corrections to UE mode of operation selection taking into account the UE's availability for voice calls in the IMS	9.3.0	9.4.0
2010-09	CT#49	CP-100506	0786	2	Handling of Detach Procedure for non-EPS services on a CSG cell which is no longer valid for the UE.and IMS EMG call is active.	9.3.0	9.4.0
2010-09	CT#49	CP-100506	0787	1	Emergency security context creation at standalone SMC	9.3.0	9.4.0
2010-09	CT#49	CP-100501	0789	1	Adding spec reference to ensure QoS alignment	9.3.0	9.4.0
2010-09	CT#49	CP-100506	0794	2	Skip Authentication for Emergency Services	9.3.0	9.4.0
2010-09	CT#49	CP-100506	0797	1	Clarification to timer T3418 and T3420 timer description in EMC case.	9.3.0	9.4.0
2010-09	CT#49	CP-100501	0812	2	On UE handling of 1xCSFB failure due to lower layer failure	9.3.0	9.4.0
2010-09	CT#49	CP-100501	0820	1	Allowing the UE to send a request for emergency call when the timer T3442 is running	9.3.0	9.4.0
2010-09	CT#49	CP-100495	0832	3	Correction on CS Fallback procedure using Release with Redirection	9.3.0	9.4.0
2010-09	CT#49	CP-100506	0842	1	Clarification to an emergency PDN connection establishment procedure.	9.3.0	9.4.0
2010-09	CT#49	CP-100506	0844	1	Handling of collision of Network Initiated Detach procdure with Service Request procedure and TAU procedure.	9.3.0	9.4.0
2010-09	CT#49	CP-100495	0850	1	No EPS bearer context activated during combined tracking area update	9.3.0	9.4.0
2010-09	CT#49	CP-100485	0852	1	Context transfer on inter-system change from A/Gb mode or Iu mode	9.3.0	9.4.0
2010-09	CT#49	CP-100506	0854	1	Skip authentication during TAU in EMC cases	9.3.0	9.4.0
2010-09	CT#49	CP-100506	0859	1	Local bearer deactivation and UE status	9.3.0	9.4.0
2010-09	CT#49	CP-100501	0868	1	Inclusion of transaction identifier	9.3.0	9.4.0
2010-09	CT#49	CP-100501	0871	1	Alignment with 23.401 for ESM cause value #52 "single address bearers only allowed"	9.3.0	9.4.0
2010-09	CT#49	CP-100517	0758	2	Local ISR deactivation in the UE when T3312 has expired	9.4.0	10.0.0
2010-09	CT#49	CP-100517	0773	2	Correcting ISR handling in UE	9.4.0	10.0.0
2010-09	CT#49	CP-100517	0788	1	Adding a definition of the term "Lower layer failure"	9.4.0	10.0.0
2010-09	CT#49	CP-100514	0799	1	PDN connection redirection in SIPTO scenario	9.4.0	10.0.0
2010-09	CT#49	CP-100517	0800	3	CSFB rejected by network without inter system change	9.4.0	10.0.0
2010-09	CT#49	CP-100514	0801	1	Clarification on PDN connection re-activation	9.4.0	10.0.0
2010-09	CT#49	CP-100517	0802	1	Correction for value setting of the mobile reachable timer	9.4.0	10.0.0
2010-09	CT#49	CP-100517	0804	2	Abnormal case handling for SMC procedure	9.4.0	10.0.0
2010-09	CT#49	CP-100517	0807	1	Clarifying the presence of APN IE	9.4.0	10.0.0
2010-09	CT#49	CP-100517	0808		CS fallback alignments	9.4.0	10.0.0
2010-09	CT#49	CP-100517	0815	1	Editorial corrections in definitions	9.4.0	10.0.0
2010-09	CT#49	CP-100517	0817	2	Fix ambiguity in the UE security capability information element	9.4.0	10.0.0
2010-09	CT#49	CP-100517	0819		Editorial corrections to 24.301	9.4.0	10.0.0
2010-09	CT#49	CP-100517	0823	1	Clarification to set TIN parameter in Attach, Tracking,Detach and PDN connectivity procedure.	9.4.0	10.0.0
2010-09	CT#49	CP-100517	0835	1	Correction of EMM main states in the UE	9.4.0	10.0.0
2010-09	CT#49	CP-100517	0837	2	Correction of network initiated detach procedure with EMM cause #2	9.4.0	10.0.0
2010-09	CT#49	CP-100517	0845	1	Clarification of TAI list assignment for network sharing	9.4.0	10.0.0

2010-09	CT#49	CP-100520	0847	2	Handling of cause #27 (missing or unknown APN)	9.4.0	10.0.0
2010-09	CT#49	CP-100517	0853	1	Removal of ESM cause #46	9.4.0	10.0.0
2010-09	CT#49	CP-100517	0855	1	Combined attached UE's behavior during PTAU with reject cause #7 or #14	9.4.0	10.0.0
2010-09	CT#49	CP-100517	0856	1	Correction on LIMITED-SERVIC substate	9.4.0	10.0.0
2010-09	CT#49	CP-100514	0857	1	Network initiated Detach procedure completion by the UE	9.4.0	10.0.0
2010-09	CT#49	CP-100517	0858	2	Support of IPv6 Prefix Delegation	9.4.0	10.0.0
2010-09	CT#49	CP-100517	0862	1	Collision of UE requested bearer resource allocation and EPS bearer context deactivation	9.4.0	10.0.0
2010-09	CT#49	CP-100517	0863	1	Establish radio bearer due to downlink ESM signaling pending	9.4.0	10.0.0
2010-09	CT#49	CP-100517	0866	1	EMM state transitions in MME	9.4.0	10.0.0
2010-09	CT#49	CP-100520	0872		Editorial correction of security context handling for network initiated detach procedure initiation	9.4.0	10.0.0
2010-12	CT#50	CP-100760	0877	1	Attach with IMSI	10.0.0	10.1.0
2010-12	CT#50	CP-100760	0878	5	Extended Tracking Area Update Timer	10.0.0	10.1.0
2010-12	CT#50	CP-100760	0879	4	Rejection due to per APN congestion	10.0.0	10.1.0
2010-12	CT#50	CP-100760	0880	1	Modified EMM Cause values for NIMTC	10.0.0	10.1.0
2010-12	CT#50	CP-100761	0881		Correction of description of EMM state machine	10.0.0	10.1.0
2010-12	CT#50	CP-100761	0882		Correction of network initiated detach procedure	10.0.0	10.1.0
2010-12	CT#50	CP-100761	0883	1	Correction of local EPS bearer context deactivation	10.0.0	10.1.0
2010-12	CT#50	CP-100761	0888		Abnormal case for Service Request	10.0.0	10.1.0
2010-12	CT#50	CP-100758	0889	2	Paging priority indication for MPS service	10.0.0	10.1.0
2010-12	CT#50	CP-100761	0896	1	CS paging with IMSI	10.0.0	10.1.0
2010-12	CT#50	CP-100747	0898	1	Deleting equivalent PLMNs list in EMC case	10.0.0	10.1.0
2010-12	CT#50	CP-100761	0901	1	Lower layer failure handling during network initiated detach procedure	10.0.0	10.1.0
2010-12	CT#50	CP-100761	0905	1	Moving GMM to detached state at reception of EMM cause #40	10.0.0	10.1.0
2010-12	CT#50	CP-100761	0912	1	Correction of T3442 behaviouir for SERVICE REJECT with cause #39	10.0.0	10.1.0
2010-12	CT#50	CP-100761	0920	1	Correction to QoS mapping at IRAT change	10.0.0	10.1.0
2010-12	CT#50	CP-100761	0927	1	UE Substate Selection	10.0.0	10.1.0
2010-12	CT#50	CP-100760	0928	4	TAU procedure when Low Priority indicator in UE changes	10.0.0	10.1.0
2010-12	CT#50	CP-100740	0931	1	ISR deactivation before TAU when UE moves from PMM-CONNECTED to E-UTRAN	10.0.0	10.1.0
2010-12	CT#50	CP-100761	0933	2	Explicit signalling of native vs mapped GUTI during TAU	10.0.0	10.1.0
2010-12	CT#50	CP-100761	0934		Removal of 2G SIM UE in E-UTRAN	10.0.0	10.1.0
2010-12	CT#50	CP-100742	0936	1	Correction in the use of cause value #2 in detach collision cases	10.0.0	10.1.0
2010-12	CT#50	CP-100760	0937	1	Adding NAS signalling priority Indication in Attach Request	10.0.0	10.1.0
2010-12	CT#50	CP-100761	0939	3	Clarification about abnormal cases on the network side for Service Request	10.0.0	10.1.0
2010-12	CT#50	CP-100761	0940	2	CSFB response for page received for1xCSFB	10.0.0	10.1.0
2010-12	CT#50	CP-100760	0945	2	Clarifying the APN congestion control for EMC attached UE	10.0.0	10.1.0
2010-12	CT#50	CP-100747	0949	1	Correction on EMM authentication failure for EMC services	10.0.0	10.1.0
2010-12	CT#50	CP-100760	0950	1	ESM procedures for low priority	10.0.0	10.1.0
2010-12	CT#50	CP-100761	0908	5	Adding e1xCSFB support for dual Rx/Tx UE and corrections to unhandled T3417 when 1x call is rejected by 1x network	10.0.0	10.1.0
2010-12	CT#50	CP-100761	0833	10	Alignment with the latest SA1 specification regarding access control for CSFB	10.0.0	10.1.0
2010-12	CT#50	CP-100753	0886	4	PDN disconnection for LIPA	10.0.0	10.1.0
2011-03	CT#51	CP-110195	0944	4	Local Bearer deactivation during CSFB	10.1.0	10.2.0
2011-03	CT#51	CP-110193	0947	3	Handling of periodic TAU timer, mobile reachable timer and MM back-off timer	10.1.0	10.2.0
2011-03	CT#51	CP-110193	0954	3	Clarification to the handling of timer T3245	10.1.0	10.2.0
2011-03	CT#51	CP-110193	0955	6	Handling of dedicated EPS bearer context activation procerdure in case of APN congestion.	10.1.0	10.2.0
2011-03	CT#51	CP-110195	0956	2	Explicit Signalling Indication During Attach	10.1.0	10.2.0
2011-03	CT#51	CP-110193	0960	3	Service Type for machine-to-machine communication – 24.301	10.1.0	10.2.0
2011-03	CT#51	CP-110193	0962	5	Mobility management congestion control and back-off timer	10.1.0	10.2.0
2011-03	CT#51	CP-110183	0965	1	Addition to Combined procedure for PDN disconnection for LIPA	10.1.0	10.2.0
2011-03	CT#51	CP-110183	0966	2	Exception for the LIPA PDN disconnection	10.1.0	10.2.0
2011-03	CT#51	CP-110195	0967	1	Providing the UE with R99 QoS	10.1.0	10.2.0
2011-03	CT#51	CP-110195	0969	1	Inter system change to S1-mode with no active PDP Context	10.1.0	10.2.0
2011-03	CT#51	CP-110195	0970		Handling of non-delivered CS SERVICE INDICATION	10.1.0	10.2.0
2011-03	CT#51	CP-110193	0974	1	Attach with IMSI Alignment of Terminology	10.1.0	10.2.0
2011-03	CT#51	CP-110193	0975		Specific requirements Alignment of Terminology	10.1.0	10.2.0
2011-03	CT#51	CP-110193	0976		Extended Periodic Timer Correction	10.1.0	10.2.0
2011-03	CT#51	CP-110193	0977	1	Attach Attempt Counter for Low Priority Devices	10.1.0	10.2.0
2011-03	CT#51	CP-110183	0978	3	Notify UE when a HeNB provides access to a residential/enterprise IP network	10.1.0	10.2.0
2011-03	CT#51	CP-110174	0980	1	Service request initiation for dual rx 1xCSFB UE	10.1.0	10.2.0
2011-03	CT#51	CP-110195	0981	1	Clarification to the ESM cause #31	10.1.0	10.2.0
2011-03	CT#51	CP-110193	0983	3	Storage and handling of the NAS signalling low priority indicator	10.1.0	10.2.0

2011-03	CT#51	CP-110195	0986	2	Correction on detach and service request collision	10.1.0	10.2.0
2011-03	CT#51	CP-110195	0987	1	Correction on UE substate selection	10.1.0	10.2.0
2011-03	CT#51	CP-110193	0988	4	Adding NAS signalling priority indication in EPS SM messages	10.1.0	10.2.0
2011-03	CT#51	CP-110195	0989	3	Correction of the handling of the Old GUTI type IE	10.1.0	10.2.0
2011-03	CT#51	CP-110195	0990		T3440 is not started when user plane radio bearers are setup during TAU	10.1.0	10.2.0
2011-03	CT#51	CP-110195	0994		EMM state after lower layers failure during TAU when TIN=P-TMSI	10.1.0	10.2.0
2011-03	CT#51	CP-110195	0995	3	Stopping T3411 when UE moves to EMM-CONNECTED	10.1.0	10.2.0
2011-03	CT#51	CP-110195	0997	1	Automatic re-attach following TAU reject or Service Request reject	10.1.0	10.2.0
2011-03	CT#51	CP-110193	1005	2	Clarification to the handling of timer T3496	10.1.0	10.2.0
2011-03	CT#51	CP-110195	1006		Correction to the condition of inclusion of PCO IE in PDN CONNECTIVITY REJECT message	10.1.0	10.2.0
2011-03	CT#51	CP-110193	1013	2	ESM Backoff timer, Editor's note removal	10.1.0	10.2.0
2011-03	CT#51	CP-110183	1015	2	Restriction on the use of PDN connection for LIPA	10.1.0	10.2.0
2011-03	CT#51	CP-110171	1018		Correction to detection of CSG cell based on CSG ID – 24.301	10.1.0	10.2.0
2011-03	CT#51	CP-110163	1021	2	Sending ESM messages together with Service request procedure	10.1.0	10.2.0
2011-03	CT#51	CP-110253	1029	4	Clarification to RRC establishment cause when device is attaching for emergency bearer services.	10.1.0	10.2.0
2011-03	CT#51	CP-110195	1034	1	Verification of dedicated bearer context activation	10.1.0	10.2.0
2011-03	CT#51	CP-110195	0959	1	Reconsidering the UE behavior when it is barred to MO CSFB	10.1.0	10.2.0
2011-03	CT#51	CP-110303	0961	5	Device properties and RRC establishment cause = Delay tolerant – 24.301	10.1.0	10.2.0
2011-06	CT#52	CP-110462	1039	1	Corrections for overload behavior	10.2.0	10.3.0
2011-06	CT#52	CP-110464	1040	1	Avoiding the problem of barring duplication for CSFB	10.2.0	10.3.0
2011-06	CT#52	CP-110455	1042		Correction on encoding of CS-LCS in EPS network feature support IE	10.2.0	10.3.0
2011-06	CT#52	CP-110462	1046	1	Clearly specify conditions for UE actions at switch off for T3245, T3446 and T3496	10.2.0	10.3.0
2011-06	CT#52	CP-110462	1047	1	Further clarification of PLMN reselection and handling of EMM back-off timer	10.2.0	10.3.0
2011-06	CT#52	CP-110467	1051	1	Support of relay node functionality	10.2.0	10.3.0
2011-06	CT#52	CP-110446	1054		Manipulation of CSG ID entries (in ACL and OCL) and the associated PLMNID - LTE	10.2.0	10.3.0
2011-06	CT#52	CP-110462	1055	1	Missing abnormal handling of EXTENDED SERVICE REQUEST	10.2.0	10.3.0
2011-06	CT#52	CP-110462	1057	1	Replace T3446 with T3346	10.2.0	10.3.0
2011-06	CT#52	CP-110476	1058		Correct conditions for including the connectivity type IE	10.2.0	10.3.0
2011-06	CT#52	CP-110476	1059	2	Correct the trigger of the LIPA PDN disconnection	10.2.0	10.3.0
2011-06	CT#52	CP-110462	1060	1	Reference to NAS configuration in USIM	10.2.0	10.3.0
2011-06	CT#52	CP-110462	1061	2	Inter RAT Change	10.2.0	10.3.0
2011-06	CT#52	CP-110462	1063	2	Handling Network initiated procedure when backoff timer is running	10.2.0	10.3.0
2011-06	CT#52	CP-110462	1064	2	Emergency attach during backoff	10.2.0	10.3.0
2011-06	CT#52	CP-110462	1065	1	Correction to the service request procedure	10.2.0	10.3.0
2011-06	CT#52	CP-110464	1066	1	Stopping Timer T3417ext upon reception of SERVICE REJECT	10.2.0	10.3.0
2011-06	CT#52	CP-110462	1068	1	alignment about MM congestion control	10.2.0	10.3.0
2011-06	CT#52	CP-110462	1081		RRC establishment cause for MT services	10.2.0	10.3.0
2011-06	CT#52	CP-110462	1083	2	Correction on UE behavior for ESM cause #26 and #27	10.2.0	10.3.0
2011-06	CT#52	CP-110462	1084		TAU attempt counter reset under T3446 running	10.2.0	10.3.0
2011-06	CT#52	CP-110464	1087		SMS paging at MME failure	10.2.0	10.3.0
2011-06	CT#52	CP-110464	1088	1	Correction to handling of reject cause #14	10.2.0	10.3.0
2011-06	CT#52	CP-110462	1089		Correction to sub-clause reference	10.2.0	10.3.0
2011-06	CT#52	CP-110464	1092	1	Initiating Service request peocedure for HRPD during intersystem change	10.2.0	10.3.0
2011-06	CT#52	CP-110462	1093	1	Clarification about APN based congeston control procedure	10.2.0	10.3.0
2011-06	CT#52	CP-110462	1096	2	Correction of T3396 handling for PDN connection reactivation	10.2.0	10.3.0
2011-06	CT#52	CP-110476	1097	2	LIPA PDN connectivity request during handover preparation	10.2.0	10.3.0
2011-06	CT#52	CP-110476	1100	2	Service reject for LIPA only	10.2.0	10.3.0
2011-06	CT#52	CP-110453	1074	1	Modification of NAS security context storage	10.2.0	10.3.0
2011-06	CT#52	CP-110463	1082	1	NAS signalling low priority indication for exception cases	10.2.0	10.3.0
2011-06	CT#52	CP-110536	0957	4	GUMMEI Type indication during establishment of NAS signalling connection	10.2.0	10.3.0
2011-09	CT#53	CP-110680	1030	4	Handling mobile reachable timer for back-off UE with emergency PDN connection	10.3.0	10.4.0
2011-09	CT#53	CP-110680	1098	5	Call forwarding, paging and long periodic timers	10.3.0	10.4.0
2011-09	CT#53	CP-110680	1108	1	EPS Bearer Context Deactivation	10.3.0	10.4.0
2011-09	CT#53	CP-110680	1110	1	Replace T3496 with T3396	10.3.0	10.4.0
2011-09	CT#53	CP-110680	1111	4	Correction and clarification on the terminologies of NAS level congestion control	10.3.0	10.4.0
2011-09	CT#53	CP-110680	1114		Correction to the service request procedure	10.3.0	10.4.0
2011-09	CT#53	CP-110679	1127	2	Relay node indication to lower layers while attaching for relay node operation	10.3.0	10.4.0
2011-09	CT#53	CP-110679	1132	1	Clarify the RN behavior as a UE part	10.3.0	10.4.0

2011-09	CT#53	CP-110682	1133	1	Clarification of UE behavior when combined TAU is not accepted	10.3.0	10.4.0
2011-09	CT#53	CP-110678	1135	4	Clarify the behavior of the UE upon receipt of the Service Reject message with Cause #40	10.3.0	10.4.0
2011-09	CT#53	CP-110680	1141	1	RRC establishment cause for Extended Service Request	10.3.0	10.4.0
2011-09	CT#53	CP-110680	1142	4	Correction to network-initiated detach procedure	10.3.0	10.4.0
2011-09	CT#53	CP-110680	1143	1	Scope of SM APN congestion control	10.3.0	10.4.0
2011-09	CT#53	CP-110678	1144		Correction to service request procedure for LIPA only	10.3.0	10.4.0
2011-09	CT#53	CP-110680	1150	1	Clarification of EXTENDED SERVICE REQUEST handling	10.3.0	10.4.0
2011-09	CT#53	CP-110680	1152	4	Clarification of TAU triggered after paging	10.3.0	10.4.0
2011-09	CT#53	CP-110680	1155	1	Establishing emergency services when T3346 is running	10.3.0	10.4.0
2011-09	CT#53	CP-110680	1163	1	Handling NAS Low Priority Indication	10.3.0	10.4.0
2011-09	CT#53	CP-110680	1173	1	Correction to cause #22 handling	10.3.0	10.4.0
2011-09	CT#53	CP-110680	1177	1	Correcting mention of Service User of MultiMedia Priority Service-alternative to C1-112930	10.3.0	10.4.0
2011-09	CT#53	CP-110680	1197	2	SM backoff while paged using IMSI	10.3.0	10.4.0
2011-09	CT#53	CP-110680	1199	1	T3423 may not be started	10.3.0	10.4.0
2011-09	CT#53	CP-110680	1202	3	Clarification on CSFB handling when PS MM back-off timer is running	10.3.0	10.4.0
2011-09	CT#53	CP-110665	1206	2	Reject Cause handling while UE attaching for emergency bearer services	10.3.0	10.4.0
2011-09	CT#53	CP-110680	1207	1	Value of timer T3412 in the network	10.3.0	10.4.0
2011-09	CT#53	CP-110694	1048	4	Clarifications for removal of numbers from the Local Emergency Numbers List	10.4.0	11.0.0
2011-09	CT#53	CP-110690	1107	3	MME Behaviour when MS Network Capability is not included in Attach/TAU	10.4.0	11.0.0
2011-09	CT#53	CP-110691	1117	3	Correction to the UE registration status for SMS	10.4.0	11.0.0
2011-09	CT#53	CP-110690	1121	3	Local EPS bearer context deactivation without ESM signalling	10.4.0	11.0.0
2011-09	CT#53	CP-110695	1123	1	Editorial correction to the ESM cause #27	10.4.0	11.0.0
2011-09	CT#53	CP-110690	1139	3	Starting deactivate ISR timer in substate PLMN-SEARCH when T3412 expires	10.4.0	11.0.0
2011-09	CT#53	CP-110690	1140	2	P-TMSI signature value derivation after handover	10.4.0	11.0.0
2011-09	CT#53	CP-110694	1145	2	Detach procedure collision handling	10.4.0	11.0.0
2011-09	CT#53	CP-110697	1159	2	vSRVCC Enhancements in TS 24.301 including vSRVCC indicator (terminology variant 1)	10.4.0	11.0.0
2011-09	CT#53	CP-110695	1165	1	Emergency Attach from PLMN-SEARCH, ATTACH NEEDED	10.4.0	11.0.0
2011-09	CT#53	CP-110690	1172		Guidelines for enhancements to MS network capability IE and UE network capability IE	10.4.0	11.0.0
2011-09	CT#53	CP-110695	1180	1	RPLMN to PLMN in handling of Emergency Numbers List	10.4.0	11.0.0
2011-09	CT#53	CP-110695	1185	3	Correction of an abnormal case during detach procedure	10.4.0	11.0.0
2011-09	CT#53	CP-110695	1187	2	Support for multiple MCC countries	10.4.0	11.0.0
2011-09	CT#53	CP-110690	1189	2	Handling of forbidden PLMNs list during attach and tracking area update	10.4.0	11.0.0
2011-09	CT#53	CP-110694	1190	1	Handling of timer T3402	10.4.0	11.0.0
2011-09	CT#53	CP-110694	1193		Correction to references	10.4.0	11.0.0
2011-09	CT#53	CP-110691	1194	2	Correction of reference to 1xRTT procedures	10.4.0	11.0.0
2011-09	CT#53	CP-110691	1198	1	Dual rx 1xCSFB procedure conflicts with note 2	10.4.0	11.0.0
2011-09	CT#53	CP-110690	1204	1	Correction to Sequence Number Handling	10.4.0	11.0.0
2011-09	CT#53	CP-110692	1208	3	Access class control for EUTRAN	10.4.0	11.0.0
2011-12	CT#54	CP-110882	1182	7	Re-attach for emergency bearer service	11.0.0	11.1.0
2011-12	CT#54	CP-110871	1210	3	Setting Mobile Reachable timer, Implicit Detach Timer	11.0.0	11.1.0
2011-12	CT#54	CP-110871	1214	1	Clarify UE action upon T3411 expiry	11.0.0	11.1.0
2011-12	CT#54	CP-110882	1219	2	Update of handling of collision between UE initiated detach procedure and network initiated detach procedure with "re-attached required"	11.0.0	11.1.0
2011-12	CT#54	CP-110888	1220	1	Correction on starting deactivate ISR timer in substate PLMN-SEARCH when T3412 expires	11.0.0	11.1.0
2011-12	CT#54	CP-110882	1224	1	Emergency bearer services from EMM-REGISTERED substates	11.0.0	11.1.0
2011-12	CT#54	CP-110882	1227		IMSI detach and EMM common procedure collision	11.0.0	11.1.0
2011-12	CT#54	CP-110882	1228	3	Correction to authentication not accepted by the UE	11.0.0	11.1.0
2011-12	CT#54	CP-110882	1229	1	Handling of Equivalent PLMN after emergency PDN connection is released.	11.0.0	11.1.0
2011-12	CT#54	CP-110882	1233	2	Correction to UE initiated bearer modification without changing packet filter(s) procedure	11.0.0	11.1.0
2011-12	CT#54	CP-110884	1235	2	Relationship between vSRVCC and SRVCC –Option2	11.0.0	11.1.0
2011-12	CT#54	CP-110888	1236	1	Clarification to paging for CSFB	11.0.0	11.1.0
2011-12	CT#54	CP-110871	1241		Removal and replacement of undefined "forbidden PLMN for attach in S1 mode" list	11.0.0	11.1.0
2011-12	CT#54	CP-110888	1242	1	Forbidden PLMNs for EPS services	11.0.0	11.1.0
2011-12	CT#54	CP-110882	1245	1	Clarification of network's knowledge of UE's valid CSG subscription	11.0.0	11.1.0
2011-12	CT#54	CP-110871	1247	1	Correction to the Service request procedure	11.0.0	11.1.0
2011-12	CT#54	CP-110871	1249	3	Clarifiaction to the SR procedure for CS emergency call when T3346 timer is running.	11.0.0	11.1.0

2011-12	CT#54	CP-110888	1254	3	Disabling EUTRAN at service reject with cause #18	11.0.0	11.1.0
2011-12	CT#54	CP-110882	1255	4	Request for CS emergency call when CS domain not available	11.0.0	11.1.0
2011-12	CT#54	CP-110888	1258		Resetting GPRS attach attempt counter and attach attempt counter	11.0.0	11.1.0
2011-12	CT#54	CP-110871	1261	2	UE initiated procedures when MM back-off timer is running	11.0.0	11.1.0
2011-12	CT#54	CP-110888	1274	2	Update of MME behavior at security protected inter-system TAU without native GUTI	11.0.0	11.1.0
2011-12	CT#54	CP-110888	1278	1	Indication of GBR in release of GBR bearer resources	11.0.0	11.1.0
2011-12	CT#54	CP-110871	1280	2	Release of the NAS signalling connection after completion of UE-initiated detach procedure	11.0.0	11.1.0
2011-12	CT#54	CP-110882	1282	1	eKSI value allocation when no eKSI value stored	11.0.0	11.1.0
2011-12	CT#54	CP-110874	1285	2	Coordination between ESM and EMM for supporting ISR	11.0.0	11.1.0
2011-12	CT#54	CP-110888	1301	1	Adding ZUC to NAS security algorithms, UE network capability and UE security capability	11.0.0	11.1.0
2011-12	CT#54	CP-110871	1311	2	Remove "CN congestion" indication	11.0.0	11.1.0
2011-12	CT#54	CP-110871	1313		Start of backoff timer when the ATTACH REJECT is not integrity protected	11.0.0	11.1.0
2011-12	CT#54	CP-110871	1315	1	Handling of APN based congestion control	11.0.0	11.1.0
2011-12	CT#54	CP-110872	1256		Trigger to stop T3246	11.0.0	11.1.0
2011-12	CT#54	CP-110871	1288	2	Back-off timer handling in connected mode mobility	11.0.0	11.1.0
2011-12	CT#54	CP-110888	1289	1	Correction of domain selection for UE in CS/PS mode 1 configured for SMS over SGs	11.0.0	11.1.0
2012-03	CT#55	CP-120111	1217	8	Correction of handling of ATTACH REJECT together with SM back-off timer	11.1.0	11.2.0
2012-03	CT#55	CP-120192	1257	5	MO SMS when T3346 is running in LTE	11.1.0	11.2.0
2012-03	CT#55	CP-120122	1305	5	Corrections to MME behaviour in Service Request Abnormal Cases handling	11.1.0	11.2.0
2012-03	CT#55	CP-120125	1316		Definition of "chosen PLMN"	11.1.0	11.2.0
2012-03	CT#55	CP-120102	1321	2	Re-attach for emergency bearer service	11.1.0	11.2.0
2012-03	CT#55	CP-120111	1324	1	Allow AC11-15 user when MM backoff timer is running	11.1.0	11.2.0
2012-03	CT#55	CP-120123	1325	2	Extended Access Barring for EUTRAN	11.1.0	11.2.0
2012-03	CT#55	CP-120122	1326	1	Local ISR deactivation in the UE upon change of the UE's usage setting or the voice domain preference for E-UTRAN	11.1.0	11.2.0
2012-03	CT#55	CP-120111	1329	2	Release of NAS signalling connection with EWT	11.1.0	11.2.0
2012-03	CT#55	CP-120122	1338	3	Correcting conditions for selecting GERAN or UTRAN due to no IMS voice	11.1.0	11.2.0
2012-03	CT#55	CP-120122	1339	1	Correcting conditions for detaching from non-EPS services due SMS using IMS	11.1.0	11.2.0
2012-03	CT#55	CP-120125	1341	1	Rejecting ESM messages with low priority indicator	11.1.0	11.2.0
2012-03	CT#55	CP-120122	1342	1	MM state handling in E-UTRAN	11.1.0	11.2.0
2012-03	CT#55	CP-120122	1343	1	Subclause reference correction	11.1.0	11.2.0
2012-03	CT#55	CP-120125	1344	1	Service request procedure when the UE has an establish PDN connection for EMC	11.1.0	11.2.0
2012-03	CT#55	CP-120122	1345	2	UE-requested modification procedure of a GBR bearer	11.1.0	11.2.0
2012-03	CT#55	CP-120125	1346	2	Local EPS bearer deactivation without ESM signalling in the network side	11.1.0	11.2.0
2012-03	CT#55	CP-120122	1348	1	Stopping timer T3417 or T3417ext in the abnormal cases of the service request procedure	11.1.0	11.2.0
2012-03	CT#55	CP-120126	1352	1	Setting of SRVCC to UTRAN/GERAN capability bit for UE not supporting vSRVCC	11.1.0	11.2.0
2012-03	CT#55	CP-120122	1354		Clarification of new EPS security context	11.1.0	11.2.0
2012-03	CT#55	CP-120125	1356	1	Correction on MO CSFB handling	11.1.0	11.2.0
2012-03	CT#55	CP-120111	1360	3	Handling NAS signalling low priority indication	11.1.0	11.2.0
2012-03	CT#55	CP-120111	1363	1	Correction for TAU triggering after paging	11.1.0	11.2.0
2012-03	CT#55	CP-120122	1369	1	Handling of stored RAND and RES values in case of connection aborted	11.1.0	11.2.0
2012-03	CT#55	CP-120111	1372	2	Correction to the handling of wait time from AS	11.1.0	11.2.0
2012-03	CT#55	CP-120122	1374		Handling of update status upon combined TAU abnormal failure	11.1.0	11.2.0
2012-03	CT#55	CP-120125	1375		Indication of supporting T3412 extended value in TAU	11.1.0	11.2.0
2012-03	CT#55				Rapporteur cleanup (editorial corrections and change of IEI for T3402 value/GPRS timer 2 in Attach Reject message)	11.2.0	11.2.1
2012-06	CT#56	CP-120308	1331	1	Inclusion of T3246 condition when reselecting to CS due to Service Reject cause #22	11.2.1	11.3.0
2012-06	CT#56	CP-120308	1350	2	Correction of detach procedure collision	11.2.1	11.3.0
2012-06	CT#56	CP-120308	1373	2	Extension of maximum bitrates in EPS QoS IE	11.2.1	11.3.0
2012-06	CT#56	CP-120308	1376	2	Traffic flow aggregate description and TFT IE extension	11.2.1	11.3.0
2012-06	CT#56	CP-120315	1377	4	Support of SMS in MME for PS-only Subscription	11.2.1	11.3.0
2012-06	CT#56	CP-120318	1378	1	Replay of NONCE_UE	11.2.1	11.3.0
2012-06	CT#56	CP-120308	1379	1	Miscellaneous corrections to authentication when PDN connection for emergency is (or is being) established	11.2.1	11.3.0
2012-06	CT#56	CP-120308	1380	1	Correction to TAU trigger for the support of terminating access domain selection for voice calls	11.2.1	11.3.0
2012-06	CT#56	CP-120318	1382	5	EUTRAN disabling correction	11.2.1	11.3.0

2012-06	CT#56	CP-120296	1385	1	Ensuring add filter resource modification targets a single traffic flow aggregate	11.2.1	11.3.0
2012-06	CT#56	CP-120318	1390		Correction of the error handling for notification messages	11.2.1	11.3.0
2012-06	CT#56	CP-120318	1391	6	Introduction of LTE Enable Timer	11.2.1	11.3.0
2012-06	CT#56	CP-120308	1394	4	Application of ESM backoff Timer when UE received ESM cause #50 or #51(Alt.3)	11.2.1	11.3.0
2012-06	CT#56	CP-120308	1396	4	Addition of SM-backoff timer handling for NW initiated PDN connectivity deactivation	11.2.1	11.3.0
2012-06	CT#56	CP-120318	1398	1	Corrections to 24.301	11.2.1	11.3.0
2012-06	CT#56	CP-120308	1399	1	Clarification on description of triggering UE to enter EMM-DEREGISTERED state	11.2.1	11.3.0
2012-06	CT#56	CP-120308	1401	1	Handling of the Local Emergency Numbers List	11.2.1	11.3.0
2012-06	CT#56	CP-120315	1404	1	Extended access barring not applicable for MT	11.2.1	11.3.0
2012-06	CT#56	CP-120318	1405	1	ISR deactivation and TAU/combined TAU in connected mode mobility from GERAN to E-UTRAN	11.2.1	11.3.0
2012-06	CT#56	CP-120318	1406		Clarification of the inclusion of "EPS bearer context status IE" in ESR.	11.2.1	11.3.0
2012-06	CT#56	CP-120308	1407	3	Use of existing NAS signalling connection for uplink signalling	11.2.1	11.3.0
2012-06	CT#56	CP-120302	1409	1	Abnormal cases when Extended Wait Time is received	11.2.1	11.3.0
2012-06	CT#56	CP-120318	1413	4	Enhancements on local release of NAS signalling connection	11.2.1	11.3.0
2012-06	CT#56	CP-120318	1416	4	E-UTRAN capability disable for CS/PS mode 2 UE	11.2.1	11.3.0
2012-06	CT#56	CP-120318	1417	2	Release of NAS signalling connection before selecting to 2G or 3G	11.2.1	11.3.0
2012-06	CT#56	CP-120318	1418	1	Congestion control for 1xCS fallback emergency call	11.2.1	11.3.0
2012-06	CT#56	CP-120318	1419	1	Allowing emergency CSFB when network is congested	11.2.1	11.3.0
2012-06	CT#56	CP-120318	1421		Correction on IE names and IE reference	11.2.1	11.3.0
2012-06	CT#56	CP-120308	1422	1	Handling of the ePLMN list on receipt of #14	11.2.1	11.3.0
2012-06	CT#56	CP-120318	1423		Setting of the update status for a UE which is IMSI attached for non-EPS services	11.2.1	11.3.0
2012-06	CT#56	CP-120308	1427		Alignment of disconnecting PDN connection	11.2.1	11.3.0
2012-06	CT#56	CP-120308	1428	3	Correction of APN based congestion control	11.2.1	11.3.0
2012-06	CT#56	CP-120308	1429		Correction of high priority user	11.2.1	11.3.0
2012-06	CT#56	CP-120308	1430		Comparison of replayed UE security capabilities	11.2.1	11.3.0
2012-06	CT#56	CP-120308	1431	3	Handling the maximum number of active EPS bearer contexts	11.2.1	11.3.0
2012-06	CT#56	CP-120309	1432	2	SGs Support for MSC in Pool to avoid dual VLR registration	11.2.1	11.3.0
2012-06	CT#56	CP-120318	1440	1	Clarification on the MS Network Capability IE of E-UTRAN disabling	11.2.1	11.3.0
2012-06	CT#56	CP-120318	1441	1	Trigger to enable the E-UTRAN capability	11.2.1	11.3.0
2012-06	CT#56	CP-120318	1446	4	Setting method of EPC capability	11.2.1	11.3.0
2012-06	CT#56	CP-120308	1447	2	How UE detects IMS registration failure	11.2.1	11.3.0
2012-06	CT#56	CP-120315	1448	1	NAS signalling low priority for dual priority device	11.2.1	11.3.0
2012-06	CT#56	CP-120315	1453	2	SM Timer handling for dual priority requirement	11.2.1	11.3.0
2012-06	CT#56	CP-120308	1454	1	Improvement in the definition of cause codes	11.2.1	11.3.0
2012-06	CT#56	CP-120318	1456		Clarification on congestion control for a 1xCS fallback for emergency call	11.2.1	11.3.0
2012-06	CT#56	CP-120309	1457	1	Restatement of detach and re-attach upon end of attached for emergency bearer service – 24.301	11.2.1	11.3.0
2012-06	CT#56	CP-120315	1459	2	MM Timer Handling for Dual Priority Support	11.2.1	11.3.0
2012-06	CT#56	CP-120315	1461	2	Handling of NAS signalling low priority overriding indication	11.2.1	11.3.0
2012-06	CT#56	CP-120308	1462	1	New SM cause codes	11.2.1	11.3.0
2012-09	CT#57	CP-120593	1397	5	Security context mapping for SRVCC from CS to PS	11.3.0	11.4.0
2012-09	CT#57	CP-120595	1460	4	PLMN selection timer for E-UTRA disabling	11.3.0	11.4.0
2012-09	CT#57	CP-120589	1467	5	Update result indication for combined procedures	11.3.0	11.4.0
2012-09	CT#57	CP-120594	1468	4	Correction and completion of handling of the maximum number of active EPS bearer contexts	11.3.0	11.4.0
2012-09	CT#57	CP-120594	1469	1	Clearing of the maximum number of active EPS bearer contexts	11.3.0	11.4.0
2012-09	CT#57	CP-120584	1471		Corrections to SGs Support for MSC in Pool	11.3.0	11.4.0
2012-09	CT#57	CP-120594	1473	2	New cause code for long term errors	11.3.0	11.4.0
2012-09	CT#57	CP-120594	1478		Clarification of requirement to include the PCO IE	11.3.0	11.4.0
2012-09	CT#57	CP-120584	1479	1	Considering ePLMN for ESM backoff Timer with cause #50 or #51	11.3.0	11.4.0
2012-09	CT#57	CP-120581	1481	2	Clarify UE behaviour after deletion of forbidden lists	11.3.0	11.4.0
2012-09	CT#57	CP-120589	1485	2	CS congestion control handling for combined procedure	11.3.0	11.4.0
2012-09	CT#57	CP-120584	1490	1	Correcting erroneous definitive of reject causes introduced by C1-122338	11.3.0	11.4.0
2012-09	CT#57	CP-120584	1491	1	Maximum number of active EPS bearer contexts in combined procedure	11.3.0	11.4.0
2012-09	CT#57	CP-120589	1492	5	Handling of PDN connection for dual-priority functionality	11.3.0	11.4.0
2012-09	CT#57	CP-120589	1493	3	Correction on handling of ESM NAS request for dual-priority functionality	11.3.0	11.4.0
2012-09	CT#57	CP-120589	1494	1	Correction on handling of SM back-off timer for dual-priority	11.3.0	11.4.0
2012-09	CT#57	CP-120589	1495	2	Dual priority definition	11.3.0	11.4.0
2012-09	CT#57	CP-120589	1496		Correction on NAS signalling low priority overriding handling	11.3.0	11.4.0
2012-09	CT#57	CP-120594	1499	3	Disabling E-UTRA capability for #7 and #14	11.3.0	11.4.0

2012-09	CT#57	CP-120594	1500		Response of TAU complete message	11.3.0	11.4.0
2012-09	CT#57	CP-120594	1502	2	UE-initiated detach procedure during attach when in EMM-DEREGISTERED state	11.3.0	11.4.0
2012-09	CT#57	CP-120594	1503	1	Clarification of UE in CS/PS mode of operation	11.3.0	11.4.0
2012-09	CT#57	CP-120594	1504	1	Clarification of E-UTRA re-enabling.	11.3.0	11.4.0
2012-09	CT#57	CP-120584	1506		Low Priority Indicator vs NAS Signalling Low Priority Indication Terminology	11.3.0	11.4.0
2012-09	CT#57	CP-120594	1507		Clarification on TAU trigger after 1xSRVCC	11.3.0	11.4.0
2012-09	CT#57	CP-120589	1510	2	UE configured for "Override_ExtendedAccessBarring"	11.3.0	11.4.0
2012-09	CT#57	CP-120656	1518	1	Reference list correction to align with the corrected TS 29.212 title	11.3.0	11.4.0
2012-12	CT#58	CP-120794	1458	4	Restructure for cause #8 in normal attach and detach	11.4.0	11.5.0
2012-12	CT#58	CP-120807	1486	3	Clarification to the ESR procedure in connected mode	11.4.0	11.5.0
2012-12	CT#58	CP-120807	1501	4	UE unable to perform 1x CS fallback for CS emergency call	11.4.0	11.5.0
2012-12	CT#58	CP-120807	1505	1	CS/PS mode 1 UE with "IMS voice not available" (revert approved CR C1-115106)	11.4.0	11.5.0
2012-12	CT#58	CP-120794	1514	2	Coordination between EMM and GMM parameters for UE receiving EMM cause #22	11.4.0	11.5.0
2012-12	CT#58	CP-120807	1520	1	Avoid to reselect E-UTRAN for #14	11.4.0	11.5.0
2012-12	CT#58	CP-120794	1521	2	Emergency handling for abnormal cases	11.4.0	11.5.0
2012-12	CT#58	CP-120794	1522		EMM state correction for network initiated EPS detach	11.4.0	11.5.0
2012-12	CT#58	CP-120794	1523		Reference correction	11.4.0	11.5.0
2012-12	CT#58	CP-120803	1525	3	Cause code setting for combined procedures in case of PS-only subscription	11.4.0	11.5.0
2012-12	CT#58	CP-120807	1526		E-UTRA disabling note removal	11.4.0	11.5.0
2012-12	CT#58	CP-120807	1527	1	E-UTRA disabling stored information deletion criteria correction	11.4.0	11.5.0
2012-12	CT#58	CP-120807	1528	1	TAU reject in shared networks in CONNECTED mode	11.4.0	11.5.0
2012-12	CT#58	CP-120807	1531	1	Fix timer specification	11.4.0	11.5.0
2012-12	CT#58	CP-120807	1532	1	UE behaviour when receiving mobile identity during periodic TAU	11.4.0	11.5.0
2012-12	CT#58	CP-120803	1533	2	Corrections for Dual priority PDN connection handling	11.4.0	11.5.0
2012-12	CT#58	CP-120794	1534	2	Handling ESR Procedure Timeout for MO CSFB	11.4.0	11.5.0
2012-12	CT#58	CP-120794	1535	2	Correction to Combined Attach/TAU Accept abnormal case handling	11.4.0	11.5.0
2012-12	CT#58	CP-120790	1536	1	Correction to Handling of #40 in Service Reject Procedure	11.4.0	11.5.0
2012-12	CT#58	CP-120794	1543	1	Network behavior in case of PDN connectivity procedure	11.4.0	11.5.0
2012-12	CT#58	CP-120803	1544	4	UE knowledge that the back-off timer is running for low or normal priority	11.4.0	11.5.0
2012-12	CT#58	CP-120807	1545	1	Incomplete and unspecified network and UE procedures for Detach	11.4.0	11.5.0
2012-12	CT#58	CP-120794	1547	7	Handling maximum number of active EPS contexts	11.4.0	11.5.0
2012-12	CT#58	CP-120807	1550	1	Distinguishing UE's disabling of EPS services	11.4.0	11.5.0
2012-12	CT#58	CP-120803	1551	4	Clarification on handling of ESM for dual priority	11.4.0	11.5.0
2012-12	CT#58	CP-120789	1553	1	Correction of Extended Service Request message and low priority indicator	11.4.0	11.5.0
2012-12	CT#58	CP-120803	1555	2	Clarification on UE with T3396 running receiving a new T3396 value	11.4.0	11.5.0
2012-12	CT#58	CP-120789	1557	1	Correction of the UE behavior after starting Timer T3396 with a random value	11.4.0	11.5.0
2012-12	CT#58	CP-120794	1558	1	MM state when EPS service only is accepted in combined procedure	11.4.0	11.5.0
2012-12	CT#58	CP-120794	1560	1	Reference correction	11.4.0	11.5.0
2012-12	CT#58	CP-120807	1562	1	Update of figure for Paging procedure using S-TMSI	11.4.0	11.5.0
2012-12	CT#58	CP-120807	1563		Correcting ambiguity caused with text "for all other cases" in Attach procedure.	11.4.0	11.5.0
2012-12	CT#58	CP-120790	1567	2	EPS bearer context deactivation required with reactivation requested when UE is EMM-IDLE	11.4.0	11.5.0
2012-12	CT#58	CP-120794	1568		Corrections to reference errors	11.4.0	11.5.0
2012-12	CT#58	CP-120913	1570	5	Paging for downlink signalling when the UE is in EMM-IDLE mode and collision case	11.4.0	11.5.0
2012-12	CT#58	CP-120807	1577	4	Solving TAU and SR Delay with Flexible re-Attach Handling	11.4.0	11.5.0
2012-12	CT#58	CP-120892	1581	3	Handling CSFB when PS domain is congested in LTE	11.4.0	11.5.0
2012-12	CT#58	CP-120803	1586	2	Handling of timer T3396 for dual priority UE.	11.4.0	11.5.0
2012-12	CT#58	CP-120807	1587	1	Correction on purpose and triggering condition of TAU procedure	11.4.0	11.5.0
2012-12	CT#58	CP-120807	1588	3	Abnormal cases of SERVICE REQUEST message for uplink signalling due to AC barring	11.4.0	11.5.0
2012-12	CT#58	CP-120807	1589	2	PDN CONNECTIVITY REQUEST handling when UE coming back to E-UTRAN coverage	11.4.0	11.5.0
2012-12	CT#58	CP-120803	1592	1	CS fallback not available	11.4.0	11.5.0
2012-12	CT#58	CP-120803	1593		Provision of LAI and TMSI for "SMS only"	11.4.0	11.5.0
2012-12	CT#58	CP-120807	1594	1	Service request procedure considered as completed from the network side	11.4.0	11.5.0
2012-12	CT#58	CP-120794	1595	2	Reject cause #8 used for normal TAU and SR	11.4.0	11.5.0
2012-12	CT#58	CP-120794	1596	1	Adding a term shared network	11.4.0	11.5.0
2012-12	CT#58	CP-120794	1597	2	NW-initiated detach with re-attach not required and no cause code	11.4.0	11.5.0

2012-12	CT#58	CP-120794	1598	1	Correction on misalignment of attach and NW initiated detach procedure collision	11.4.0	11.5.0
2013-03	CT#59	CP-130115	1599	3	Correction and cleanup of maximum number of context procedures	11.5.0	11.6.0
2013-03	CT#59	CP-130113	1600	1	Correcting condition for executing procedures when IMS registration status changes	11.5.0	11.6.0
2013-03	CT#59	CP-130108	1606	1	LAI and TMSI for "SMS-only" in case of SMS in MME	11.5.0	11.6.0
2013-03	CT#59	CP-130099	1611	2	Inclusion of PLMN ID for the CS domain	11.5.0	11.6.0
2013-03	CT#59	CP-130113	1618	3	Detach procedure to disable EPS services	11.5.0	11.6.0
2013-03	CT#59	CP-130123	1619	1	LAI setting over NAS in network sharing	11.5.0	11.6.0
2013-03	CT#59	CP-130113	1623	2	Correcting anomalies on timer guarding enabling of E-UTRA capability	11.5.0	11.6.0
2013-03	CT#59	CP-130185	1584	5	Correction of de-activating EPS bearer context	11.6.0	12.0.0
2013-03	CT#59	CP-130125	1608	1	Allow UEs to proceed with CSFB after Service Reject #9 or #10	11.6.0	12.0.0
2013-03	CT#59	CP-130125	1620	1	UE identity used for initial NAS message routing	11.6.0	12.0.0
2013-03	CT#59	CP-130125	1621		E-UTRA capability alignment	11.6.0	12.0.0
2013-03	CT#59	CP-130125	1622	3	Correction to ISR handling during PS handover	11.6.0	12.0.0
2013-03	CT#59	CP-130125	1634	1	Correction on the entity which handles EPS bearer contexts	11.6.0	12.0.0
2013-06	CT#60	CP-130258	1604	2	TAU trigger at return to LTE after failed CSFB	12.0.0	12.1.0
2013-06	CT#60	CP-130264	1628	3	Performing Emergency Attach from Attempting to Attach/Update substates	12.0.0	12.1.0
2013-06	CT#60	CP-130258	1633	8	EPS bearer deactivation procedure during EPS bearer context unsynchronization	12.0.0	12.1.0
2013-06	CT#60	CP-130264	1639	4	Adding the requests from CM layers as combined attach/TAU trigger	12.0.0	12.1.0
2013-06	CT#60	CP-130258	1640	5	Correcting UE behaviour when receiving a cause code requiring search for a suitable cell	12.0.0	12.1.0
2013-06	CT#60	CP-130258	1641	2	EPS timer usage in GERAN and UTRAN	12.0.0	12.1.0
2013-06	CT#60	CP-130264	1651	2	Setting of Device properties IE by NAS for UEs allowed to use AC 11 to 15	12.0.0	12.1.0
2013-06	CT#60	CP-130247	1653	2	Wrong indication of T3340 and missing stop condition for T3440	12.0.0	12.1.0
2013-06	CT#60	CP-130258	1655	2	Incorrect checks on existing EPS bearer identities	12.0.0	12.1.0
2013-06	CT#60	CP-130264	1656	1	Correction to T3421 in timer tables	12.0.0	12.1.0
2013-06	CT#60	CP-130247	1659	1	Addressing backward compatibility concerns related to TAU Complete handling	12.0.0	12.1.0
2013-06	CT#60	CP-130258	1660	2	Clarifications to "Abnormal Cases in the UE" for EPS detach procedure	12.0.0	12.1.0
2013-06	CT#60	CP-130264	1661	1	Clarifications on terminology of last PDN connection	12.0.0	12.1.0
2013-06	CT#60	CP-130264	1662	2	Modification of Cause #65 to not include consideration for emergency EPS bearers.	12.0.0	12.1.0
2013-06	CT#60	CP-130258	1664	1	Cause value for the Forbidden list in S101 mode	12.0.0	12.1.0
2013-06	CT#60	CP-130258	1667	1	Non-EPS service in the combined TAU	12.0.0	12.1.0
2013-06	CT#60	CP-130264	1668	2	Obtain PDN address during attcach procedure	12.0.0	12.1.0
2013-06	CT#60	CP-130258	1671	2	Initiation of TAU in EMM-REGISTERED substates	12.0.0	12.1.0
2013-06	CT#60	CP-130258	1672	4	Correction for collision between NW initiated IMSI detach and service request	12.0.0	12.1.0
2013-06	CT#60	CP-130258	1673	1	Correction to UE behaviour when UE requests for PDN type IPv4v6 but the NW only allows IPv4 or IPv6	12.0.0	12.1.0
2013-06	CT#60	CP-130264	1674	3	Updating forbidden lists during TAU for a UE with emergency bearers	12.0.0	12.1.0
2013-06	CT#60	CP-130258	1678	1	Local deactivation of EPS bearers during service request procedure	12.0.0	12.1.0
2013-06	CT#60	CP-130404	1681	5	Handling CSFB when PS domain is backed off	12.0.0	12.1.0
2013-06	CT#60	CP-130258	1682	2	Procedure when UE changes voice domain preference or SMS configuration	12.0.0	12.1.0
2013-06	CT#60	CP-130264	1683	2	Non-EPS update triggered during periodic tracking area update	12.0.0	12.1.0
2013-06	CT#60	CP-130264	1685	2	Service request procedure initiation for a UE configured for NAS signalling low priority	12.0.0	12.1.0
2013-06	CT#60	CP-130244	1687	1	Correction to the exception of not stopping T3396 for dual-priority UE	12.0.0	12.1.0
2013-06	CT#60	CP-130244	1689	5	Correction to TMSI for "SMS-only" in case of SMS in MME	12.0.0	12.1.0
2013-06	CT#60	CP-130244	1691	2	No ISR for SMS in MME	12.0.0	12.1.0
2013-06	CT#60	CP-130258	1692	2	Start T3440 for EMM cause#35	12.0.0	12.1.0
2013-06	CT#60	CP-130258	1693	1	Correction to the use of the null integrity protection algorithm	12.0.0	12.1.0
2013-06	CT#60	CP-130258	1694	1	Set of the KSI to all zeros and editorials	12.0.0	12.1.0
2013-06	CT#60	CP-130258	1695	3	Select 2G/3G after 5 times failure of periodic TAU for combined UE	12.0.0	12.1.0
2013-06	CT#60	CP-130267	1696	6	Terminology for SIPTO at the local network	12.0.0	12.1.0
2013-06	CT#60	CP-130267	1697	4	Updates to EMM and ESM procedures because of SIPTO at the local network	12.0.0	12.1.0
2013-06	CT#60	CP-130258	1702	3	Addition of T3402 timer handling	12.0.0	12.1.0
2013-06	CT#60	CP-130258	1707	1	Correction on UE behavior for attach not accepted by the network	12.0.0	12.1.0
2013-06	CT#60	CP-130258	1710		Correction of term 'PDP type' to EPS terminology	12.0.0	12.1.0

2013-06	CT#60	CP-130258	1712	5	NAS security setup without a new EPS authentication for initial NAS messages	12.0.0	12.1.0
2013-06	CT#60	CP-130250	1718	1	Correction of local IP address indication	12.0.0	12.1.0
2013-06	CT#60	CP-130258	1727	1	Removal of dependency on SGs state in the NW when determining update type	12.0.0	12.1.0
2013-06	CT#60	CP-130264	1732	3	Correction on encoding for EPS QoS information element	12.0.0	12.1.0
2013-06	CT#60	CP-130258	1733	1	Clarifications of the specification of T3412 Extended Value	12.0.0	12.1.0
2013-06	CT#60	CP-130239	1737	2	Updating conditions to enable E-UTRAN	12.0.0	12.1.0
2013-06	CT#60	CP-130258	1738	2	Remove NOTE on disabling LTE capability	12.0.0	12.1.0
2013-06	CT#60	CP-130258	1739		Correction on NAS security parameters from E-UTRA IE definition	12.0.0	12.1.0
2013-06	CT#60	CP-130264	1740	1	Adding term definition for UE and MS	12.0.0	12.1.0
2013-06	CT#60	CP-130264	1747	2	Clarification to the attach attempt counter	12.0.0	12.1.0
2013-06	CT#60	CP-130264	1753	2	UE behaviour on cause #25 in messages that are NOT integrity protected	12.0.0	12.1.0
2013-09	CT#61	CP-130505	1755	2	E-UTRA re-enabling after UE initiated detach for EPS services	12.1.0	12.2.0
2013-09	CT#61	CP-130510	1763	1	Correction of conditions brought about by approval of C1-132662	12.1.0	12.2.0
2013-09	CT#61	CP-130510	1764	1	Addition of cause #25 to "abnormal cases in the UE"	12.1.0	12.2.0
2013-09	CT#61	CP-130505	1765	1	Update of EMM-REGISTERED.ATTEMPTING-TO-UPDATE definition	12.1.0	12.2.0
2013-09	CT#61	CP-130510	1771	2	EPS QoS GBR/MBR rate handling at the NAS interface	12.1.0	12.2.0
2013-09	CT#61	CP-130505	1772	2	TAU trigger at return to LTE after CSFB cancellation	12.1.0	12.2.0
2013-09	CT#61	CP-130505	1775	1	Clarification of the update type to be used in TAU Request	12.1.0	12.2.0
2013-09	CT#61	CP-130498	1780	1	Control of the release of the NAS signalling connection for reject messages	12.1.0	12.2.0
2013-09	CT#61	CP-130505	1781	2	TIN set to "P-TMSI" and inclusion of the NonceUE in the TRACKING AREA UPDATE REQUEST message	12.1.0	12.2.0
2013-09	CT#61	CP-130510	1783	1	Non-EPS update triggered during periodic tracking area update	12.1.0	12.2.0
2013-09	CT#61	CP-130510	1786	1	Conditions when T3346 is not running	12.1.0	12.2.0
2013-09	CT#61	CP-130514	1792	1	Service request procedure for SIPTO at the local network with stand-along GW	12.1.0	12.2.0
2013-09	CT#61	CP-130497	1794		Correcting requirement for including SRVCC support indicator	12.1.0	12.2.0
2013-09	CT#61	CP-130505	1795		Clean-up of agreed correction for failed CSFB cases	12.1.0	12.2.0
2013-09	CT#61	CP-130514	1796	1	Local home network identifier	12.1.0	12.2.0
2013-09	CT#61	CP-130510	1806	1	Suitable cell search when the UE receives a EMM cause code #15 or #25	12.1.0	12.2.0
2013-09	CT#61	CP-130510	1809	1	Collision of UE behavior for UE abnormal case in TAU procedure	12.1.0	12.2.0
2013-09	CT#61	CP-130505	1813	1	Handling of update status upon combined Attach abnormal failure	12.1.0	12.2.0
2013-09	CT#61	CP-130505	1814	1	On NAS Security Mode control and KeNB re-keying	12.1.0	12.2.0
2013-09	CT#61	CP-130505	1815		Fixing table 4.3.2.5.2 implementation error	12.1.0	12.2.0
2013-12	CT#62	CP-130754	1759	5	Correcting LIPA PDN connection deactivation upon SR	12.2.0	12.3.0
2013-12	CT#62	CP-130762	1784	3	UE-initiated detach procedure during tracking area updating procedure	12.2.0	12.3.0
2013-12	CT#62	CP-130762	1785	2	Update of ePLMN list for a UE with a PDN connection for emergency bearer services	12.2.0	12.3.0
2013-12	CT#62	CP-130762	1788	3	Deletion of the ePLMNs list upon receipt of #9, #10 or #40	12.2.0	12.3.0
2013-12	CT#62	CP-130754	1816	1	T3396 timer handling	12.2.0	12.3.0
2013-12	CT#62	CP-130769	1818	2	Detect that SIPTO@LN PDN connection involves a stand-alone GW after during inter-MME HO	12.2.0	12.3.0
2013-12	CT#62	CP-130754	1828		Alignment of EMM state change of agreed corrections	12.2.0	12.3.0
2013-12	CT#62	CP-130762	1829		GUTI handling in the network abnormal case in attach procedure	12.2.0	12.3.0
2013-12	CT#62	CP-130762	1830		Stop ongoing user data transmission for UE abnormal case in TAU procedure	12.2.0	12.3.0
2013-12	CT#62	CP-130754	1836	1	Trigger for Combined TAU with IMSI attach	12.2.0	12.3.0
2013-12	CT#62	CP-130762	1839	1	Clarification to the combined TAU procedure when rejected with EMM cause #10	12.2.0	12.3.0
2013-12	CT#62	CP-130741	1844		Correcting conditions for performing TAU when T3346 is running	12.2.0	12.3.0
2013-12	CT#62	CP-130762	1852	3	Paging response when running T3346	12.2.0	12.3.0
2013-12	CT#62	CP-130762	1853	2	Requirement for resetting the Attach/TAU attempt counter	12.2.0	12.3.0
2013-12	CT#62	CP-130754	1854	2	TAU procedure initiation following CSFB failure or CSFB cancellation	12.2.0	12.3.0
2013-12	CT#62	CP-130754	1857	1	Clarification to description of the EMM cause value#40	12.2.0	12.3.0
2013-12	CT#62	CP-130754	1859	1	Correction of conditions for re-enablement of E-UTRA having received cause #14	12.2.0	12.3.0
2013-12	CT#62	CP-130754	1860	2	Condition to stop the paging timer	12.2.0	12.3.0
2013-12	CT#62	CP-130754	1863	1	RRC establishment cause for 1xCSFB	12.2.0	12.3.0
2013-12	CT#62	CP-130738	1868	3	Keeping ongoing realtime and multimedia services if IMS VoPS change	12.2.0	12.3.0
2013-12	CT#62	CP-130762	1873		Missing sentence in the sub-clause 6.5.4.6	12.2.0	12.3.0
2013-12	CT#62	CP-130754	1874	1	PLMN identity for the CS domain in the acceptance messages	12.2.0	12.3.0
2013-12	CT#62	CP-130762	1875	1	Clarification of requirements for UEs configured for dual priority	12.2.0	12.3.0
2013-12	CT#62	CP-130754	1879	2	Clarification for T3423 start condition	12.2.0	12.3.0
2013-12	CT#62	CP-130769	1882		TAU procedure actions because of SIPTO at local network	12.2.0	12.3.0

2013-12	CT#62	CP-130769	1734	4	ISR handling for SIPTO at the local network	12.2.0	12.3.0
2013-12	CT#62	CP-130769	1761	13	Removal of SIPTO@LN procedures upon SR reject unless SR received is not due to CS fallback or 1xCS fallback	12.2.0	12.3.0
2013-12	CT#62	CP-130745	1832	2	Local deactivation of ISR after CSFB to correct resume of packet services	12.2.0	12.3.0
2013-12	CT#62	CP-130769	1846	1	Correcting IE name transporting L-GW address in INITIAL UE MESSAGE message for SIPTO@LN	12.2.0	12.3.0
2013-12	CT#62	CP-130799	1861	5	MME behaviour after sending Reject message with cause#9	12.2.0	12.3.0
2014-03	CT#63	CP-140134	1848	5	TMSI handling during tracking area update procedures	12.3.0	12.4.0
2014-03	CT#63	CP-140142	1864	3	Handling Service Request failure due to timeout	12.3.0	12.4.0
2014-03	CT#63	CP-140126	1885	4	Keeping ongoing realtime and multimedia services if IMS VoPS change for a CS/PS mode 1 UE registered for EPS services only	12.3.0	12.4.0
2014-03	CT#63	CP-140144	1890	3	Emergency Attach in the network not supporting IMS emergency call for limited service state	12.3.0	12.4.0
2014-03	CT#63	CP-140144	1893	1	RRC Establishment Cause for TAU procedure	12.3.0	12.4.0
2014-03	CT#63	CP-140141	1894	3	Implicitly detached cause	12.3.0	12.4.0
2014-03	CT#63	CP-140141	1895	1	Combined TAU trigger for U2 NOT UPDATED	12.3.0	12.4.0
2014-03	CT#63	CP-140144	1898	2	Missing condition for cause of start of T3402	12.3.0	12.4.0
2014-03	CT#63	CP-140141	1901	1	RRC establishment cause used for extended service request	12.3.0	12.4.0
2014-03	CT#63	CP-140125	1904	1	Delay tolerant setting and back-off timer start for Service Request with low priority	12.3.0	12.4.0
2014-03	CT#63	CP-140131	1906	1	RRC establishment cause setting for dual priority UEs	12.3.0	12.4.0
2014-03	CT#63	CP-140142	1907	2	UE behavior for ESM #54 "PDN connection does not exist"	12.3.0	12.4.0
2014-03	CT#63	CP-140136	1909	3	Introduction of UE power saving mode	12.3.0	12.4.0
2014-06	CT#64	CP-140310	1866	5	Continuation of EAB override for requests on a PDN connection established with EAB override	12.4.0	12.5.0
2014-06	CT#64	CP-140331	1876	5	Conditionsfor performing TAU for UE configured with Dual Priority	12.4.0	12.5.0
2014-06	CT#64	CP-140331	1878	4	Start T3440 for EMM cause values #7, #8	12.4.0	12.5.0
2014-06	CT#64	CP-140331	1917	3	Introduce enhanced EMM cause #15 for disabling the E-UTRA capability	12.4.0	12.5.0
2014-06	CT#64	CP-140331	1919		Abbreviation update	12.4.0	12.5.0
2014-06	CT#64	CP-140329	1921	2	Service Request attempt counter	12.4.0	12.5.0
2014-06	CT#64	CP-140331	1922	3	T3412 and T3417 correction	12.4.0	12.5.0
2014-06	CT#64	CP-140326	1924	3	Indication of UE ProSe capability	12.4.0	12.5.0
2014-06	CT#64	CP-140331	1928	7	Handling of Abnormal Cases related to Emergency PDN Connectivity Request Procedure	12.4.0	12.5.0
2014-06	CT#64	CP-140304	1931	1	Handling CS Service Notification	12.4.0	12.5.0
2014-06	CT#64	CP-140328	1934	1	MME behavior when there is lower layer failure during TAU procedure	12.4.0	12.5.0
2014-06	CT#64	CP-140329	1935	1	Attach retry for ESM #54 "PDN connection does not exist"	12.4.0	12.5.0
2014-06	CT#64	CP-140328	1936	3	Behaviour of CS/PS mode 1 UE with IMS voice available	12.4.0	12.5.0
2014-06	CT#64	CP-140311	1938	4	TFT validity criteria	12.4.0	12.5.0
2014-06	CT#64	CP-140323	1939	3	Editorials on power saving mode	12.4.0	12.5.0
2014-06	CT#64	CP-140328	1940	4	Local release of NAS signalling connection for emergency sessions after IMSI detach	12.4.0	12.5.0
2014-06	CT#64	CP-140331	1941	4	Using default value for T3402 upon attach failure in new PLMN	12.4.0	12.5.0
2014-06	CT#64	CP-140329	1946	3	Handling of Service request procedure for emergency bearer services.	12.4.0	12.5.0
2014-06	CT#64	CP-140328	1950	1	MME handling on collision between attach and paging for EPS services	12.4.0	12.5.0
2014-06	CT#64	CP-140323	1951	2	No data transmission when PSM is activated	12.4.0	12.5.0
2014-06	CT#64	CP-140331	1959	1	Setting the values of MRT and IDT in the MME	12.4.0	12.5.0
2014-06	CT#64	CP-140328	1960	1	Handling of the update status upon receipt of Service Reject	12.4.0	12.5.0
2014-06	CT#64	CP-140326	1961	2	Addition of SR trigger for ProSe	12.4.0	12.5.0
2014-06	CT#64	CP-140331	1963	2	Emergency call clarifications	12.4.0	12.5.0
2014-06	CT#64	CP-140331	1964	2	ISR should be activated in the UE when T3312 is deactivated.	12.4.0	12.5.0
2014-06	CT#64	CP-140323	1965	2	Clarifications on emergency attach and PSM	12.4.0	12.5.0
2014-06	CT#64	CP-140328	1966	3	Coordination between EMM and ESM when UE receives cause #19 to initial attach	12.4.0	12.5.0
2014-06	CT#64	CP-140328	1970	1	Paging timer stop for TAU as a paging response in case of integrity check failure	12.4.0	12.5.0
2014-06	CT#64	CP-140309	1975		Aligment of the UE behaviour between attach and TAU procedures	12.4.0	12.5.0
2014-06	CT#64	CP-140328	1976		UE in CS/PS mode of operation 1	12.4.0	12.5.0

2014-06	CT#64	CP-140323	1977	1	T3324 value set to zero	12.4.0	12.5.0
2014-06	CT#64	CP-140323	1978	2	ISR deactivation for Power Saving Mode	12.4.0	12.5.0
2014-06	CT#64	CP-140331	1979	2	Correction for attempt counter	12.4.0	12.5.0
2014-06	CT#64	CP-140331	1980	2	UE behaviour in abnormal cases for Attach and TAU procedures	12.4.0	12.5.0
2014-06	CT#64	CP-140323	1981		Corrections to UE power saving mode	12.4.0	12.5.0
2014-06	CT#64	CP-140323	1983	1	The set of mobile reachable timer and implicit detach timer considering PSM	12.4.0	12.5.0
2014-09	CT#65	CP-140661	1923	5	Clarifications on the selection of another RAT when disabling E-UTRA.	12.5.0	12.6.0
2014-09	CT#65	CP-140662	1962	3	Handling of SCM at NAS layer	12.5.0	12.6.0
2014-09	CT#65	CP-140640	1969	4	Correction on handling of cause #27 (missing or unknown APN)	12.5.0	12.6.0
2014-09	CT#65	CP-140664	1984	3	Stopping T3312 for TAU ACCEPT (ISR not activated)	12.5.0	12.6.0
2014-09	CT#65	CP-140664	1989		Immediate restart of attach procedure for transmission failures	12.5.0	12.6.0
2014-09	CT#65	CP-140670	1992	2	Add the WLAN offloadability to the NAS message	12.5.0	12.6.0
2014-09	CT#65	CP-140573	1995	2	Service request counter for AC 11-15 UEs	12.5.0	12.6.0
2014-09	CT#65	CP-140664	1996		TMSI handling in the combined attach procedure	12.5.0	12.6.0
2014-09	CT#65	CP-140661	1997	1	Access barring for terminating calls	12.5.0	12.6.0
2014-09	CT#65	CP-140643	2004	1	Exception for dual priority UE(s)	12.5.0	12.6.0
2014-09	CT#65	CP-140664	2005	1	Editorial Corrections	12.5.0	12.6.0
2014-09	CT#65	CP-140657	2006	3	Optimization for PSM	12.5.0	12.6.0
2014-09	CT#65	CP-140642	2010	1	MS network capability setting after disabling LTE capability	12.5.0	12.6.0
2014-09	CT#65	CP-140664	2011		Abnormal case handling for SMC	12.5.0	12.6.0
2014-09	CT#65	CP-140664	2013		Stop NAS retry timer upon receipt of EWT from AS	12.5.0	12.6.0
2014-09	CT#65	CP-140661	2014	1	Expiry of T3440	12.5.0	12.6.0
2014-09	CT#65	CP-140657	2018	1	MS network feature support usage with PSM	12.5.0	12.6.0
2014-09	CT#65	CP-140643	2020	1	Correction to EAB override	12.5.0	12.6.0
2014-09	CT#65	CP-140651	2024	3	Introducing new QCIs for MCPTT signaling	12.5.0	12.6.0
2014-12	CT#66	CP-140847	1994	3	Addition of SR trigger for ProSe direct communication	12.6.0	12.7.0
2014-12	CT#66	CP-140836	2012	4	Request for emergency services allowed even if back-off timer running	12.6.0	12.7.0
2014-12	CT#66	CP-140855	2029	3	NAS recovery when NAS has received START indications of different types.	12.6.0	12.7.0
2014-12	CT#66	CP-140836	2035		Aligning to the term "UE configured to use AC11 – 15 in selected PLMN"	12.6.0	12.7.0
2014-12	CT#66	CP-140854	2039	2	Handling of WLAN offload indication from the MME	12.6.0	12.7.0
2014-12	CT#66	CP-140832	2041	2	Correction of handling of repeated periodic TAU failure	12.6.0	12.7.0
2014-12	CT#66	CP-140832	2042	2	GBR and MBR values during EPS bearer context modification	12.6.0	12.7.0
2014-12	CT#66	CP-140843	2043		Implicit detach timer setting for PSM UE	12.6.0	12.7.0
2014-12	CT#66	CP-140850	2048	2	MCPTT QCI usage limitation	12.6.0	12.7.0
2014-12	CT#66	CP-140846	2049	4	Trigger to re-initiate service request procedure.	12.6.0	12.7.0
2014-12	CT#66	CP-140854	2051	8	Add WLAN offload indication to NAS	12.6.0	12.7.0
2014-12	CT#66	CP-140854	2052		MME initiating SM procedure	12.6.0	12.7.0
2014-12	CT#66	CP-140832	2055	4	Misalignment between attach and TAU	12.6.0	12.7.0
2014-12	CT#66	CP-140855	2056	4	Handling of SCM during TAU procedure	12.6.0	12.7.0
2014-12	CT#66	CP-140836	2057		Stopping T3312 for TAU ACCEPT (ISR not activated)	12.6.0	12.7.0
2014-12	CT#66	CP-140850	2063	2	QCI code values "spare for future use"	12.6.0	12.7.0
2014-12	CT#66	CP-140824	2066	2	Conditions to stop timer	12.6.0	12.7.0
2014-12	CT#66	CP-140847	2069	2	Conditions for setting "active" flag in TAU Request	12.6.0	12.7.0
2014-12	CT#66	CP-140836	2070	1	Clarification on EMM Procedure Timer handling during authentication failure timers during emergency call	12.6.0	12.7.0
2014-12	CT#66	CP-140843	2073	2	Condition for including the T3324 IE	12.6.0	12.7.0
2014-12	CT#66	CP-140843	2075	5	Trigger to TAU procedure	12.6.0	12.7.0
2014-12	CT#66	CP-140836	2032	2	Solution to Non-availability of Services due to LTE-Roaming	12.6.0	12.7.0
2014-12	CT#66	CP-140858	2030		Removal of EPS update status in substates "NORMAL-SERVICE" and "LIMITED-SERVICE" of "EMM-DEREGISTERED".	12.7.0	13.0.0
2014-12	CT#66	CP-140858	2038		Deletion of TAI list when GUTI and last visited registered TAI are deleted	12.7.0	13.0.0
2014-12	CT#66	CP-140862	2040	2	Correction of description of security protection	12.7.0	13.0.0
2014-12	CT#66	CP-140862	2044	4	ISR activation at the UE	12.7.0	13.0.0

2014-12	CT#66	CP-140862	2053	1	Retransmit non-delivered NAS PDU due to handover	12.7.0	13.0.0
2014-12	CT#66	CP-140862	2064	1	Handling NAS procedure re-attempts	12.7.0	13.0.0
2014-12	CT#66	CP-140858	2074	1	Editorials on PSM	12.7.0	13.0.0
2014-12	CT#66	CP-140858	2076	2	Network failing the authentication check	12.7.0	13.0.0
2015-03	CT#67	CP-150066	2081	1	Paging trigger for IMS PDN connection restoration	13.0.0	13.1.0
2015-03	CT#67	CP-150204	2082	5	Correcting ESM re-activation attempts at PLMN change when only one IP version is supported by the network.	13.0.0	13.1.0
2015-03	CT#67	CP-150064	2085	2	Handling of PDN connectivity reject from the network due to APN based congestion control	13.0.0	13.1.0
2015-03	CT#67	CP-150064	2087	1	Correction on ESM congestion control handling	13.0.0	13.1.0
2015-03	CT#67	CP-150069	2089	4	UE retry behavior for ESM cause codes	13.0.0	13.1.0
2015-03	CT#67	CP-150076	2091	1	ACB skip for low priority and dual priority UEs	13.0.0	13.1.0
2015-03	CT#67	CP-150075	2093	2	Clarification on WLAN offload indication	13.0.0	13.1.0
2015-03	CT#67	CP-150083	2098	2	Corrections to the EPS attach procedure when LTE roaming is not allowed.	13.0.0	13.1.0
2015-03	CT#67	CP-150193	2096	3	Unsuccessful PDN connectivity with #50 or #51	13.0.0	13.1.0
2015-06	CT#68	CP-150323	2083	3	Detach and re-attach required for changes in E-UTRAN capabilities	13.1.0	13.2.0
2015-06	CT#68	CP-150315	2098	4	Correction of UE retry behaviour after rejection by the network	13.1.0	13.2.0
2015-06	CT#68	CP-150329	2099	1	Handling of authentication timers after loss or release of signalling connection	13.1.0	13.2.0
2015-06	CT#68	CP-150329	2100	1	Handling of access class barring when accessing the network for emergency bearer sevices	13.1.0	13.2.0
2015-06	CT#68	CP-150315	2107		Remove the note for ESM cause value #27	13.1.0	13.2.0
2015-06	CT#68	CP-150329	2116	1	Clarification on T3346	13.1.0	13.2.0
2015-06	CT#68	CP-150308	2119	1	ESM re-activation attempts	13.1.0	13.2.0
2015-06	CT#68	CP-150316	2121	4	Proper Call Type for service request in ProSe	13.1.0	13.2.0
2015-06	CT#68	CP-150323	2122	2	Clarfication for TMSI handling during combined tracking area update procedure	13.1.0	13.2.0
2015-06	CT#68	CP-150329	2126		Correction on UE's behaviour for EWT from the lower layers	13.1.0	13.2.0
2015-06	CT#68	CP-150323	2127		TAU trigger at T3417ext expiry for MO CSFB	13.1.0	13.2.0
2015-06	CT#68	CP-150329	2132	2	Handling of ESM cause value #50, #51	13.1.0	13.2.0
2015-06	CT#68	CP-150329	2133		Removal of dependency on EPS Update Status from EMM-DEREGISTERED.ATTEMPTING-TO-ATTACH	13.1.0	13.2.0
2015-06	CT#68	CP-150316	2137	2	Correction of service request triggering condition for ProSe direct service	13.1.0	13.2.0
2015-06	CT#68	CP-150329	2138		Handling of timers T3346	13.1.0	13.2.0
2015-06	CT#68	CP-150329	2139	1	Setting of the Device properties IE for CSFB emergency call and 1x CSFB emergency call	13.1.0	13.2.0
2015-06	CT#68	CP-150323	2140		Clarifications on Disabling E-UTRA	13.1.0	13.2.0
2015-06	CT#68	CP-150323	2141	1	Clarifications on Enabling E-UTRA when UE performs PLMN selection	13.1.0	13.2.0
2015-06	CT#68	CP-150310	2145	1	Rollback of changes on reset attempt counters	13.1.0	13.2.0
2015-06	CT#68	CP-150329	2148	1	Handling of timer T3245	13.1.0	13.2.0
2015-06	CT#68	CP-150329	2150		Alignment of UE behaviour for EWT in Service Request procedure	13.1.0	13.2.0
2015-06	CT#68	CP-150323	2151	1	RRC release with redirection for CSFB or 1x CSFB	13.1.0	13.2.0
2015-06	CT#68	CP-150315	2154	2	UE back-off timer for EPS session management rejections	13.1.0	13.2.0
2015-06	CT#68	CP-150323	2155	1	Clarifications on Enabling E-UTRA after handover	13.1.0	13.2.0
2015-06	CT#68	CP-150323	2167	1	Allow UEs to proceed with CSFB after TAU Reject #9,#10 or #40	13.1.0	13.2.0
2015-06	CT#68	CP-150313	2147	2	Trigger to initate Tracking area procedure (PSM)	13.1.0	13.2.0
2015-06	CT#68	CP-150329	2149	1	Enable ISR for PS-only UE	13.1.0	13.2.0
2015-06	CT#68	CP-150326	2163	3	Updates to mobile reachable timer and network behaviour because of MONTE	13.1.0	13.2.0
2015-09	CT#69	CP-150526	2169	2	NBIFOM - coding of Access usability	13.2.0	13.3.0
2015-09	CT#69	CP-150519	2174	1	CSFB cancellation invalidating need to restart service request procedure	13.2.0	13.3.0
2015-09	CT#69	CP-150526	2177	2	NBIFOM - coding of RAN rules related indications	13.2.0	13.3.0
2015-09	CT#69	CP-150529	2178	2	Correction of criterion for clearing a maximum number of EPS bearer contexts	13.2.0	13.3.0
2015-09	CT#69	CP-150529	2179	2	Correction of criterion for stopping timer T3346	13.2.0	13.3.0
2015-09	CT#69	CP-150516	2181		Removal of incorrect reference to PLMN selection	13.2.0	13.3.0

2015-09	CT#69	CP-150523	2182	2	Back-off timer mechanism for equivalent PLMNs	13.2.0	13.3.0
2015-09	CT#69	CP-150526	2183	1	Addition of an access using E-UTRAN in UE-initiated mode	13.2.0	13.3.0
2015-09	CT#69	CP-150519	2185	2	T3440 for TAU reject with cause #9,10,40	13.2.0	13.3.0
2015-09	CT#69	CP-150519	2186	2	RRC establishment cause for TAU procedure	13.2.0	13.3.0
2015-09	CT#69	CP-150526	2190	1	UE-initiated IP flow mobility	13.2.0	13.3.0
2015-09	CT#69	CP-150526	2191	1	Network-initiated IP flow mobility	13.2.0	13.3.0
2015-09	CT#69	CP-150523	2192		Correction of MS retry behaviour after rejection with #8, #27, #32, #33	13.2.0	13.3.0
2015-09	CT#69	CP-150519	2193	2	Extended service request message rejected with #12 and #15	13.2.0	13.3.0
2015-09	CT#69	CP-150529	2194		UE-initiated detach for "switch off" and change of cell into a new TAI	13.2.0	13.3.0
2015-09	CT#69	CP-150529	2195	1	Expiry of T3412 when the UE is attached for emergency bearer services	13.2.0	13.3.0
2015-09	CT#69	CP-150529	2198	2	Clarification on the handling of the back-off timer when the UE is switched off	13.2.0	13.3.0
2015-09	CT#69	CP-150529	2200		Enhancement on NW initiated EPS bearer deactivation	13.2.0	13.3.0
2015-09	CT#69	CP-150529	2201		Handling of back-off timer at switch-on	13.2.0	13.3.0
2015-09	CT#69	CP-150519	2202	2	Correction on CSFB in TAU reject with #9,#10 or #40	13.2.0	13.3.0
2015-09	CT#69	CP-150516	2204	2	Delete the incorrect cause values in UE requested bearer resource modification procedure	13.2.0	13.3.0
2015-09	CT#69	CP-150519	2207	2	Correction on reporting of EPS bearer context status information	13.2.0	13.3.0
2015-09	CT#69	CP-150519	2210		Clarification on TAU and access class barring	13.2.0	13.3.0
2015-09	CT#69	CP-150536	2212	2	Introduction of extended idle mode DRX cycle	13.2.0	13.3.0
2015-09	CT#69	CP-150543	2135	5	Handling of Application specific Congestion control for Data Communication (ACDC)	13.2.0	13.3.0
2015-12	CT#70	CP-150710	2034	5	Local deactivation of EPS bearers contexts upon receipt of ESM reject cause #49	13.3.0	13.4.0
2015-12	CT#70	CP-150696	2037	6	UE actions on detach request indicating "re-attach not required" without EMM cause	13.3.0	13.4.0
2015-12	CT#70	CP-150710	2172	3	Incorrect test condition on linkage of override EAB and override NSLPI	13.3.0	13.4.0
2015-12	CT#70	CP-150706	2214	2	Define ESM cause for the rejection of additional access to a PDN connection	13.3.0	13.4.0
2015-12	CT#70	CP-150710	2216		Correction on UE behaviour for SR rejected with #10	13.3.0	13.4.0
2015-12	CT#70	CP-150710	2217	3	Alignment on NW initiated EPS bearer deactivation	13.3.0	13.4.0
2015-12	CT#70	CP-150696	2218		T3440 for emergency service PDN Connection	13.3.0	13.4.0
2015-12	CT#70	CP-150696	2219	1	Stand-alone PDN connectivity procedure without APN IE	13.3.0	13.4.0
2015-12	CT#70	CP-150696	2221	1	Handling of CSFB requests in ATTEMPTING-TO-ATTACH and ATTEMPTING-TO-UPDATE	13.3.0	13.4.0
2015-12	CT#70	CP-150702	2228	1	Handling of Re-attempt indicator IE	13.3.0	13.4.0
2015-12	CT#70	CP-150713	2229	4	Extended DRX IE addition	13.3.0	13.4.0
2015-12	CT#70	CP-150713	2230	1	Extended DRX accepted by the network	13.3.0	13.4.0
2015-12	CT#70	CP-150706	2232	4	Inclusion of RAN rules and access usability IEs in NBIFOM container	13.3.0	13.4.0
2015-12	CT#70	CP-150696	2237	2	TAU successful for "EPS service only" with a persistent EPS bearer context	13.3.0	13.4.0
2015-12	CT#70	CP-150713	2238	2	Interaction between PSM and eDRX	13.3.0	13.4.0
2015-12	CT#70	CP-150713	2239		eDRX abbreviation, reference to TS 24.008 and some corrections	13.3.0	13.4.0
2015-12	CT#70	CP-150713	2240		eDRX and emergency bearer services	13.3.0	13.4.0
2015-12	CT#70	CP-150713	2241	3	Lack of requirement on mandating repeating the request of eDRX at TAU	13.3.0	13.4.0
2015-12	CT#70	CP-150713	2242	1	Support of eDRX in the UE	13.3.0	13.4.0
2015-12	CT#70	CP-150702	2243	1	Correction to the UE retry behaviour for PDN connectivity procedure	13.3.0	13.4.0
2015-12	CT#70	CP-150702	2244	2	Correction to UE-requested bearer resource allocation and modification procedures after rejection with #32, #33	13.3.0	13.4.0
2015-12	CT#70	CP-150704	2245	1	Group specific congestion control	13.3.0	13.4.0
2015-12	CT#70	CP-150710	2248	4	Clarification about timer T3245 usage	13.3.0	13.4.0
2015-12	CT#70	CP-150706	2250	1	NBIFOM Container IEI	13.3.0	13.4.0
2015-12	CT#70	CP-150713	2253		use of the eDRX parameters provided by the network	13.3.0	13.4.0
2015-12	CT#70	CP-150696	2255		Starting timer T3440 for EMM cause value #25	13.3.0	13.4.0

2015-12	CT#70	CP-150688	2258	2	Correction of UE-initiated detach request during tracking area updating procedure	13.3.0	13.4.0
2015-12	CT#70	CP-150702	2259	2	Retry restriction for default APN	13.3.0	13.4.0
2015-12	CT#70	CP-150696	2260		Alignment of TAU reject with #9,#10 or #40 for CSFB	13.3.0	13.4.0
2015-12	CT#70	CP-150696	2261	2	Enhancement of CSFB and network initiated detach collision	13.3.0	13.4.0
2015-12	CT#70	CP-150696	2262	1	Removal of duplicated UE behaviour	13.3.0	13.4.0
2015-12	CT#70	CP-150710	2263	2	Correction to UE initiated release of bearer resources	13.3.0	13.4.0
2015-12	CT#70	CP-150708	2264	2	Remote UE Report procedure addition	13.3.0	13.4.0
2015-12	CT#70	CP-150710	2265		Clarification regarding update status in LTE RAT	13.3.0	13.4.0
2015-12	CT#70	CP-150696	2272		Correction on the EPS security context term	13.3.0	13.4.0
2015-12	CT#70	CP-150716	2273		Dedicated core networks	13.3.0	13.4.0
2015-12	CT#70	CP-150710	2274		Incorrect reference about treating the active cell as barred	13.3.0	13.4.0
2015-12	CT#70	CP-150713	2275	1	Paging for a UE which the network accepted to use eDRX	13.3.0	13.4.0
2015-12	CT#70	CP-150710	2276		Fixing underlined text and editorial	13.3.0	13.4.0
2015-12	CT#70	CP-150710	2278	3	Handling of back off timer T3346 and T3396	13.3.0	13.4.0
2015-12	CT#70	CP-150710	2281	1	Stop running T3323	13.3.0	13.4.0
2015-12	CT#70	CP-150719	2282	1	ACDC handling for emergency call and IMS	13.3.0	13.4.0
2015-12	CT#70	CP-150719	2283	1	Handling of ACDC mechanism	13.3.0	13.4.0
2016-03	CT#71	CP-160085	2277	6	Starting Timer T3440 in service request procedure for CS Fallback	13.4.0	13.5.0
2016-03	CT#71	CP-160085	2292	6	Correction of handling NAS reject messages without Integrity protection	13.4.0	13.5.0
2016-03	CT#71	CP-160071	2295	5	Support of CIoT EPS optimization	13.4.0	13.5.0
2016-03	CT#71	CP-160069	2300	5	Handling of uncategorized app for ACDC	13.4.0	13.5.0
2016-03	CT#71	CP-160072	2306	6	MT-SMS triggered Paging handling for UE using eDRX	13.4.0	13.5.0
2016-03	CT#71	CP-160085	2307		Correction on active timer in timer table	13.4.0	13.5.0
2016-03	CT#71	CP-160073	2309	2	Addition of Remote UE report to general ESM procedures	13.4.0	13.5.0
2016-03	CT#71	CP-160072	2312	2	Handling when UE wants to disable eDRX	13.4.0	13.5.0
2016-03	CT#71	CP-160082	2313	3	Ending CS domain congestion when network accepts to provide service	13.4.0	13.5.0
2016-03	CT#71	CP-160073	2314	1	Adding UE-to-Network Relay capability in UE nework capability IE	13.4.0	13.5.0
2016-03	CT#71	CP-160067	2318	2	RRC establishment cause for mobile-originated VoLTE calls	13.4.0	13.5.0
2016-03	CT#71	CP-160158	2321	7	Enhacements to the EPS attach procedure for CIoT	13.4.0	13.5.0
2016-03	CT#71	CP-160072	2325	1	Enabling eDRX when T3346 running	13.4.0	13.5.0
2016-03	CT#71	CP-160085	2327		Correction of handling of timer T3346 and T3396 at detach without switch-off	13.4.0	13.5.0
2016-03	CT#71	CP-160085	2328	2	APN change after ESM failure	13.4.0	13.5.0
2016-03	CT#71	CP-160073	2329	3	Update of remote UE report procedure	13.4.0	13.5.0
2016-03	CT#71	CP-160073	2330	1	UE behavior at the failure of Remote UE Report procedure	13.4.0	13.5.0
2016-03	CT#71	CP-160069	2331	1	Correction of ACDC handling for IMS services	13.4.0	13.5.0
2016-03	CT#71	CP-160085	2333	2	Naming service request guard timer	13.4.0	13.5.0
2016-03	CT#71	CP-160072	2334	1	eDRX cleanup	13.4.0	13.5.0
2016-03	CT#71	CP-160085	2335	1	Moving the note for T3324 to right place	13.4.0	13.5.0
2016-03	CT#71	CP-160085	2337		Correction of SM Retry Timer to SM_RetryWaitTime	13.4.0	13.5.0
2016-03	CT#71	CP-160071	2340	2	Enhancement on detach procedure for CIoT	13.4.0	13.5.0
2016-03	CT#71	CP-160071	2341	2	Enhancement on PDN connection/disconnect trigger for CIoT	13.4.0	13.5.0
2016-03	CT#71	CP-160071	2343	3	Addition of User Plane EPS optimization	13.4.0	13.5.0
2016-03	CT#71	CP-160071	2344	2	Introduction of ROHC	13.4.0	13.5.0
2016-03	CT#71	CP-160071	2345	1	Enhacements to the tracking area updating procedure for CIoT	13.4.0	13.5.0
2016-03	CT#71	CP-160071	2347	2	Paging for MT-SMS when the UE is EPS attached	13.4.0	13.5.0
2016-03	CT#71	CP-160071	2348	2	Downlink data delivery when the UE is in power saving mode	13.4.0	13.5.0
2016-06	CT#72	CP-160312	2315	8	Use of eDRX in case of emergency bearer services	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2324	9	CIoT ESM Procedure for Transfer of Data via MME	13.5.0	13.6.0
2016-06	CT#72	CP-160315	2326	5	Handling of T3396 for PDN connections established without APN	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2342	11	Support of EMM-REGISTERED without PDN connection	13.5.0	13.6.0
2016-06	CT#72	CP-160315	2350		Correction of the handing of the Re-attempt indicator IE for cause #66	13.5.0	13.6.0

2016-06	CT#72	CP-160318	2351		Further corrections of handling of NAS reject messages without integrity protection	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2353	7	Update of User Plane EPS optimization	13.5.0	13.6.0
2016-06	CT#72	CP-160318	2360	1	Cleanup for NAS reject messages without Integrity protection	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2364	5	Header compression configuration IEI value	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2365	4	Paging response for MT CIoT data	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2366	4	Priority handling of NAS signalling vs CIoT data over NAS	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2367	3	Re-establish DRBs in CP CIoT optimization	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2368	2	Partly ciphered CIoT Data via MME for the ECM-IDLE UE	13.5.0	13.6.0
2016-06	CT#72	CP-160325	2369		Wrong 24.008 subclause referenced for NBIFOM container	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2370	1	Optional support for header compression during attach for CIoT EPS optimization	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2372	3	Correction to the coding of the Supported Network Behavior	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2374	7	NAS priority configuration for NB-IoT and non-NB-IoT UE	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2378	3	Paging handling for the UE using User Plane CIoT optimization	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2379	1	Control-plane CIoT EPS optimization for UEs in NB-S1 mode	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2380	1	EPS services and "SMS only" for a UE that supports NB-S1 mode only	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2381	6	Indication of support of CIoT EPS optimizations to the UE	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2382	2	Support of Header compression for control-plane EPS CIoT optimization	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2383	1	Correction to description of CIoT EPS optimizations	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2384	1	Alignement on terminology	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2385	3	DRX during attach and TAU when in NB-S1 mode	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2386	1	Indication of support of emergency bearer services when UE accesses via NB-S1 mode	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2387	3	User-plane EPS optimization and S1-U data transfer	13.5.0	13.6.0
2016-06	CT#72	CP-160312	2389	1	Interaction between legacy DRX and eDRX	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2390	2	Limitation on EPS bearer activation for non-IP PDN in EPS CP CIoT optimization	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2393	1	Update to voice domain preference and UE's usage setting conditions	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2394		Correction on network behavior negotiation during CIoT attach	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2401		Timer table for Data Service Request	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2405	1	Trigger to resume NAS signalling in EMM procedures	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2406	6	NAS signalling connection recovery for CP CIoT Optimization	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2412		General subscription update for new ESM procedure for CIoT data transfer	13.5.0	13.6.0
2016-06	CT#72	CP-160318	2416	1	Handling of PLMN background scan timer during PSM	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2417	4	Encoding of the Header Compression Configuration IE	13.5.0	13.6.0
2016-06	CT#72	CP-160325	2420		Adding NBIFOM container IE to PDN CONNECTIVITY REJECT message content	13.5.0	13.6.0
2016-06	CT#72	CP-160311	2422	2	Addition of IMEI support in remote UE report procedure	13.5.0	13.6.0
2016-06	CT#72	CP-160325	2423	1	Update the ESM cause value list with an indication that the PDN connectivity procedure was not accepted by the network	13.5.0	13.6.0
2016-06	CT#72	CP-160325	2425	1	Local deactivation related to NBIFOM multi-access PDN connection	13.5.0	13.6.0
2016-06	CT#72	CP-160325	2426		Delete the NBIFOM container IE in TS 24.301	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2427	3	Update of NAS timers to support NB-S1 mode	13.5.0	13.6.0
2016-06	CT#72	CP-160318	2428	2	Update of NAS timers to support WB-S1 mode for IoT	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2429	2	Header compression configuration status IE handling	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2430		Correction to the CIoT definitions	13.5.0	13.6.0
2016-06	CT#72	CP-160318	2431	2	SIB indications about support of CIoT optimizations	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2433	1	EPS attached without PDN connectivity Indication	13.5.0	13.6.0
2016-06	CT#72	CP-160318	2437		CS domain congestion and SMS	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2441	1	Introducing Access Barring (AB) for NB-IoT	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2446	1	ACB handling in NB-S1 mode	13.5.0	13.6.0

2016-06	CT#72	CP-160309	2448		Principles of address handling for new ESM DATA TRANSPORT message	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2449	1	Principles of address handling for new ESM DUMMY MESSAGE	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2450		Clean-up Editorial Notes for CIoT	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2454	1	Paging timer for resume	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2461		Updates to the UE network capability IE due to CIoT	13.5.0	13.6.0
2016-06	CT#72	CP-160318	2415	2	Addition of extended protocol configuration options	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2354	2	Clean up of CIoT terms	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2371	6	Header Compression Configuration status in the TAU Accept message	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2397	7	Serving PLMN rate control	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2398	6	Procedures for APN Rate Control	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2400	1	Network features per TAI list	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2408	2	SMS transfer using Control Plane CIoT EPS optimization	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2409	6	Signalling of link MTU during non-IP connection establishment	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2410	2	Enabling to switch from CP to UP CIoT EPS optimization	13.5.0	13.6.0
2016-06	CT#72	CP-160325	2419	1	"Multiple accesses to a PDN connection not allowed" in NW-initiated PDN disconnection procedure	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2460		Support of PCO signaling for SCEF PDN connection	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2435	3	EPS attach with CIoT EPS Optimisation based on System information	13.5.0	13.6.0
2016-06	CT#72	CP-160363	2455	4	Active Flag handling in CP-CIoT EPS optimization	13.5.0	13.6.0
2016-06	CT#72	CP-160309	2395	11	CIoT Updates to Service Request Procedure for Transfer of Data via MME	13.5.0	13.6.0
2016-06	CT#72	CP-160339	2445	1	Rollback of MME paging behaviour in CP optimization and eDRX are used	13.5.0	13.6.0
2016-06	CT#72	CP-160331	2352	2	Correction of UE behaviour in substate ATTEMPTING-TO-UPDATE	13.6.0	14.0.0
2016-06	CT#72	CP-160331	2375		T3411 handling correction for RRC connection failure case	13.6.0	14.0.0
2016-06	CT#72	CP-160331	2376	1	Collision case handling for service request for SMS and IMSI detach from network	13.6.0	14.0.0
2016-06	CT#72	CP-160331	2418	1	T3396 running due to the release message from network	13.6.0	14.0.0
2016-06	CT#72				Various corrections	14.0.0	14.0.1

Change history							
Date	Meeting	TDoc	CR	Rev	Cat	Subject/Comment	New version
2016-09	CT#73	CP-160516	2459	2	F	Handling of MO/MT CSFB in EMM-REGISTERED.ATTEMPTING-TO-UPDATE-MM	14.1.0
2016-09	CT#73	CP-160516	2462		D	Incorrectly formatted bullet list of PDN type values	14.1.0
2016-09	CT#73	CP-160488	2464	1	A	NAS timer handling for eMTC	14.1.0
2016-09	CT#73	CP-160470	2466	2	A	Addition of DelayTolerant RRC establishment cause for NB-IoT	14.1.0
2016-09	CT#73	CP-160488	2475	2	A	Extended Wait Time for non-low access priority UEs in NB-IoT	14.1.0
2016-09	CT#73	CP-160486	2477	3	A	Clarification for EMM-REGISTERED without PDN connection	14.1.0
2016-09	CT#73	CP-160493	2478		A	Message type for REMOTE UE REPORT and REMOTE UE REPORT RESPONSE message	14.1.0
2016-09	CT#73	CP-160486	2481		A	Correction of ePCO indication IE	14.1.0
2016-09	CT#73	CP-160488	2483	2	A	Indication of Support of CIOT EPS optimizations	14.1.0
2016-09	CT#73	CP-160488	2485	2	A	piggyback ESM data transport in CP service request	14.1.0
2016-09	CT#73	CP-160525	2492	3	A	When to send service accept message	14.1.0
2016-09	CT#73	CP-160489	2495	1	A	Preferred CIoT network behaviour when CIoT optimization is not supported	14.1.0
2016-09	CT#73	CP-160486	2497	1	A	Alignment on Control Plane Service Request related usage	14.1.0
2016-09	CT#73	CP-160488	2501	1	A	Non IP PDN type in the PDN address	14.1.0
2016-09	CT#73	CP-160492	2507		A	Wrong ordering of and repeated requirements on eDRX parameters handling	14.1.0
2016-09	CT#73	CP-160512	2508	1	B	Introduction of eCall over IMS in TS 24.301	14.1.0
2016-09	CT#73	CP-160527	2510	2	A	Multiple DRB capability handling	14.1.0
2016-09	CT#73	CP-160489	2512	1	A	Resolution of editor's note on abnormal cases during service request procedure	14.1.0
2016-09	CT#73	CP-160486	2514	1	A	Correction of use of broadcast support indications of CIoT optimizations	14.1.0
2016-09	CT#73	CP-160486	2518	1	A	Alignment for consistent use of term "Control plane"and "User plane"	14.1.0
2016-09	CT#73	CP-160487	2520		A	Correction to NAS timer extension multiplier to support NB-S1 mode	14.1.0
2016-09	CT#73	CP-160487	2522		A	EMM NAS timers for applying extension to support NB-S1 mode	14.1.0
2016-09	CT#73	CP-160487	2524	1	A	Editor's note in sub-clauses 5.5.1.2.4 and 5.5.3.2.4	14.1.0
2016-09	CT#73	CP-160487	2528		A	Correction to requirement on requesting CIoT EPS optimizations	14.1.0
2016-09	CT#73	CP-160487	2530		A	Correction to procedure to inform the UE of any local serving PLMN rate control	14.1.0
2016-09	CT#73	CP-160487	2532		A	Correction to the use of NB-IoT RAT	14.1.0
2016-09	CT#73	CP-160492	2534		A	Paging for EPS service for UE using eDRX	14.1.0
2016-09	CT#73	CP-160488	2536		A	Partial ciphering for SMS transfer over CIoT CP optimization	14.1.0
2016-09	CT#73	CP-160516	2537	1	F	Clarification on general description of ESM procedrue	14.1.0
2016-09	CT#73	CP-160486	2543	3	A	Correction on usage of extended protocol configuration options	14.1.0
2016-09	CT#73	CP-160488	2545	2	A	ePCO support by UEs supporting NB-S1 mode or Non-IP PDN type	14.1.0
2016-09	CT#73	CP-160487	2547		A	Editor's note in sub-clause 5.5.2.3.4	14.1.0
2016-09	CT#73	CP-160570	2553	4	A	Correction on T3440 when "signalling active" flag is used	14.1.0
2016-09	CT#73	CP-160487	2559	1	A	Corrections to Table D.1.1 regarding exception data reporting	14.1.0
2016-09	CT#73	CP-160489	2561	1	A	Remove duplication in triggering the establishment of UP bearers in EMM-CONNECTED for a UE using CP CIoT optimization	14.1.0
2016-09	CT#73	CP-160488	2565	1	A	Encoding of additional header compression context setup parameters	14.1.0
2016-09	CT#73	CP-160489	2567	1	A	Release Assistance Information Alignment	14.1.0
2016-09	CT#73	CP-160486	2569	2	A	Attach reject due to incompatibility between CIoT features supported by the UE and the network	14.1.0
2016-09	CT#73	CP-160487	2571	1	A	DL NAS prioritization	14.1.0
2016-12	CT#74	CP-160723	2516	2	A	Removal of options related to CP/UP switch	14.2.0
2016-12	CT#74	CP-160722	2573	3	A	MME behavior when accepting control plane service request	14.2.0
2016-12	CT#74	CP-160723	2579	1	A	Synchronization for EPS bearer contexts associated with CP only indication	14.2.0
2016-12	CT#74	CP-160798	2580	2	B	Handover of emergency PDN connection from non-3GPP access to 3GPP access	14.2.0
2016-12	CT#74	CP-160722	2584	6	A	PDN connection restriction due to subscription restriction (Alt4)	14.2.0
2016-12	CT#74	CP-160720	2586	2	A	Control Plane "pinning" and CP to UP switching	14.2.0
2016-12	CT#74	CP-160726	2589	2	A	Paging with TMSI for eDRX UE	14.2.0
2016-12	CT#74	CP-160753	2591	3	F	Reduce running NAS time in the MME	14.2.0
2016-12	CT#74	CP-160721	2594	2	A	Correction of the use of broadcasted CIoT optimization support indications	14.2.0
2016-12	CT#74	CP-160738	2595	4	B	Addition of DCN ID handling for eDecor	14.2.0
2016-12	CT#74	CP-160720	2597	1	A	Addition of Non-IP related cause values	14.2.0
2016-12	CT#74	CP-160749	2598	1	F	Improved clarification on general description of ESM procedure	14.2.0
2016-12	CT#74	CP-160723	2602	1	A	Updates to Handle multiple DRB Capability	14.2.0
2016-12	CT#74	CP-160738	2606	2	F	DCN-ID in GUTI Reallocation Command Message	14.2.0
2016-12	CT#74	CP-160739	2607		F	Removal of Editor's note on normal emergency call by UE in eCall only mode	14.2.0
2016-12	CT#74	CP-160739	2608	1	F	Correction of eCall timer names	14.2.0

2016-12	CT#74	CP-160720	2610	2	A	Abnormal case for ESM DATA TRANSPORT	14.2.0
2016-12	CT#74	CP-160723	2616	1	A	Restarting T3440 when CP optimisation applied	14.2.0
2016-12	CT#74	CP-160722	2618	2	A	Exception data handling	14.2.0
2016-12	CT#74	CP-160723	2620	5	A	RRC Establishment cause and Call Type corrections.	14.2.0
2016-12	CT#74	CP-160753	2621	2	F	Correction of local deactivation of EPS bearer context handling	14.2.0
2016-12	CT#74	CP-160721	2625	5	A	Correction to the implementation of the PNB/SNB framework	14.2.0
2016-12	CT#74	CP-160721	2629	2	A	Correction to the definitions related to CIOT	14.2.0
2016-12	CT#74	CP-160721	2633	2	A	Correction on CPSR usage for user plane establishment	14.2.0
2016-12	CT#74	CP-160720	2635		A	Correction of partial encryption of CPSR	14.2.0
2016-12	CT#74	CP-160722	2637	2	A	Initial NAS message discard at successful RRC Resume	14.2.0
2016-12	CT#74	CP-160722	2639	3	A	Re-insert ePCO IE in PDN Connectivity Request	14.2.0
2016-12	CT#74	CP-160722	2641	1	A	Further alignment on Control plane service type usage	14.2.0
2016-12	CT#74	CP-160721	2645	4	A	Correction to the setting of the Control plane only indication	14.2.0
2016-12	CT#74	CP-160723	2647	2	A	TAU reject upon inter-RAT mobility involving NB-S1 mode	14.2.0
2016-12	CT#74	CP-160722	2654	2	A	Exception data reporting initiation when T3346 is running	14.2.0
2016-12	CT#74	CP-160721	2658		A	Correction on the length of Header Compression Configuration IE	14.2.0
2016-12	CT#74	CP-160754	2659		F	New QCI values for V2X services	14.2.0
2016-12	CT#74	CP-160735	2661	4	A	Traffic flow aggregate IE	14.2.0
2016-12	CT#74	CP-160721	2663	1	A	Correction to EPS MM and SM timers in NB-S1 mode	14.2.0
2016-12	CT#74	CP-160723	2665	2	A	Correction to EPS MM and SM timers in WB-S1 mode	14.2.0
2016-12	CT#74	CP-160753	2666	2	D	Editorials and minor correction on CIoT	14.2.0
2016-12	CT#74	CP-160718	2669	3	A	Correction to cases which all EPS bearer contexts to a given APN are deactivated	14.2.0
2016-12	CT#74	CP-160753	2670		F	Detach procedure triggered due to USIM removal	14.2.0
2016-12	CT#74	CP-160749	2671		F	Correction to initiation of TAU when the EPS update status is set to EU2 NOT UPDATED	14.2.0
2016-12	CT#74	CP-160749	2672	1	F	Correction to network cases to release the NAS signalling connection	14.2.0
2016-12	CT#74	CP-160749	2673		F	Correction to EPS attach counter after successful registration	14.2.0
2016-12	CT#74	CP-160754	2674	2	B	Introduction ofV2X capability in ATTACH REQUEST and TRACKING AREA UPDATE REQUEST messages	14.2.0
2016-12	CT#74	CP-160754	2675	4	B	New trigger conditions for service request and tracking area updating procedures due to V2X	14.2.0
2016-12	CT#74	CP-160720	2677	3	A	Correction of the abnormal case handling for EMM-REGISTERED without PDN connection	14.2.0
2016-12	CT#74	CP-160722	2679		A	Removal of editor's note for CP service request	14.2.0
2016-12	CT#74	CP-160721	2681	1	A	Correction to encoding of UE network capability IE and TAU initiation	14.2.0
2016-12	CT#74	CP-160753	2682		F	Information on RRC establishment cause change at MMTEL Video	14.2.0
2016-12	CT#74	CP-160723	2684	1	A	Synchronisation of CP only EPS bearers	14.2.0
2016-12	CT#74	CP-160720	2686	1	A	Alignment of MTU for CP user data	14.2.0
2016-12	CT#74	CP-160722	2690		A	NAS message container successfully deciphered	14.2.0
2016-12	CT#74	CP-160738	2691	1	B	Trigger TAU at Default DCN-ID change	14.2.0
2016-12	CT#74	CP-160718	2697	1	A	Indication to upper layers on first expiry of T3482 for emergency bearer services	14.2.0
2016-12	CT#74	CP-160720	2701	3	A	APN rate Control and Emergency bearer services	14.2.0
2016-12	CT#74	CP-160720	2703		A	Alignment of the ROHC support requirements	14.2.0
2016-12	CT#74	CP-160753	2707	3	D	Correction to the handling of the Link MTU parameters	14.2.0
2016-12	CT#74	CP-160721	2709	2	A	Enabling SMS over SGs for NB-IoT only UEs	14.2.0
2016-12	CT#74	CP-160749	2710		F	Alignment on UE's behaviour for CS fallback failure	14.2.0
2016-12	CT#74	CP-160749	2711	1	F	Clarification to EMM-REGISTERED.UPDATE-NEEDED state	14.2.0
2016-12	CT#74	CP-160749	2712	1	F	Service request initiated for CS fallback - abnormal case in the UE	14.2.0
2016-12	CT#74	CP-160720	2715	2	A	Alignment of CP Service Request for abnormal case	14.2.0
2016-12	CT#74	CP-160723	2719	1	A	Service Request Counter	14.2.0
2016-12	CT#74	CP-160721	2723		A	Correction on NAS timer usage condition for CE mode B	14.2.0
2016-12	CT#74	CP-160753	2725		F	Aligning definitions of EMM_DEREGISTERED.PLMN-SEARCH and EMM_DEREGISTERED.NO-IMSI	14.2.0
2016-12	CT#74	CP-160753	2726	1	F	Clarification to the CIOT EPS optimisation procedure	14.2.0
2017-03	CT#75	CP-170136	2490	4	F	Voice domain preference change during "CSFB not available", "CSFB not preferred" or "SMS only"	14.3.0
2017-03	CT#75	CP-170136	2724	1	F	Handling paging in EMM-REGISTERED.ATTEMPTING-TO-UPDATE	14.3.0
2017-03	CT#75	CP-170136	2730	2	F	Correction for the Additional update result IE in Tracking Area Update Accept message	14.3.0
2017-03	CT#75	CP-170136	2734	1	D	Correction to the usage of the Control plane only indication	14.3.0
2017-03	CT#75	CP-170110	2736	2	A	Correction to the UE behavior for completion of the service request procedure	14.3.0
2017-03	CT#75	CP-170110	2742		A	Release of NAS signalling due to service reject to CPSR	14.3.0
2017-03	CT#75	CP-170136	2746	1	F	Correction of Additional update type inclusion criteria in TAU	14.3.0
2017-03	CT#75	CP-170110	2748	1	A	Encryption at resume of NAS signalling connection	14.3.0
2017-03	CT#75	CP-170136	2751	1	F	Addition of TAU triggers for ProSe in table D.1.1	14.3.0
2017-03	CT#75	CP-170121	2752	1	B	TAU support for NB-S1	14.3.0
2017-03	CT#75	CP-170121	2762	2	B	Restriction of use of Coverage Enhancement	14.3.0

2017-03	CT#75	CP-170130	2763	7	B	Introduction of 3GPP PS data off UE status and 3GPP PS data off support indicator	14.3.0
2017-03	CT#75	CP-170110	2765	4	A	Values for the EPS MM and SM timers in WB-S1 mode	14.3.0
2017-03	CT#75	CP-170121	2768	1	B	Interaction between PSM and MBMS	14.3.0
2017-03	CT#75	CP-170110	2771	3	A	Failure case handling of SMS over SGs for NB-IoT only UEs	14.3.0
2017-03	CT#75	CP-170136	2773	1	F	Correction on multiple DRB Capability handling	14.3.0
2017-03	CT#75	CP-170133	2774	1	F	Skip back-off timer for emergency CSFB call	14.3.0
2017-03	CT#75	CP-170136	2775	3	F	Clarification to the Suspend and Resume procedure	14.3.0
2017-03	CT#75	CP-170136	2781	1	F	SGi PDN connections for CP to UP switching	14.3.0
2017-03	CT#75	CP-170136	2783	3	F	Exception data handling in Attempting to Update or Attach state.	14.3.0
2017-03	CT#75	CP-170122	2791	3	F	Resolve DCN-ID length	14.3.0
2017-03	CT#75	CP-170119	2793		A	Further corrections of handling of NAS reject messages without integrity protection	14.3.0
2017-03	CT#75	CP-170110	2795		A	Extended wait time for CPSR with low priority indicator	14.3.0
2017-03	CT#75	CP-170136	2797	1	F	Correction to the handling ot Serving PLMN rate control values	14.3.0
2017-03	CT#75	CP-170136	2798	1	F	UE configuration for exception data reporting via USIM	14.3.0
2017-03	CT#75	CP-170136	2801	1	F	UE getting detached when last PDN connection moved to non-3GPP access	14.3.0
2017-03	CT#75	CP-170136	2803	2	F	Multiple bearer capability handling independent of CIoT user plane optimization	14.3.0
2017-03	CT#75	CP-170119	2807		A	Correction to the handling of non-integrity proctected reject messages	14.3.0
2017-03	CT#75	CP-170136	2808	1	F	Local EPS bearer context deactivation	14.3.0
2017-03	CT#75	CP-170136	2810	2	F	Service accept message for CPSR with active flag	14.3.0
2017-03	CT#75	CP-170133	2813	1	F	Emergency CS/PS call handling when T3440 started due to g) in subclause 5.3.1.2.1	14.3.0
2017-03	CT#75	CP-170121	2815	2	B	Intra-MME mobility enhancements for DL data transmission for NB-IoT	14.3.0
2017-03	CT#75	CP-170136	2817	2	F	(Sol A) Extended DRX parameters handling	14.3.0
2017-03	CT#75	CP-170121	2822	2	B	Mobility enhancements for UL data transmission for NB-IoT	14.3.0
2017-03	CT#75	CP-170134	2823		B	Support of handovers of emergency sessions over WLAN to 3GPP access	14.3.0
2017-06	CT#76	CP-171089	2761	3	B	Indicating policy related to emergency numbers/types received via non-3GPP access	14.4.0
2017-06	CT#76	CP-171073	2766	4	B	Congestion control for transport of user data via the control plane	14.4.0
2017-06	CT#76	CP-171089	2796	4	B	Inclusion of Local Emergency Numbers List over non-3GPP access	14.4.0
2017-06	CT#76	CP-171069	2826	2	A	Correction of ePCO for EPS	14.4.0
2017-06	CT#76	CP-171088	2827	1	F	Correction to the handling of paging in EMM-REGISTERED.ATTEMPTING-TO-UPDATE	14.4.0
2017-06	CT#76	CP-171088	2828	1	F	Handling of IMS voice not available in substate ATTEMPTING-TO-UPDATE-MM	14.4.0
2017-06	CT#76	CP-171062	2830	1	A	Handling of UE initiated PDN connectivity request for emergency bearer services	14.4.0
2017-06	CT#76	CP-171085	2831	1	F	Corrections on PS data off	14.4.0
2017-06	CT#76	CP-171092	2832	1	F	Correction in Service Request procedure for ACB handling in NB-S1 mode	14.4.0
2017-06	CT#76	CP-171068	2838	2	A	TAU procedure initiation following CSFB failure or CSFB cancellation	14.4.0
2017-06	CT#76	CP-171062	2840	1	A	Correction of description of ePCO IE in PDN Connectivity Request	14.4.0
2017-06	CT#76	CP-171075	2841	1	F	Correction on subclause of eCall inactivity procedure	14.4.0
2017-06	CT#76	CP-171073	2848	1	F	T3440 timer and CP Data BO timer.	14.4.0
2017-06	CT#76	CP-171092	2850	1	F	The UE behavior for successful completion of the service request procedure	14.4.0
2017-06	CT#76	CP-171088	2853	2	B	Protecting against the modification of Attach/TAU Request attacks	14.4.0
2017-06	CT#76	CP-171062	2855	1	A	Assign IEI for SMS services status IE	14.4.0
2017-06	CT#76	CP-171092	2857	1	F	Support of Data volume reporting in User Plane CIoT EPS optimization	14.4.0
2017-06	CT#76	CP-171062	2859	1	A	Correction of TAU triggering after paging for Control Plane CIoT Optimization	14.4.0
2017-06	CT#76	CP-171073	2860	4	F	UE support of restriction on enhanced coverage	14.4.0
2017-06	CT#76	CP-171073	2861	1	F	Correction to mobility enhancement for UL CP data	14.4.0
2017-06	CT#76	CP-171092	2862		F	Correction to local context deactivation	14.4.0
2017-06	CT#76	CP-171062	2865		A	EPS network feature support length	14.4.0
2017-06	CT#76	CP-171085	2867	1	F	Removal of editor's note [WI PS_DATA_OFF-CT CR#2763] on when the user activates or deactivates 3GPP PS data off while connected via WLAN access only	14.4.0
2017-06	CT#76	CP-171085	2868	1	B	XCAP over Ut interface - new case for except service	14.4.0
2017-06	CT#76	CP-171092	2869		F	Paging procedure for eDRX	14.4.0
2017-06	CT#76	CP-171092	2870	1	F	EMM-REGISTERED without PDN connection in attach procedure	14.4.0
2017-06	CT#76	CP-171092	2871	2	F	Correction of handling of MO detach without integrity protection	14.4.0
2017-06	CT#76	CP-171092	2873	2	F	Correction on header compression configuration re-negotiation	14.4.0
2017-06	CT#76	CP-171062	2875		A	Correction to add ESM #57 and ESM#58 to ESM cause IE	14.4.0
2017-06	CT#76	CP-171075	2879	1	F	Storage of EMM parameters for eCall only UE	14.4.0

2017-06	CT#76	CP-171073	2880	1	F	Change Editorial Note to Note for DL data transmission for NB-IoT in inter-MME mobility cases	14.4.0
2017-06	CT#76	CP-171073	2881	1	B	Support for reliable data service	14.4.0
2017-06	CT#76	CP-171073	2883	4	B	Correction of the condition to initiate the setup of the user plane radio bearers	14.4.0
2017-06	CT#76	CP-171092	2885	1	F	Correction in EMM-REGISTERED.UPDATE-NEEDED state description	14.4.0
2017-06	CT#76	CP-171069	2887	5	A	Further corrections to the handling of NAS reject messages without integrity protection	14.4.0
2017-06	CT#76	CP-171088	2889	1	F	Correction to TAU trigger case with pending IMSI detach procedure	14.4.0
2017-09	CT#77	CP-172114	2843	6	F	Enhanced correction of procedures for CIoT Control Plane optimization	14.5.0
2017-09	CT#77	CP-172098	2894	2	F	Update of eCall inactivity procedure	14.5.0
2017-09	CT#77	CP-172097	2896	1	F	Paging response when T3448 running	14.5.0
2017-09	CT#77	CP-172106	2898		F	Definition of ePCO is given in 24.008 (Rel-14 onwards)	14.5.0
2017-09	CT#77	CP-172111	2899		F	Aligning IE name to Non-3GPP NW provided policies	14.5.0
2017-09	CT#77	CP-172097	2901	2	F	Stop of CP backoff timer	14.5.0
2017-09	CT#77	CP-172114	2902	3	F	Extending time for sending DETACH REQUEST in NB-S1 and WB-S1 (EC)	14.5.0
2017-09	CT#77	CP-172098	2905	2	F	Handling of inter-RAT mobility for UE in eCall only mode capable of eCall over IMS	14.5.0
2017-09	CT#77	CP-172114	2908		F	Stopping timer T3440 upon receiving signalling from network for UE using only CP CIoT	14.5.0
2017-09	CT#77	CP-172114	2909		F	Keep forbidden PLMN after receiving integrity protected EMM #11,14,35	14.5.0
2017-09	CT#77	CP-172114	2910	1	F	Update to ROHC RFCs	14.5.0
2017-09	CT#77	CP-172097	2912	1	F	Correction to RRC establishment cause for Control Plane Service Request	14.5.0
2017-09	CT#77	CP-172097	2914	2	F	Synchronizaton between UE and MME regarding CP congestion situation.	14.5.0
2017-09	CT#77	CP-172114	2915	1	F	Removing redundant information related to RAI	14.5.0
2017-09	CT#77	CP-172155	2891	6	F	Extending maximum bitrate in EPS QoS IE	15.0.0
2017-09	CT#77	CP-172116	2892	1	B	Addition of UE NAS capability for support of dual connectivity with NR	15.0.0
2017-09	CT#77	CP-172116	2893	1	B	Addition of NAS indication for dual connectivity with NR being restricted	15.0.0
2017-09	CT#77	CP-172122	2895		F	Clarification on eDRX handling with assigning a new GUTI	15.0.0
2017-09	CT#77	CP-172120	2900	1	C	Handling of timer expiry during extended service request procedure for MT CSFB	15.0.0
2017-09	CT#77	CP-172120	2913	1	F	Correction to MT CSFB call failure problem in CONNECTED mode	15.0.0
2017-09	CT#77	CP-172120	2916		F	UE behaviour in #18 for persistent EPS bearer context	15.0.0
2017-09	CT#77	CP-172122	2917		F	Ignoring EWT for UE using AC11-15 in NB-S1 mode	15.0.0
2017-09	CT#77					addition of missing IEI value	15.0.1
2017-12	CT#78	CP-173078	2897	1	F	Correction of inconsistency in EMM timers table	15.1.0
2017-12	CT#78	CP-173072	2919	1	F	Handling of extended EPS quality of service IE and extended APN-AMBR IE	15.1.0
2017-12	CT#78	CP-173067	2921	1	A	Correction to attempting to ATTACH/TAU for exception data	15.1.0
2017-12	CT#78	CP-173050	2924	1	A	No support for dedicated bearers in NB-IoT RAT	15.1.0
2017-12	CT#78	CP-173067	2925	1	A	T3440 starting for UE attaching without PDN connections	15.1.0
2017-12	CT#78	CP-173078	2926		F	Correction of the handling of counters for "SIM/USIM considered invalid" events	15.1.0
2017-12	CT#78	CP-173078	2931	4	F	Correction of Additional update type for CIoT	15.1.0
2017-12	CT#78	CP-173050	2932	1	A	Service request handling for EMM-REGISTERED without PDN connection	15.1.0
2017-12	CT#78	CP-173067	2935		A	Correction for support of multiple TAC in shared network deployments	15.1.0
2017-12	CT#78	CP-173078	2936	1	F	Attach and Detach Collision	15.1.0
2017-12	CT#78	CP-173078	2937	1	F	Attempting EPS Attach for Emergency Bearer Services	15.1.0
2017-12	CT#78	CP-173077	2938	1	F	Alignment on ESM cause #66 on back-off timer handling	15.1.0
2017-12	CT#78	CP-173078	2939		F	Correction on UE behaviour of CP back-off timer	15.1.0
2017-12	CT#78	CP-173078	2940	1	F	Adding missing abnormal case handling for T3448	15.1.0
2017-12	CT#78	CP-173060	2944	2	A	CP data back-off timer for EWT CP data received from lower layers	15.1.0
2017-12	CT#78	CP-173067	2947	2	A	Correction to SERVICE ACCEPT handling at control plane CIoT case	15.1.0
2017-12	CT#78	CP-173072	2949		F	Correction of Extended EPS quality of service IE naming	15.1.0
2017-12	CT#78	CP-173077	2950		F	Bit allocation correction in EPS bearer context status	15.1.0
2017-12	CT#78	CP-173078	2951	3	B	Network policy indication on LTE call redirection to GERAN	15.1.0
2017-12	CT#78	CP-173077	2952		F	Correction on TAI list coding	15.1.0
2017-12	CT#78	CP-173078	2953	1	F	Storing CE Mode B in MME	15.1.0
2017-12	CT#78	CP-173078	2955	1	B	UE behaviour on congestion for MO MMtel voice call	15.1.0
2017-12	CT#78	CP-173078	2956	1	F	Handling IMS calls when starting timer T3325	15.1.0
2017-12	CT#78	CP-173060	2942	3	A	Enhancement of APN rate control for MO exception data	15.1.0
2017-12	CT#78	CP-173072	2954	2	B	Signalling of UE's additional security capabilities	15.1.0

2017-12	CT#78	CP-173078	2961	1	C	Support for Reliable Data Service with PtP SGi Tunneling	15.1.0
2017-12	CT#78	CP-173072	2960	2	B	Security algorithm support for Dual Connectivity	15.1.0
2018-01	CT#78					Assigning IEI values for new IEs by Rapporteur	15.1.1
2018-03	CT#79	CP-180089	2963	1	F	Correction of network policy indication on LTE call redirection to GERAN	15.2.0
2018-03	CT#79	CP-180104	2964	4	F	Correction of Extended EPS QoS IE	15.2.0
2018-03	CT#79	CP-180077	2965	4	B	Handling of S-NSSAI and PDU session ID during mobility between EPS and 5GS	15.2.0
2018-03	CT#79	CP-180077	2968	3	B	Intersystem change from N1 mode to S1 in Idle mode using TAU procedure	15.2.0
2018-03	CT#79	CP-180075	2969	1	B	Including NG-RAN in the Scope	15.2.0
2018-03	CT#79	CP-180081	2972		F	Addition of new QCIs	15.2.0
2018-03	CT#79	CP-180088	2973	1	F	Updates to UE behaviour in state ATTEMPTING-TO-UPDATE	15.2.0
2018-03	CT#79	CP-180065	2975	3	A	Data support for "voice centric" UE supporting CE mode B	15.2.0
2018-03	CT#79	CP-180089	2976	2	F	Updating periodic TAU timer and PSM during service request	15.2.0
2018-03	CT#79	CP-180077	2977	2	B	QoS provision for interworking with 5GS	15.2.0
2018-03	CT#79	CP-180077	2979	2	B	Mode selection for inter-system change between EPS and 5GS	15.2.0
2018-03	CT#79	CP-180089	2981		F	Correction to EMM/GMM coordination	15.2.0
2018-03	CT#79	CP-180089	2982	2	B	Introduction of Service Gap Control; basics and feature negotiation	15.2.0
2018-03	CT#79	CP-180089	2983	2	B	Service Gap Control feature; non supporting UEs	15.2.0
2018-03	CT#79	CP-180089	2984	2	B	Service Gap Control; UE behaviour service gap timer is running	15.2.0
2018-03	CT#79	CP-180069	2990		A	Hash-MME extended usage	15.2.0
2018-03	CT#79	CP-180076	2993	1	C	Update the UE's usage setting to be applicable to 5GS.	15.2.0
2018-03	CT#79	CP-180065	2995		A	Remove Editor's note on HASHMME computation	15.2.0
2018-03	CT#79	CP-180089	2996	1	F	Adding back UP CIoT indication in PNB-CIoT	15.2.0
2018-03	CT#79	CP-180077	2998	3	B	Emergency numbers list with URN formats	15.2.0
2018-03	CT#79	CP-180089	2999	3	F	Enabling E-UTRA capability triggered by emergency call	15.2.0
2018-03	CT#79	CP-180089	3000		F	S1-u data capability indication correction	15.2.0
2018-03	CT#79	CP-180065	3002	1	A	Numbering of timer Txy	15.2.0
2018-03	CT#79	CP-180077	3003	1	B	Coordination between ESM and 5GSM	15.2.0
2018-06	CT#80	CP-181059	3006	1	F	Supporting ePCO for N1 mode capable UE and network supporting 5GS interworking	15.3.0
2018-06	CT#80	CP-181076	3007		F	Applying EAB for attach and detach and skiping EAB for paging	15.3.0
2018-06	CT#80	CP-181075	3008		F	Keep PTI during UE initiated PDN disconnect procedure	15.3.0
2018-06	CT#80	CP-181069	3009	7	B	Support of 15 EPS Bearer IDs in NAS	15.3.0
2018-06	CT#80	CP-181076	3010	2	B	Service Gap Control feature cleanup and corrections	15.3.0
2018-06	CT#80	CP-181063	3011		F	Correction to the length of UE additional security capability IE	15.3.0
2018-06	CT#80	CP-181059	3012	2	B	Extended and local emergency numbers and applicable domain for call initiation	15.3.0
2018-06	CT#80	CP-181059	3013	3	B	Storage of extended local emergency numbers	15.3.0
2018-06	CT#80	CP-181059	3014		B	Update of eCall timers start and stop conditions to support eCall over IMS in 5GS	15.3.0
2018-06	CT#80	CP-181069	3015	3	B	Addition of UE and network NAS capabilities for support of 15 EPS bearers	15.3.0
2018-06	CT#80	CP-181059	3017		D	Remove "-" between N1 and mode	15.3.0
2018-06	CT#80	CP-181049	3023	2	A	Receipt of the EPS network feature support IE	15.3.0
2018-06	CT#80	CP-181075	3024		C	Handling of PDN Connectivity Reject (cause #66) during an attach procedure	15.3.0
2018-06	CT#80	CP-181059	3026	3	F	Secondary authentication/authorization revocation by DN-AAA server after intersystem change from N1 mode to S1.	15.3.0
2018-06	CT#80	CP-181074	3027	1	B	Enabling 3GPP PS data off in roaming	15.3.0
2018-06	CT#80	CP-181059	3028	4	B	EPS mobile identity and UE status in the ATTACH REQUEST message	15.3.0
2018-06	CT#80	CP-181059	3030	3	C	Intersystem interworking improvement	15.3.0
2018-06	CT#80	CP-181075	3031	1	F	Correction of APN-AMBR	15.3.0
2018-06	CT#80	CP-181059	3032	2	F	Disabling and re-enabling S1 mode	15.3.0
2018-06	CT#80	CP-181059	3033	2	B	Extended Emergency Number List IE	15.3.0
2018-06	CT#80	CP-181076	3035	3	B	Extended EMM cause for NB-IoT	15.3.0
2018-06	CT#80	CP-181076	3036	2	C	Service Gap Control, attach without PDN connection for supporting UEs	15.3.0
2018-06	CT#80	CP-181063	3037	1	F	MSB & LSB in the coding of Extended QoS and Extended APN AMBR IE	15.3.0
2018-06	CT#80	CP-181076	3038	2	F	UE Radio Capability Update using TAU procedure	15.3.0
2018-06	CT#80	CP-181076	3039	1	F	Corrections to handling of timer T3402	15.3.0
2018-06	CT#80	CP-181076	3042		F	Correction on service request as paging response	15.3.0
2018-06	CT#80	CP-181076	3043		F	Correction on EPS network feature support IE	15.3.0
2018-06	CT#80	CP-181063	3044	1	F	Removal of Extended EPS QoS IE	15.3.0
2018-06	CT#80	CP-181059	3047	1	B	5GMM parameter handling for TAU rejected with EMM cause #9	15.3.0
2018-06	CT#80	CP-181075	3050		F	Non-semantical mandatory information element errors for EMM	15.3.0
2018-06	CT#80	CP-181076	3041	1	B	Ciphering keys delivery for broadcast of ciphered assistance data	15.3.0

History

Document history		
V15.3.0	June 2018	Publication

EXHIBIT J

ETSI TS 138 331 V15.2.1 (2018-06)

5G;
NR;
Radio Resource Control (RRC);
Protocol specification
(3GPP TS 38.331 version 15.2.1 Release 15)

Reference
RTS/TSGR-0238331vf21

Keywords
5G

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Important notice

The present document can be downloaded from:
http://www.etsi.org/standards-search

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the only prevailing document is the print of the Portable Document Format (PDF) version kept on a specific network drive within ETSI Secretariat.

Users of the present document should be aware that the document may be subject to revision or change of status.
Information on the current status of this and other ETSI documents is available at
https://portal.etsi.org/TB/ETSIDeliverableStatus.aspx

If you find errors in the present document, please send your comment to one of the following services:
https://portal.etsi.org/People/CommiteeSupportStaff.aspx

Copyright Notification

No part may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm except as authorized by written permission of ETSI.
The content of the PDF version shall not be modified without the written authorization of ETSI.
The copyright and the foregoing restriction extend to reproduction in all media.

© ETSI 2018.
All rights reserved.

DECT™, **PLUGTESTS**™, **UMTS**™ and the ETSI logo are trademarks of ETSI registered for the benefit of its Members.
3GPP™ and **LTE**™ are trademarks of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners.
oneM2M logo is protected for the benefit of its Members.
GSM® and the GSM logo are trademarks registered and owned by the GSM Association.

Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (https://ipr.etsi.org/).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

Foreword

This Technical Specification (TS) has been produced by ETSI 3rd Generation Partnership Project (3GPP).

The present document may refer to technical specifications or reports using their 3GPP identities, UMTS identities or GSM identities. These should be interpreted as being references to the corresponding ETSI deliverables.

The cross reference between GSM, UMTS, 3GPP and ETSI identities can be found under http://webapp.etsi.org/key/queryform.asp.

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

Contents

Intellectual Property Rights 2
Foreword 2
Modal verbs terminology 2
Foreword 11
1 Scope 12
2 References 12
3 Definitions, symbols and abbreviations 13
3.1 Definitions 13
3.2 Abbreviations 13
4 General 15
4.1 Introduction 15
4.2 Architecture 15
4.2.1 UE states and state transitions including inter RAT 15
4.2.2 Signalling radio bearers 18
4.3 Services 18
4.3.1 Services provided to upper layers 18
4.3.2 Services expected from lower layers 18
4.4 Functions 18
5 Procedures 19
5.1 General 19
5.1.1 Introduction 19
5.1.2 General requirements 19
5.2 System information 19
5.2.1 Introduction 20
5.2.2 System information acquisition 20
5.2.2.1 General UE requirements 20
5.2.2.2 SI validity and need to (re)-acquire SI 21
5.2.2.2.1 SI validity 21
5.2.2.2.2 SI change indication and PWS notification 21
5.2.2.3 Acquisition of System Information 22
5.2.2.3.1 Acquisition of *MIB* and *SIB1* 22
5.2.2.3.2 Acquisition of an SI message 22
5.2.2.3.3 Request for on demand system information 23
5.2.2.4 Actions upon receipt of SI message 24
5.2.2.4.1 Actions upon reception of the *MIB* 24
5.2.2.4.2 Actions upon reception of the SystemInformationBlockType1 24
5.2.2.4.3 Actions upon reception of SystemInformationBlockTypeX 24
5.2.2.5 Essential system information missing 24
5.3 Connection control 25
5.3.1 Introduction 25
5.3.2 Paging 25
5.3.3 RRC connection establishment 25
5.3.4 Initial security activation 25
5.3.5 RRC reconfiguration 25
5.3.5.1 General 25
5.3.5.2 Initiation 26
5.3.5.3 Reception of an *RRCReconfiguration* by the UE 26
5.3.5.4 Secondary cell group release 27
5.3.5.5 Cell Group configuration 27
5.3.5.5.1 General 27
5.3.5.5.2 Reconfiguration with sync 28
5.3.5.5.3 RLC bearer release 28
5.3.5.5.4 RLC bearer addition/modification 28
5.3.5.5.5 MAC entity configuration 29

5.3.5.5.6 RLF Timers & Constants configuration 29
5.3.5.5.7 SPCell Configuration 30
5.3.5.5.8 SCell Release 30
5.3.5.5.9 SCell Addition/Modification 30
5.3.5.6 Radio Bearer configuration 30
5.3.5.6.1 General 30
5.3.5.6.2 SRB release 31
5.3.5.6.3 SRB addition/modification 31
5.3.5.6.4 DRB release 32
5.3.5.6.5 DRB addition/modification 32
5.3.5.7 Security key update 33
5.3.5.8 Reconfiguration failure 33
5.3.5.8.1 Integrity check failure 33
5.3.5.8.2 Inability to comply with RRCReconfiguration 33
5.3.5.8.3 T304 expiry (Reconfiguration with sync Failure) 34
5.3.5.9 Other configuration 34
5.3.5.10 EN-DC release 34
5.3.6 Counter check 34
5.3.7 RRC connection re-establishment 34
5.3.9 RRC connection release requested by upper layers 34
5.3.10 Radio link failure related actions 34
5.3.10.1 Detection of physical layer problems in RRC_CONNECTED 34
5.3.10.2 Recovery of physical layer problems 35
5.3.10.3 Detection of radio link failure 35
5.3.11 UE actions upon leaving RRC_CONNECTED 35
5.3.12 UE actions upon PUCCH/SRS release request 36
5.4 Inter-RAT mobility 36
5.5 Measurements 36
5.5.1 Introduction 36
5.5.2 Measurement configuration 37
5.5.2.1 General 37
5.5.2.2 Measurement identity removal 38
5.5.2.3 Measurement identity addition/modification 38
5.5.2.4 Measurement object removal 39
5.5.2.5 Measurement object addition/modification 39
5.5.2.6 Reporting configuration removal 40
5.5.2.7 Reporting configuration addition/modification 41
5.5.2.8 Quantity configuration 41
5.5.2.9 Measurement gap configuration 41
5.5.2.10 Reference signal measurement timing configuration 42
5.5.2.11 Measurement gap sharing configuration 42
5.5.3 Performing measurements 42
5.5.3.1 General 42
5.5.3.2 Layer 3 filtering 44
5.5.3.3 Derivation of cell measurement results 44
5.5.3.3a Derivation of layer 3 beam filtered measurement 45
5.5.4 Measurement report triggering 45
5.5.4.1 General 45
5.5.4.2 Event A1 (Serving becomes better than threshold) 47
5.5.4.3 Event A2 (Serving becomes worse than threshold) 47
5.5.4.4 Event A3 (Neighbour becomes offset better than SpCell) 48
5.5.4.5 Event A4 (Neighbour becomes better than threshold) 49
5.5.4.6 Event A5 (SpCell becomes worse than threshold1 and neighbour becomes better than threshold2) 49
5.5.4.7 Event A6 (Neighbour becomes offset better than SCell) 50
5.5.5 Measurement reporting 51
5.5.5.1 General 51
5.5.5.2 Reporting of beam measurement information 53
5.6 UE capabilities 54
5.6.1 UE capability transfer 54
5.6.1.1 General 54
5.6.1.2 Initiation 54

5.6.1.3 Reception of the *UECapabilityEnquiry* by the UE 54
5.6.1.4 Compilation of band combinations supported by the UE 54
5.6.1.5 Compilation of baseband processing combinations supported by the UE 54
5.7 Other 55
5.7.1 DL information transfer 55
5.7.2 UL information transfer 55
5.7.3 SCG failure information 55
5.7.3.1 General 55
5.7.3.2 Initiation 55
5.7.3.3 Failure type determination 56
5.7.3.4 Setting the contents of *MeasResultSCG-Failure* 56

6 Protocol data units, formats and parameters (ASN.1) 58
6.1 General 58
6.1.1 Introduction 58
6.1.2 Need codes and conditions for optional downlink fields 58
6.2 RRC messages 59
6.2.1 General message structure 59
– *NR-RRC-Definitions* 59
– *BCCH-BCH-Message* 59
– *DL-DCCH-Message* 59
– *UL-DCCH-Message* 60
6.2.2 Message definitions 60
– *MIB* 60
– *MeasurementReport* 62
– *RRCReconfiguration* 63
– *RRCReconfigurationComplete* 64
– *SIB1* 64
6.3 RRC information elements 66
6.3.0 Parameterized types 66
– *SetupRelease* 66
6.3.1 System information blocks 66
6.3.2 Radio resource control information elements 67
– *AdditionalSpectrumEmission* 67
– *Alpha* 67
– *ARFCN-ValueNR* 67
– *BWP* 67
– *BWP-Id* 71
– *BeamFailureRecoveryConfig* 71
– *CellGroupConfig* 74
– *CellGroupId* 76
– *CodebookConfig* 76
– *ConfiguredGrantConfig* 78
– *ControlResourceSet* 81
– *ControlResourceSetId* 82
– *CrossCarrierSchedulingConfig* 83
– *CSI-AperiodicTriggerStateList* 84
– *CSI-FrequencyOccupation* 85
– *CSI-IM-Resource* 86
– *CSI-IM-ResourceId* 87
– *CSI-IM-ResourceSet* 87
– *CSI-IM-ResourceSetId* 88
– *CSI-MeasConfig* 88
– *CSI-ReportConfig* 89
– *CSI-ReportConfigId* 95
– *CSI-ResourceConfig* 95
– *CSI-ResourceConfigId* 96
– *CSI-ResourcePeriodicityAndOffset* 96
– *CSI-RS-ResourceConfigMobility* 97
– *CSI-RS-ResourceMapping* 99
– *CSI-SemiPersistentOnPUSCH-TriggerStateList* 100
– *CSI-SSB-ResourceSetId* 101

– *CSI-SSB-ResourceSet* 101
– *DMRS-DownlinkConfig* 101
– *DMRS-UplinkConfig* 102
– *DownlinkConfigCommon* 104
– *DownlinkPreemption* 104
– *DRB-Identity* 105
– *EUTRA-MBSFN-SubframeConfigList* 105
– *FilterCoefficient* 106
– *FreqBandIndicatorNR* 107
– FrequencyInfoDL 107
– *FrequencyInfoUL* 108
– *Hysteresis* 109
- *LogicalChannelConfig* 109
– *LogicalChannelIdentity* 111
– *MAC-CellGroupConfig* 112
– *MeasConfig* 116
– *MeasGapConfig* 117
– *MeasGapSharingConfig* 118
– *MeasId* 119
– *MeasIdToAddModList* 119
– *MeasObjectEUTRA* 119
– *MeasObjectId* 120
– *MeasObjectNR* 120
– *MeasObjectToAddModList* 125
– *MeasResults* 125
– *MeasResultSCG-Failure* 127
– *MeasResult*CellList*SFTD* 128
– *MultiFrequencyBandListNR* 129
– *NZP-CSI-RS-Resource* 129
– *NZP-CSI-RS-ResourceId* 130
– *NZP-CSI-RS-ResourceSet* 130
– *NZP-CSI-RS-ResourceSetId* 131
– *P-Max* 131
– *PCI-List* 132
– *PCI-Range* 132
– *PCI-RangeElement* 133
– *PCI-RangeIndex* 133
– *PCI-RangeIndexList* 133
– *PDCCH-Config* 134
– *PDCCH-ConfigCommon* 135
– *PDCCH-ServingCellConfig* 136
– *PDCP-Config* 137
– *PDSCH-Config* 140
– *PDSCH-ConfigCommon* 143
– *PDSCH-ServingCellConfig* 143
– *PDSCH-TimeDomainResourceAllocationList* 144
– *PhysCellId* 145
– *PhysicalCellGroupConfig* 146
– *PRB-Id* 147
– *PTRS-DownlinkConfig* 148
– *PTRS-UplinkConfig* 148
– *PUCCH-Config* 149
– *PUCCH-ConfigCommon* 153
– *PUCCH-PathlossReferenceRS-Id* 154
– *PUCCH-PowerControl* 154
– *PUCCH-TPC-CommandConfig* 156
– *PUSCH-Config* 157
– *PUSCH-ConfigCommon* 160
– *PUSCH-PowerControl* 161
– *PUSCH-ServingCellConfig* 163
– *PUSCH-TimeDomainResourceAllocationList* 164
– *PUSCH-TPC-CommandConfig* 165

– *Q-OffsetRange* 166
– *QuantityConfig* 166
– *RACH-ConfigCommon* 167
– *RACH-ConfigGeneric* 169
– *RACH-ConfigDedicated* 170
– *RA-Prioritization* 172
– *RadioBearerConfig* 173
– *RadioLinkMonitoringConfig* 175
– *RadioLinkMonitoringRSId* 176
– *RateMatchPattern* 176
– *RateMatchPatternId* 178
– *RateMatchPatternLTE-CRS* 178
– *ReportConfigId* 179
– *ReportConfigNR* 180
– *ReportConfigToAddModList* 184
– *ReportInterval* 184
– *RLC-BearerConfig* 184
– *RLC-Config* 185
– *RLF-TimersAndConstants* 188
– *RNTI-Value* 188
– *RSRP-Range* 188
– *RSRQ-Range* 189
– *SCellIndex* 189
– *SchedulingRequestConfig* 189
– *SchedulingRequestId* 190
– *SchedulingRequestResourceConfig* 191
– *SchedulingRequestResourceId* 192
– *ScramblingId* 192
– *SCS-SpecificCarrier* 193
– *SDAP-Config* 193
– *SearchSpace* 194
– *SearchSpaceId* 198
– *SecurityAlgorithmConfig* 198
– *ServCellIndex* 199
– *ServingCellConfig* 199
– *ServingCellConfigCommon* 202
– *SINR-Range* 205
– *SlotFormatCombinationsPerCell* 205
– *SlotFormatIndicator* 206
– *SS-RSSI-Measurement* 207
– *SPS-Config* 207
– *SRB-Identity* 208
– *SRS-Config* 208
– *SRS-CarrierSwitching* 213
– *SRS-TPC-CommandConfig* 215
– *SSB-Index* 215
– *SSB-MTC* 216
– *SubcarrierSpacing* 217
– *TCI-State* 217
– *TCI-StateId* 218
– *TDD-UL-DL-Config* 218
– *TimeToTrigger* 220
– *UplinkConfigCommon* 221
– *ZP-CSI-RS-Resource* 221
– *ZP-CSI-RS-ResourceSet* 222
– *ZP-CSI-RS-ResourceSetId* 223
6.3.3 UE capability information elements 223
– *AccessStratumRelease* 223
– *BandCombinationList* 223
– *CA-BandwidthClassNR* 224
– *CA-BandwidthClassEUTRA* 224
– *CA-ParametersNR* 224

– *CA-ParametersEUTRA* 225
– *FeatureSetCombination* 225
– *FeatureSetCombinationId* 226
– *FeatureSetDownlink* 227
– *FeatureSetDownlinkId* 229
– *FeatureSetEUTRA-DownlinkId* 229
– *FeatureSetDownlinkPerCC* 229
– *FeatureSetDownlinkPerCC-Id* 230
– *FeatureSetUplink* 230
– *FeatureSetUplinkId* 231
– *FeatureSetEUTRA-UplinkId* 231
– *FeatureSetUplinkPerCC* 232
– *FeatureSetUplinkPerCC-Id* 232
– *FeatureSets* 233
– *FreqBandIndicatorEUTRA* 233
– *FreqBandList* 233
– *FreqSeparationClass* 234
– *MIMO-Layers* 234
– *ModulationOrder* 235
– *MRDC-Parameters* 235
– *RAT-Type* 235
– *SupportedBandwidth* 236
– *UE-CapabilityRAT-ContainerList* 236
– *UE-MRDC-Capability* 236
– *RF-ParametersMRDC* 237
– *MeasParametersMRDC* 238
– *UE-NR-Capability* 239
– *Phy-Parameters* 240
– *RF-Parameters* 242
– *MIMO-ParametersPerBand* 243
– *PDCP-Parameters* 245
– *RLC-Parameters* 246
– *MAC-Parameters* 246
– *MeasParameters* 247
6.3.4 Other information elements 247
– *RRC-TransactionIdentifier* 247
6.4 RRC multiplicity and type constraint values 248
– Multiplicity and type constraint definitions 248
– End of NR-RRC-Definitions 251

7 Variables and constants 252
7.1 Timers 252
7.1.1 Timers (Informative) 252
7.1.2 Timer handling 252
7.2 Counters 252
7.3 Constants 253
7.4 UE variables 253
– *NR-UE-Variables* 253
– *VarMeasConfig* 253
– *VarMeasReportList* 254
– End of *NR-UE-Variables* 255

8 Protocol data unit abstract syntax 256
8.1 General 256
8.2 Structure of encoded RRC messages 256
8.3 Basic production 256
8.4 Extension 256
8.5 Padding 257

9 Specified and default radio configurations 257
9.1 Specified configurations 257
9.1.1 Logical channel configurations 257
9.1.2 SRB configurations 257

9.1.2.1 SRB1/SRB1S 257
9.1.2.2 SRB2/SRB2S 258
9.1.2.3 SRB3 258
9.2 Default radio configurations 258
9.2.1 SRB configurations 258
9.2.1.1 SRB1/SRB1S 258
9.2.1.2 SRB2/SRB2S 258
9.2.1.3 SRB3 259

10 Generic error handling 259
10.1 General 259
10.2 ASN.1 violation or encoding error 260
10.3 Field set to a not comprehended value 260
10.4 Mandatory field missing 260
10.5 Not comprehended field 261

11 Radio information related interactions between network nodes 262
11.1 General 262
11.2 Inter-node RRC messages 262
11.2.1 General 262
11.2.2 Message definitions 263
– *HandoverCommand* 263
– *HandoverPreparationInformation* 263
– *CG-Config* 265
– *CG-ConfigInfo* 267
– *MeasurementTimingConfiguration* 270
11.3 Inter-node RRC information element definitions 271
11.4 Inter-node RRC multiplicity and type constraint values 272
– Multiplicity and type constraints definitions 272
– *End of NR-InterNodeDefinitions* 272

12 Processing delay requirements for RRC procedures 273

Annex A (informative): Guidelines, mainly on use of ASN.1 274

A.1 Introduction 274

A.2 Procedural specification 274
A.2.1 General principles 274
A.2.2 More detailed aspects 274

A.3 PDU specification 275
A.3.1 General principles 275
A.3.1.1 ASN.1 sections 275
A.3.1.2 ASN.1 identifier naming conventions 276
A.3.1.3 Text references using ASN.1 identifiers 277
A.3.2 High-level message structure 278
A.3.3 Message definition 279
A.3.4 Information elements 281
A.3.5 Fields with optional presence 282
A.3.6 Fields with conditional presence 283
A.3.7 Guidelines on use of lists with elements of SEQUENCE type 283
A.3.8 Guidelines on use of parameterised SetupRelease type 284
A.3.9 Guidelines on use of ToAddModList and ToReleaseList 285

A.4 Extension of the PDU specifications 286
A.4.1 General principles to ensure compatibility 286
A.4.2 Critical extension of messages and fields 287
A.4.3 Non-critical extension of messages 289
A.4.3.1 General principles 289
A.4.3.2 Further guidelines 290
A.4.3.3 Typical example of evolution of IE with local extensions 290
A.4.3.4 Typical examples of non critical extension at the end of a message 292
A.4.3.5 Examples of non-critical extensions not placed at the default extension location 292

– *ParentIE-WithEM* 292
– *ChildIE1-WithoutEM* 293
– *ChildIE2-WithoutEM* 294

A.5 Guidelines regarding inclusion of transaction identifiers in RRC messages 295

A.6 Guidelines regarding use of need codes 295

A.7 Guidelines regarding use of conditions 296

Annex B (informative): Change history 297

History 298

Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

- x the first digit:
  - 1 presented to TSG for information;
  - 2 presented to TSG for approval;
  - 3 or greater indicates TSG approved document under change control.
- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The present document specifies the Radio Resource Control protocol for the radio interface between UE and NG-RAN.

The scope of the present document also includes:

- the radio related information transported in a transparent container between source gNB and target gNB upon inter gNB handover;
- the radio related information transported in a transparent container between a source or target gNB and another system upon inter RAT handover.
- the radio related information transported in a transparent container between a source eNB and target gNB during E-UTRA-NR Dual Connectivity.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 38.300: "NR; Overall description; Stage 2".

[3] 3GPP TS 38.321: "NR; Medium Access Control (MAC); Protocol specification".

[4] 3GPP TS 38.322: "NR; Radio Link Control (RLC) protocol specification".

[5] 3GPP TS 38.323: "NR; Packet Data Convergence Protocol (PDCP) protocol specification".

[6] ITU-T Recommendation X.680 (08/2015) "Information Technology - Abstract Syntax Notation One (ASN.1): Specification of basic notation" (Same as the ISO/IEC International Standard 8824-1).

[7] ITU-T Recommendation X.681 (08/2015) "Information Technology - Abstract Syntax Notation One (ASN.1): Information object specification" (Same as the ISO/IEC International Standard 8824-2).

[8] ITU-T Recommendation X.691 (08/2015) "Information technology - ASN.1 encoding rules: Specification of Packed Encoding Rules (PER)" (Same as the ISO/IEC International Standard 8825-2).

[9] 3GPP TS 38.215: "NR; Physical layer measurements".

[10] 3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRA) Radio Resource Control (RRC); Protocol Specification".

[11] 3GPP TS 33.501: "Security Architecture and Procedures for 5G System".

[12] 3GPP TS 38.104: "NR; Base Station (BS) radio transmission and reception".

[13] 3GPP TS 38.213: "NR; Physical layer procedures for control".

[14] 3GPP TS 38.133: "NR; Requirements for support of radio resource management".

[15] 3GPP TS 38.101: "NR; User Equipment (UE) radio transmission and reception".

[16] 3GPP TS 38.211: "NR; Physical channels and modulation".

[17] 3GPP TS 38.212: "NR; Multiplexing and channel coding".

[18] ITU-T Recommendation X.683 (08/2015) "Information Technology - Abstract Syntax Notation One (ASN.1): Parameterization of ASN.1 specifications" (Same as the ISO/IEC International Standard 8824-4).

[19] 3GPP TS 38.214: "NR; Physical layer procedures for data".

[20] 3GPP TS 38.304: "NR; User Equipment (UE) procedures in Idle mode and RRC Inactive state".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

Field: The individual contents of an information element are referred as fields.

Floor: Mathematical function used to 'round down' i.e. to the nearest integer having a lower or equal value.

Information element: A structural element containing a single or multiple fields is referred as information element.

Primary Cell: The MCG cell, operating on the primary frequency, in which the UE either performs the initial connection establishment procedure or initiates the connection re-establishment procedure.

Primary SCG Cell: For dual connectivity operation, the SCG cell in which the UE performs random access when performing the Reconfiguration with Sync procedure.

PUCCH SCell: An SCell configured with PUCCH.

RLC bearer configuration: The lower layer part of the radio bearer configuration comprising the RLC and logical channel configurations.

Secondary Cell: For a UE configured with CA, a cell providing additional radio resources on top of Special Cell.

Secondary Cell Group: For a UE configured with dual connectivity, the subset of serving cells comprising of the PSCell and zero or more secondary cells.

Serving Cell: For a UE in RRC_CONNECTED not configured with CA/DC there is only one serving cell comprising of the primary cell. For a UE in RRC_CONNECTED configured with CA/ DC the term 'serving cells' is used to denote the set of cells comprising of the Special Cell(s) and all secondary cells.

Special Cell: For Dual Connectivity operation the term Special Cell refers to the PCell of the MCG or the PSCell of the SCG, otherwise the term Special Cell refers to the PCell.

SRB1S: The SCG part of MCG split SRB1 for EN-DC.

SRB2S: The SCG part of MCG split SRB2 for EN-DC.

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

5GC	5G Core Network
ACK	Acknowledgement
AM	Acknowledged Mode

ARQ	Automatic Repeat Request
AS	Access Stratum
ASN.1	Abstract Syntax Notation One
BLER	Block Error Rate
BWP	Bandwidth Part
CA	Carrier Aggregation
CCCH	Common Control Channel
CG	Cell Group
CMAS	Commercial Mobile Alert Service
CP	Control Plane
C-RNTI	Cell RNTI
CSI	Channel State Information
DC	Dual Connectivity
DCCH	Dedicated Control Channel
DCI	Downlink Control Information
DL	Downlink
DL-SCH	Downlink Shared Channel
DRB	(user) Data Radio Bearer
DRX	Discontinuous Reception
DTCH	Dedicated Traffic Channel
EPC	Evolved Packet Core
EPS	Evolved Packet System
ETWS	Earthquake and Tsunami Warning System
E-UTRA	Evolved Universal Terrestrial Radio Access
E-UTRAN	Evolved Universal Terrestrial Radio Access Network
FDD	Frequency Division Duplex
FFS	For Further Study
GERAN	GSM/EDGE Radio Access Network
GNSS	Global Navigation Satellite System
GSM	Global System for Mobile Communications
HARQ	Hybrid Automatic Repeat Request
IE	Information element
IMSI	International Mobile Subscriber Identity
kB	Kilobyte (1000 bytes)
L1	Layer 1
L2	Layer 2
L3	Layer 3
MAC	Medium Access Control
MCG	Master Cell Group
MIB	Master Information Block
N/A	Not Applicable
PCell	Primary Cell
PDCP	Packet Data Convergence Protocol
PDU	Protocol Data Unit
PLMN	Public Land Mobile Network
PSCell	Primary Secondary Cell
QoS	Quality of Service
RAN	Radio Access Network
RAT	Radio Access Technology
RLC	Radio Link Control
RNTI	Radio Network Temporary Identifier
ROHC	RObust Header Compression
RRC	Radio Resource Control
RS	Reference Signal
SCell	Secondary Cell
SCG	Secondary Cell Group
SFN	System Frame Number
SFTD	SFN and Frame Timing Difference
SI	System Information
SIB	System Information Block
SpCell	Special Cell
SRB	Signalling Radio Bearer

SSB	Synchronization Signal Block
TAG	Timing Advance Group
TDD	Time Division Duplex
TM	Transparent Mode
UE	User Equipment
UL	Uplink
UM	Unacknowledged Mode
UP	User Plane

In the ASN.1, lower case may be used for some (parts) of the above abbreviations e.g. c-RNTI.

4 General

4.1 Introduction

This specification is organised as follows:

- sub-clause 4.2 describes the RRC protocol model;
- sub-clause 4.3 specifies the services provided to upper layers as well as the services expected from lower layers;
- sub-clause 4.4 lists the RRC functions;
- clause 5 specifies RRC procedures, including UE state transitions;
- clause 6 specifies the RRC messages in ASN.1 and description;
- clause 7 specifies the variables (including protocol timers and constants) and counters to be used by the UE;
- clause 8 specifies the encoding of the RRC messages;
- clause 9 specifies the specified and default radio configurations;
- clause 10 specifies generic error handling;
- clause 11 specifies the RRC messages transferred across network nodes;
- clause 12 specifies the UE capability related constraints and performance requirements.

4.2 Architecture

Editor's note The state model is still a subject for discussion.FFS

4.2.1 UE states and state transitions including inter RAT

Editor's Note: For EN_DC, only RRC_CONNECTED is applicable.

A UE is either in RRC_CONNECTED state or in RRC_INACTIVE state when an RRC connection has been established. If this is not the case, i.e. no RRC connection is established, the UE is in RRC_IDLE state. The RRC states can further be characterised as follows:

- **RRC_IDLE**:
  - A UE specific DRX may be configured by upper layers;
  - UE controlled mobility based on network configuration;
  - The UE:
    - Monitors a Paging channel;
    - Performs neighbouring cell measurements and cell (re-)selection;
    - Acquires system information.

- **RRC_INACTIVE**:
  - A UE specific DRX may be configured by upper layers or by RRC layer;
  - UE controlled mobility based on network configuration;
  - The UE stores the AS context;
  - The UE:
    - Monitors a Paging channel;
    - Performs neighbouring cell measurements and cell (re-)selection;
    - Performs RAN-based notification area updates when moving outside the RAN-based notification area;

Editor's Note: FFS Whether a RAN-based notification area is always configured or not.

Editor's Note: FFS UE behavior if it is decided that a RAN-based notification area is not always configured.

    - Acquires system information.

- **RRC_CONNECTED:**
  - The UE stores the AS context;
  - Transfer of unicast data to/from UE;
  - At lower layers, the UE may be configured with a UE specific DRX;
  - For UEs supporting CA, use of one or more SCells, aggregated with the SpCell, for increased bandwidth;
  - For UEs supporting DC, use of one SCG, aggregated with the MCG, for increased bandwidth;
  - Network controlled mobility within NR and to/from E-UTRAN;
  - The UE:
    - Monitors a Paging channel;
    - Monitors control channels associated with the shared data channel to determine if data is scheduled for it;
    - Provides channel quality and feedback information;
    - Performs neighbouring cell measurements and measurement reporting;
    - Acquires system information.

Figure 4.2.1-1 illustrates an overview of UE RRC state machine and state transitions in NR. A UE has only one RRC state in NR at one time.

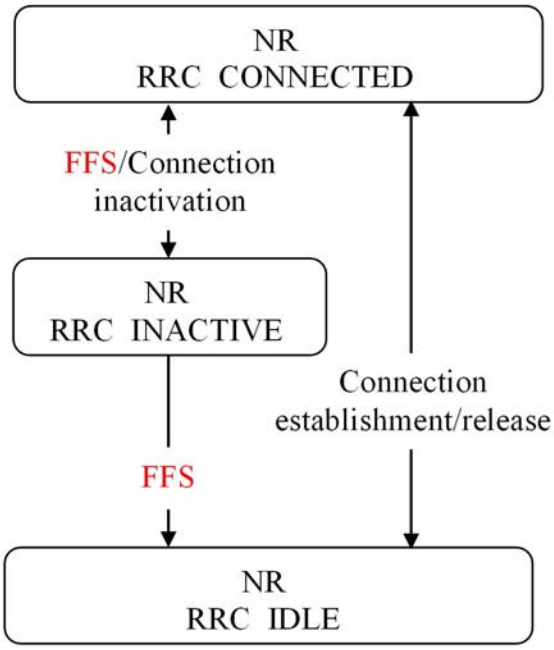


Figure 4.2.1-1: UE state machine and state transitions in NR

Figure 4.2.1-2 illustrates an overview of UE state machine and state transitions in NR as well as the mobility procedures supported between NR/NGC and E-UTRAN/EPC.

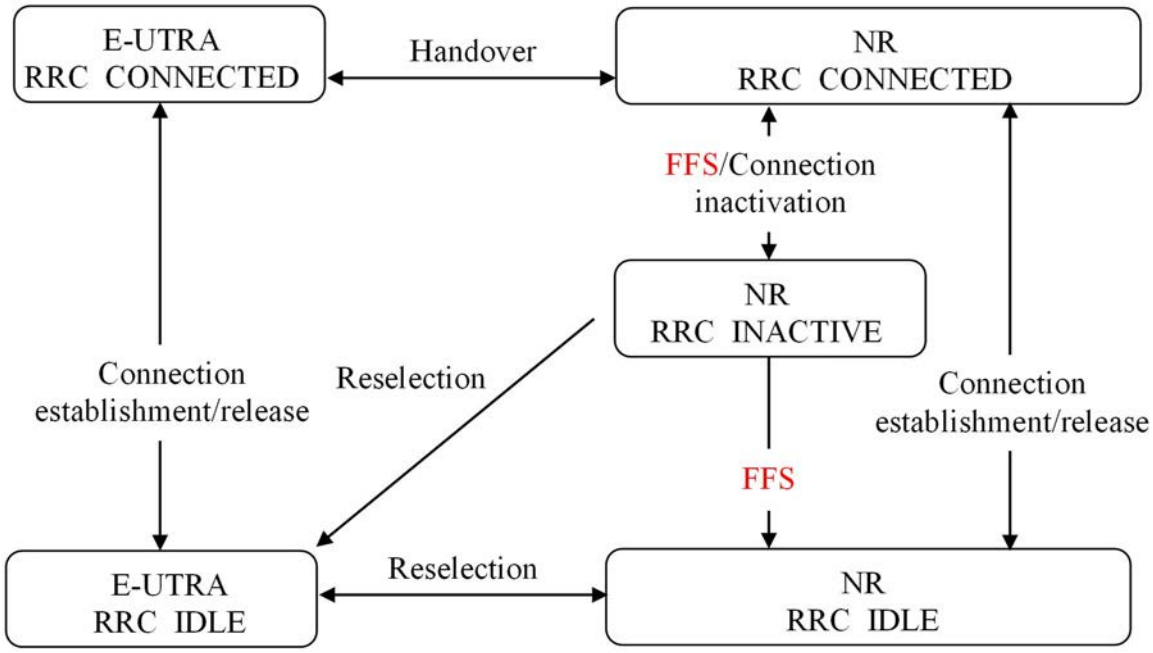


Figure 4.2.1-2: UE state machine and state transitions between NR/NGC and E-UTRAN/EPC

The UE state machine, state transition and mobility procedures between NR/NGC and E-UTRA/NGC is FFS.

4.2.2 Signalling radio bearers

4.3 Services

4.3.1 Services provided to upper layers

The RRC protocol offers the following services to upper layers:

- Broadcast of common control information;
- Notification of UEs in RRC_IDLE, e.g. about a terminating call [FFS, for ETWS, for CMAS];
- Transfer of dedicated control information, i.e. information for one specific UE.

4.3.2 Services expected from lower layers

In brief, the following are the main services that RRC expects from lower layers:

- PDCP: integrity protection, ciphering and in-sequence delivery of information without duplication [FFS if duplication need to be listed];
- RLC: reliable transfer of information, without introducing duplicates and with support for segmentation.

4.4 Functions

The RRC protocol includes the following main functions:

- Broadcast of system information:
  - Including NAS common information;
  - Information applicable for UEs in RRC_IDLE and RRC_INACTIVE, e.g. cell (re-)selection parameters, neighbouring cell information and information (also) applicable for UEs in RRC_CONNECTED, e.g. common channel configuration information;
  - [FFS Including ETWS notification, CMAS notification].
- RRC connection control:
  - Paging;
  - Establishment/modification/suspension/resumption/release of RRC connection, including e.g. assignment/modification of UE identity (C-RNTI), establishment/modification/release of SRBs, access class barring;

Editor's Note: The terminology for establishment/modification/suspension/resumption is FFS.

  - Initial security activation, i.e. initial configuration of AS integrity protection (SRBs) and AS ciphering (SRBs, DRBs);
  - RRC connection mobility including e.g. intra-frequency and inter-frequency handover, associated security handling, i.e. key/algorithm change, specification of RRC context information transferred between network nodes;
  - Establishment/modification/release of RBs carrying user data (DRBs);
  - Radio configuration control including e.g. assignment/modification of ARQ configuration, HARQ configuration, DRX configuration;
  - In case of DC, cell management including e.g. change of PSCell, addition/modification/release of SCG cell(s);
  - In case of CA, cell management including e.g. addition/modification/release of SCell(s);
  - Recovery from radio link failure.

- Inter-RAT mobility including e.g. security activation, transfer of RRC context information;
- Measurement configuration and reporting:
  - Establishment/modification/release of measurements (e.g. intra-frequency, inter-frequency and inter- RAT measurements);
  - Setup and release of measurement gaps;
  - Measurement reporting.
- Other functions including e.g. transfer of dedicated NAS information, transfer of UE radio access capability information [FFS support for RAN sharing (multiple PLMN identities)].

5 Procedures

5.1 General

5.1.1 Introduction

This section covers the general requirements.

5.1.2 General requirements

The UE shall:

1> process the received messages in order of reception by RRC, i.e. the processing of a message shall be completed before starting the processing of a subsequent message;

NOTE: Network may initiate a subsequent procedure prior to receiving the UE's response of a previously initiated procedure.

1> within a sub-clause execute the steps according to the order specified in the procedural description;

1> consider the term 'radio bearer' (RB) to cover SRBs and DRBs unless explicitly stated otherwise;

1> set the *rrc-TransactionIdentifier* in the response message, if included, to the same value as included in the message received from NR that triggered the response message;

1> upon receiving a choice value set to *setup*:

2> apply the corresponding received configuration and start using the associated resources, unless explicitly specified otherwise;

1> upon receiving a choice value set to *release*:

2> clear the corresponding configuration and stop using the associated resources;

1> in case the size of a list is extended, upon receiving an extension field comprising the entries in addition to the ones carried by the original field (regardless of whether NR signals more entries in total); apply the following generic behaviour unless explicitly stated otherwise:

2> create a combined list by concatenating the additional entries included in the extension field to the original field while maintaining the order among both the original and the additional entries;

2> for the combined list, created according to the previous, apply the same behaviour as defined for the original field.

5.2 System information

Editor's Note: Targeted for completion in September2018. For EN_DC, only parts related to MIB acquisition, in sub-clauses 5.2.2.3.1 and 5.2.2.4.1, are applicable.

5.2.1 Introduction

System Information (SI) is divided into the *MasterInformationBlock* (MIB) and a number of *SystemInformationBlocks* (SIBs) where:

- the *MasterInformationBlock* (MIB) is always transmitted on the BCH with a periodicity of 80 ms and repetitions made within 80 ms [38.212, Section 7.1] and it includes parameters that are needed to acquire *SystemInformationBlockType1* (SIB1) from the cell;
- the *SystemInformationBlockType1* (SIB1) is transmitted on the DL-SCH with a periodicity of [X] and repetitions made within [X]. SIB1 includes information regarding the availability and scheduling (e.g. periodicity, SI-window size) of other SIBs. It also indicates whether they (i.e. other SIBs) are provided via periodic broadcast basis or only on-demand basis (refer Figure 5.2.2.X.X FFS_Ref). If other SIBs are provided on-demand then SIB1 includes information for the UE to perform SI request;
- SIBs other than *SystemInformationBlockType1* are carried in *SystemInformation* (SI) messages, which are transmitted on the DL-SCH. Each SI message is transmitted within periodically occurring time domain windows (referred to as SI-windows);
- For PSCell and SCells, RAN provides the required SI by dedicated signalling. Nevertheless, the UE shall acquire MIB of the PSCell to get SFN timing of the SCG (which may be different from MCG). Upon change of relevant SI for SCell, RAN releases and adds the concerned SCell. For PSCell, SI can only be changed with Reconfiguration with Sync.

Editor's Note: Reference to RAN1 specification may be used for the MIB/SIB1 periodicities [X].FFS

5.2.2 System information acquisition

5.2.2.1 General UE requirements

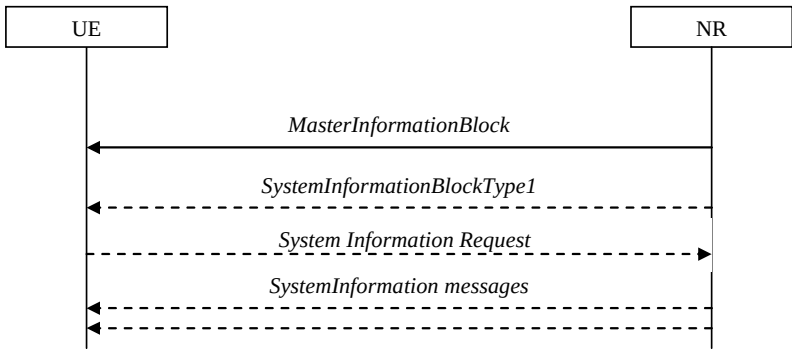


Figure 5.2.2.1-1: System information acquisition

The UE applies the SI acquisition procedure to acquire the AS- and NAS information. The procedure applies to UEs in RRC_IDLE, in RRC_INACTIVE and in RRC_CONNECTED.

The UE in RRC_IDLE and RRC_INACTIVE shall ensure having a valid version of (at least) the *MasterInformationBlock*, *SystemInformationBlockType1* as well as *SystemInformationBlockTypeX* through *SystemInformationBlockTypeY* (depending on support of the concerned RATs for UE controlled mobility).

The UE in RRC_CONNECTED shall ensure having a valid version of (at least) the *MasterInformationBlock*, *SystemInformationBlockType1* as well as *SystemInformationBlockTypeX* (depending on support of mobility towards the concerned RATs).

The UE shall store relevant SI acquired from the currently camped/serving cell. A version of the SI that the UE acquires and stores remains valid only for a certain time. The UE may use such a stored version of the SI e.g. after cell re-selection, upon return from out of coverage or after SI change indication.

Editor's Note: [FFS_Standalone if the UE is required to store SI other than for the currently camped/serving cell].

Editor's Note: [FFS_Standalone if different versions of SIBs are provided].

Editor's Note: [FFS_Standalone UE may or shall store several versions of SI].

Editor's Note: FFS_Standalone To be updated when above is resolved. Another sub-clause under 5.2.2.2 can be considered depending on the resolution of above.

5.2.2.2 SI validity and need to (re)-acquire SI

The UE shall apply the SI acquisition procedure as defined in clause 5.2.2.3 upon cell selection (e.g. upon power on), cell-reselection, return from out of coverage, after reconfiguration with sync completion, after entering RAN from another RAT; whenever the UE does not have a valid version in the stored SI.

Editor's Note: [FFS_Standalone if upon receiving HO command the SI acquisition depend on stored SI]

When the UE acquires a *MasterInformationBlock* or a *SystemInformationBlockType1* or a SI message in a currently camped/serving cell as described in clause 5.2.2.3, the UE shall store the acquired SI.

5.2.2.2.1 SI validity

The UE shall:

1> delete any stored version of SI after [FFS] hours from the moment it was successfully confirmed as valid;

1> if the UE does not have in the stored SI a valid version for the required SI corresponding to the *systemInfoAreaIdentifier* and *systemInfoValueTag*/*systemInfoConfigurationIndex* of that SI in the currently camped/serving cell:

2> (re)acquire the SI as specified in clause 5.2.2.3.

NOTE: At the SI acquisition procedure, the UE may assume the acquired SI in the currently camped/serving cell to be valid in other cells than the currently camped/serving cell based on *systemInfoAreaIdentifier* and *systemInfoValueTag*/*systemInfoConfigurationIndex*.

Editor's Note: [FFS_Standalone terminology to be used is systemInfoValueTag or systemInfoConfigurationIndex]

Editor's Note: [FFS_Standalone terminology to be used for area ID is systemInfoAreaIdentifier]

Editor's Note: [FFS_Standalone whether the area ID and valuetag is separately signalled or as a single identifier]

Editor's Note: [FFS_Standalone whether the area ID is associated to each SIB/SI message or associated to a group of SIBs/SI messages or all SIBs/SI messages]

5.2.2.2.2 SI change indication and PWS notification

A modification period is used, i.e. updated SI is provided in the modification period following the one where SI change indication is transmitted. RAN transmits SI change indication and PWS notification through paging. Repetitions of SI change indication may occur within preceding modification period.

Editor's Note : The above descriptive text can remain in this sub-clause or moved under 5.2.1. FFS_Standalone

If the UE is in RRC_CONNECTED or is configured to use a DRX cycle smaller than the modification period in RRC_IDLE or in RRC_INACTIVE and receives a Paging message:

1> if the received Paging message includes the *etws*/*cmasNotification*;

2> the UE shall immediately re-acquire the SIB1 and apply the SI acquisition procedure as defined in sub-clause [X.X.X.X FFS_Ref];

1> else, if the received Paging message includes the *systemInfoModification*;

2> the UE shall apply the SI acquisition procedure as defined in sub-clause [X.X.X.X FFS_Ref] from the start of the next modification period.

NOTE For PWS notification the SIB1 is re-acquired to know the scheduling information for the PWS messages.

Editor's Note: [FFS_Standalone if upon receiving a SI change indication the SI acquisition depend on stored SI]

Editor's Note: [FFS_Standalone if value tags and area identifier included in paging message to reacquire SIB1]

Editor's Note: [FFS_Standalone the update mechanism for access control notifications and other non-access control configuration updates]

Editor's Note: [FFS_StandaloneWhether to make a generic bit to indicate immediate acquisition of SI will be considered after AC discussion has progressed]

Editor's Note: [FFS_Standalone terminology to be used for PWS Notification]

5.2.2.3 Acquisition of System Information

5.2.2.3.1 Acquisition of *MIB* and *SIB1*

The UE shall:

1> if the cell is a PSCell:

2> acquire the *MIB*, which is scheduled as specified in TS 38.213 [13];

2> perform the actions specified in section 5.2.2.4.1;

1> else:

2> acquire the *MIB*, which is scheduled as specified in TS 38.213 [13];

2> if the UE is unable to acquire the *MIB*;

3> follow the actions as specified in clause 5.2.2.5;

2> else:

3> perform the actions specified in section 5.2.2.4.1.

2> acquire the SystemInformationBlockType1 as specified in [X];

2> if the UE is unable to acquire the SystemInformationBlockType1:

3> follow the actions as specified in clause 5.2.2.5;

2> else:

3>perform the actions specified in section 5.2.2.4.2.

Editor's Note: Reference to RAN1 [X] specification may be used for the scheduling of SIB1.FFS_Standalone

5.2.2.3.2 Acquisition of an SI message

When acquiring an SI message, the UE shall:

1> determine the start of the SI-window for the concerned SI message as follows:

Editor's Note: [FFS_Standalone the details of the mapping to subframes/slots where the SI messages are scheduled]

Editor's Note: [FFS_Standalone if there are any exceptions on e.g. subframes where SI messages cannot be transmitted]

Editor's Note: [FFS_Standalone if the SI-windows of different SI messages do not overlap].

Editor's Note: [FFS_Standalone if multiple SI messages can be mapped to same SI window]

Editor's Note: [FFS_Standalone if the length of SI-window is common for all SI messages or if it is configured per SI message]

Editor's Note: [FFS_Standalone if the UE may accumulate the SI-Message transmissions across several SI-Windows within the Modification Period]

1> if SI message acquisition not triggered due to UE request:

2> receive DL-SCH using the SI-RNTI from the start of the SI-window and continue until the end of the SI-window whose absolute length in time is given by *si-WindowLength*, or until the SI message was received;

2> if the SI message was not received by the end of the SI-window, repeat reception at the next SI-window occasion for the concerned SI message;

1> if SI message acquisition triggered due to UE request:

2> [FFS_Standalone receive DL-SCH using the SI-RNTI from the start of the SI-window and continue until the end of the SI-window whose absolute length in time is given by si-WindowLength, or until the SI message was received];

2> [FFS_Standalone if the SI message was not received by the end of the SI-window, repeat reception at the next SI-window occasion for the concerned SI message];

Editor's Note: [FFS_Standalone on the details of from which SI-window the UE shall receive the DL-SCH upon triggering the SI request.

Editor's Note: [FFS_Standalone on the details of how many SI-windows the UE should monitor for SI message reception if transmission triggered by UE request]

Editor's Note: [FFS_Standalone if UE need to monitor all the TTIs in SI window for receiving SI message]

1> store the acquired SI message as specified in clause 5.2.2.2.

Editor's Note: FFS_Standalone The procedural text for SI message acquisition triggered by UE request will be updated upon finalizing the details.

5.2.2.3.3 Request for on demand system information

When acquiring an SI message, which according to the SystemInformationBlockType1 is indicated to be provided upon UE request, the UE shall:

1> if in RRC_IDLE or in RRC_INACTIVE:

2> if the [FFS_Standalone] field is received in *SIB1*:

3> the UE shall trigger the lower layer to initiate the preamble transmission procedure in accordance with TS 38.321 [3] using the [indicated PRACH preamble] and [indicated PRACH resource];

3> if acknowledgement for SI request is received from lower layer;

4> acquire the requested SI message(s) as defined in sub-clause 5.2.2.3.2;

Editor's Note: To be updated with details of the Msg1 request procedure.FFS_Standalone

2> else

3> the UE shall trigger the lower layer to initiate the random access procedure in accordance with TS 38.321 [3];

3> if acknowledgement for SI request is received;

4> acquire the requested SI message(s) as defined in sub-clause 5.2.2.3.2;

Editor's Note: To be updated with details of the Msg3 request procedure. FFS_Standalone

1> else (in RRC_CONNECTED):

2> [details FFS_Standalone].

Editor's Note: To be updated with details of the on-demand request procedure in RRC_CONNECTED. FFS_Standalone

Editor's Note: [FFS_Standalone if there is a need for a separate sub-clause to describe case where on demand SI is not successfully received by the UE and where it should initiate a new request]

5.2.2.4 Actions upon receipt of SI message

5.2.2.4.1 Actions upon reception of the *MIB*

Upon receiving the *MIB* the UE shall:

1> store the acquired *MIB*;

1> if the UE is in RRC_IDLE or if the UE is in RRC_INACTIVE or if the UE is in RRC_CONNECTED while *T311* is running: [FFS]

2> if the *cellBarred* in the acquired MIB is set to *barred*;

3> consider the cell as barred in accordance with TS 38.304 [FFS];

2> else,

3> apply the received parameter(s) [FFS] to acquire *SIB1*.

5.2.2.4.2 Actions upon reception of the SystemInformationBlockType1

Upon receiving the SystemInformationBlockType1 the UE shall:

1> store the acquired *SIB1*;

1> if the UE has a stored valid version of the required SIB(s) associated with the *systemInfoAreaIdentifier* and *systemInfoValueTag*/*systemInfoConfigurationIndex* in the acquired *SIB1*:

2> use that stored version of the SIB;

1> else if the *SIB1* message indicates that the SI message(s) is only provided on request:

2> trigger a request to acquire the SI message(s) (if needed) as defined in sub-clause 5.2.2.3;

1> else:

2> acquire the SI message(s) (if needed) as defined in sub-clause 5.2.2.3.2, which are provided according to the schedulingInfoList in the SystemInformationBlockType1.

Editor's Note: [FFS_Standalone Whether there is an additional indication that an on-demand SI is actually being broadcast at this instant in time]

Editor's Note: To be updated when content of the SystemInformationBlockType1 has been agreed. FFS_Standalone.

Editor's Note: To be updated how to capture the UE behaviour when some required SIBs are from broadcast and other required SIBs through SI request.

5.2.2.4.3 Actions upon reception of SystemInformationBlockTypeX

Editor's Note: To be extended with further sub-clauses as more SIBs are defined. FFS_Standalone

5.2.2.5 Essential system information missing

The UE shall:

1> if in RRC_IDLE or in RRC_INACTIVE:

2> if the UE is unable to acquire the *MIB*; or

2> if the UE is unable to acquire the *SIB1* and UE does not have a stored valid version of SIB1; or

2> [FFS_Standalone if the UE is unable to acquire the [FFS essential SystemInformationBlockTypeX] and UE does not have a stored valid version of SystemInformationBlockTypeX];

3> consider the cell as barred in accordance with TS 38.304 [X]; and

3> perform barring as if *intraFreqReselection* is set to *allowed*.

Editor's Note: [FFS_Standalone on details of RRC connection re-establishment procedure and corresponding reading of SI in RRC_CONNECTED].

Editor's Note: [FFS_Standalone whether all the information needed to access the cell is included in SIB1 or if both SIB1 and SIB2 are essential in NR].

5.3 Connection control

Editor's note: FFS The structure and content of this subclause is a subject for discussion, e.g. potential merging of connection establishment and re-establishment messages, mobility aspects etc.

5.3.1 Introduction

5.3.2 Paging

Editor's Note: Targeted for completion in Sept 2018.

5.3.3 RRC connection establishment

Editor's Note: Targeted for completion in Sept 2018.

5.3.4 Initial security activation

Editor's Note: Targeted for completion in Sept 2018.

5.3.5 RRC reconfiguration

5.3.5.1 General

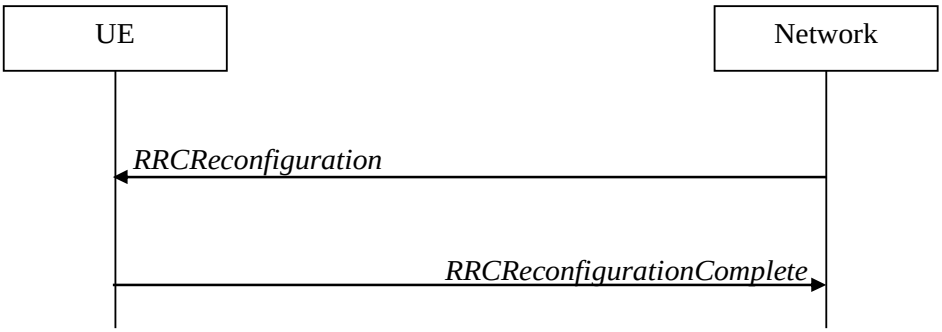


Figure 5.3.5.1-1: RRC reconfiguration, successful

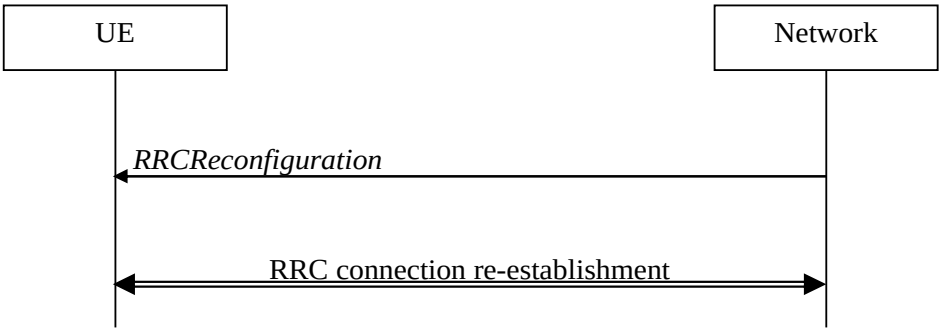


Figure 5.3.5.1-2: RRC reconfiguration, failure

The purpose of this procedure is to modify an RRC connection, e.g. to establish/modify/release RBs, to perform reconfiguration with sync, to setup/modify/release measurements, to add/modify/release SCells and cell groups. As part of the procedure, NAS dedicated information may be transferred from the Network to the UE.

In EN-DC, SRB3 can be used for measurement configuration and reportingto (re-)configure MAC, RLC, physical layer and RLF timers and constants of the SCG configuration, and to reconfigure PDCP for DRBs associated with the S-KgNB or SRB3, provided that the (re-)configuration does not require any MeNB involvement.

5.3.5.2 Initiation

The Network may initiate the RRC reconfiguration procedure to a UE in RRC_CONNECTED. The Network applies the procedure as follows:

- the establishment of RBs (other than SRB1, that is established during RRC connection establishment) is performed only when AS security has been activated;
- the addition of Secondary Cell Group and SCells is performed only when AS security has been activated;
- the *reconfigurationWithSync* is included in *secondaryCellGroup* only when at least one DRB is setup in SCG.

5.3.5.3 Reception of an *RRCReconfiguration* by the UE

The UE shall perform the following actions upon reception of the *RRCReconfiguration*:

1> if the *RRCReconfiguration* includes the secondaryCellGroup:

2> perform the cell group configuration for the SCG according to 5.3.5.5;

1> if the *RRCReconfiguration* message contains the radioBearerConfig:

2> perform the radio bearer configuration according to 5.3.5.6;

1> if the *RRCReconfiguration* message includes the *measConfig*:

2> perform the measurement configuration procedure as specified in 5.5.2;

1> if the UE is configured with E-UTRA *nr-SecondaryCellGroupConfig* (MCG is E-UTRA):

2> if *RRCReconfiguration* was received via SRB1:

3> construct *RRCReconfigurationComplete* message and submit it via the EUTRA MCG embedded in E-UTRA RRC message *RRCConnectionReconfigurationComplete* as specified in TS 36.331 [10];

3> if *reconfigurationWithSync* was included in *spCellConfig* of an SCG:

4> initiate the random access procedure on the SpCell, as specified in TS 38.321 [3];

3> else:

4> the procedure ends;

NOTE: The order the UE sends the *RRCConnectionReconfigurationComplete* message and performs the Random Access procedure towards the SCG is left to UE implementation.

2> else (*RRCReconfiguration* was received via SRB3):

3> submit the *RRCReconfigurationComplete* message via SRB3 to lower layers for transmission using the new configuration;

NOTE: In the case of SRB1, the random access is triggered by RRC layer itself as there is not necessarily other UL transmission. In the case of SRB3, the random access is triggered by the MAC layer due to arrival of *RRCReconfigurationComplete*.

1> if *reconfigurationWithSync* was included in *spCellConfig* of an SCG, and when MAC of an NR cell group successfully completes a random access procedure triggered above;

2> stop timer T304 for that cell group;

2> apply the parts of the CQI reporting configuration, the scheduling request configuration and the sounding RS configuration that do not require the UE to know the SFN of the respective target SpCell, if any;

2> apply the parts of the measurement and the radio resource configuration that require the UE to know the SFN of the respective target SpCell (e.g. measurement gaps, periodic CQI reporting, scheduling request configuration, sounding RS configuration), if any, upon acquiring the SFN of that target SpCell;

2> the procedure ends.

5.3.5.4 Secondary cell group release

The UE shall:

1> as a result of SCG release triggered by E-UTRA:

2> reset SCG MAC, if configured;

2> for each RLC bearer that is part of the SCG configuration:

3> perform RLC bearer release procedure as specified in 5.3.5.5.3;

2> release the SCG configuration;

2> stop timer T310 for the corresponding SpCell, if running;

2> stop timer T304 for the corresponding SpCell, if running.

NOTE: Release of cell group means only release of the lower layer configuration of the cell group but the *RadioBearerConfig* may not be released.

5.3.5.5 Cell Group configuration

5.3.5.5.1 General

The network configures the UE with one Secondary Cell Group (SCG). For EN-DC, the MCG is configured as specified in TS 36.331 [10]. The network provides the configuration parameters for a cell group in the *CellGroupConfig* IE.

The UE performs the following actions based on a received *CellGroupConfig* IE:

1> if the *CellGroupConfig* contains the *spCellConfig* with *reconfigurationWithSync*:

2> perform Reconfiguration with sync according to 5.3.5.5.2;

2> resume all suspended radio bearers and resume SCG transmission for all radio bearers, if suspended;

1> if the *CellGroupConfig* contains the *rlc-BearerToReleaseList*:

2> perform RLC bearer release as specified in 5.3.5.5.3;

1> if the *CellGroupConfig* contains the *rlc-BearerToAddModList*:

2> perform the RLC bearer addition/modification as specified in 5.3.5.5.4;

1> if the *CellGroupConfig* contains the *mac-CellGroupConfig*:

2> configure the MAC entity of this cell group as specified in 5.3.5.5.5;

1> if the *CellGroupConfig* contains the s*CellToReleaseLis*t:

2> perform SCell release as specified in 5.3.5.5.8;

1> if the *CellGroupConfig* contains the *spCellConfig*:

2> configure the SpCell as specified in 5.3.5.5.7;

1> if the CellGroupConfig contains the *sCellToAddModList*:

2> perform SCell addition/modification as specified in 5.3.5.5.9.

5.3.5.5.2 Reconfiguration with sync

The UE shall perform the following actions to execute a reconfiguration with sync.

1> stop timer T310 for the corresponding SpCell, if running;

1> start timer T304 for the corresponding SpCell with the timer value set to *t304*, as included in the *reconfigurationWithSync*;

1> if the *frequencyInfoDL* is included:

2> consider the target SpCell to be one on the frequency indicated by the *frequencyInfoDL* with a physical cell identity indicated by the *physCellId*;

1> else:

2> consider the target SpCell to be one on the frequency of the source SpCell with a physical cell identity indicated by the *physCellId*;

1> start synchronising to the DL of the target SpCell and acquire the *MIB* of the target SpCell as specified in 5.2.2.3.1;

NOTE: The UE should perform the reconfiguration with sync as soon as possible following the reception of the RRC message triggering the reconfiguration with sync, which could be before confirming successful reception (HARQ and ARQ) of this message.

1> reset the MAC entity of this cell group;

1> consider the SCell(s) of this cell group, if configured, to be in deactivated state;

1> apply the value of the *newUE-Identity* as the C-RNTI for this cell group;

Editor's Note: Verify that this does not configure some common parameters which are later discarded due to e.g. SCell release or due to LCH release.

1> configure lower layers in accordance with the received s*pCellConfigCommon*;

1> consider the bandwidth part indicated in *firstActiveUplinkBWP-Id* to be the active uplink bandwidth part;

1> consider the bandwidth part indicated in *firstActiveDownlinkBWP-Id* to be the active downlink bandwidth part;

1> configure lower layers in accordance with any additional fields, not covered in the previous, if included in the received *reconfigurationWithSync.*

5.3.5.5.3 RLC bearer release

The UE shall:

1> for each *logicalChannelIdentity* value included in the *rlc-BearerToReleaseList* that is part of the current UE configuration (LCH release); or

1> for each *logicalChannelIdentity* value that is to be released as the result of an SCG release according to 5.3.5.4:

2> release the RLC entity or entities (includes discarding all pending RLC PDUs and RLC SDUs);

2> release the corresponding logical channel.

5.3.5.5.4 RLC bearer addition/modification

For each *RLC-BearerConfig* received in the *rlc-BearerToAddModList* IE the UE shall:

1> if the UE's current configuration contains a RLC bearer with the received *logicalChannelIdentity*:

2> if *reestablishRLC* is received:

3> re-establish the RLC entity as specified in TS 38.322 [4];

2> reconfigure the RLC entity or entities in accordance with the received *rlc-Config*;

2> reconfigure the logical channel in accordance with the received *mac-LogicalChannelConfig*;

NOTE: The network does not re-associate an already configured logical channel with another radio bearer. Hence *servedRadioBearer* is not present in this case.

1> else (a logical channel with the given *logicalChannelIdentity* was not configured before):

2> if the *logicalChannelIdentity* corresponds to an SRB and *rlc-Config* is not included:

3> establish an RLC entity in accordance with the default configuration defined in 9.2 for the corresponding SRB;

2> else:

3> establish an RLC entity in accordance with the received *rlc-Config*;

2> if the *logicalChannelIdentity* corresponds to an SRB and if *mac-LogicalChannelConfig* is not included:

3> configure this MAC entity with a logical channel in accordance to the default configuration defined in 9.2 for the corresponding SRB;

2> else:

3> configure this MAC entity with a logical channel in accordance to the received *mac-LogicalChannelConfig*;

2> associate this logical channel with the PDCP entity identified by *servedRadioBearer*.

5.3.5.5.5 MAC entity configuration

The UE shall:

1> if SCG MAC is not part of the current UE configuration (i.e. SCG establishment):

2> create an SCG MAC entity;

1> reconfigure the MAC main configuration of the cell group in accordance with the received *mac-CellGroupConfig* other than *tag-ToReleaseList* and *tag-ToAddModList*;

1> if the received *mac-CellGroupConfig* includes the *tag-ToReleaseList*:

2> for each *TAG-Id* value included in the *tag-ToReleaseList* that is part of the current UE configuration:

3> release the TAG indicated by *TAG-Id*;

1> if the received mac-CellGroupConfig includes the *tag-ToAddModList*:

2> for each *tag-Id* value included in *tag-ToAddModList* that is not part of the current UE configuration (TAG addition):

3> add the TAG, corresponding to the *tag-Id*, in accordance with the received *timeAlignmentTimer*;

2> for each *tag-Id* value included in *tag-ToAddModList* that is part of the current UE configuration (TAG modification):

3> reconfigure the TAG, corresponding to the *tag-Id*, in accordance with the received *timeAlignmentTimer*.

5.3.5.5.6 RLF Timers & Constants configuration

The UE shall:

1> if the received *rlf-TimersAndConstants* is set to release:

NOTE: In EN-DC, *rlf-TimersAndConstants* cannot be released.

Editor's Note: Standalone part to be complete by Sept 2018.

2> stop timer T310 for this cell group, if running, and

2> release the value of timer *t310* as well as constants *n310* and *n311* for this cell group;

1> else:

2> reconfigure the value of timers and constants in accordance with received *rlf-TimersAndConstants*.

2> stop timer T310 for this cell group, if running, and

2> reset the counters N310 and N311

5.3.5.5.7 SPCell Configuration

The UE shall:

1> if the *SpCellConfig* contains the rlf-TimersAndConstants:

2> configure the RLF timers and constants for this cell group as specified in 5.3.5.5.6.

1> if the *SpCellConfig* contains *spCellConfigDedicated*:

2> configure the SpCell in accordance with the *spCellConfigDedicated*.

5.3.5.5.8 SCell Release

The UE shall:

1> if the release is triggered by reception of the *sCellToReleaseList*:

2> for each *sCellIndex* value included in the *sCellToReleaseList*:

3> if the current UE configuration includes an SCell with value *sCellIndex*:

4> release the SCell.

5.3.5.5.9 SCell Addition/Modification

The UE shall:

1> for each *sCellIndex* value included in the *sCellToAddModList* that is not part of the current UE configuration (SCell addition):

2> add the SCell, corresponding to the *sCellIndex*, in accordance with the *sCellConfigCommon* and *sCellConfigDedicated*;

2> configure lower layers to consider the SCell to be in deactivated state;

Editor's Note: FFS Check automatic measurement handling for SCells.

2> for each *measId* included in the *measIdList* within *VarMeasConfig*:

3> if SCells are not applicable for the associated measurement; and

3> if the concerned SCell is included in *cellsTriggeredList* defined within the *VarMeasReportList* for this *measId*:

4> remove the concerned SCell from *cellsTriggeredList* defined within the *VarMeasReportList* for this *measId*;

1> for each *sCellIndex* value included in the *sCellToAddModList* that is part of the current UE configuration (SCell modification):

2> modify the SCell configuration in accordance with the *sCellConfigDedicated*.

5.3.5.6 Radio Bearer configuration

5.3.5.6.1 General

The UE shall perform the following actions based on a received *RadioBearerConfig* IE:

1> if the *RadioBearerConfig* includes the *srb3-ToRelease* and set to true:

2> perform the SRB release as specified in 5.3.5.6.2;

1> if the RadioBearerConfig includes the srb-ToAddModList:

2> perform the SRB addition or reconfiguration as specified in 5.3.5.6.3;

1> if the RadioBearerConfig includes the drb-ToReleaseList:

2> perform DRB release as specified in 5.3.5.6.4;

1> if the RadioBearerConfig includes the drb-ToAddModList:

2> perform DRB addition or reconfiguration as specified in 5.3.5.6.5.

5.3.5.6.2 SRB release

The UE shall:

1> release the PDCP entity of the SRB3.

5.3.5.6.3 SRB addition/modification

The UE shall:

1> for each *srb-Identity* value included in the *srb-ToAddModList* that is not part of the current UE configuration (SRB establishment or reconfiguration from E-UTRA PDCP to NR PDCP):

2> establish a PDCP entity and configure it with the security algorithms according to *securityConfig* and apply the keys (K_{RRCenc} and K_{RRCint}) associated with the K_{eNB}/S-K_{gNB} as indicated in *keyToUse*, if applicable;

2> if the current UE configuration as configured by E-UTRA in TS 36.331 includes an SRB identified with the same *srb-Identity* value:

3> associate the E-UTRA RLC entity and DCCH of this SRB with the NR PDCP entity;

3> release the E-UTRA PDCP entity of this SRB;

2> if the *pdcp-Config* is included:

3> configure the PDCP entity in accordance with the received *pdcp-Config*;

2> else:

3> configure the PDCP entity in accordance with the default configuration defined in 9.2.1 for the corresponding SRB;

1> for each *srb-Identity* value included in the *srb-ToAddModList* that is part of the current UE configuration:

2> if reestablishPDCP is set:

3> configure the PDCP entity to apply the integrity protection algorithm and K_{RRCint} key associated with the K_{eNB}/S-K_{gNB} as indicated in *keyToUse* , i.e. the integrity protection configuration shall be applied to all subsequent messages received and sent by the UE, including the message used to indicate the successful completion of the procedure;

3> configure the PDCP entity to apply the ciphering algorithm and K_{RRCenc} key associated with the K_{eNB}/S-K_{gNB} as indicated in *keyToUse*, i.e. the ciphering configuration shall be applied to all subsequent messages received and sent by the UE, including the message used to indicate the successful completion of the procedure;

3> re-establish the PDCP entity of this SRB as specified in 38.323 [5];

2> else, if *discardOnPDCP* is set:

3> trigger the PDCP entity to perform SDU discard as specified in TS 38.323 [5];

2> if the *pdcp-Config* is included:

3> reconfigure the PDCP entity in accordance with the received *pdcp-Config*.

5.3.5.6.4 DRB release

Editor's Note: FFS / TODO: Add handling for the new QoS concept (mapping of flows; configuration of QFI-to-DRB mapping; reflective QoS...) but keep also EPS-Bearer handling for the EN-DC case

The UE shall:

1> for each *drb-Identity* value included in the *drb-ToReleaseList* that is part of the current UE configuration (DRB release):

2> release the PDCP entity;

1> if a new bearer is not added either with NR or E-UTRA with same *eps-BearerIdentity*:

2> if the procedure was triggered due to reconfiguration with sync:

3> indicate the release of the DRB and the *eps-BearerIdentity* of the released DRB to upper layers after successful reconfiguration with sync;

2> else:

3> indicate the release of the DRB and the *eps-BearerIdentity* of the released DRB to upper layers immediately.

NOTE 1: The UE does not consider the message as erroneous if the *drb-ToReleaseList* includes any *drb-Identity* value that is not part of the current UE configuration.

NOTE 2: Whether or not the RLC and MAC entities associated with this PDCP entity are reset or released is determined by the *CellGroupConfig*.

5.3.5.6.5 DRB addition/modification

The UE shall:

1> for each *drb-Identity* value included in the *drb-ToAddModList* that is not part of the current UE configuration (DRB establishment including the case when full configuration option is used):

2> establish a PDCP entity and configure it in accordance with the received *pdcp-Config*;

2> configure the PDCP entity with the security algorithms according to *securityConfig* and apply the keys (K_{UPenc}) associated with the K_{eNB}/S-K_{gNB} as indicated in *keyToUse*;

2> if the DRB was configured with the same *eps-BearerIdentity* either by NR or E-UTRA prior to receiving this reconfiguration:

3> associate the established DRB with the corresponding *eps-BearerIdentity;*

2> else:

3> indicate the establishment of the DRB(s) and the *eps-BearerIdentity* of the established DRB(s) to upper layers;

1> for each *drb-Identity* value included in the *drb-ToAddModList* that is part of the current UE configuration:

2> if reestablishPDCP is set:

3> configure the PDCP entity of this *RadioBearerConfig* to apply the ciphering algorithm and K_{UPenc} key associated with the KeNB/S-KgNB as indicated in *keyToUse*, i.e. the ciphering configuration shall be applied to all subsequent PDCP PDUs received and sent by the UE;

3> re-establish the PDCP entity of this DRB as specified in 38.323 [5], section 5.1.2;

2> else, if *recoverPDCP* is set:

3> trigger the PDCP entity of this DRB to perform data recovery as specified in 38.323;

2> if the *pdcp-Config* is included:

3> reconfigure the PDCP entity in accordance with the received *pdcp-Config*.

NOTE 1: Removal and addition of the same *drb-Identity* in a single *radioResourceConfig* is not supported. In case *drb-Identity* is removed and added due to reconfiguration with sync or re-establishment with the full configuration option, the network can use the same value of *drb-Identity*.

NOTE 2: When determining whether a drb-Identity value is part of the current UE configuration, the UE does not distinguish which *RadioBearerConfig* and *DRB-ToAddModList* that DRB was originally configured in. To re-associate a DRB with a different key (KeNB to S-KeNB or vice versa), the network provides the *drb-Identity* value in the (target) *drb-ToAddModList* and sets the *reestablishPDCP* flag. The network does not list the *drb-Identity* in the (source) *drb-ToReleaseList*.

NOTE 3: When setting the *reestablishPDCP* flag for a radio bearer, the network ensures that the RLC receiver entities do not deliver old PDCP PDUs to the re-established PDCP entity. It does that e.g. by triggering a reconfiguration with sync of the cell group hosting the old RLC entity or by releasing the old RLC entity.

NOTE 4: In this specification, UE configuration refers to the parameters configured by NR RRC unless otherwise stated.

5.3.5.7 Security key update

Upon reception of *sk-Counter* as specified in TS 36.331 [10] the UE shall:

1> update the S-K_{gNB} key based on the K_{eNB} key and using the received *sk-Counter* value, as specified in TS 33.501 [11];

1> derive K_{RRCenc} and K_{UPenc} key as specified in TS 33.501 [11];

1> derive the K_{RRCint} and K_{UPint} key as specified in TS 33.501 [11].

5.3.5.8 Reconfiguration failure

5.3.5.8.1 Integrity check failure

Editor's Note: Removed "SIB3" from heading so that this sub-section can easily be expanded to stand-alone case (if considered necessary). FFS_Standalone

The UE shall:

1> upon integrity check failure indication from NR lower layers for SRB3:

2> initiate the SCG failure information procedure as specified in subclause 5.7.3 to report SRB3 integrity check failure.

5.3.5.8.2 Inability to comply with RRCReconfiguration

The UE shall:

1> if the UE is operating in EN-DC:

2> if the UE is unable to comply with (part of) the configuration included in the *RRCReconfiguration* message received over SRB3;

3> continue using the configuration used prior to the reception of *RRCReconfiguration* message;

3> initiate the SCG failure information procedure as specified in subclause 5.7.3 to report SCG reconfiguration error, upon which the connection reconfiguration procedure ends;

2> else, if the UE is unable to comply with (part of) the configuration included in the *RRCReconfiguration* message received over MCG SRB1;

3> continue using the configuration used prior to the reception of *RRCReconfiguration* message;

3> initiate the connection re-establishment procedure as specified in TS 36.331 [10, 5.3.7], upon which the connection reconfiguration procedure ends.

NOTE 1: The UE may apply above failure handling also in case the *RRCReconfiguration* message causes a protocol error for which the generic error handling as defined in 10 specifies that the UE shall ignore the message.

NOTE 2: If the UE is unable to comply with part of the configuration, it does not apply any part of the configuration, i.e. there is no partial success/failure.

5.3.5.8.3 T304 expiry (Reconfiguration with sync Failure)

The UE shall:

1> if T304 of a secondary cell group expires:

2> release rach-ContentionFree;

2> initiate the SCG failure information procedure as specified in subclause 5.7.3 to report SCG reconfiguration with sync failure, upon which the RRC reconfiguration procedure ends.

5.3.5.9 Other configuration

Editor's Note: Targeted for completion in Sept 2018.

5.3.5.10 EN-DC release

The UE shall:

1> as a result of EN-DC release triggered by E-UTRA:

2> release SRB3 (configured according to *radioBearerConfig*), if present;

2> release *measConfig*;

2> release the SCG configuration as specified in section 5.3.5.4.

5.3.6 Counter check

FFS

5.3.7 RRC connection re-establishment

Editor's Note: Targeted for completion in Sept 2018.

5.3.8 RRC connection release

Editor's Note: Targeted for completion in Sept 2018.

5.3.9 RRC connection release requested by upper layers

Editor's Note: Targeted for completion in Sept 2018.

5.3.10 Radio link failure related actions

5.3.10.1 Detection of physical layer problems in RRC_CONNECTED

The UE shall:

1> upon receiving N310 consecutive "out-of-sync" indications for the SpCell from lower layers while T311 is not running:

2> start timer T310 for the corresponding SpCell.

Editor's Note: FFS: Under which condition physical layer problems detection is performed, e.g. neither T300, T301, T304 nor T311 is running. It's subject to the harmonization of the RRC procedures for RRC Connection establishment/resume/re-establishment and RRC connection reconfiguration.

5.3.10.2 Recovery of physical layer problems

Upon receiving N311 consecutive "in-sync" indications for the SpCell from lower layers while T310 is running, the UE shall:

1> stop timer T310 for the corresponding SpCell.

NOTE 1: In this case, the UE maintains the RRC connection without explicit signalling, i.e. the UE maintains the entire radio resource configuration.

NOTE 2: Periods in time where neither "in-sync" nor "out-of-sync" is reported by layer 1 do not affect the evaluation of the number of consecutive "in-sync" or "out-of-sync" indications.

5.3.10.3 Detection of radio link failure

The UE shall:

1> upon T310 expiry in PCell; or

1> upon random access problem indication from MCG MAC while T311 is not running; or

Editor's Note: FFS: Under which condition physical layer problems detection is performed, e.g. neither T300, T301, T304 nor T311 is running. It's subject to the harmonization of the RRC procedures for RRC Connection establishment/resume/re-establishment and RRC connection reconfiguration.

1> upon indication from MCG RLC that the maximum number of retransmissions has been reached:

Editor's Note: FFS whether maximum ARQ retransmission is only criteria for RLC failure.

2> consider radio link failure to be detected for the MCG i.e. RLF;

Editor's Note: FFS Whether indications related to beam failure recovery may affect the declaration of RLF.

Editor's Note: FFS: How to handle RLC failure in CA duplication for MCG DRB and SRB.

Editor's Note: FFS: RLF related measurement reports e.g. *VarRLF-Report* is supported in NR.

2> if AS security has not been activated:

3> perform the actions upon leaving RRC_CONNECTED as specified in x.x.x FFS_Ref, with release cause 'other';

2> else:

3> initiate the connection re-establishment procedure as specified in x.x.x FFS_Ref.

The UE shall:

1> upon T310 expiry in PSCell; or

1> upon random access problem indication from SCG MAC; or

1> upon indication from SCG RLC that the maximum number of retransmissions has been reached:

2> consider radio link failure to be detected for the SCG i.e. SCG-RLF;

Editor's Note: FFS: How to handle RLC failure in CA duplication for SCG DRB and SRB.

2> initiate the SCG failure information procedure as specified in 5.7.3 to report SCG radio link failure.

5.3.11 UE actions upon leaving RRC_CONNECTED

Editor's Note: Targeted for completion in Sept 2018.

5.3.12 UE actions upon PUCCH/SRS release request

Upon receiving a PUCCH release request from lower layers, for all bandwidth parts of an indicated serving cell the UE shall:

1> release PUCCH-CSI-Resources c1onfigured in CSI-ReportConfig;

1> release SchedulingRequestResourceConfig instances configured in PUCCH-Config.

Upon receiving an SRS release request from lower layers, for all bandwidth parts of an indicated serving cell the UE shall:

1> release *SRS-Resource* instances configured in *SRS-Config*.

5.4 Inter-RAT mobility

Editor's Note: Targeted for completion in Sept 2018.

5.5 Measurements

5.5.1 Introduction

The network may configure an RRC_CONNECTED UE to perform measurements and report them in accordance with the measurement configuration. The measurement configuration is provided by means of dedicated signalling i.e. using the *RRCReconfiguration*.

The network may configure the UE to perform the following types of measurements:

- NR measurements;
- Inter-RAT measurements of E-UTRA frequencies.

The network may configure the UE to report the following measurement information based on SS/PBCH block(s):

- Measurement results per SS/PBCH block;
- Measurement results per cell based on SS/PBCH block(s);
- SS/PBCH block(s) indexes.

The network may configure the UE to report the following measurement information based on CSI-RS resources:

- Measurement results per CSI-RS resource;
- Measurement results per cell based on CSI-RS resource(s);
- CSI-RS resource measurement identifiers.

The measurement configuration includes the following parameters:

1. **Measurement objects:** A list of objects on which the UE shall perform the measurements.
   - For intra-frequency and inter-frequency measurements a measurement object indicates the frequency/time location and subcarrier spacing of reference signals to be measured. Associated with this measurement object, the network may configure a list of cell specific offsets, a list of 'blacklisted' cells and a list of 'whitelisted' cells. Blacklisted cells are not applicable in event evaluation or measurement reporting. Whitelisted cells are the only ones applicable in event evaluation or measurement reporting.
   - The *measObjectId* of the MO which corresponds to each serving cell is indicated by *servingCellMO* within the serving cell configuration.
   - For inter-RAT E-UTRA measurements a measurement object is a single EUTRA carrier frequency. Associated with this E-UTRA carrier frequency, the network can configure a list of cell specific offsets, a list of 'blacklisted' cells and a list of 'whitelisted' cells. Blacklisted cells are not applicable in event evaluation or

measurement reporting. Whitelisted cells are the only ones applicable in event evaluation or measurement reporting.

2. **Reporting configurations:** A list of reporting configurations where there can be one or multiple reporting configurations per measurement object. Each reporting configuration consists of the following:

   - Reporting criterion: The criterion that triggers the UE to send a measurement report. This can either be periodical or a single event description;.
   - RS type: The RS that the UE uses for beam and cell measurement results (SS/PBCH block or CSI-RS).
   - Reporting format: The quantities per cell and per beam that the UE includes in the measurement report (e.g. RSRP) and other associated information such as the maximum number of cells and the maximum number beams per cell to report.

3. **Measurement identities:** A list of measurement identities where each measurement identity links one measurement object with one reporting configuration. By configuring multiple measurement identities, it is possible to link more than one measurement object to the same reporting configuration, as well as to link more than one reporting configuration to the same measurement object. The measurement identity is also included in the measurement report that triggered the reporting, serving as a reference to the network.

4. **Quantity configurations:** The quantity configuration defines the measurement filtering configuration used for all event evaluation and related reporting of that measurement type. For NR measurements, the network may configure up to 2 quantity configurations with a reference in the NR measurement object to the configuration that is to be used. In each configuration, different filter coefficients can be configured for different measurement quantities, for different RS types, and for measurements per cell and per beam.

5. **Measurement gaps:** Periods that the UE may use to perform measurements, i.e. no (UL, DL) transmissions are scheduled.

A UE in RRC_CONNECTED maintains a measurement object list, a reporting configuration list, and a measurement identities list according to signalling and procedures in this specification. The measurement object list possibly includes NR intra-frequency object(s), NR inter-frequency object(s) and inter-RAT objects. Similarly, the reporting configuration list includes NR and inter-RAT reporting configurations. Any measurement object can be linked to any reporting configuration of the same RAT type. Some reporting configurations may not be linked to a measurement object. Likewise, some measurement objects may not be linked to a reporting configuration.

The measurement procedures distinguish the following types of cells:

1. The NR serving cell(s) - these are the SpCell and one or more SCells.
2. Listed cells - these are cells listed within the measurement object(s).
3. Detected cells - these are cells that are not listed within the measurement object(s) but are detected by the UE on the SSB frequency(ies) and subcarrier spacing(s) indicated by the measurement object(s).

For NR measurement object(s), the UE measures and reports on the serving cell(s), listed cells and/or detected cells.

Whenever the procedural specification, other than contained in sub-clause 5.5.2, refers to a field it concerns a field included in the *VarMeasConfig* unless explicitly stated otherwise i.e. only the measurement configuration procedure covers the direct UE action related to the received *measConfig*.

5.5.2 Measurement configuration

5.5.2.1 General

The network applies the procedure as follows:

- to ensure that, whenever the UE has a *measConfig*, it includes a *measObject* for the SpCell and for each NR SCell to be measured.

Editor's Note: FFS How the procedure is used for CGI reporting.

The UE shall:

1> if the received *measConfig* includes the *measObjectToRemoveList*:

2> perform the measurement object removal procedure as specified in 5.5.2.4;

1> if the received *measConfig* includes the *measObjectToAddModList*:

2> perform the measurement object addition/modification procedure as specified in 5.5.2.5;

1> if the received *measConfig* includes the *reportConfigToRemoveList*:

2> perform the reporting configuration removal procedure as specified in 5.5.2.6;

1> if the received *measConfig* includes the *reportConfigToAddModList*:

2> perform the reporting configuration addition/modification procedure as specified in 5.5.2.7;

1> if the received *measConfig* includes the *measIdToRemoveList*:

2> perform the measurement identity removal procedure as specified in 5.5.2.2;

1> if the received *measConfig* includes the *measIdToAddModList*:

2> perform the measurement identity addition/modification procedure as specified in 5.5.2.3;

1> if the received *measConfig* includes the *measGapConfig*:

2> perform the measurement gap configuration procedure as specified in 5.5.2.9;

1> if the received *measConfig* includes the *measGapSharingConfig*:

2> perform the measurement gap sharing configuration procedure as specified in 5.5.2.11;

1> if the received *measConfig* includes the *s-MeasureConfig*:

2> if *s-MeasureConfig* is set to *ssb-RSRP*, set parameter *ssb-RSRP*of *s-MeasureConfig* within *VarMeasConfig* to the lowest value of the RSRP ranges indicated by the received value of *s-MeasureConfig;*

2> else, set parameter *csi-RSRP* of *s-MeasureConfig* within *VarMeasConfig* to the lowest value of the RSRP ranges indicated by the received value of *s-MeasureConfig*.

5.5.2.2 Measurement identity removal

The UE shall:

1> for each *measId* included in the received *measIdToRemoveList* that is part of the current UE configuration in *VarMeasConfig*:

2> remove the entry with the matching *measId* from the *measIdList* within the *VarMeasConfig*;

2> remove the measurement reporting entry for this *measId* from the *VarMeasReportList*, if included;

2> stop the periodical reporting timer if running and reset the associated information (e.g. *timeToTrigger*) for this *measId*.

NOTE: The UE does not consider the message as erroneous if the *measIdToRemoveList* includes any *measId* value that is not part of the current UE configuration.

5.5.2.3 Measurement identity addition/modification

The network applies the procedure as follows:

- configure a *measId* only if the corresponding measurement object, the corresponding reporting configuration and the corresponding quantity configuration, are configured.

The UE shall:

1> for each *measId* included in the received *measIdToAddModList*:

2> if an entry with the matching *measId* exists in the *measIdList* within the *VarMeasConfig*:

3> replace the entry with the value received for this *measId*;

2> else:

3> add a new entry for this *measId* within the *VarMeasConfig*;

2> remove the measurement reporting entry for this *measId* from the *VarMeasReportList*, if included;

2> stop the periodical reporting timer and reset the associated information (e.g. *timeToTrigger*) for this *measId*.

5.5.2.4 Measurement object removal

The UE shall:

1> for each measObjectId included in the received measObjectToRemoveList that is part of measObjectList in VarMeasConfig:

2> remove the entry with the matching *measObjectId* from the *measObjectList* within the *VarMeasConfig*;

2> remove all *measId* associated with this *measObjectId* from the *measIdList* within the *VarMeasConfig*, if any;

2> if a *measId* is removed from the *measIdList*:

3> remove the measurement reporting entry for this *measId* from the *VarMeasReportList*, if included;

3> stop the periodical reporting timer and reset the associated information (e.g. *timeToTrigger*) for this *measId*.

NOTE: The UE does not consider the message as erroneous if the *measObjectToRemoveList* includes any *measObjectId* value that is not part of the current UE configuration.

5.5.2.5 Measurement object addition/modification

The UE shall:

1> for each *measObjectId* included in the received *measObjectToAddModList*:

2> if an entry with the matching *measObjectId* exists in the *measObjectList* within the *VarMeasConfig*, for this entry:

3> reconfigure the entry with the value received for this measObject, except for the fields cellsToAddModList, blackCellsToAddModList, whiteCellsToAddModList, cellsToRemoveList,blackCellsToRemoveList, whiteCellsToRemoveList, absThreshSS-BlocksConsolidation,absThreshCSI-RS-Consolidation, nrofSS-BlocksToAverage,nroCSI-RS-ResourcesToAverage;

3> if the received *measObject* includes the *cellsToRemoveList*:

4> for each *physCellId* included in the *cellsToRemoveList*:

5> remove the entry with the matching *physCellId* from the *cellsToAddModList*;

3> if the received *measObject* includes the *cellsToAddModList*:

4> for each *physCellId* value included in the *cellsToAddModList*:

5> if an entry with the matching *physCellId* exists in the *cellsToAddModList*:

6> replace the entry with the value received for this *physCellId*;

5> else:

6> add a new entry for the received *physCellId* to the *cellsToAddModList*;

3> if the received *measObject* includes the *blackCellsToRemoveList*:

4> for each pci-RangeIndex included in the blackCellsToRemoveList:

5> remove the entry with the matching *pci-RangeIndex* from the *blackCellsToAddModList*;

NOTE: For each *pci-RangeIndex* included in the *blackCellsToRemoveList* that concerns overlapping ranges of cells, a cell is removed from the black list of cells only if all cell indexes containing it are removed.

3> if the received *measObject* includes the *blackCellsToAddModList*:

4> for each pci-RangeIndex included in the blackCellsToAddModList:

5> if an entry with the matching *pci-RangeIndex* is included in the *blackCellsToAddModList*:

6> replace the entry with the value received for this *pci-RangeIndex*;

5> else:

6> add a new entry for the received *pci-RangeIndex* to the *blackCellsToAddModList*;

3> if the received *measObject* includes the *whiteCellsToRemoveList*:

4> for each pci-RangeIndex included in the whiteCellsToRemoveList:

5> remove the entry with the matching *pci-RangeIndex* from the *whiteCellsToAddModList*;

3> if the received *measObject* includes the *whiteCellsToAddModList*:

4> for each pci-RangeIndex included in the whiteCellsToAddModList:

5> if an entry with the matching *pci-RangeIndex* is included in the *whiteCellsToAddModList*:

6> replace the entry with the value received for this *pci-RangeIndex*;

5> else:

6> add a new entry for the received *pci-RangeIndex* to the *whiteCellsToAddModList*;

3> for each *measId* associated with this *measObjectId* in the *measIdList* within the *VarMeasConfig*, if any:

4> remove the measurement reporting entry for this *measId* from the *VarMeasReportList*, if included;

4> stop the periodical reporting timer and reset the associated information (e.g. *timeToTrigger*) for this *measId*;

2> else:

3> add a new entry for the received *measObject* to the *measObjectList* within *VarMeasConfig*.

5.5.2.6 Reporting configuration removal

The UE shall:

1> for each *reportConfigId* included in the received *reportConfigToRemoveList* that is part of the current UE configuration in *VarMeasConfig*:

2> remove the entry with the matching *reportConfigId* from the *reportConfigList* within the *VarMeasConfig*;

2> remove all *measId* associated with the *reportConfigId* from the *measIdList* within the *VarMeasConfig*, if any;

2> if a measId is removed from the *measIdList*:

3> remove the measurement reporting entry for this *measId* from the *VarMeasReportList*, if included;

3> stop the periodical reporting timer and reset the associated information (e.g. *timeToTrigger*) for this *measId*.

NOTE: The UE does not consider the message as erroneous if the *reportConfigToRemoveList* includes any *reportConfigId* value that is not part of the current UE configuration.

5.5.2.7 Reporting configuration addition/modification

The UE shall:

1> for each *reportConfigId* included in the received *reportConfigToAddModList*:

2> if an entry with the matching *reportConfigId* exists in the *reportConfigList* within the *VarMeasConfig*, for this entry:

3> reconfigure the entry with the value received for this *reportConfig*;

3> for each *measId* associated with this *reportConfigId* included in the *measIdList* within the *VarMeasConfig*, if any:

4> remove the measurement reporting entry for this *measId* from the *VarMeasReportList*, if included;

4> stop the periodical reporting timer and reset the associated information (e.g. *timeToTrigger*) for this *measId*;

2> else:

3> add a new entry for the received reportConfig to the *reportConfigList* within the *VarMeasConfig*.

5.5.2.8 Quantity configuration

The UE shall:

1> for each RAT for which the received *quantityConfig* includes parameter(s):

2> set the corresponding parameter(s) in *quantityConfig* within *VarMeasConfig* to the value of the received *quantityConfig* parameter(s);

1> for each *measId* included in the *measIdList* within *VarMeasConfig*:

2> remove the measurement reporting entry for this *measId* from the *VarMeasReportList*, if included;

2> stop the periodical reporting timer and reset the associated information (e.g. *timeToTrigger*) for this *measId*.

5.5.2.9 Measurement gap configuration

The UE shall:

1> if the UE is operating in EN-DC;

2> if *gapFR2* is set to setup:

3> if an FR2 measurement gap configuration is already setup, release the FR2 measurement gap configuration;

3> setup the FR2 measurement gap configuration indicated by the *measGapConfig* in accordance with the received *gapOffset*, i.e., the first subframe of each gap occurs at an SFN and subframe meeting the following condition (SFN and subframe of SCG cells on FR2):

SFN mod *T* = FLOOR(*gapOffset*/10);

subframe = *gapOffset* mod 10;

with *T* = MGRP/10 as defined in TS 38.133 [x];

3> if *mgta* is configured, apply the specified timing advance to the gap occurences calculated above (i.e. the UE starts the measurement *mgta* ms before the gap subframe occurences);

2> else if *gapFR2* is set to release:

3> release the FR2 measurement gap configuration.

5.5.2.10 Reference signal measurement timing configuration

The UE shall setup the first SS/PBCH block measurement timing configuration (SMTC) in accordance with the received *periodicityAndOffset* parameter (providing *Periodicity* and *Offset* value for the following condition) in the *smtc1* configuration. The first subframe of each SMTC occasion occurs at an SFN and subframe of the NR SpCell meeting the following condition:

SFN mod *T* = FLOOR ((*Offset*/10)) mod *T*;

if the *Periodicity* is larger than sf5:

subframe = *Offset* mod 10;

else:

subframe = *Offset* or (*Offset* +5);

with *T* = *Periodicity*/10.

If *smtc2* is present, for cells indicated in the *pci-List* parameter in *smtc2* in the same *MeasObjectNR*, the UE shall setup an additional SS/PBCH block measurement timing configuration (SMTC) in accordance with the received *periodicity* parameter in the *smtc2* configuration and use the *Offset* (derived from parameter *periodicityAndOffset*) and *duration* parameter from the *smtc1* configuration. The first subframe of each SMTC occasion occurs at an SFN and subframe of the NR SpCell meeting the above condition:

On the indicated *ssbFrequency*, the UE shall not consider SS/PBCH block transmission in subframes outside the SMTC occasion for measurements including RRM measurements.

5.5.2.11 Measurement gap sharing configuration

The UE shall:

1> if the UE is operating in EN-DC:

2> if *gapSharingFR2* is set to setup:

3> if an FR2 measurement gap sharing configuration is already setup, release the measurement gap sharing configuration;

3> setup the FR2 measurement gap sharing configuration indicated by the *measGapSharingConfig* in accordance with the received *measGapSharingScheme* as defined in TS 38.133 [14];

2> else:

3> release the FR2 measurement gap sharing configuration.

5.5.3 Performing measurements

5.5.3.1 General

An RRC_CONNECTED UE shall derive cell measurement results by measuring one or multiple beams associated per cell as configured by the network, as described in 5.5.3.3. For all cell measurement results in RRC_CONNECTED the UE applies the layer 3 filtering as specified in 5.5.3.2, before using the measured results for evaluation of reporting criteria and measurement reporting. For cell measurements, the network can configure RSRP, RSRQ or SINR as trigger quantity. Reporting quantities can be the same as trigger quantity or combinations of quantities (i.e. RSRP and RSRQ; RSRP and SINR; RSRQ and SINR; RSRP, RSRQ and SINR).

The network may also configure the UE to report measurement information per beam (which can either be measurement results per beam with respective beam identifier(s) or only beam identifier(s)), derived as described in 5.5.3.3a. If beam measurement information is configured to be included in measurement reports, the UE applies the layer 3 beam filtering as specified in 5.5.3.2. On the other hand, the exact layer 1 filtering of beam measurements used to derive cell measurement results is implementation dependent.

The UE shall:

1> whenever the UE has a *measConfig*, perform RSRP and RSRQ measurements for each serving cell for which *servingCellMO* is configured as as follows:

2> if at least one *measId* included in the *measIdList* within *VarMeasConfig* contains an *rsType* set to *ssb*:

3> if at least one measId included in the measIdList within VarMeasConfig contains a reportQuantityRsIndexes and maxNrofRSIndexesToReport:

4> derive layer 3 filtered RSRP and RSRQ per beam for the serving cell based on SS/PBCH block, as described in 5.5.3.3a;

3> derive serving cell measurement results based on SS/PBCH block, as described in 5.5.3.3;

2> if at least one *measId* included in the *measIdList* within *VarMeasConfig* contains an *rsType* set to *csi-rs*:

3> if at least one measId included in the measIdList within VarMeasConfig contains a reportQuantityRsIndexes and maxNrofRSIndexesToReport:

4> derive layer 3 filtered RSRP and RSRQ per beam for the serving cell based on CSI-RS, as described in 5.5.3.3a;

3> derive serving cell measurement results based on CSI-RS, as described in 5.5.3.3;

1> if at least one *measId* included in the *measIdList* within *VarMeasConfig* contains SINR as trigger quantity and/or reporting quantity:

2> if the associated *reportConfig* contains *rsType* set to *ssb*:

3> if the measId contains a reportQuantityRsIndexes and maxNrofRSIndexesToReport:

4> derive layer 3 filtered SINR per beam for the serving cell based on SS/PBCH block, as described in 5.5.3.3a;

3> derive serving cell SINR based on SS/PBCH block, as described in 5.5.3.3;

2> if the associated *reportConfig* contains *rsType* set to *csi-rs*:

3> if the measId contains a reportQuantityRsIndexes and maxNrofRSIndexesToReport:

4> derive layer 3 filtered SINR per beam for the serving cell based on CSI-RS, as described in 5.5.3.3a;

3> derive serving cell SINR based on CSI-RS, as described in 5.5.3.3;

1> for each *measId* included in the *measIdList* within *VarMeasConfig*:

2> if the reportType for the associated reportConfig is periodical or eventTriggered:

3> if a measurement gap configuration is setup, or

3> if the UE does not require measurement gaps to perform the concerned measurements:

4> if *s-MeasureConfig* is not configured, or

4> if *s-MeasureConfig* is set to *ssb-RSRP* and the NR SpCell RSRP based on SS/PBCH block, after layer 3 filtering, is lower than *ssb-RSRP*,or

4> if *s-MeasureConfig* is set to *csi-RSRP* and the NR SpCell RSRP based on CSI-RS, after layer 3 filtering, is lower than *csi-RSRP*:

5> if the *measObject* is associated to NR and the *rsType* is set to *csi-rs*:

6> if reportQuantityRsIndexes and maxNrofRSIndexesToReport for the associated reportConfig are configured:

7> derive layer 3 filtered beam measurements only based on CSI-RS for each measurement quantity indicated in *reportQuantityRsIndexes*, as described in 5.5.3.3a;

6> derive cell measurement results based on CSI-RS for each trigger quantity and each measurement quantity indicated in *reportQuantityCell* using parameters from the associated *measObject*, as described in 5.5.3.3;

5> if the *measObject* is associated to NR and the *rsType* is set to *ssb*:

6> if reportQuantityRsIndexes and maxNrofRSIndexesToReport for the associated reportConfig are configured:

7> derive layer 3 beam measurements only based on SS/PBCH block for each measurement quantity indicated in *reportQuantityRsIndexes*, as described in 5.5.3.3a;

6> derive cell measurement results based on SS/PBCH block for each trigger quantity and each measurement quantity indicated in *reportQuantityCell* using parameters from the associated *measObject*, as described in 5.5.3.3;

5> if the *measObject* is associated to E-UTRA:

6> perform the corresponding measurements associated to neighbouring cells on the frequencies indicated in the concerned *measObject*;

2> perform the evaluation of reporting criteria as specified in 5.5.4.

5.5.3.2 Layer 3 filtering

The UE shall:

1> for each cell measurement quantity and for each beam measurement quantity that the UE performs measurements according to 5.5.3.1:

2> filter the measured result, before using for evaluation of reporting criteria or for measurement reporting, by the following formula:

$$F_n = (1-a) \cdot F_{n-1} + a \cdot M_n$$

where

M_n is the latest received measurement result from the physical layer;

F_n is the updated filtered measurement result, that is used for evaluation of reporting criteria or for measurement reporting;

F_{n-1} is the old filtered measurement result, where F_0 is set to M_1 when the first measurement result from the physical layer is received; and

$a = 1/2^{(k/4)}$, where k is the *filterCoefficient* for the corresponding measurement quantity received by the *quantityConfig*;

2> adapt the filter such that the time characteristics of the filter are preserved at different input rates, observing that the *filterCoefficient k* assumes a sample rate equal to X ms; The value of X is equivalent to one intra-frequency L1 measurement period as defined in 38.331 [14] assuming non-DRX operation, and depends on frequency range.

NOTE 1: If k is set to 0, no layer 3 filtering is applicable.

NOTE 2: The filtering is performed in the same domain as used for evaluation of reporting criteria or for measurement reporting, i.e., logarithmic filtering for logarithmic measurements.

NOTE 3: The filter input rate is implementation dependent, to fulfil the performance requirements set in TS 38.133[14]. For further details about the physical layer measurements, see TS 38.133 [14].

5.5.3.3 Derivation of cell measurement results

The network may configure the UE to derive RSRP, RSRQ and SINR measurement results per cell associated to NR measurement objects based on parameters configured in the *measObject* (e.g. maximum number of beams to be

averaged and beam consolidation thresholds) and in the *reportConfig* (*rsType* to be measured, SS/PBCH block or CSI-RS).

The UE shall:

1> for each cell measurement quantity to be derived based on SS/PBCH block:

2> if *nrofSS-BlocksToAverage* in the associated *measObject* is not configured; or

2> if *absThreshSS-BlocksConsolidation* in the associated *measObject* is not configured; or

2> if the highest beam measurement quantity value is below *absThreshSS-BlocksConsolidation*:

3> derive each cell measurement quantity based on SS/PBCH block as the highest beam measurement quantity value, where each beam measurement quantity is described in TS 38.215 [9];

2> else:

3> derive each cell measurement quantity based on SS/PBCH block as the linear average of the power values of the highest beam measurement quantity values above *absThreshSS-BlocksConsolidation* where the total number of averaged beams shall not exceed *nrofSS-BlocksToAverage*;

2> apply layer 3 cell filtering as described in 5.5.3.2;

1> for each cell measurement quantity to be derived based on CSI-RS:

2> consider a CSI-RS resource to be applicable for deriving cell measurements when the concerned CSI-RS resource is included in the *csi-rs-ResourceCellMobility* including the *physCellId* of the cell in the *CSI-RS-ConfigMobility* in the associated *measObject*;

2> if *nrofCSI-RS-ResourcesToAverage* in the associated *measObject* is not configured; or

2> if *absThreshCSI-RS-Consolidation* in the associated *measObject* is not configured; or

2> if the highest beam measurement quantity value is below *absThreshCSI-RS-Consolidation*:

3> derive each cell measurement quantity based on applicable CSI-RS resources for the cell as the highest beam measurement quantity value, where each beam measurement quantity is described in TS 38.215 [9];

2> else:

3> derive each cell measurement quantity based on CSI-RS as the linear average of the power values of the highest beam measurement quantity values above *absThreshCSI-RS-Consolidation* where the total number of averaged beams shall not exceed *nroCSI-RS-ResourcesToAverage*;

2> apply layer 3 cell filtering as described in 5.5.3.2.

5.5.3.3a Derivation of layer 3 beam filtered measurement

The UE shall:

1> for each layer 3 beam filtered measurement quantity to be derived based on SS/PBCH block;

2> derive each configured beam measurement quantity based on SS/PBCH block as described in TS 38.215[9], and apply layer 3 beam filtering as described in 5.5.3.2;

1> for each layer 3 beam filtered measurement quantity to be derived based on CSI-RS;

2> derive each configured beam measurement quantity based on CSI-RS as described in TS 38.215 [9], and apply layer 3 beam filtering as described in 5.5.3.2.

5.5.4 Measurement report triggering

5.5.4.1 General

If security has been activated successfully, the UE shall:

1> for each *measId* included in the *measIdList* within *VarMeasConfig*:

2> if the corresponding *reportConfig*includes a *reportType* set to *eventTriggered* or *periodical*;

3> if the corresponding *measObject* concerns NR;

4> if the *eventA1* or *eventA2* is configured in the corresponding *reportConfig*:

5> consider only the serving cell to be applicable;

4> else:

5> for events involving a serving cell associated with a *measObjectNR* and neighbours associated with another *measObjectNR*, consider any serving cell associated with the other *measObjectNR* to be a neighbouring cell as well;

5> if *useWhiteCellList* is set to TRUE:

6> consider any neighbouring cell detected based on parameters in the associated *measObjectNR* to be applicable when the concerned cell is included in the *whiteCellsToAddModList* defined within the *VarMeasConfig* for this measId;

5> else:

6> consider any neighbouring cell detected based on parameters in the associated *measObjectNR* to be applicable when the concerned cell is not included in the *blackCellsToAddModList* defined within the *VarMeasConfig* for this measId;

2> if the *reportType* is set to *eventTriggered* and if the entry condition applicable for this event, i.e. the event corresponding with the *eventId* of the corresponding *reportConfig* within *VarMeasConfig*, is fulfilled for one or more applicable cells for all measurements after layer 3 filtering taken during *timeToTrigger* defined for this event within the *VarMeasConfig*, while the *VarMeasReportList* does not include a measurement reporting entry for this *measId* (a first cell triggers the event):

3> include a measurement reporting entry within the *VarMeasReportList* for this *measId*;

3> set the *numberOfReportsSent* defined within the *VarMeasReportList* for this *measId* to 0;

3> include the concerned cell(s) in the *cellsTriggeredList* defined within the *VarMeasReportList* for this *measId*;

3> initiate the measurement reporting procedure, as specified in 5.5.5;

2> if the *reportType* is set to *eventTriggered* and if the entry condition applicable for this event, i.e. the event corresponding with the *eventId* of the corresponding *reportConfig* within *VarMeasConfig*, is fulfilled for one or more applicable cells not included in the *cellsTriggeredList* for all measurements after layer 3 filtering taken during *timeToTrigger* defined for this event within the *VarMeasConfig* (a subsequent cell triggers the event):

3> set the *numberOfReportsSent* defined within the *VarMeasReportList* for this *measId* to 0;

3> include the concerned cell(s) in the *cellsTriggeredList* defined within the *VarMeasReportList* for this *measId*;

3> initiate the measurement reporting procedure, as specified in 5.5.5;

2> if the *reportType* is set to *eventTriggered* and if the leaving condition applicable for this event is fulfilled for one or more of the cells included in the *cellsTriggeredList* defined within the *VarMeasReportList* for this *measId* for all measurements after layer 3 filtering taken during *timeToTrigger* defined within the *VarMeasConfig* for this event:

3> remove the concerned cell(s) in the *cellsTriggeredList* defined within the *VarMeasReportList* for this *measId*;

3> if *reportOnLeave* is set to *TRUE* for the corresponding reporting configuration:

4> initiate the measurement reporting procedure, as specified in 5.5.5;

3> if the *cellsTriggeredList* defined within the *VarMeasReportList* for this *measId* is empty:

4> remove the measurement reporting entry within the *VarMeasReportList* for this *measId*;

4> stop the periodical reporting timer for this *measId*, if running;

2> if *reportType* is set to *periodical* and if a (first) measurement result is available:

3> include a measurement reporting entry within the *VarMeasReportList* for this *measId*;

3> set the *numberOfReportsSent* defined within the *VarMeasReportList* for this *measId* to 0;

4> if the *reportAmount* exceeds 1:

5> initiate the measurement reporting procedure,as specified in 5.5.5, immediately after the quantity to be reported becomes available for the NR SpCell;

4> else (i.e. the *reportAmount* is equal to 1):

5> initiate the measurement reportingprocedure, as specified in 5.5.5, immediately after the quantity to be reported becomes available for the NR SpCelland for the strongest cell among the applicable cells;

2> upon expiry of the periodical reporting timer for this *measId*:

3> initiate the measurement reporting procedure, as specified in 5.5.5.

5.5.4.2 Event A1 (Serving becomes better than threshold)

The UE shall:

1> consider the entering condition for this event to be satisfied when condition A1-1, as specified below, is fulfilled;

1> consider the leaving condition for this event to be satisfied when condition A1-2, as specified below, is fulfilled;

1> for this measurement, consider the NR serving cell corresponding to the associated *measObjectNR* associated with this event.

Inequality A1-1 (Entering condition)

$Ms - Hys > Thresh$

Inequality A1-2 (Leaving condition)

$Ms + Hys < Thresh$

The variables in the formula are defined as follows:

Ms is the measurement result of the serving cell, not taking into account any offsets.

Hys is the hysteresis parameter for this event (i.e. *hysteresis*as defined within*reportConfigNR*for this event).

Thresh is the threshold parameter for this event (i.e. *a1-Threshold* as defined within*reportConfigNR*for this event).

Ms is expressed in dBm in case of RSRP, or in dB in case of RSRQ and RS-SINR.

Hys is expressed in dB.

Thresh is expressed in the same unit as ***Ms***.

5.5.4.3 Event A2 (Serving becomes worse than threshold)

The UE shall:

1> consider the entering condition for this event to be satisfied when condition A2-1, as specified below, is fulfilled;

1> consider the leaving condition for this event to be satisfied when condition A2-2, as specified below, is fulfilled;

1> for this measurement, consider the serving cell indicated by the *measObjectNR* associated to this event.

Inequality A2-1 (Entering condition)

$Ms+Hys<Thresh$

Inequality A2-2 (Leaving condition)

$Ms-Hys>Thresh$

The variables in the formula are defined as follows:

Ms is the measurement result of the serving cell, not taking into account any offsets.

Hys is the hysteresis parameter for this event (i.e. *hysteresis* as defined within *reportConfigNR* for this event).

Thresh is the threshold parameter for this event (i.e. *a2-Threshold* as defined within *reportConfigNR* for this event).

Ms is expressed in dBm in case of RSRP, or in dB in case of RSRQ and RS-SINR.

Hys is expressed in dB.

Thresh is expressed in the same unit as ***Ms***.

5.5.4.4 Event A3 (Neighbour becomes offset better than SpCell)

The UE shall:

1> consider the entering condition for this event to be satisfied when condition A3-1, as specified below, is fulfilled;

1> consider the leaving condition for this event to be satisfied when condition A3-2, as specified below, is fulfilled;

1> use the PSCell for *Mp, Ofp and Ocp*.

NOTE The cell(s) that triggers the event has reference signals indicated in the *measObjectNR* associated to this event which may be different from the NR SpCell *measObjectNR*.

Inequality A3-1 (Entering condition)

$Mn+Ofn+Ocn-Hys>Mp+Ofp+Ocp+Off$

Inequality A3-2 (Leaving condition)

$Mn+Ofn+Ocn+Hys<Mp+Ofp+Ocp+Off$

The variables in the formula are defined as follows:

Mn is the measurement result of the neighbouring cell, not taking into account any offsets.

Ofn is the measurement object specific offset of the reference signal of the neighbour cell (i.e. *offsetMO* as defined within *measObjectNR* corresponding to the neighbour cell).

Ocn is the cell specific offset of the neighbour cell (i.e. *cellIndividualOffset* as defined within *measObjectNR* corresponding to the frequency of the neighbour cell), and set to zero if not configured for the neighbour cell.

Mp is the measurement result of the SpCell, not taking into account any offsets.

Ofp is the measurement object specific offset of the SpCell (i.e. *offsetMO* as defined within *measObjectNR* corresponding to the SpCell).

Ocp is the cell specific offset of the SpCell (i.e. *cellIndividualOffset* as defined within *measObjectNR* corresponding to the SpCell), and is set to zero if not configured for the SpCell.

Hys is the hysteresis parameter for this event (i.e. *hysteresis* as defined within*reportConfigNR* for this event).

Off is the offset parameter for this event (i.e. *a3-Offset* as defined within*reportConfigNR* for this event).

Mn, Mp are expressed in dBm in case of RSRP, or in dB in case of RSRQ and RS-SINR.

Ofn, ***Ocn***, ***Ofp***, ***Ocp***, ***Hys***, ***Off*** are expressed in dB.

5.5.4.5 Event A4 (Neighbour becomes better than threshold)

The UE shall:

1> consider the entering condition for this event to be satisfied when condition A4-1, as specified below, is fulfilled;

1> consider the leaving condition for this event to be satisfied when condition A4-2, as specified below, is fulfilled.

Inequality A4-1 (Entering condition)

$Mn + Ofn + Ocn - Hys > Thresh$

Inequality A4-2 (Leaving condition)

$Mn + Ofn + Ocn + Hys < Thresh$

The variables in the formula are defined as follows:

Mn is the measurement result of the neighbouring cell, not taking into account any offsets.

Ofn is the measurement object specific offset of the neighbour cell (i.e. *offsetMO* as defined within *measObjectNR* corresponding to the neighbour cell).

Ocn is the measurement object specific offset of the neighbour cell (i.e. *cellIndividualOffset* as defined within *measObjectNR* corresponding to the neighbour cell), and set to zero if not configured for the neighbour cell.

Hys is the hysteresis parameter for this event (i.e. *hysteresis* as defined within *reportConfigNR*for this event).

Thresh is the threshold parameter for this event (i.e. *a4-Threshold* as defined within *reportConfigNR*for this event).

Mn is expressed in dBm in case of RSRP, or in dB in case of RSRQ and RS-SINR.

Ofn, Ocn, Hys are expressed in dB.

Thresh is expressed in the same unit as ***Mn***.

5.5.4.6 Event A5 (SpCell becomes worse than threshold1 and neighbour becomes better than threshold2)

The UE shall:

1> consider the entering condition for this event to be satisfied when both condition A5-1 and condition A5-2, as specified below, are fulfilled;

1> consider the leaving condition for this event to be satisfied when condition A5-3 or condition A5-4, i.e. at least one of the two, as specified below, is fulfilled;

1> use the PSCell for *Mp*.

NOTE: The parameters of the reference signal(s) of the cell(s) that triggers the event are indicated in the *measObjectNR* associated to the event which may be different from the *measObjectNR* of the NR SpCell.

Inequality A5-1 (Entering condition 1)

$Mp + Hys < Thresh1$

Inequality A5-2 (Entering condition 2)

$Mn + Ofn + Ocn - Hys > Thresh2$

Inequality A5-3 (Leaving condition 1)

$Mp - Hys > Thresh1$

Inequality A5-4 (Leaving condition 2)

$Mn + Ofn + Ocn + Hys < Thresh2$

The variables in the formula are defined as follows:

Mp is the measurement result of the NR SpCell, not taking into account any offsets.

Mnis the measurement result of the neighbouring cell, not taking into account any offsets.

Ofn is the measurement object specific offset of the neighbour cell (i.e. *offsetMO* as defined within *measObjectNR* corresponding to the neighbour cell).

Ocn is the cell specific offset of the neighbour cell (i.e. *cellIndividualOffset* as defined within *measObjectNR* corresponding to the neighbour cell), and set to zero if not configured for the neighbour cell.

Hys is the hysteresis parameter for this event (i.e. *hysteresis* as defined within *reportConfigNR*for this event).

Thresh1 is the threshold parameter for this event (i.e. *a5-Threshold1* as defined within *reportConfigNR* for this event).

Thresh2 is the threshold parameter for this event (i.e. *a5-Threshold2* as defined within *reportConfigNR* for this event).

Mn, Mp are expressed in dBm in case of RSRP, or in dB in case of RSRQ and RS-SINR.

Ofn, Ocn, Hys are expressed in dB.

Thresh1is expressed in the same unit as ***Mp***.

Thresh2 is expressed in the same unit as ***Mn***.

5.5.4.7 Event A6 (Neighbour becomes offset better than SCell)

The UE shall:

1> consider the entering condition for this event to be satisfied when condition A6-1, as specified below, is fulfilled;

1> consider the leaving condition for this event to be satisfied when condition A6-2, as specified below, is fulfilled;

1> for this measurement, consider the (secondary) cell corresponding to the *measObjectNR* associated to this event to be the serving cell.

NOTE: The reference signal(s) of the neighbour(s) and the reference signal(s) of the SCell are both indicated in the associated *measObjectNR*.

Inequality A6-1 (Entering condition)

$Mn + Ocn - Hys > Ms + Ocs + Off$

Inequality A6-2 (Leaving condition)

$Mn + Ocn + Hys < Ms + Ocs + Off$

The variables in the formula are defined as follows:

Mnis the measurement result of the neighbouring cell, not taking into account any offsets.

Ocn is the cell specific offset of the neighbour cell (i.e. *cellIndividualOffset* as defined within the associated *measObjectNR*), and set to zero if not configured for the neighbour cell.

Msis the measurement result of the serving cell, not taking into account any offsets.

Ocs is the cell specific offset of the serving cell (i.e. *cellIndividualOffset* as defined within the associated *measObjectNR*), and is set to zero if not configured for the serving cell.

Hys is the hysteresis parameter for this event (i.e. *hysteresis* as defined within*reportConfigNR* for this event).

Off is the offset parameter for this event (i.e. *a6-Offset* as defined within*reportConfigNR* for this event).

Mn, Ms are expressed in dBm in case of RSRP, or in dB in case of RSRQ and RS-SINR.

Ocn, Ocs, Hys, Off are expressed in dB.

5.5.5 Measurement reporting

5.5.5.1 General

Figure 5.5.5.1-1: Measurement reporting

The purpose of this procedure is to transfer measurement results from the UE to the network. The UE shall initiate this procedure only after successful security activation.

For the *measId* for which the measurement reporting procedure was triggered, the UE shall set the *measResults* within the *MeasurementReport* message as follows:

1> set the *measId* to the measurement identity that triggered the measurement reporting;

1> set the *measResultServingCell* within *measResultServingMOList* to include RSRP, RSRQ and the available SINR for each configured serving cell derived based on the *rsType* indicated in the associated *reportConfig*;

1> set the *measResultServingCell* within *measResultServingMOList* to include for each NR serving cell that is configured with *servingCellMO*, if any, the *servCellId*;

1> if the *reportConfig* associated with the *measId* that triggered the measurement reporting includes *reportQuantityRsIndexes* and *maxNrofRSIndexesToReport*:

2> for each serving cell configured with *servingCellMO*, include beam measurement information according to the associated *reportConfig* as described in 5.5.5.2;

1> if the *reportConfig* associated with the *measId* that triggered the measurement reporting includes *reportAddNeighMeas*:

2>for each serving cell *measObjectId* referenced in the *measIdList*, other than the *measObjectId* corresponding with the *measId* that triggered the measurement reporting:

3> set the *measResultBestNeighCell* within *measResultServingMOList* to include the *physCellId* and the available measurement quantities based on the *reportQuantityCell* and *rsType* indicated in *reportConfig* of the non-serving cell corresponding to the concerned *measObjectNR* with the highest measured RSRP if RSRP measurement results are available for cells corresponding to this *measObjectNR*, otherwise with the highest measured RSRQ if RSRQ measurement results are available for cells corresponding to this *measObjectNR*, otherwise with the highest measured SINR;

3> if the *reportConfig* associated with the *measId* that triggered the measurement reporting includes *reportQuantityRsIndexes* and *maxNrofRSIndexesToReport:*

4> for each best non-serving cell included in the measurement report:

5>include beam measurement information according to the associated *reportConfig* as described in 5.5.5.2;

1> if there is at least one applicable neighbouring cell to report:

2> set the *measResultNeighCells* to include the best neighbouring cells up to *maxReportCells* in accordance with the following:

3> if the *reportType* is set to *eventTriggered*:

4> include the cells included in the *cellsTriggeredList* as defined within the *VarMeasReportList* for this *measId*;

3> else:

4> include the applicable cells for which the new measurement results became available since the last periodical reporting or since the measurement was initiated or reset;

4> if *reportQuantityRsIndexes* and *maxNrofRSIndexesToReport* are configured, include beam measurement information as described in 5.5.5.2;

3> for each cell that is included in the *measResultNeighCells*, include the *physCellId*;

3> if the *reportType* is set to *eventTriggered*:

4> for each included cell, include the layer 3 filtered measured results in accordance with the *reportConfig* for this *measId*, ordered as follows:

5> if the *measObject* associated with this *measId* concerns NR:

6> if *rsType* in the associated *reportConfig* is set to *ssb*:

7> set *resultsSSB-Cell* within the *measResult* to include the SS/PBCH block based quantity(ies) indicated in the *reportQuantityCell* within the concerned *reportConfig*, in order of decreasing trigger quantity, i.e. the best cell is included first:

8> if *reportQuantityRsIndexes* and *maxNrofRSIndexesToReport* are configured, include beam measurement information as described in 5.5.5.2;

6> else if *rsType* in the associated *reportConfig* is set to *csi-rs*:

7> set *resultsCSI-RS-Cell* within the *measResult* to include the CSI-RS based quantity(ies) indicated in the *reportQuantityCell* within the concerned *reportConfig*, in order of decreasing trigger quantity, i.e. the best cell is included first:

8> if *reportQuantityRsIndexes* and *maxNrofRSIndexesToReport* are, include beam measurement information as described in 5.5.5.2;

1> increment the *numberOfReportsSent* as defined within the *VarMeasReportList* for this measId by 1;

1> stop the periodical reporting timer, if running;

1> if the *numberOfReportsSent* as defined within the *VarMeasReportList* for this *measId* is less than the *reportAmount* as defined within the corresponding *reportConfig* for this *measId*:

2> start the periodical reporting timer with the value of *reportInterval* as defined within the corresponding *reportConfig* for this *measId*;

1> else:

2> if the *reportType* is set to *periodical*:

3> remove the entry within the *VarMeasReportList* for this *measId*;

3> remove this *measId* from the *measIdList* within *VarMeasConfig*;

1> if the UE is configured with EN-DC:

2> if SRB3 is configured:

3> submit the *MeasurementReport* message via SRB3 to lower layers for transmission, upon which the procedure ends;

2>else:

3> submit the *MeasurementReport* message via the EUTRA MCG embedded in E-UTRA RRC message *ULInformationTransferMRDC* as specified in TS 36.331 [10].

1> else:

2>submit the *MeasurementReport* message to lower layers for transmission, upon which the procedure ends.

5.5.5.2 Reporting of beam measurement information

For beam measurement information to be included in a measurement report the UE shall:

1> if *reportType* is set to *eventTriggered*:

2> consider the trigger quantity as the sorting quantity;

1> if *reportType* is set to *periodical*:

2> if a single reporting quantity is set to TRUE in *reportQuantityRsIndexes*;

3> consider the configured single quantity as the sorting quantity;

2> else:

3> if *rsrp* is set to TRUE;

4> consider RSRP as the sorting quantity;

3> else:

4> consider RSRQ as the sorting quantity;

1> set *rsIndexResults* to include up to *maxNrofRsIndexesToReport*SS/PBCH block indexes or CSI-RS indexes in order of decreasing sorting quantity as follows:

2> if the measurement information to be included is based on SS/PBCH block:

3> include within *resultsSSB-Indexes* the index associated to the best beam for that SS/PBCH block sorting quantity and if *absThreshSS-BlocksConsolidation* is included in the *VarMeasConfig* for the corresponding *measObject*, the remaining beams whose sorting quantity is above *absThreshSS-BlocksConsolidation* defined in the *VarMeasConfig* for the corresponding *measObject*;

3> if *includeBeamMeasurements* is configured, include the SS/PBCH based measurement results for the quantities in *reportQuantityRsIndexes* set to TRUE for each SS/PBCH blockindex;

2> else if the beam measurement information to be included is based on CSI-RS:

3> include within *resultsCSI-RS-Indexes* the index associated to the best beam for that CSI-RS sorting quantity and, if *absThreshCSI-RS-Consolidation* is included in the *VarMeasConfig* for the corresponding *measObject*, the remaining beams whose sorting quantity is above *absThreshCSI-RS-Consolidation* defined in the *VarMeasConfig* for the corresponding *measObject*;

3> if *includeBeamMeasurements*is configured, include the CSI-RS based measurement results for the quantities in *reportQuantityRsIndexes* set to TRUE for each CSI-RS index.

5.6 UE capabilities

5.6.1 UE capability transfer

5.6.1.1 General

Editor's Note: Targeted for completion in Sept 2018

5.6.1.2 Initiation

Editor's Note: Targeted for completion in Sept 2018.

5.6.1.3 Reception of the *UECapabilityEnquiry* by the UE

Editor's Note: Targeted for completion in Sept 2018.

5.6.1.4 Compilation of band combinations supported by the UE

The UE shall:

1> if *FreqBandList* is received:

2> if the received *FreqBandList* contains at least one of *maximumBandwidthRequestedDL*, *maximumBandwidthRequestedUL*, *maximumNumberOfDLCarriersRequested* or *maximumNumberOfULCarriersRequested* for atleast one of the bands:

3> compile a list of band combinations, candidate for inclusion in the *UECapabilityInformation* message, only consisting of bands included in *FreqBandList*, where for each band in the band combination, the parameters of the band do not exceed the corresponding parameters provided by the IEs *maximumBandwidthRequestedDL*, *maximumBandwidthRequestedUL*, *maximumNumberOfDLCarriersRequested* or *maximumNumberOfULCarriersRequested*, whichever are recevied.

2> else:

3> compile a list of band combinations, candidate for inclusion in the *UECapabilityInformation* message, only consisting of bands included in *FreqBandList*, and prioritized in the order of *FreqBandList*, (i.e. first include remaining band combinations containing the first-listed band, then include remaining band combinations containing the second-listed band, and so on);

2> for each band combination included in the candidate list:

3> if it is regarded as a fallback band combination with the same capabilities of another band combination included in the list of candidates as specified in TS 38.306 [xx]:

4> remove the band combination from the list of candidates;

2> include all band combinations in the candidate list into *supportedBandCombination*;

2> include the received FreqBandList in the field appliedFreqBandListFilter of the requested UE capability;

1> else:

2> include all band combinations supported by the UE into *supportedBandCombination*, excluding fallback band combinations with the same capabilities of another band combination included in the list of band combinations supported by the UE.

5.6.1.5 Compilation of baseband processing combinations supported by the UE

The UE shall:

1> for each band combination included in *supportedBandCombination*:

2> include the baseband processing combination supported for the band combination into *supportedBasebandProcessingCombination*, unless it is already included;

2> if there are the fallback baseband processing combinations of this baseband processing combination as specified in TS 38.306 [xx] for which supported baseband capabilities are different from this baseband processing combination:

3> include only these baseband processing combinations into *supportedBasebandProcessingCombination*.

5.7 Other

5.7.1 DL information transfer

Editor's Note: Targeted for completion in Sept 2018.

5.7.2 UL information transfer

Editor's Note: Targeted for completion in Sept 2018.

5.7.3 SCG failure information

5.7.3.1 General

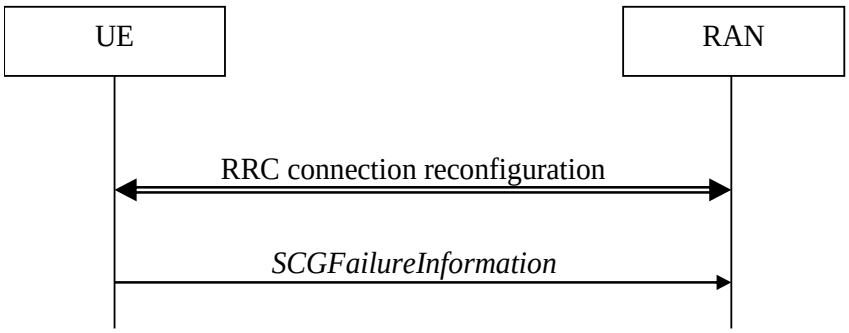


Figure 5.7.3.1-1: SCG failure information

The purpose of this procedure is to inform EUTRAN or NR MN about an SCG failure the UE has experienced i.e. SCG radio link failure, e failure of SCG reconfiguration with sync, SCG configuration failure for RRC message on SRB3, SCG integrity check failure and exceeding the maximum uplink transmission timing difference.

Editor's Note: SCG failure considers the case of exceeding the maximum uplink transmission timing difference if RAN1 decides that EN-DC supports the synchronised operation case. FFS how to capture

Editor's Note: FFS whether to include the handling of SCell Failure in CA duplication case in SCGfailureinformation procedure and whether to rename SCGfailureinformation.

5.7.3.2 Initiation

A UE initiates the procedure to report SCG failures when SCG transmission is not suspended and when one of the following conditions is met:

1> upon detecting radio link failure for the SCG, in accordance with subclause 5.3.10.3;

1> upon reconfiguration with sync failure of the SCG, in accordance with subclause 5.3.5.8.3;

1> upon SCG configuration failure, in accordance with subclause 5.3.5.8.2;

1> upon integrity check failure indication from SCG lower layers, in accordance with subclause 5.3.5.8.1.

Upon initiating the procedure, the UE shall:

1> suspend SCG transmission for all SRBs and DRBs;

1> reset SCG-MAC;

1> stop T304, if running;

1> if the UE is operating in EN-DC:

2> initiate transmission of the *SCGFailureInformationNR* message as specified in TS 36.331 [10, 5.6.13a].

Editor's Note: The section for transmission of SCGFailureInformation in NR RRC entity for SA is FFS_Standalone.

5.7.3.3 Failure type determination

Editor's Note: FFS / TODO: Either use this section also for NR-DC or change section title (add "for EN-DC").

The UE shall set the SCG failure type as follows:

1> if the UE initiates transmission of the *SCGFailureInformationNR* message due to T310 expiry:

2> set the failureType as t310-Expiry;

1> else if the UE initiates transmission of the *SCGFailureInformationNR* message to provide reconfiguration with sync failure information for an SCG:

2> set the failureType as scg-ChangeFailure;

Editor's Note: FFS whether to change scg-ChangeFailure to synchronousReconfigurationFailure-SCG.

1> else if the UE initiates transmission of the *SCGFailureInformationNR* message to provide random access problem indication from SCG MAC:

2> set the failureType as randomAccessProblem;

1> else if the UE initiates transmission of the *SCGFailureInformationNR* message to provide indication from SCG RLC that the maximum number of retransmissions has been reached:

2> set the failureType as rlc-MaxNumRetx;

1> else, if the UE initiates transmission of the *SCGFailureInformationNR* message due to SRB3 IP check failure:

2> set the failureType as srb3-IntegrityFailure;

1> else, if the UE initiates transmission of the *SCGFailureInformationNR* message due to Reconfiguration failure of NR RRC reconfiguration message:

2> set the failureType as scg-reconfigFailure.

Editor's Note: FFS: whether to include *rrc-TransactionIdentifier* information.

5.7.3.4 Setting the contents of *MeasResultSCG-Failure*

The UE shall set the contents of the *MeasResultSCG-Failure* as follows:

1> for each *MeasOjectNR* for which a *measId* is configured and measurement results are available;

2> include an entry in *measResultsPerMOList*;

2> if there is a *measId* configured with the *MeasObjectNR* and a *reportConfig* which has *rsType* set to *ssb*:

3> set *ssbFrequency* to the value indicated by *ssbFrequency* as included in the *MeasObjectNR*;

2> if there is a *measId* configured with the *MeasObjectNR* and a *reportConfig* which has *rsType* set to *csi-rs*:

3> set *refFreqCSI-RS* to the value indicated by *refFreqCSI-RS* as included in the associated measurement object;

2> if a serving cell is associated with the *MeasObjectNR*:

3> set *measResultServingCell* to include the available quantities of the concerned cell and in accordance with the performance requirements in [FFS_Ref];

2> set the *measResultNeighCellList* to include the best measured cells, ordered such that the best cell is listed first, and based on measurements collected up to the moment the UE detected the failure, and set its fields as follows;

3> ordering the cells with sorting as follows:

4> based on SS/PBCH block if SS/PBCH block measurement results are available available and otherwise based on CSI-RS,

4> using RSRP if RSRP measurement results are available, otherwise using RSRQ if RSRQ measurement results are available, otherwise using SINR,

3> for each neighbour cell included:

4> include the optional fields that are available.

NOTE: The measured quantities are filtered by the L3 filter as configured in the mobility measurement configuration. The measurements are based on the time domain measurement resource restriction, if configured. Blacklisted cells are not required to be reported.

6 Protocol data units, formats and parameters (ASN.1)

6.1 General

6.1.1 Introduction

The contents of each RRC message is specified in sub-clause 6.2 using ASN.1 to specify the message syntax and using tables when needed to provide further detailed information about the fields specified in the message syntax. The syntax of the information elements that are defined as stand-alone abstract types is further specified in a similar manner in sub-clause 6.3.

6.1.2 Need codes and conditions for optional downlink fields

The need for fields to be present in a message or an abstract type, i.e., the ASN.1 fields that are specified as OPTIONAL in the abstract notation (ASN.1), is specified by means of comment text tags attached to the OPTIONAL statement in the abstract syntax. All comment text tags are available for use in the downlink direction only. The meaning of each tag is specified in table 6.1.2-1.

If conditions are used, a conditional presence table is provided for the message or information element specifying the need of the field for each condition case. The table also specifies whether UE maintains or releases the value in case the field is not present. The conditions clarify what the UE may expect regarding the setting of the message by the network. Violation of conditions is regarded as invalid network behaviour, which the UE is not required to cope with. Hence the general error handling defined in 10.4 does not apply in case a field is absent although it is mandatory according to the CondC or CondM condition.

For guidelines on the use of need codes and conditions, see Annex A.6 and A.7.

Table 6.1.2-1: Meaning of abbreviations used to specify the need for fields to be present

Abbreviation	Meaning
CondC conditionTag	Configuration condition Presence of the field is conditional to other configuration settings.
CondM conditionTag	Message condition Presence of the field is conditional to other fields included in the message.
Need S	*Specified* Used for (configuration) fields, whose field description or procedure **specifies** the UE behavior performed upon receiving a message with the field absent (and not if field description or procedure specifies the UE behavior when field is not configured).
Need M	*Maintain* Used for (configuration) fields that are stored by the UE i.e. not one-shot. Upon receiving a message with the field absent, the UE maintains the current value.
Need N	*No action* (one-shot configuration that is not maintained) Used for (configuration) fields that are not stored and whose presence causes a one-time action by the UE. Upon receiving message with the field absent, the UE takes no action.
Need R	*Release* Used for (configuration) fields that are stored by the UE i.e. not one-shot. Upon receiving a message with the field absent, the UE releases the current value.

6.2 RRC messages

6.2.1 General message structure

– *NR-RRC-Definitions*

This ASN.1 segment is the start of the NR RRC PDU definitions.

```
-- ASN1START
-- TAG-NR-RRC-DEFINITIONS-START

NR-RRC-Definitions DEFINITIONS AUTOMATIC TAGS ::=

BEGIN

-- TAG-NR-RRC-DEFINITIONS-STOP
-- ASN1STOP
```

– *BCCH-BCH-Message*

The *BCCH-BCH-Message* class is the set of RRC messages that may be sent from the network to the UE via BCH on the BCCH logical channel.

```
-- ASN1START
-- TAG-BCCH-BCH-MESSAGE-START

BCCH-BCH-Message ::= SEQUENCE {
    message                                     BCCH-BCH-MessageType
}

BCCH-BCH-MessageType ::= CHOICE {
    mib                                         MIB,
    messageClassExtension   SEQUENCE {}
}

-- TAG-BCCH-BCH-MESSAGE-STOP
-- ASN1STOP
```

– *DL-DCCH-Message*

The *DL-DCCH-Message* class is the set of RRC messages that may be sent from the network to the UE on the downlink DCCH logical channel.

```
-- ASN1START
-- TAG-DL-DCCH-MESSAGE-START

DL-DCCH-Message ::= SEQUENCE {
    message                                     DL-DCCH-MessageType
}
```

```
DL-DCCH-MessageType ::= CHOICE {
    c1                      CHOICE {
        rrcReconfiguration                          RRCReconfiguration,
        spare15 NULL, spare14 NULL, spare13 NULL,
        spare12 NULL, spare11 NULL, spare10 NULL,
        spare9 NULL, spare8 NULL, spare7 NULL,
        spare6 NULL, spare5 NULL, spare4 NULL,
        spare3 NULL, spare2 NULL, spare1 NULL
    },
    messageClassExtension   SEQUENCE {}
}

-- TAG-DL-DCCH-MESSAGE-STOP
-- ASN1STOP
```

– *UL-DCCH-Message*

The *UL-DCCH-Message* class is the set of RRC messages that may be sent from the UE to the network on the uplink DCCH logical channel.

```
-- ASN1START
-- TAG-UL-DCCH-MESSAGE-START

UL-DCCH-Message ::= SEQUENCE {
    message                                         UL-DCCH-MessageType
}

UL-DCCH-MessageType ::= CHOICE {
    c1                      CHOICE {
        measurementReport                           MeasurementReport,
        rrcReconfigurationComplete                  RRCReconfigurationComplete,
        spare14 NULL, spare13 NULL, spare12 NULL,
        spare11 NULL, spare10 NULL, spare9 NULL,
        spare8 NULL, spare7 NULL, spare6 NULL,
        spare5 NULL, spare4 NULL, spare3 NULL,
        spare2 NULL, spare1 NULL
    },
    messageClassExtension   SEQUENCE {}
}

-- TAG-UL-DCCH-MESSAGE-STOP
-- ASN1STOP
```

6.2.2 Message definitions

– *MIB*

The *MIB* includes the system information transmitted on BCH.

Signalling radio bearer: N/A

RLC-SAP: TM

Logical channel: BCCH

Direction: Network to UE

MIB

```
-- ASN1START
-- TAG-MIB-START

MIB ::=                             SEQUENCE {
    systemFrameNumber                   BIT STRING (SIZE (6)),
    subCarrierSpacingCommon             ENUMERATED {scs15or60, scs30or120},
    ssb-SubcarrierOffset                INTEGER (0..15),
    dmrs-TypeA-Position                 ENUMERATED {pos2, pos3},
    pdcch-ConfigSIB1                    INTEGER (0..255),
    cellBarred                          ENUMERATED {barred, notBarred},
    intraFreqReselection                ENUMERATED {allowed, notAllowed},
    spare                               BIT STRING (SIZE (1))
}

-- TAG-MIB-STOP
-- ASN1STOP
```

MIB field descriptions
cellBarred Indicates whether the cell allows UEs to camp on this cell, as specified in TS 38.304 [20].
dmrs-TypeA-Position Position of (first) DL DM-RS. Corresponds to L1 parameter 'DL-DMRS-typeA-pos' (see 38.211, section 7.4.1.1.1)
intraFreqReselection Controls cell reselection to intra-frequency cells when the highest ranked cell is barred, or treated as barred by the UE, as specified in TS 38.304 [20}.
pdcch-ConfigSIB1 Corresponds to RMSI-PDCCH-Config in TS 38.213 [13], section 4.1. Determines a bandwidth for PDCCH/SIB, a common ControlResourceSet (CORESET) a common search space and necessary PDCCH parameters. If the field ssb-SubcarrierOffset indicates that *SIB1* is not present, the field pdcch-ConfigSIB1 indicate the frequency positions where the UE may find SS/PBCH block with *SIB1* or the frequency range where the network does not provide SS/PBCH block with *SIB1* (see TS 38.213 [13], section 13).
ssb-SubcarrierOffset Corresponds to k_{SSB} (see TS 38.213, section 4.1, 13), which is the frequency domain offset between SSB and the overall resource block grid in number of subcarriers. (See 38.211, section 7.4.3.1). The value range of this field may be extended by an additional most significant bit encoded within PBCH as specified in 38.213 [13]. This field may indicate that this cell does not provide SIB1 and that there is hence no common CORESET (see TS 38.213 [13], section 13). In this case, the field *pdcch-ConfigSIB1* may indicate the frequency positions where the UE may (not) find a SS/PBCH with a control resource set and search space for SIB1 (see 38.213 [13], section 13).
subCarrierSpacingCommon Subcarrier spacing for SIB1, Msg.2/4 for initial access and broadcast SI-messages. If the UE acquires this MIB on a carrier frequency <6GHz, the value *scs15or60* corresponds to 15 Khz and the value *scs30or120* corresponds to 30 kHz. If the UE acquires this MIB on a carrier frequency >6GHz, the value *scs15or60* corresponds to 60 Khz and the value *scs30or120* corresponds to 120 kHz.
systemFrameNumber The 6 most significant bit (MSB) of the 10 bit System Frame Number. The 4 LSB of the SFN are conveyed in the PBCH transport block as part of channel coding (i.e. outside the MIB encoding).

– *MeasurementReport*

The *MeasurementReport* message is used for the indication of measurement results.

Signalling radio bearer: SRB1, SRB3

RLC-SAP: AM

Logical channel: DCCH

Direction: UE to Network

MeasurementReport message

```
-- ASN1START
-- TAG-MEASUREMENTREPORT-START

MeasurementReport ::=               SEQUENCE {
    criticalExtensions                  CHOICE {
        measurementReport                   MeasurementReport-IEs,
        criticalExtensionsFuture            SEQUENCE {}
    }
```

```
}

MeasurementReport-IEs ::=           SEQUENCE {
    measResults                         MeasResults,

    lateNonCriticalExtension                OCTET STRING                                                OPTIONAL,
    nonCriticalExtension                    SEQUENCE{}                                                  OPTIONAL
}

-- TAG-MEASUREMENTREPORT-STOP
-- ASN1STOP
```

– *RRCReconfiguration*

The *RRCReconfiguration* message is the command to modify an RRC connection. It may convey information for measurement configuration, mobility control, radio resource configuration (including RBs, MAC main configuration and physical channel configuration) including and security configuration.

Signalling radio bearer: SRB1 or SRB3

RLC-SAP: AM

Logical channel: DCCH

Direction: Network to UE

RRCReconfiguration message

```
-- ASN1START
-- TAG-RRCRECONFIGURATION-START

RRCReconfiguration ::=              SEQUENCE {
    rrc-TransactionIdentifier           RRC-TransactionIdentifier,
    criticalExtensions                  CHOICE {
        rrcReconfiguration                  RRCReconfiguration-IEs,
        criticalExtensionsFuture            SEQUENCE {}
    }
}

RRCReconfiguration-IEs ::=          SEQUENCE {
    radioBearerConfig                       RadioBearerConfig                                   OPTIONAL, -- Need M
    secondaryCellGroup                      OCTET STRING (CONTAINING CellGroupConfig)           OPTIONAL, -- Need M
    measConfig                              MeasConfig                                          OPTIONAL, -- Need M

    lateNonCriticalExtension                OCTET STRING                                        OPTIONAL,
    nonCriticalExtension                    SEQUENCE {}                                         OPTIONAL
}

-- TAG-RRCRECONFIGURATION-STOP
-- ASN1STOP
```

RRCReconfiguration-IEs field descriptions
radioBearerConfig Configuration of Radio Bearers (DRBs, SRBs) including SDAP/PDCP. In EN-DC this field may only be present if the RRCReconfiguration is transmitted over SRB3.
secondaryCellGroup Configuration of secondary cell group (EN-DC).

– *RRCReconfigurationComplete*

The *RRCReconfigurationComplete* message is used to confirm the successful completion of an RRC connection reconfiguration.

Signalling radio bearer: SRB1 or SRB3

RLC-SAP: AM

Logical channel: DCCH

Direction: UE to Network

RRCReconfigurationComplete message

```
-- ASN1START
-- TAG-RRCRECONFIGURATIONCOMPLETE-START

RRCReconfigurationComplete ::=          SEQUENCE {
    rrc-TransactionIdentifier               RRC-TransactionIdentifier,
    criticalExtensions                      CHOICE {
        rrcReconfigurationComplete              RRCReconfigurationComplete-IEs,
        criticalExtensionsFuture                SEQUENCE {}
    }
}

RRCReconfigurationComplete-IEs ::= SEQUENCE {
    lateNonCriticalExtension                OCTET STRING                                    OPTIONAL,
    nonCriticalExtension                    SEQUENCE {}                                     OPTIONAL
}

-- TAG-RRCRECONFIGURATIONCOMPLETE-STOP
-- ASN1STOP
```

– *SIB1*

Editor's Note: Targeted for completion in September 2018. Not used in EN-DC.

SIB1 contains information relevant when evaluating if a UE is allowed to access a cell and defines the scheduling of other system information. It also contains radio resource configuration information that is common for all UEs.

Signalling radio bearer: N/A

RLC-SAP: TM

Logical channels: BCCH and BR-BCCH

Direction: Network to UE

SIB1 message

```
-- ASN1START
-- TAG-SIB1-START

SIB1 ::=        SEQUENCE {

    -- FFS / TODO: Add other parameters.
    frequencyOffsetSSB              ENUMERATED {khz-5, khz5}                                    OPTIONAL,   -- Need R
    ssb-PositionsInBurst                SEQUENCE {
        inOneGroup                          BIT STRING (SIZE (8)),
        groupPresence                       BIT STRING (SIZE (8))                               OPTIONAL -- Cond above6GHzOnly
    },
    ssb-PeriodicityServingCell          ENUMERATED {ms5, ms10, ms20, ms40, ms80, ms160, spare1, spare2},
    ss-PBCH-BlockPower                  INTEGER (-60..50),

    uplinkConfigCommon                  UplinkConfigCommon                                      OPTIONAL,
    supplementaryUplink                 SEQUENCE {
        uplinkConfigCommon                  UplinkConfigCommon                                  OPTIONAL
        -- FFS: Add additional (selection) criteria determining when/whether the UE shall use the SUL frequency
    }                                                                                           OPTIONAL, -- Cond SUL

    tdd-UL-DL-Configuration             TDD-UL-DL-ConfigCommon                                  OPTIONAL, -- Cond TDD
    tdd-UL-DL-configurationCommon2      TDD-UL-DL-ConfigCommon                                  OPTIONAL, -- Cond TDD

    pdcch-ConfigCommon                  PDCCH-ConfigCommon                                      OPTIONAL,
    pucch-ConfigCommon                  PUCCH-ConfigCommon                                      OPTIONAL,

    lateNonCriticalExtension            OCTET STRING                                            OPTIONAL,
    nonCriticalExtension                SEQUENCE{}                                              OPTIONAL
}

-- TAG-SIB1-STOP
-- ASN1STOP
```

SIB1 field descriptions
frequencyOffsetSSB Frequency offset for the SSB of -5kHz (M=-1) or +5kHz (M=1). When the field is absent, the UE applies no offset (M=0). The offset is only applicable for the frequency range 0-2.65GHz. Corresponds to parameter 'M' (see 38.101, section FFS_Section)
groupPresence For above 6 GHz: indicates which groups of SSBs is present
inOneGroup Indicates the presence of the up to 8 SSBs in one group
ss-PBCH-BlockPower TX power that the NW used for SSB transmission. The UE uses it to estimate the RA preamble TX power. (see 38.213, section 7.4)
ssb-PeriodicityServingCell The SSB periodicity in msec for the rate matching purpose (see 38.211, section [7.4.3.1])
ssb-PositionsInBurst Time domain positions of the transmitted SS-blocks in an SS-Burst-Set (see 38.213, section 4.1)
supplementaryUplink FFS: How to indicate the FrequencyInfoUL for the SUL

6.3 RRC information elements

6.3.0 Parameterized types

– *SetupRelease*

SetupRelease allows the *ElementTypeParam* to be used as the referenced data type for the setup and release entries. See A.3.8 for guidelines.

```
-- ASN1START
-- TAG-SETUP-RELEASE-START

SetupRelease { ElementTypeParam } ::= CHOICE {
    release         NULL,
    setup           ElementTypeParam
}

-- TAG-SETUP-RELEASE-STOP
-- ASN1STOP
```

6.3.1 System information blocks

6.3.2 Radio resource control information elements

– *AdditionalSpectrumEmission*

The IE *AdditionalSpectrumEmission* is used to indicate emission requirements to be fulfilled by the UE (see 38.101, section FFS_Section)

AdditionalSpectrumEmission information element

```
-- ASN1START
-- TAG-ADDITIONALSPECTRUMEMISSION-START

AdditionalSpectrumEmission ::=              INTEGER (0..7)

-- TAG-ADDITIONALSPECTRUMEMISSION-STOP
-- ASN1STOP
```

– *Alpha*

The IE Alpha defines possible values for uplink power control.

```
-- ASN1START
-- TAG-ALPHA-START

Alpha ::=                       ENUMERATED {alpha0, alpha04, alpha05, alpha06, alpha07, alpha08, alpha09, alpha1}

-- TAG-ALPHA-STOP
-- ASN1STOP
```

– *ARFCN-ValueNR*

The IE *ARFCN-ValueNR* is used to indicate the ARFCN applicable for a downlink, uplink or bi-directional (TDD) NR global frequency raster, as defined in TS 38.101- [15], section 5.4.2.

```
-- ASN1START
-- TAG-ARFCN-VALUE-NR-START

ARFCN-ValueNR ::=               INTEGER (0..3279165)

-- TAG-ARFCN-VALUE-NR-STOP
-- ASN1STOP
```

– *BWP*

The *BWP* IE is used to configure a bandwidth part as defined in 38.211, section 4.2.2.

For each serving cell the network configures at least an initial bandwidth part comprising of at least a downlink bandwidth part and one (if the serving cell is configured with an uplink) or two (if using supplementary uplink (SUL)) uplink bandwidth parts. Furthermore, the network may configure additional uplink and downlink bandwidth parts for a serving cell.

The bandwidth part configuration is split into uplink and downlink parameters and into common and dedicated parameters. Common parameters (in BWP-UplinkCommon and BWP-DownlinkCommon) are "cell specific" and the network ensures the necessary alignment with corresponding parameters of other UEs. The common parameters of the initial bandwidth part of the PCell are also provided via system information. For all other serving cells, the network provides the common parameters via dedicated signalling.

BWP information element

```
-- ASN1START
-- TAG-BANDWIDTH-PART-START

BWP ::=                             SEQUENCE {
    locationAndBandwidth                INTEGER (0..37949),
    subcarrierSpacing                   SubcarrierSpacing,
    cyclicPrefix                        ENUMERATED { extended }                                 OPTIONAL -- Need R
}

BWP-Uplink ::=                      SEQUENCE {
    bwp-Id                              BWP-Id,
    bwp-Common                          BWP-UplinkCommon                                        OPTIONAL,   -- Need M
    bwp-Dedicated                       BWP-UplinkDedicated                                     OPTIONAL,   -- Need M
    ...
}

BWP-UplinkCommon ::=                SEQUENCE {
    genericParameters                   BWP,
    rach-ConfigCommon                   SetupRelease { RACH-ConfigCommon }                      OPTIONAL,   -- Need M
    pusch-ConfigCommon                  SetupRelease { PUSCH-ConfigCommon }                     OPTIONAL,   -- Need M
    pucch-ConfigCommon                  SetupRelease { PUCCH-ConfigCommon }                     OPTIONAL,   -- Need M
    ...
}

BWP-UplinkDedicated ::=             SEQUENCE {
    pucch-Config                        SetupRelease { PUCCH-Config }                           OPTIONAL,   -- Need M
    pusch-Config                        SetupRelease { PUSCH-Config }                           OPTIONAL,   -- Cond SetupOnly
    configuredGrantConfig               SetupRelease { ConfiguredGrantConfig }                  OPTIONAL,   -- Need M
    srs-Config                          SetupRelease { SRS-Config }                             OPTIONAL,   -- Need M
    beamFailureRecoveryConfig           SetupRelease { BeamFailureRecoveryConfig }              OPTIONAL,   -- Cond SpCellOnly
    ...
}

BWP-Downlink ::=                    SEQUENCE {
    bwp-Id                              BWP-Id,
    bwp-Common                          BWP-DownlinkCommon                                      OPTIONAL,   -- Need M
    bwp-Dedicated                       BWP-DownlinkDedicated                                   OPTIONAL,   -- Need M
    ...
}

BWP-DownlinkCommon ::=              SEQUENCE {
    genericParameters                   BWP,
```

```
    pdcch-ConfigCommon                  SetupRelease { PDCCH-ConfigCommon }                 OPTIONAL,   -- Need M
    pdsch-ConfigCommon                  SetupRelease { PDSCH-ConfigCommon }                 OPTIONAL,   -- Need M
    ...
}

BWP-DownlinkDedicated ::=           SEQUENCE {
    pdcch-Config                        SetupRelease { PDCCH-Config }                       OPTIONAL,   -- Need M
    pdsch-Config                        SetupRelease { PDSCH-Config }                       OPTIONAL,   -- Need M
    sps-Config                          SetupRelease { SPS-Config }                         OPTIONAL,   -- Need M
    radioLinkMonitoringConfig           SetupRelease { RadioLinkMonitoringConfig }          OPTIONAL,   -- Need M
    ...
}

-- TAG-BANDWIDTH-PART-STOP
-- ASN1STOP
```

BWP field descriptions
cyclicPrefix Indicates whether to use the extended cyclic prefix for this bandwidth part. If not set, the UE uses the normal cyclic prefix. Normal CP is supported for all numerologies and slot formats. Extended CP is supported only for 60 kHz subcarrier spacing. (see 38.211, section 4.2.2)
locationAndBandwidth Frequency domain location and bandwidth of this bandwidth part. The value of the field shall be interpreted as resource indicator value (RIV) as defined TS 38.214 with assumptions as described in TS 38.213, section 12, i.e. setting N_{BWP}^{size}=275. The first PRB is a PRB determined by subcarrierSpacing of this BWP and offsetToCarrier (configured in SCS-SpecificCarrier contained within FrequencyInfoDL) corresponding to this subcarrier spacing. In case of TDD, a BWP-pair (UL BWP and DL BWP with the same bwp-Id) must have the same center frequency (see 38.213, section 12)
subcarrierSpacing Subcarrier spacing to be used in this BWP for all channels and reference signals unless explicitly configured elsewhere. Corresponds to subcarrier spacing according to 38.211, Table 4.2-1. The value kHz15 corresponds to μ=0, kHz30 to μ=1, and so on. Only the values 15, 30, or 60 kHz (<6GHz), and 60 or 120 kHz (>6GHz) are applicable.

BWP-Downlink field descriptions
bwp-Id An identifier for this bandwidth part. Other parts of the RRC configuration use the BWP-Id to associate themselves with a particular bandwidth part. The BWP ID=0 is always associated with the initial BWP and may hence not be used here (in other bandwidth parts). The NW may trigger the UE to swtich UL or DL BWP using a DCI field. The four code points in that DCI field map to the RRC-configured BWP-ID as follows: For up to 3 configured BWPs (in addition to the initial BWP) the DCI code point is equivalent to the BWP ID (initial = 0, first dedicated = 1, ...). If the NW configures 4 dedicated bandwidth parts, they are identified by DCI code points 0 to 3. In this case it is not possible to switch to the initial BWP using the DCI field. Corresponds to L1 parameter 'DL-BWP-index'. (see 38.211, 38.213, section 12)

BWP-DownlinkCommon field descriptions
pdcch-ConfigCommon Cell specific parameters for the PDCCH of this BWP
pdsch-ConfigCommon Cell specific parameters for the PDSCH of this BWP

BWP-DownlinkDedicated field descriptions
pdcch-Config UE specific PDCCH configuration for one BWP
pdsch-Config UE specific PDSCH configuration for one BWP
sps-Config UE specific SPS (Semi-Persistent Scheduling) configuration for one BWP.
radioLinkMonitoringConfig UE specific configuration of radio link monitoring for detecting cell- and beam radio link failure occasions.

BWP-Uplink field descriptions
bwp-Id An identifier for this bandwidth part. Other parts of the RRC configuration use the BWP-Id to associate themselves with a particular bandwidth part. The BWP ID=0 is always associated with the initial BWP and may hence not be used here (in other bandwidth parts). The NW may trigger the UE to swtich UL or DL BWP using a DCI field. The four code points in that DCI field map to the RRC-configured BWP-ID as follows: For up to 3 configured BWPs (in addition to the initial BWP) the DCI code point is equivalent to the BWP ID (initial = 0, first dedicated = 1, ...). If the NW configures 4 dedicated bandwidth parts, they are identified by DCI code points 0 to 3. In this case it is not possible to switch to the initial BWP using the DCI field. Corresponds to L1 parameter 'UL-BWP-index'. (see 38.211, 38.213, section 12)

BWP-UplinkCommon field descriptions
pucch-ConfigCommon Cell specific parameters for the PUCCH
pusch-ConfigCommon Cell specific parameters for the PUSCH
rach-ConfigCommon Configuration of cell specific random access parameters which the UE uses for contention based and contention free random access as well as for contention based beam failure recovery. The NW configures SSB-based RA (and hence RACH-ConfigCommon) only for UL BWPs if the linked DL BWPs allows the UE to acquire the SSB associated to the serving cell.

BWP-UplinkDedicated field descriptions
beamFailureRecoveryConfig Determines how the UE performs Beam Failure Recovery upon detection of a Beam Failure (see RadioLinkMonitoringConfig)
configuredGrantConfig A Configured-Grant of typ1 or type2. It may be configured for UL or SUL but in case of type1 [FFS also type2] not for both at a time.
pucch-Config PUCCH configuration for one BWP of the regular UL or SUL of a serving cell. If the UE is configured with SUL, the network configures PUCCH only on the BWPs of one of the uplinks (UL or SUL).The network configures PUCCH-Config for each SpCell. If supported by the UE, the network may configure at most one additional SCell of a cell group with PUCCH-Config (i.e. PUCCH SCell).
pusch-Config PUSCH configuration for one BWP of the regular UL or SUL of a serving cell. If the UE is configured with SUL and if it has a PUSCH-Config for both UL and SUL, a carrier indicator field in DCI indicates for which of the two to use an UL grant. See also L1 parameter 'dynamicPUSCHSUL' (see 38.213, section FFS_Section)
srs-Config Uplink sounding reference signal configuration

Conditional Presence	Explanation
SetupOnly	The field is optionally present, Need M, upon configuration of a new SCell. It is absent otherwise.
SpCellOnly	The field is optionally present, Need M, in the BWP-UplinkDedicated of an SpCell. It is absent otherwise.

– *BWP-Id*

The IE *BWP-Id* is used to refer to Bandwidth Parts (BWP). The initial BWP is referred to by BWP-Id 0. The other BWPs are referred to by BWP-Id 1 to *maxNrofBWPs*.

BWP-Id information element

```
-- ASN1START
-- TAG-BWP-ID-START

BWP-Id ::=                          INTEGER (0..maxNrofBWPs)

-- TAG-BWP-ID-STOP
-- ASN1STOP
```

– *BeamFailureRecoveryConfig*

The BeamFailureRecoveryConfig IE is used to configure the UE with RACH resources and candidate beams for beam failure recovery in case of beam failure detection. See also 38.321, section 5.1.1.

BeamFailureRecoveryConfig information element

```
-- ASN1START
-- TAG-BEAM-FAILURE-RECOVERY-CONFIG-START

BeamFailureRecoveryConfig ::=       SEQUENCE {
    rootSequenceIndex-BFR               INTEGER (0..137)                                        OPTIONAL,   -- Need M
```

```
    rach-ConfigBFR                  RACH-ConfigGeneric                                              OPTIONAL,   -- Need M
    rsrp-ThresholdSSB               RSRP-Range                                                    OPTIONAL,   -- Need M
    candidateBeamRSList                 SEQUENCE (SIZE(1..maxNrofCandidateBeams)) OF PRACH-ResourceDedicatedBFR    OPTIONAL,   -- Need M
    ssb-perRACH-Occasion                ENUMERATED {oneEighth, oneFourth, oneHalf, one, two, four, eight, sixteen} OPTIONAL,   -- Need M
    ra-ssb-OccasionMaskIndex            INTEGER (0..15)                                             OPTIONAL,   -- Need M
    recoverySearchSpaceId               SearchSpaceId                                               OPTIONAL,   -- Cond CF-BFR
    ra-Prioritization                   RA-Prioritization                                           OPTIONAL,   -- Need R
    beamFailureRecoveryTimer            ENUMERATED {ms10, ms20, ms40, ms60, ms80, ms100, ms150, ms200}      OPTIONAL,   -- Need M
    ...
}

PRACH-ResourceDedicatedBFR ::=      CHOICE {
    ssb                                 BFR-SSB-Resource,
    csi-RS                              BFR-CSIRS-Resource
}

BFR-SSB-Resource ::=            SEQUENCE {
    ssb                             SSB-Index,
    ra-PreambleIndex                INTEGER (0..63),
    ...
}

BFR-CSIRS-Resource ::=          SEQUENCE {
    csi-RS                          NZP-CSI-RS-ResourceId,
    ra-OccasionList                 SEQUENCE (SIZE(1..maxRA-OccasionsPerCSIRS)) OF INTEGER (0..maxRA-Occasions-1)  OPTIONAL,   -- Need R
    ra-PreambleIndex                INTEGER (0..63)                                             OPTIONAL,   -- Need R
    ...
}

-- TAG-BEAM-FAILURE-RECOVERY-CONFIG-STOP
-- ASN1STOP
```

BeamFailureRecoveryConfig field descriptions
beamFailureRecoveryTimer Timer for beam failure recovery timer. Upon expiration of the timer the UE does not use CFRA for BFR. Value in ms. ms10 corresponds to 10ms, ms20 to 20ms, and so on.
candidateBeamRSList A list of reference signals (CSI-RS and/or SSB) identifying the candidate beams for recovery and the associated RA parameters
rsrp-ThresholdSSB L1-RSRP threshold used for determining whether a candidate beam may be used by the UE to attempt contention free Random Access to recover from beam failure. The signalled threshold is applied directly for SSB; a threshold for CSI-RS is determined by linearly scaling singalled value based on Pc_ss corresponding to the CSI-RS resource. (see FFS_Specification, FFS_Section)
ra-prioritization Parameters which apply for prioritized random access procedure for BFR (see 38.321, section 5.1.1).
ra-ssb-OccasionMaskIndex Explicitly signalled PRACH Mask Index for RA Resource selection in TS 36.321. The mask is valid for all SSB resources
rach-ConfigBFR Configuration of contention free random access occasions for BFR
recoverySearchSpaceId Search space to use for BFR RAR.
ssb-perRACH-Occasion Number of SSBs per RACH occasion (L1 parameter 'SSB-per-rach-occasion')

BFR-CSIRS-Resource field descriptions
csi-RS The ID of a NZP-CSI-RS-Resource configured in the CSI-MeasConfig of this serving cell. This reference signal determines a candidate beam for beam failure recovery (BFR).
ra-OccasionList RA occasions that the UE shall use when performing BFR upon selecting the candidate beam identified by this CSI-RS. If the field is absent the UE uses the RA occasion associated with the SSB that is QCLed with this CSI-RS.
ra-PreambleIndex The RA preamble index to use in the RA occasions associated with this CSI-RS. If the field is absent, the UE uses the preamble index associated with the SSB that is QCLed with this CSI-RS.

BFR-SSB-Resource field descriptions
ra-PreambleIndex The preamble index that the UE shall use when performing BFR upon selecting the candidate beams identified by this SSB.
ssb The ID of an SSB transmitted by this serving cell. It determines a candidate beam for beam failure recovery (BFR)

Conditional Presence	Explanation
CF-BFR	The field is mandatory present, Need R, if CF-BFR is configured. It is optionally present otherwise.

– *CellGroupConfig*

The *CellGroupConfig* IE is used to configure a master cell group (MCG) or secondary cell group (SCG). A cell group comprises of one MAC entity, a set of logical channels with associated RLC entities and of a primary cell (SpCell) and one or more secondary cells (SCells).

CellGroupConfig information element

```
-- ASN1START
-- TAG-CELL-GROUP-CONFIG-START

-- Configuration of one Cell-Group:
CellGroupConfig ::=                 SEQUENCE {
    cellGroupId                         CellGroupId,

    rlc-BearerToAddModList              SEQUENCE (SIZE(1..maxLC-ID)) OF RLC-BearerConfig          OPTIONAL,   -- Need N
    rlc-BearerToReleaseList             SEQUENCE (SIZE(1..maxLC-ID)) OF LogicalChannelIdentity       OPTIONAL,   -- Need N

    mac-CellGroupConfig                 MAC-CellGroupConfig                                       OPTIONAL,   -- Need M

    physicalCellGroupConfig             PhysicalCellGroupConfig                                   OPTIONAL,   -- Need M

    spCellConfig                        SpCellConfig                                              OPTIONAL,   -- Need M
    sCellToAddModList                   SEQUENCE (SIZE (1..maxNrofSCells)) OF SCellConfig         OPTIONAL,   -- Need N
    sCellToReleaseList                  SEQUENCE (SIZE (1..maxNrofSCells)) OF SCellIndex          OPTIONAL,   -- Need N
    ...
}



-- Serving cell specific MAC and PHY parameters for a SpCell:
SpCellConfig ::=                    SEQUENCE {
    servCellIndex                       ServCellIndex                                             OPTIONAL,   -- Cond SCG
    reconfigurationWithSync             ReconfigurationWithSync                                   OPTIONAL,   -- Cond ReconfWithSync
    rlf-TimersAndConstants              SetupRelease { RLF-TimersAndConstants }                   OPTIONAL,   -- Need M
    rlmInSyncOutOfSyncThreshold         ENUMERATED {n1}                                           OPTIONAL,   -- Need S
    spCellConfigDedicated               ServingCellConfig                                         OPTIONAL,   -- Need M
    ...
}

ReconfigurationWithSync ::=         SEQUENCE {
    spCellConfigCommon                  ServingCellConfigCommon                                   OPTIONAL,   -- Need M
    newUE-Identity                      RNTI-Value,
    t304                                ENUMERATED {ms50, ms100, ms150, ms200, ms500, ms1000, ms2000, ms10000},
        rach-ConfigDedicated                CHOICE {
            uplink                              RACH-ConfigDedicated,
            supplementaryUplink             RACH-ConfigDedicated
    }                                                                                             OPTIONAL,   -- Need N
    ...
}

SCellConfig ::=                     SEQUENCE {
    sCellIndex                          SCellIndex,
    sCellConfigCommon                   ServingCellConfigCommon                                   OPTIONAL,   -- Cond SCellAdd
```

```
    sCellConfigDedicated                ServingCellConfig                                   OPTIONAL,   -- Cond SCellAddMod
    ...
}

-- TAG-CELL-GROUP-CONFIG-STOP
-- ASN1STOP
```

***CellGroupConfig* field descriptions**
mac-CellGroupConfig MAC parameters applicable for the entire cell group.
rlc-BearerToAddModList Configuration of the MAC Logical Channel, the corresponding RLC entities and association with radio bearers.
rlmInSyncOutOfSyncThreshold BLER threshold pair index for IS/OOS indication generation, see TS 38.133 ([14], Table 8.1.1-1). *n1* corresponds to the value 1. When the field is absent, the UE applies the value 0. Whenever this is reconfigured, UE resets on-going RLF timers and counter.
sCellToAddModList List of seconary serving cells (SCells) to be added or modified.
sCellToReleaseList List of seconary serving cells (SCells) to be released
spCellConfig Parameters for the SpCell of this cell group (PCell of MCG or PSCell of SCG).

***ReconfigurationWithSync* field descriptions**
rach-ConfigDedicated Random access configuration to be used for the reconfiguration with sync (e.g. handover). The UE performs the RA according to these parameters in the firstActiveUplinkBWP (see UplinkConfig).

SpCellConfig field descriptions
reconfigurationWithSync Parameters for the synchronous reconfiguration to the target SpCell.
servCellIndex Serving cell ID of a PSCell. The PCell of the Master Cell Group uses ID = 0.

Conditional Presence	Explanation
LCH-SetupOnly	The field is mandatory present if the corresponding LCH is being set up; otherwise it is not present.
LCH-Setup	The field is mandatory present if the corresponding LCH is being set up for DRB; otherwise it is optionally present, need M.
ReconfWithSync	The field is mandatory present in case of SpCell change and security key change; otherwise it is optionally present, need M.
SCellAdd	The field is mandatory present, need M, upon SCell addition; otherwise it is not present
SCellAddMod	The field is mandatory present upon SCell addition; otherwise it is optionally present, need M.

– *CellGroupId*

The IE *CellGroupId* is used to identify a cell group. 0 identifies the master cell group. Other values identify secondary cell groups. In this version of the specification only values 0 and 1 are supported.

CellGroupId information element

```
-- ASN1START
-- TAG-CELLGROUPID-START

CellGroupId ::=                             INTEGER (0.. maxSecondaryCellGroups)

-- TAG-CELLGROUPID-STOP
-- ASN1STOP
```

– *CodebookConfig*

The IE *CodebookConfig* is used to configure codebooks of Type-I and Type-II (see 38.214, section 5.2.2.2)

CodebookConfig information element

```
-- ASN1START
-- TAG-CODEBOOKCONFIG-START
CodebookConfig ::=                                  SEQUENCE {
    codebookType                                        CHOICE {
        type1                                               SEQUENCE {
            subType                                         CHOICE {
                typeI-SinglePanel                                       SEQUENCE {
                    nrOfAntennaPorts                                        CHOICE {
                        two                                                     SEQUENCE {
                            twoTX-CodebookSubsetRestriction                         BIT STRING (SIZE (6))
                        },
                        moreThanTwo                                             SEQUENCE {
                            n1-n2                                                   CHOICE {
                                two-one-TypeI-SinglePanel-Restriction                   BIT STRING (SIZE (8)),
                                two-two-TypeI-SinglePanel-Restriction                   BIT STRING (SIZE (64)),
                                four-one-TypeI-SinglePanel-Restriction                  BIT STRING (SIZE (16)),
                                three-two-TypeI-SinglePanel-Restriction                 BIT STRING (SIZE (96)),
                                six-one-TypeI-SinglePanel-Restriction                   BIT STRING (SIZE (24)),
                                four-two-TypeI-SinglePanel-Restriction                  BIT STRING (SIZE (128)),
                                eight-one-TypeI-SinglePanel-Restriction                 BIT STRING (SIZE (32)),
                                four-three-TypeI-SinglePanel-Restriction                BIT STRING (SIZE (192)),
                                six-two-TypeI-SinglePanel-Restriction                   BIT STRING (SIZE (192)),
                                twelve-one-TypeI-SinglePanel-Restriction                BIT STRING (SIZE (48)),
                                four-four-TypeI-SinglePanel-Restriction                 BIT STRING (SIZE (256)),
                                eight-two-TypeI-SinglePanel-Restriction                 BIT STRING (SIZE (256)),
                                sixteen-one-TypeI-SinglePanel-Restriction               BIT STRING (SIZE (64))
                            },
                            typeI-SinglePanel-codebookSubsetRestriction-i2      BIT STRING (SIZE (16))  OPTIONAL
                        }
                    },
```

```
                typeI-SinglePanel-ri-Restriction                    BIT STRING (SIZE (8))
            },
            typeI-MultiPanel                                    SEQUENCE {
                ng-n1-n2                                                CHOICE {
                    two-two-one-TypeI-MultiPanel-Restriction                BIT STRING (SIZE (8)),
                    two-four-one-TypeI-MultiPanel-Restriction               BIT STRING (SIZE (16)),
                    four-two-one-TypeI-MultiPanel-Restriction               BIT STRING (SIZE (8)),
                    two-two-two-TypeI-MultiPanel-Restriction                BIT STRING (SIZE (64)),
                    two-eight-one-TypeI-MultiPanel-Restriction              BIT STRING (SIZE (32)),
                    four-four-one-TypeI-MultiPanel-Restriction              BIT STRING (SIZE (16)),
                    two-four-two-TypeI-MultiPanel-Restriction               BIT STRING (SIZE (128)),
                    four-two-two-TypeI-MultiPanel-Restriction               BIT STRING (SIZE (64))
                },
                ri-Restriction                          BIT STRING (SIZE (4))
            }
        },
        codebookMode                                        INTEGER (1..2)

    },
    type2                                   SEQUENCE {
        subType                                 CHOICE {
            typeII                                  SEQUENCE {
                n1-n2-codebookSubsetRestriction         CHOICE {
                    two-one                                 BIT STRING (SIZE (16)),
                    two-two                                 BIT STRING (SIZE (43)),
                    four-one                                BIT STRING (SIZE (32)),
                    three-two                               BIT STRING (SIZE (59)),
                    six-one                                 BIT STRING (SIZE (48)),
                    four-two                                BIT STRING (SIZE (75)),
                    eight-one                               BIT STRING (SIZE (64)),
                    four-three                              BIT STRING (SIZE (107)),
                    six-two                                 BIT STRING (SIZE (107)),
                    twelve-one                              BIT STRING (SIZE (96)),
                    four-four                               BIT STRING (SIZE (139)),
                    eight-two                               BIT STRING (SIZE (139)),
                    sixteen-one                             BIT STRING (SIZE (128))
                },
                typeII-RI-Restriction                   BIT STRING (SIZE (2))
            },
            typeII-PortSelection                    SEQUENCE {
                portSelectionSamplingSize               ENUMERATED {n1, n2, n3, n4}             OPTIONAL,      -- Cond TypeII-PortSelection
                typeII-PortSelectionRI-Restriction      BIT STRING (SIZE (2))
            }
        },
        phaseAlphabetSize                       ENUMERATED {n4, n8},
        subbandAmplitude                        BOOLEAN,
        numberOfBeams                           ENUMERATED {two, three, four}
    }
  }
}

-- TAG-CODEBOOKCONFIG-STOP
-- ASN1STOP
```

CodebookConfig field descriptions
codebookMode CodebookMode as specified in 38.214 section 5.2.2.2.2
codebookType CodebookType including possibly sub-types and the corresponding parameters for each. Corresponds to L1 parameter 'CodebookType' (see 38.214, section 5.2.2.2)
n1-n2-codebookSubsetRestriction Number of antenna ports in first (n1) and second (n2) dimension and codebook subset restriction. Corresponds to L1 parameters 'CodebookConfig-N1', 'CodebookConfig-N2' The CHOICE name indicates the value of n1 and n2, the CHOICE contents is the codebook subset restriction bitmap Corresponds to L1 parameter ' TypeII-CodebookSubsetRestriction' (see 38.214 section 5.2.2.2.3) Number of bits for codebook subset restriction is ceil(log2(nchoosek(O1*O2,4)))+8*n1*n2 where nchoosek(a,b) = a!/(b!(a-b)!)
n1-n2 Number of antenna ports in first (n1) and second (n2) dimension and codebook subset restriction. Corresponds to L1 parameters 'CodebookConfig-N1', 'CodebookConfig-N2' 'TypeI-SinglePanel-CodebookSubsetRestriction ' (see 38.214 section 5.2.2.2.1)
ng-n1-n2 Codebook subset restriction for Type I Multi-panel codebook Corresponds to L1 parameter 'TypeI-MultiPanel-CodebookSubsetRestriction' (see 38.214, section 5.2.2.2.2)
numberOfBeams Number of beams, L, used for linear combination
phaseAlphabetSize The size of the PSK alphabet, QPSK or 8-PSK
portSelectionSamplingSize The size of the port selection codebook (parameter d)
ri-Restriction Restriction for RI for TypeI-MultiPanel-RI-Restriction Corresponds to L1 parameter 'TypeI-MultiPanel-RI-Restriction' (see 38.214, section 5.2.2.2.2)
subbandAmplitude If subband amplitude reporting is activated (true)
twoTX-CodebookSubsetRestriction Codebook subset restriction for 2TX codebook Corresponds to L1 parameter ' TypeI-SinglePanel-2Tx-CodebookSubsetRestriction' (see 38.214 section 5.2.2.2.1)
typeI-SinglePanel-codebookSubsetRestriction-i2 i2 codebook subset restriction for Type I Single-panel codebook used when reportQuantity is CRI/Ri/i1/CQI Corresponds to L1 parameter 'TypeI-SinglePanel-CodebookSubsetRestriction-i2' (see 38.214 section 5.2.2.2.1)
typeI-SinglePanel-ri-Restriction Restriction for RI for TypeI-SinglePanel-RI-Restriction Corresponds to L1 parameter 'TypeI-SinglePanel-RI-Restriction' (see 38.214, section 5.2.2.2.1)
typeII-PortSelectionRI-Restriction Restriction for RI for TypeII-PortSelection-RI-Restriction Corresponds to L1 parameter 'TypeII-PortSelection-RI-Restriction' (see 38.214, section 5.2.2.4)
typeII-RI-Restriction Restriction for RI for TypeII-RI-Restriction Corresponds to L1 parameter 'TypeII-RI-Restriction' (see 38.214, section 5.2.2.2.3)

– *ConfiguredGrantConfig*

The IE *ConfiguredGrantConfig* is used to configure uplink transmission without dynamic grant according to two possible schemes. The actual uplink grant may either be configured via RRC (type1) or provided via the PDCCH (addressed to CS-RNTI) (type2).

***ConfiguredGrantConfig* information element**

```
-- ASN1START
-- TAG-CONFIGUREDGRANTCONFIG-START
```

```
ConfiguredGrantConfig ::=               SEQUENCE {
    frequencyHopping                        ENUMERATED {mode1, mode2}                               OPTIONAL,   -- Need S,
    cg-DMRS-Configuration                   DMRS-UplinkConfig,
    mcs-Table                               ENUMERATED {qam256, spare1}                         OPTIONAL, -- Need S
    mcs-TableTransformPrecoder              ENUMERATED {qam256, spare1}                             OPTIONAL,   -- Need S
    uci-OnPUSCH                             SetupRelease { CG-UCI-OnPUSCH },
    resourceAllocation                      ENUMERATED { resourceAllocationType0, resourceAllocationType1, dynamicSwitch },
    rbg-Size                                ENUMERATED {config2}                                    OPTIONAL,   -- Need S
    powerControlLoopToUse                   ENUMERATED {n0, n1},
    p0-PUSCH-Alpha                          P0-PUSCH-AlphaSetId,
    transformPrecoder                       ENUMERATED {enabled}                                    OPTIONAL,   -- Need S
    nrofHARQ-Processes                      INTEGER(1..16),
    repK                                    ENUMERATED {n1, n2, n4, n8},
    repK-RV                                 ENUMERATED {s1-0231, s2-0303, s3-0000}                  OPTIONAL,   -- Cond RepK
    periodicity                             ENUMERATED {
                                                sym2, sym7, sym1x14, sym2x14, sym4x14, sym5x14, sym8x14, sym10x14, sym16x14, sym20x14,
                                                sym32x14, sym40x14, sym64x14, sym80x14, sym128x14, sym160x14, sym256x14, sym320x14, sym512x14,
                                                sym640x14, sym1024x14, sym1280x14, sym2560x14, sym5120x14,
                                                sym6, sym1x12, sym2x12, sym4x12, sym5x12, sym8x12, sym10x12, sym16x12, sym20x12, sym32x12,
                                                sym40x12, sym64x12, sym80x12, sym128x12, sym160x12, sym256x12, sym320x12, sym512x12, sym640x12,
                                                sym1280x12, sym2560x12
                                            },
    configuredGrantTimer                    INTEGER (1..64)                                         OPTIONAL,   -- Need R
    rrc-ConfiguredUplinkGrant               SEQUENCE {
            timeDomainOffset                    INTEGER  (0..5119),
            timeDomainAllocation                INTEGER  (0..15),
            frequencyDomainAllocation           BIT STRING (SIZE(18)),
            antennaPort                         INTEGER   (0..31),
            dmrs-SeqInitialization              INTEGER   (0..1)                                    OPTIONAL,  -- Cond NoTransformPrecoder
            precodingAndNumberOfLayers          INTEGER   (0..63),
            srs-ResourceIndicator               INTEGER   (0..15),
            mcsAndTBS                           INTEGER (0..31),
            frequencyHoppingOffset              INTEGER (1.. maxNrofPhysicalResourceBlocks-1)       OPTIONAL,   -- Need M
            pathlossReferenceIndex              INTEGER (0..maxNrofPUSCH-PathlossReferenceRSs-1),
            ...
    }                                                                                               OPTIONAL  -- Need R
}

CG-UCI-OnPUSCH ::= CHOICE {
    dynamic                                 SEQUENCE (SIZE (1..4)) OF BetaOffsets,
    semiStatic                              BetaOffsets
}

-- TAG-CONFIGUREDGRANTCONFIG-STOP
-- ASN1STOP
```

ConfiguredGrantConfig field descriptions
antennaPort Indicates the anntenna port(s) to be used for this configuration, and the maximum bitwidth is 5. See TS 38.214, section 6.1.2, and TS 38.212, section 7.3.1.
cg-DMRS-Configuration DMRS configuration, corresponds to L1 parameter 'UL-TWG-DMRS' (see TS 38.214, section 6.1.2).
configuredGrantTimer Indicates the initial value of the configured grant timer (see TS 38.321) in number of periodicities.
frequencyDomainAllocation Indicates the frequency domain resource allocation, see TS 38.214, section 6.1.2, and TS 38.212, section 7.3.1).
frequencyHopping Frequency hopping. If not configured, frequency hopping is not configured.
frequencyHoppingOffset Enables intra-slot frequency hopping with the given frequency hopping offset. Frequency hopping offset used when frequency hopping is enabled. Corresponds to L1 parameter 'Frequency-hopping-offset' (see TS 38.214, section 6.1.2).
mcs-Table Indicates the MCS table the UE shall use for PUSCH without transform precoding. If the field is absent the UE applies the value 64QAM.
mcs-TableTransformPrecoder Indicates the MCS table the UE shall use for PUSCH with transform precoding. If the field is absent the UE applies the value 64QAM.
mcsAndTBS The modulation order, target code rate and TB size (see TS38.214, section 6.1.2).
nrofHARQ-Processes The number of HARQ processes configured. It applies for both Type 1 and Type 2. See TS 38.321, section 5.4.1.
p0-PUSCH-Alpha Index of the P0-PUSCH-AlphaSet to be used for this configuration.
periodicity Periodicity for UL transmission without UL grant for type 1 and type 2. Corresponds to L1 parameter 'UL-TWG-periodicity' (see TS 38.321, section 5.8.2). The following periodicities are supported depending on the configured subcarrier spacing [symbols]: 15kHz: 2, 7, n*14, where n={1, 2, 4, 5, 8, 10, 16, 20, 32, 40, 64, 80, 128, 160, 320, 640} 30kHz: 2, 7, n*14, where n={1, 2, 4, 5, 8, 10, 16, 20, 32, 40, 64, 80, 128, 160, 256, 320, 640, 1280} 60kHz with normal CP: 2, 7, n*14, where n={1, 2, 4, 5, 8, 10, 16, 20, 32, 40, 64, 80, 128, 160, 256, 320, 512, 640, 1280, 2560} 60kHz with ECP: 2, 6, n*12, where n={1, 2, 4, 5, 8, 10, 16, 20, 32, 40, 64, 80, 128, 160, 256, 320, 512, 640, 1280, 2560} 120kHz: 2, 7, n*14, where n={1, 2, 4, 5, 8, 10, 16, 20, 32, 40, 64, 80, 128, 160, 256, 320, 512, 640, 1024, 1280, 2560, 5120} (see 38.214, Table 6.1.2.3-1)
powerControlLoopToUse Closed control loop to apply. Corresponds to L1 parameter 'PUSCH-closed-loop-index' (see TS 38.213, section 7.7.1).
rbg-Size Selection between config 1 and config 2 for RBG size for PUSCH. When the field is absent the UE applies the value config1. Note: rbg-Size is used when the transformPrecoder parameter is disabled.
repK-RV If repetitions is used, this field indicates the redundancy version (RV) sequence to use. See TS 38.214, section 6.1.2.
repK The number or repetitions of K.
resourceAllocation Configuration of resource allocation type 0 and resource allocation type 1. For Type 1 UL data transmission without grant, "resourceAllocation" should be resourceAllocationType0 or resourceAllocationType1.

rrc-ConfiguredUplinkGrant Configuration for "configured grant" transmission with fully RRC-configured UL grant (Type1).If this field is absent the UE uses UL grant configured by DCI addressed to CS-RNTI (Type2). Type 1 confgured grant may be configured for UL or SUL, but not for both simultaneously.
timeDomainAllocation Indicates a combination of start symbol and length and PUSCH mapping type, see TS 38.214, section 6.1.2 and TS 38.212, section 7.3.1.
timeDomainOffset Offset related to SFN=0, see TS 38.321, section 5.8.2.
transformPrecoder Enable transformer precoder for type1 and type2. If the field is absent, the UE considers the transformer precoder is disabled, see 38.214, section 6.1.3.
uci-OnPUSCH Selection between and configuration of dynamic and semi-static beta-offset. For Type 1 UL data transmission without grant, *uci-OnPUSCH* should be set to *semiStatic.*

Conditional Presence	Explanation
RepK	The field is mandatory present if *repK* is set to *n2, n4,*or *n8*. It is not present if *repK* is set to *n1*.

– *ControlResourceSet*

The IE *ControlResourceSet* is used to configure a time/frequency control resource set (CORESET) in which to search for downlink control information (see 38.213, section FFS_Section).

ControlResourceSet information element

```
-- ASN1START
-- TAG-CONTROLRESOURCESET-START

ControlResourceSet ::=                  SEQUENCE {
    controlResourceSetId                    ControlResourceSetId,

    frequencyDomainResources                BIT STRING (SIZE (45)),
    duration                                INTEGER (1..maxCoReSetDuration),
    cce-REG-MappingType                     CHOICE {
        interleaved                             SEQUENCE {
            reg-BundleSize                          ENUMERATED {n2, n3, n6},
            interleaverSize                         ENUMERATED {n2, n3, n6},
            shiftIndex                              INTEGER(0..maxNrofPhysicalResourceBlocks-1)                OPTIONAL   -- Need S
        },
        nonInterleaved                          NULL
    },
    precoderGranularity                     ENUMERATED {sameAsREG-bundle, allContiguousRBs},
    tci-StatesPDCCH-ToAddList                   SEQUENCE(SIZE (1..maxNrofTCI-StatesPDCCH)) OF TCI-StateId          OPTIONAL,   -- Need N
        tci-StatesPDCCH-ToReleaseList           SEQUENCE(SIZE (1..maxNrofTCI-StatesPDCCH)) OF TCI-StateId          OPTIONAL,   -- Need N
tci-PresentInDCI                        ENUMERATED {enabled}                                                   OPTIONAL,   -- Need S
    pdcch-DMRS-ScramblingID                 INTEGER (0..65535)                                                 OPTIONAL,   -- Need S
    ...
}

-- TAG-CONTROLRESOURCESET-STOP
-- ASN1STOP
```

ControlResourceSet field descriptions
cce-REG-MappingType Mapping of Control Channel Elements (CCE) to Resource Element Groups (REG). Corresponds to L1 parameter 'CORESET-CCE-REG-mapping-type' (see 38.211Section sections 7.3.2.2 and 7.4.1.3.2).
controlResourceSetId Corresponds to L1 parameter 'CORESET-ID'. Value 0 identifies the common CORESET configured in MIB and in ServingCellConfigCommon. Values 1..maxNrofControlResourceSets-1 identify CORESETs configured by dedicated signalling. The controlResourceSetId is unique among the BWPs of a ServingCell.
duration Contiguous time duration of the CORESET in number of symbols. Corresponds to L1 parameter 'CORESET-time-duration' (see 38.211, section 7.3.2.2FFS_Section)
frequencyDomainResources Frequency domain resources for the CORESET. Each bit corresponds a group of 6 RBs, with grouping starting from PRB 0, which is fully contained in the bandwidth part within which the CORESET is configured. The most significant bit corresponds to the group of lowest frequency which is fully contained in the bandwidth part within which the CORESET is configured, each next subsequent lower significance bit corresponds to the next lowest frequency group fully contained within the bandwidth part within which the CORESET is configured, if any. Bits corresponding to a group not fully contained within the bandwidth part within which the CORESET is configured are set to zero. Corresponds to L1 parameter 'CORESET-freq-dom'(see 38.211, section 7.3.2.2).
interleaverSize Corresponds to L1 parameter 'CORESET-interleaver-size' (see 38.211, 38.213, section FFS_Section).
pdcch-DMRS-ScramblingID PDCCH DMRS scrambling initalization. Corresponds to L1 parameter 'PDCCH-DMRS-Scrambling-ID' (see 38.211, section 7.4.1). When the field is absent the UE applies the value of the *physCellId* configured for this serving cell.
precoderGranularity Precoder granularity in frequency domain. Corresponds to L1 parameter 'CORESET-precoder-granuality' (see 38.211, sections 7.3.2.2 and 7.4.1.3.2).
reg-BundleSize Resource Element Groups (REGs) can be bundled to create REG bundles. This parameter defines the size of such bundles. Corresponds to L1 parameter 'CORESET-REG-bundle-size' (see 38.211, section FFS_Section).
shiftIndex Corresponds to L1 parameter 'CORESET-shift-index'. When the field is absent the UE applies the value of the *physCellId* configured for this serving cell (see 38.211, section 7.3.2.2).
tci-PresentInDCI If at least spatial QCL is configured/indicated, this field indicates if TCI field is present or not present in DL-related DCI. When the field is absent the UE considers the TCI to be absent/disabled. Corresponds to L1 parameter 'TCI-PresentInDCI' (see 38,213, section 5.1.5).
tci-StatesPDCCH-ToAddList, tci-StatesPDCCH-ToReleaseList A subset of the TCI states defined in TCI-States used for providing QCL relationships between the DL RS(s) in one RS Set (TCI-State) and the PDCCH DMRS ports. Corresponds to L1 parameter 'TCI-StatesPDCCH' (see 38.213, section10.). The network configures at most *maxNrofTCI-StatesPDCCH* entries.

– *ControlResourceSetId*

The *ControlResourceSetId* IE concerns a short identity, used to identify a control resource set within a serving cell. The *ControlResourceSetId* = 0 identifies the ControlResourceSet configured via PBCH (MIB) and in ServingCellConfigCommon. The ID space is used across the BWPs of a Serving Cell. The number of CORESETs per BWP is limited to 3 (including the initial CORESET).

***ControlResourceSetId* information element**

```
-- ASN1START
```

```
-- TAG-CONTROL-RESOURCE-SET-ID-START

ControlResourceSetId ::=                INTEGER (0..maxNrofControlResourceSets-1)

-- TAG-CONTROL-RESOURCE-SET-ID-STOP
-- ASN1STOP
```

– *CrossCarrierSchedulingConfig*

The IE *CrossCarrierSchedulingConfig* is used to specify the configuration when the cross-carrier scheduling is used in a cell.

CrossCarrierSchedulingConfig information elements

```
-- ASN1START

CrossCarrierSchedulingConfig ::=        SEQUENCE {
    schedulingCellInfo                      CHOICE {
        own                                     SEQUENCE {                  -- No cross carrier scheduling
            cif-Presence                            BOOLEAN
        },
        other                                   SEQUENCE {                  -- Cross carrier scheduling
            schedulingCellId                        ServCellIndex,
            cif-InSchedulingCell                    INTEGER (1..7)
        }                                                                   -- Cond SCellOnly
    },
    ...
}

-- ASN1STOP
```

***CrossCarrierSchedulingConfig* field descriptions**
cif-Presence The field is used to indicate whether carrier indicator field is present (value TRUE) or not (value FALSE) in PDCCH/EPDCCH DCI formats, see TS 38.213 [REF, SECTION].
cif-InSchedulingCell The field indicates the CIF value used in the scheduling cell to indicate a grant or assignment applicable for this cell, see TS 38.213 [REF, SECTION]. If *cif-Presence* is set to true, the CIF value indicating a grant or assignment for this cell is 0.
pdsch-Start The starting OFDM symbol of PDSCH for the concerned SCell, see TS [REF]. Values 1, 2, 3 are applicable when *dl-Bandwidth* for the concerned SCell is greater than 10 resource blocks, values 2, 3, 4 are applicable when *dl-Bandwidth* for the concerned SCell is less than or equal to 10 resource blocks, see TS [REF].
schedulingCellId Indicates which cell signals the downlink allocations and uplink grants, if applicable, for the concerned SCell. In case the UE is configured with DC, the scheduling cell is part of the same cell group (i.e. MCG or SCG) as the scheduled cell.

Conditional Presence	Explanation
SCellOnly	This field is optionally present, Need M, for SCells. It is absent otherwise

– *CSI-AperiodicTriggerStateList*

The *CSI-AperiodicTriggerStateList* IE is used to configure the UE with a list of aperiodic trigger states. Each codepoint of the DCI field "CSI request" is associated with one trigger state. Upon reception of the value associated with a trigger state, the UE will perform measurement of aperiodic CSI-RS (reference signals) and aperiodic reporting on L1 according to all entries in the *associatedReportConfigInfoList* for that trigger state.

***CSI-AperiodicTriggerStateList* information element**

```
-- ASN1START
-- TAG-CSI-APERIODICTRIGGERSTATELIST-START

CSI-AperiodicTriggerStateList ::=   SEQUENCE (SIZE (1..maxNrOfCSI-AperiodicTriggers)) OF CSI-AperiodicTriggerState

CSI-AperiodicTriggerState ::=       SEQUENCE {
    associatedReportConfigInfoList      SEQUENCE (SIZE(1..maxNrofReportConfigPerAperiodicTrigger)) OF CSI-AssociatedReportConfigInfo,
    ...
}

CSI-AssociatedReportConfigInfo ::=      SEQUENCE {
    reportConfigId                      CSI-ReportConfigId,
    resourcesForChannel                 CHOICE {
        nzp-CSI-RS                          SEQUENCE {
            resourceSet                         INTEGER (1..maxNrofNZP-CSI-RS-ResourceSetsPerConfig),
            qcl-info                            SEQUENCE (SIZE(1..maxNrofAP-CSI-RS-ResourcesPerSet)) OF TCI-StateId OPTIONAL -- Cond Aperiodic
        },
        csi-SSB-ResourceSet                 INTEGER (1..maxNrofCSI-SSB-ResourceSetsPerConfig)
    },
    csi-IM-ResourcesforInteference      INTEGER(1..maxNrofCSI-IM-ResourceSetsPerConfig)         OPTIONAL, -- Cond CSI-IM-forInterference
    nzp-CSI-RS-ResourcesforInterference INTEGER (1..maxNrofNZP-CSI-RS-ResourceSetsPerConfig)    OPTIONAL, -- Cond NZP-CSI-RS-forInterference
    ...
}

-- TAG-CSI-APERIODICTRIGGERSTATELIST-STOP
-- ASN1STOP
```

CSI-AssociatedReportConfigInfo field descriptions
csi-IM-ResourcesforInteference CSI-IM-ResourceSet for interference measurement. Entry number in csi-IM-ResourceSetList in the CSI-ResourceConfig indicated by csi-IM-ResourcesForInterference in the CSI-ReportConfig indicated by reportConfigId above (1 corresponds to the first entry, 2 to the second entry, and so on). The indicated CSI-IM-ResourceSet should have exactly the same number of resources like the NZP-CSI-RS-ResourceSet indicated in nzp-CSI-RS-ResourcesforChannel.
csi-SSB-ResourceSet CSI-SSB-ResourceSet for channel measurements. Entry number in csi-SSB-ResourceSetList in the CSI-ResourceConfig indicated by resourcesForChannelMeasurement in the CSI-ReportConfig indicated by reportConfigId above (1 corresponds to the first entry, 2 to the second entry, and so on).
nzp-CSI-RS-ResourcesforInterference NZP-CSI-RS-ResourceSet for interference measurement. Entry number in nzp-CSI-RS-ResourceSetList in the CSI-ResourceConfig indicated by nzp-CSI-RS-ResourcesForInterference in the CSI-ReportConfig indicated by reportConfigId above (1 corresponds to the first entry, 2 to the second entry, and so on). The indicated NZP-CSI-RS-ResourceSet should have exactly the same number of resources like the NZP-CSI-RS-ResourceSet indicated in nzp-CSI-RS-ResourcesforChannel.
qcl-info List of references to TCI-States for providing the QCL source and QCL type for for each NZP-CSI-RS-Resource listed in nzp-CSI-RS-Resources of the NZP-CSI-RS-ResourceSet indicated by nzp-CSI-RS-ResourcesforChannel. Each *TCI-StateId* refers to the TCI-State which has this value for *tci-StateId* and is defined in *tci-StatesToAddModList* in the *PDSCH-Config* included in the *BWP-Downlink* corresponding to the serving cell and to the DL BWP to which the *resourcesForChannelMeasurement* (in the *CSI-ReportConfig* indicated by *reportConfigId* above) belong to. First entry in qcl-info-forChannel corresponds to first entry in nzp-CSI-RS-Resources of that NZP-CSI-RS-ResourceSet, second entry in qcl-info-forChannel corresponds to second entry in nzp-CSI-RS-Resources, and so on. Corresponds to L1 parameter 'QCL-Info-aPeriodicReportingTrigger' (see 38.214, section 5.2.1.5.1)
reportConfigId The reportConfigId of one of the CSI-ReportConfigToAddMod configured in CSI-MeasConfig
resourceSet NZP-CSI-RS-ResourceSet for channel measurements. Entry number in nzp-CSI-RS-ResourceSetList in the CSI-ResourceConfig indicated by resourcesForChannelMeasurement in the CSI-ReportConfig indicated by reportConfigId above (1 corresponds to the first entry, 2 to thesecond entry, and so on).

Conditional Presence	Explanation
Aperiodic	The field is mandatory present if the *NZP-CSI-RS-Resources* in the associated *resourceSet* have the resourceType aperiodic. The field is absent otherwise.
CSI-IM-forInterference	This field is optional need M if the *CSI-ReportConfig* identified by *reportConfigId* is configured with *csi-IM-ResourcesForInterference*; otherwise it is absent.
NZP-CSI-RS-forInterference	This field is optional need M if the *CSI-ReportConfig* identified by *reportConfigId* is configured with *nzp-CSI-RS-ResourcesForInterference*; otherwise it is absent.

– *CSI-FrequencyOccupation*

The IE *CSI-FrequencyOccupation* is used to configure the frequency domain occupation of a channel state information measurement resource (e.g. *NZP-CSI-RS-Resource*, *CSI-IM-Resource*).

CSI-FrequencyOccupation information element

```
-- ASN1START
-- TAG-CSI-FREQUENCYOCCUPATION-START

CSI-FrequencyOccupation ::=         SEQUENCE {
    startingRB                          INTEGER (0..maxNrofPhysicalResourceBlocks-1),
```

```
    nrofRBs                         INTEGER (24..maxNrofPhysicalResourceBlocksPlus1),
    ...
}

-- TAG-CSI-FREQUENCYOCCUPATION-STOP
-- ASN1STOP
```

CSI-FrequencyOccupation field descriptions
nrofRBs
Number of PRBs across which this CSI resource spans. Only multiples of 4 are allowed. The smallest configurable number is the minimum of 24 and the width of the associated BWP. If the configured value is larger than the width of the corresponding BWP, the UE shall assume that the actual CSI-RS bandwidth is equal to the width of the BWP.
startingRB
PRB where this CSI resource starts in relation tocommon resource block #0 (CRB#0) on the common resource block grid. Only multiples of 4 are allowed (0, 4, ...)

– *CSI-IM-Resource*

The IE *CSI-IM-Resource* is used to configure one CSI Interference Management (IM) resource.

CSI-IM-Resource information element

```
-- ASN1START
-- TAG-CSI-IM-RESOURCE-START

CSI-IM-Resource ::=                 SEQUENCE {
    csi-IM-ResourceId                   CSI-IM-ResourceId,
    csi-IM-ResourceElementPattern           CHOICE {
        pattern0                                SEQUENCE {
            subcarrierLocation-p0                   ENUMERATED { s0, s2, s4, s6, s8, s10 },
            symbolLocation-p0                       INTEGER (0..12)
        },
        pattern1                                SEQUENCE {
            subcarrierLocation-p1                   ENUMERATED { s0, s4, s8 },
            symbolLocation-p1                       INTEGER (0..13)
        }
    }                                                                               OPTIONAL,   -- Need M
    freqBand                            CSI-FrequencyOccupation                     OPTIONAL,   -- Need M
    periodicityAndOffset                CSI-ResourcePeriodicityAndOffset            OPTIONAL,   -- Cond PeriodicOrSemiPersistent
    ...
}

-- TAG-CSI-IM-RESOURCE-STOP
-- ASN1STOP
```

CSI-IM-Resource field descriptions
csi-IM-ResourceElementPattern The resource element pattern (Pattern0 (2,2) or Pattern1 (4,1)) with corresponding parameters. Corresponds to L1 parameter 'CSI-IM-RE-pattern' (see 38.214, section 5.2.2.3.4)
freqBand Frequency-occupancy of CSI-IM. Corresponds to L1 parameter 'CSI-IM-FreqBand' (see 38.214, section 5.2.2.3.2)
periodicityAndOffset Periodicity and slot offset for periodic/semi-persistent CSI-IM. Corresponds to L1 parameter 'CSI-IM-timeConfig'
subcarrierLocation-p0 OFDM subcarrier occupancy of the CSI-IM resource for Pattern0. Corresponds to L1 parameter 'CSI-IM-ResourceMapping' (see 38.214, section 5.2.2.3.4)
subcarrierLocation-p1 OFDM subcarrier occupancy of the CSI-IM resource for Pattern1. Corresponds to L1 parameter 'CSI-IM-ResourceMapping' (see 38.214, section 5.2.2.3.4)
symbolLocation-p0 OFDM symbol location of the CSI-IM resource for Pattern0. Corresponds to L1 parameter 'CSI-IM-ResourceMapping' (see 38.214, section 5.2.2.3.4)
symbolLocation-p1 OFDM symbol location of the CSI-IM resource for Pattern1. Corresponds to L1 parameter 'CSI-IM-ResourceMapping' (see 38.214, section 5.2.2.3.4)

Conditional Presence	Explanation
PeriodicOrSemiPersistent	The field is mandatory present, Need M, for periodic and semi-persistent CSI-IM-Resources (as indicated in CSI-ResourceConfig). The field is absent otherwise.

– *CSI-IM-ResourceId*

The IE *CSI-IM-ResourceId* is used to identify one *CSI-IM-Resource*.

CSI-IM-ResourceId information element

```
-- ASN1START
-- TAG-CSI-IM-RESOURCEID-START

CSI-IM-ResourceId ::=               INTEGER (0..maxNrofCSI-IM-Resources-1)

-- TAG-CSI-IM-RESOURCEID-STOP
-- ASN1STOP
```

– *CSI-IM-ResourceSet*

The IE *CSI-IM-ResourceSet* is used to configure a set of one or more CSI Interference Management (IM) resources (their IDs) and set-specific parameters.

CSI-IM-ResourceSet information element

```
-- ASN1START
-- TAG-CSI-IM-RESOURCESET-START

CSI-IM-ResourceSet ::=              SEQUENCE {
```

```
    csi-IM-ResourceSetId                CSI-IM-ResourceSetId,
    csi-IM-Resources                    SEQUENCE (SIZE(1..maxNrofCSI-IM-ResourcesPerSet)) OF CSI-IM-ResourceId,
    ...
}
-- TAG-CSI-IM-RESOURCESET-STOP
-- ASN1STOP
```

CSI-IM-ResourceSet field descriptions
csi-IM-Resources
CSI-IM-Resources associated with this CSI-IM-ResourceSet. Corresponds to L1 parameter 'CSI-IM-ResourceConfigList' (see 38.214, section 5.2)

– *CSI-IM-ResourceSetId*

The IE *CSI-IM-ResourceSetId* is used to identify *CSI-IM-ResourceSet*s.

CSI-IM-ResourceSetId information element

```
-- ASN1START
-- TAG-CSI-IM-RESOURCESETID-START

CSI-IM-ResourceSetId ::=            INTEGER (0..maxNrofCSI-IM-ResourceSets-1)

-- TAG-CSI-IM-RESOURCESETID-STOP
-- ASN1STOP
```

– *CSI-MeasConfig*

The *CSI-MeasConfig* IE is used to configure CSI-RS (reference signals) belonging to the serving cell in which *CSI-MeasConfig* is included, channel state information reports to be transmitted on PUCCH on the serving cell in which *CSI-MeasConfig* is included and channel state information reports on PUSCH triggered by DCI received on the serving cell in which *CSI-MeasConfig* is included. See also 38.214, section 5.2.

CSI-MeasConfig information element

```
-- ASN1START
-- TAG-CSI-MEAS-CONFIG-START

CSI-MeasConfig ::=                  SEQUENCE {
    nzp-CSI-RS-ResourceToAddModList     SEQUENCE (SIZE (1..maxNrofNZP-CSI-RS-Resources)) OF NZP-CSI-RS-Resource            OPTIONAL, -- Need N
    nzp-CSI-RS-ResourceToReleaseList    SEQUENCE (SIZE (1..maxNrofNZP-CSI-RS-Resources)) OF NZP-CSI-RS-ResourceId          OPTIONAL, -- Need N
    nzp-CSI-RS-ResourceSetToAddModList  SEQUENCE (SIZE (1..maxNrofNZP-CSI-RS-ResourceSets)) OF NZP-CSI-RS-ResourceSet      OPTIONAL, -- Need N
    nzp-CSI-RS-ResourceSetToReleaseList SEQUENCE (SIZE (1..maxNrofNZP-CSI-RS-ResourceSets)) OF NZP-CSI-RS-ResourceSetId      OPTIONAL, -- Need N
    csi-IM-ResourceToAddModList         SEQUENCE (SIZE (1..maxNrofCSI-IM-Resources)) OF CSI-IM-Resource                  OPTIONAL, -- Need N
    csi-IM-ResourceToReleaseList        SEQUENCE (SIZE (1..maxNrofCSI-IM-Resources)) OF CSI-IM-ResourceId                OPTIONAL, -- Need N
    csi-IM-ResourceSetToAddModList      SEQUENCE (SIZE (1..maxNrofCSI-IM-ResourceSets)) OF CSI-IM-ResourceSet            OPTIONAL, -- Need N
    csi-IM-ResourceSetToReleaseList     SEQUENCE (SIZE (1..maxNrofCSI-IM-ResourceSets)) OF CSI-IM-ResourceSetId          OPTIONAL, -- Need N
    csi-SSB-ResourceSetToAddModList     SEQUENCE (SIZE (1..maxNrofCSI-SSB-ResourceSets)) OF CSI-SSB-ResourceSet          OPTIONAL, -- Need N
    csi-SSB-ResourceSetToAddReleaseList SEQUENCE (SIZE (1..maxNrofCSI-SSB-ResourceSets)) OF CSI-SSB-ResourceSetId       OPTIONAL, -- Need N
```

```
    csi-ResourceConfigToAddModList      SEQUENCE (SIZE (1..maxNrofCSI-ResourceConfigurations)) OF CSI-ResourceConfig        OPTIONAL, -- Need N
    csi-ResourceConfigToReleaseList     SEQUENCE (SIZE (1..maxNrofCSI-ResourceConfigurations)) OF CSI-ResourceConfigId      OPTIONAL, -- Need N
    csi-ReportConfigToAddModList        SEQUENCE (SIZE (1..maxNrofCSI-ReportConfigurations)) OF CSI-ReportConfig         OPTIONAL, -- Need N
    csi-ReportConfigToReleaseList       SEQUENCE (SIZE (1..maxNrofCSI-ReportConfigurations)) OF CSI-ReportConfigId          OPTIONAL, -- Need N

    reportTriggerSize                   INTEGER (0..6)                                                                  OPTIONAL,
    aperiodicTriggerStateList           SetupRelease { CSI-AperiodicTriggerStateList }                                  OPTIONAL, -- Need M
    semiPersistentOnPUSCH-TriggerStateList          SetupRelease { CSI-SemiPersistentOnPUSCH-TriggerStateList }             OPTIONAL, -- Need M
    ...
}

-- TAG-CSI-MEAS-CONFIG-STOP
-- ASN1STOP
```

CSI-MeasConfig field descriptions
aperiodicTriggerStateList Contains trigger states for dynamically selecting one or more aperiodic and semi-persistent reporting configurations and/or triggering one or more aperiodic CSI-RS resource sets for channel and/or interference measurement. FFS: How to address the MAC-CE configuration
csi-IM-ResourceSetToAddModList Pool of CSI-IM-ResourceSet which can be referred to from CSI-ResourceConfig or from MAC CEs
csi-IM-ResourceToAddModList Pool of CSI-IM-Resource which can be referred to from CSI-IM-ResourceSet
csi-ReportConfigToAddModList Configured CSI report settings as specified in TS 38.214 section 5.2.1.1
csi-ResourceConfigToAddModList Configured CSI resource settings as specified in TS 38.214 section 5.2.1.2
csi-SSB-ResourceSetToAddModList Pool of CSI-SSB-ResourceSet which can be referred to from CSI-ResourceConfig
nzp-CSI-RS-ResourceSetToAddModList Pool of NZP-CSI-RS-ResourceSet which can be referred to from CSI-ResourceConfig or from MAC CEs
nzp-CSI-RS-ResourceToAddModList Pool of NZP-CSI-RS-Resource which can be referred to from NZP-CSI-RS-ResourceSet
reportTriggerSize Size of CSI request field in DCI (bits). Corresponds to L1 parameter 'ReportTriggerSize' (see 38.214, section 5.2)

– *CSI-ReportConfig*

The IE *CSI-ReportConfig* is used to configure a periodic or semi-persistent report sent on PUCCH on the cell in which the *CSI-ReportConfig* is included, or to configure a semi-persistent or aperiodic report sent on PUSCH triggered by DCI received on the cell in which the CSI-ReportConfig is included (in this case, the cell on which the report is sent is determined by the received DCI). See 38.214, section 5.2.1.

CSI-ReportConfig information element

```
-- ASN1START
-- TAG-CSI-REPORTCONFIG-START

CSI-ReportConfig ::=                SEQUENCE {
```

```
    reportConfigId                          CSI-ReportConfigId,
    carrier                                 ServCellIndex                   OPTIONAL,   -- Need S
    resourcesForChannelMeasurement          CSI-ResourceConfigId,
    csi-IM-ResourcesForInterference         CSI-ResourceConfigId        OPTIONAL,   -- Need R
    nzp-CSI-RS-ResourcesForInterference     CSI-ResourceConfigId        OPTIONAL,   -- Need R
    reportConfigType                        CHOICE {
        periodic                                SEQUENCE {
            reportSlotConfig                        CSI-ReportPeriodicityAndOffset,
            pucch-CSI-ResourceList                  SEQUENCE (SIZE (1..maxNrofBWPs)) OF PUCCH-CSI-Resource
        },
        semiPersistentOnPUCCH                   SEQUENCE {
            reportSlotConfig                        CSI-ReportPeriodicityAndOffset,
            pucch-CSI-ResourceList                  SEQUENCE (SIZE (1..maxNrofBWPs)) OF PUCCH-CSI-Resource
        },
        semiPersistentOnPUSCH                   SEQUENCE {
            reportSlotConfig                        ENUMERATED {sl5, sl10, sl20, sl40, sl80, sl160, sl320},
            reportSlotOffsetList                SEQUENCE (SIZE (1.. maxNrofUL-Allocations)) OF INTEGER(0..32),
            p0alpha                                 P0-PUSCH-AlphaSetId
        },
        aperiodic                               SEQUENCE {
            reportSlotOffsetList                SEQUENCE (SIZE (1..maxNrofUL-Allocations)) OF INTEGER(0..32)
        }
    },
    reportQuantity                          CHOICE {
        none                                    NULL,
        cri-RI-PMI-CQI                          NULL,
        cri-RI-i1                               NULL,
        cri-RI-i1-CQI                           SEQUENCE {
            pdsch-BundleSizeForCSI                  ENUMERATED {n2, n4}     OPTIONAL
        },
        cri-RI-CQI                              NULL,
        cri-RSRP                                NULL,
        ssb-Index-RSRP                          NULL,
        cri-RI-LI-PMI-CQI                       NULL
    },
    reportFreqConfiguration                  SEQUENCE {
        cqi-FormatIndicator                     ENUMERATED { widebandCQI, subbandCQI }                          OPTIONAL,   -- Need R
        pmi-FormatIndicator                     ENUMERATED { widebandPMI, subbandPMI }                          OPTIONAL,   -- Need R
        csi-ReportingBand                       CHOICE {
            subbands3                               BIT STRING(SIZE(3)),
            subbands4                               BIT STRING(SIZE(4)),
            subbands5                               BIT STRING(SIZE(5)),
            subbands6                               BIT STRING(SIZE(6)),
            subbands7                               BIT STRING(SIZE(7)),
            subbands8                               BIT STRING(SIZE(8)),
            subbands9                               BIT STRING(SIZE(9)),
            subbands10                              BIT STRING(SIZE(10)),
            subbands11                              BIT STRING(SIZE(11)),
            subbands12                              BIT STRING(SIZE(12)),
            subbands13                              BIT STRING(SIZE(13)),
            subbands14                              BIT STRING(SIZE(14)),
            subbands15                              BIT STRING(SIZE(15)),
            subbands16                              BIT STRING(SIZE(16)),
            subbands17                              BIT STRING(SIZE(17)),
```

```
            subbands18                          BIT STRING(SIZE(18)),
            ...
        }   OPTIONAL    -- Need S

    }                                                                                                   OPTIONAL,   -- Need R
    timeRestrictionForChannelMeasurements               ENUMERATED {configured, notConfigured},
    timeRestrictionForInterferenceMeasurements          ENUMERATED {configured, notConfigured},
    codebookConfig                              CodebookConfig                                          OPTIONAL,   -- Need R
    nrofCQIsPerReport                           ENUMERATED {n1, n2}                                     OPTIONAL,   -- Need R
    groupBasedBeamReporting                     CHOICE {
        enabled                                     NULL,
        disabled                                    SEQUENCE {
            nrofReportedRS                          ENUMERATED {n1, n2, n3, n4}                             OPTIONAL -- Need S
        }
    },
    cqi-Table                           ENUMERATED {table1, table2, spare2, spare1}                     OPTIONAL,   -- Need R
    subbandSize                         ENUMERATED {value1, value2},
    non-PMI-PortIndication              SEQUENCE (SIZE (1..maxNrofNZP-CSI-RS-ResourcesPerConfig)) OF PortIndexFor8Ranks OPTIONAL,   -- Need R
    ...
}

CSI-ReportPeriodicityAndOffset ::=  CHOICE {
    slots4                              INTEGER(0..3),
    slots5                              INTEGER(0..4),
    slots8                              INTEGER(0..7),
    slots10                             INTEGER(0..9),
    slots16                             INTEGER(0..15),
    slots20                             INTEGER(0..19),
    slots40                             INTEGER(0..39),
    slots80                             INTEGER(0..79),
    slots160                            INTEGER(0..159),
    slots320                            INTEGER(0..319)
}

PUCCH-CSI-Resource ::=              SEQUENCE {
    uplinkBandwidthPartId               BWP-Id,
    pucch-Resource                      PUCCH-ResourceId
}

PortIndexFor8Ranks ::=              CHOICE {
    portIndex8                          SEQUENCE{
        rank1-8                             PortIndex8                                      OPTIONAL,   -- Need R
        rank2-8                             SEQUENCE(SIZE(2)) OF PortIndex8                 OPTIONAL,   -- Need R
        rank3-8                             SEQUENCE(SIZE(3)) OF PortIndex8                 OPTIONAL,   -- Need R
        rank4-8                             SEQUENCE(SIZE(4)) OF PortIndex8                 OPTIONAL,   -- Need R
        rank5-8                             SEQUENCE(SIZE(5)) OF PortIndex8                 OPTIONAL,   -- Need R
        rank6-8                             SEQUENCE(SIZE(6)) OF PortIndex8                 OPTIONAL,   -- Need R
        rank7-8                             SEQUENCE(SIZE(7)) OF PortIndex8                 OPTIONAL,   -- Need R
        rank8-8                             SEQUENCE(SIZE(8)) OF PortIndex8                 OPTIONAL -- Need R
    },
    portIndex4                          SEQUENCE{
        rank1-4                             PortIndex4                                      OPTIONAL,   -- Need R
        rank2-4                             SEQUENCE(SIZE(2)) OF PortIndex4                 OPTIONAL,   -- Need R
        rank3-4                             SEQUENCE(SIZE(3)) OF PortIndex4                 OPTIONAL,   -- Need R
```

```
        rank4-4                         SEQUENCE(SIZE(4)) OF PortIndex4                 OPTIONAL -- Need R
    },
    portIndex2                      SEQUENCE{
        rank1-2                         PortIndex2                                      OPTIONAL,   -- Need R
        rank2-2                         SEQUENCE(SIZE(2)) OF PortIndex2                 OPTIONAL -- Need R
    },
    portIndex1                      NULL
}

PortIndex8::=                   INTEGER (0..7)
PortIndex4::=                   INTEGER (0..3)
PortIndex2::=                   INTEGER (0..1)

-- TAG-CSI-REPORTCONFIG-STOP
-- ASN1STOP
```

CSI-ReportConfig field descriptions
carrier Indicates in which serving cell the CSI-ResourceConfig indicated below are to be found. If the field is absent, the resources are on the same serving cell as this report configuration.
codebookConfig Codebook configuration for Type-1 or Type-II including codebook subset restriction
cqi-FormatIndicator Indicates whether the UE shall report a single (wideband) or multiple (subband) CQI. (see 38.214, section 5.2.1.4)
cqi-Table Which CQI table to use for CQI calculation. Corresponds to L1 parameter 'CQI-table' (see 38.214, section 5.2.2.1)
csi-IM-ResourcesForInterference CSI IM resources for interference measurement. csi-ResourceConfigId of a CSI-ResourceConfig included in the configuration of the serving cell indicated with the field "carrier" above. The bwp-Id in that CSI-ResourceConfigToAddMod is the same value like the bwp-Id in the CSI-ResourceConfig indicated by resourcesForChannelMeasurement.
csi-ReportingBand Indicates a contiguous or non-contigous subset of subbands in the bandwidth part which CSI shall be reported for. Each bit in the bit-string represents one subband. The right-most bit in the bit string represents the lowest subband in the BWP. (see 38.214, section 5.2.1.4) The number of subbands is determined according to 38.214 section 5.2.1.4. It is absent if there are less than 24 PRBs (no sub band) and present otherwise, the number of sub bands can be from 3 (24 PRBs, sub band size 8) to 18 (72 PRBs, sub band size 4).
groupBasedBeamReporting Turning on/off group beam based reporting (see 38.214, section 5.2.1.4)
non-PMI-PortIndication Port indication for RI/CQI calculation. For each CSI-RS resource in the linked ResourceConfig for channel measurement, a port indication for each rank R, indicating which R ports to use. Applicable only for non-PMI feedback. Corresponds to L1 parameter 'Non-PMI-PortIndication' (see 38.214, section FFS_Section). The first entry in non-PMI-PortIndication corresponds to the NZP-CSI-RS-Resource indicated by the first entry in nzp-CSI-RS-Resources in the NZP-CSI-RS-ResourceSet indicated in the first entry of nzp-CSI-RS-ResourceSetList of the CSI-ResourceConfig whose CSI-ResourceConfigId is indicated in a CSI-MeasId together with the above CSI-ReportConfigId; the second entry in non-PMI-PortIndication corresponds to the NZP-CSI-RS-Resource indicated by the second entry in nzp-CSI-RS-Resources in the NZP-CSI-RS-ResourceSet indicated in the first entry of nzp-CSI-RS-ResourceSetList of the same CSI-ResourceConfig, and so on until the NZP-CSI-RS-Resource indicated by the last entry in nzp-CSI-RS-Resources in the in the NZP-CSI-RS-ResourceSet indicated in the first entry of nzp-CSI-RS-ResourceSetList of the same CSI-ResourceConfig. Then the next entry corresponds to the NZP-CSI-RS-Resource indicated by the first entry in nzp-CSI-RS-Resources in the NZP-CSI-RS-ResourceSet indicated in the second entry of nzp-CSI-RS-ResourceSetList of the same CSI-ResourceConfig and so on.
nrofCQIsPerReport Maximum number of CQIs per CSI report (cf. 1 for 1-CW, 2 for 2-CW)
nrofReportedRS The number (N) of measured RS resources to be reported per report setting in a non-group-based report. N <= N_max, where N_max is either 2 or 4 depending on UE capability. FFS: The signaling mechanism for the gNB to select a subset of N beams for the UE to measure and report. FFS: Note: this parameter may not be needed for certain resource and/or report settings FFS_ASN1: Change groupBasedBeamReporting into a CHOICE and include this field into the "no" option? (see 38.214, section FFS_Section) When the field is absent the UE applies the value 1
nzp-CSI-RS-ResourcesForInterference NZP CSI RS resources for interference measurement. csi-ResourceConfigId of a CSI-ResourceConfigToAddMod included in the configuration of the serving cell indicated with the field "carrier" above. The bwp-Id in that CSI-ResourceConfigToAddMod is the same value like the bwp-Id in the CSI-ResourceConfigToAddMod indicated by resourcesForChannelMeasurement.
p0alpha Index of the p0-alpha set determining the power control for this CSI report transmission. Corresponds to L1 parameter 'SPCSI-p0alpha' (see 38.214, section FFS_Section)
pdsch-BundleSizeForCSI PRB bundling size to assume for CQI calcuation when reportQuantity is CRI/RI/i1/CQI. Corresponds to L1 parameter 'PDSCH-bundle-size-for-CSI' (see 38.214, section 5.2.1.4)

pmi-FormatIndicator Indicates whether the UE shall report a single (wideband) or multiple (subband) PMI. (see 38.214, section 5.2.1.4)
pucch-CSI-ResourceList Indicates which PUCCH resource to use for reporting on PUCCH.
reportConfigType Time domain behavior of reporting configuration
reportFreqConfiguration Reporting configuration in the frequency domain. (see 38.214, section 5.2.1.4)
reportQuantity The CSI related quanities to report. Corresponds to L1 parameter 'ReportQuantity' (see 38.214, section REF)
reportSlotConfig Periodicity and slot offset. Corresponds to L1 parameter 'ReportPeriodicity'and 'ReportSlotOffset' (see 38.214, section section 5.2.1.4) as well as to L1 parameter 'Reportperiodicity-spCSI'. (see 38.214, section 5.2.1.1?FFS_Section)
reportSlotOffsetList Timing offset Y for semi persistent reporting using PUSCH. This field lists the allowed offset values. This list must have the same number of entries as the *pusch-TimeDomainAllocationList* in *PUSCH-Config*. A particular value is indicated in DCI. The network indicates in the DCI field of the UL grant, which of the configured report slot offsets the UE shall apply. The DCI value 0 corresponds to the first report slot offset in this list, the DCI value 1 corresponds to the second report slot offset in this list, and so on. The first report is transmitted in slot n+Y, second report in n+Y+P, where P is the configured periodicity. Timing offset Y for aperiodic reporting using PUSCH. This field lists the allowed offset values. This list must have the same number of entries as the *pusch-TimeDomainAllocationList* in *PUSCH-Config*. A particular value is indicated in DCI. The network indicates in the DCI field of the UL grant, which of the configured report slot offsets the UE shall apply. The DCI value 0 corresponds to the first report slot offset in this list, the DCI value 1 corresponds to the second report slot offset in this list, and so on (see 38.214, section 5.2.3).
resourcesForChannelMeasurement Resources for channel measurement. csi-ResourceConfigId of a CSI-ResourceConfig included in the configuration of the serving cell indicated with the field "carrier" above. This CSI-ReportConfig is associated with the DL BWP indicated by bwp-Id in that CSI-ResourceConfig.
subbandSize Indicates one out of two possible BWP-dependent values for the subband size as indicated in 38.214 table 5.2.1.4-2 Corresponds to L1 parameter 'SubbandSize' (see 38.214, section 5.2.1.4)
timeRestrictionForChannelMeasurements Time domain measurement restriction for the channel (signal) measurements. Corresponds to L1 parameter 'MeasRestrictionConfig-time-channel' (see 38.214, section 5.2.1.1)
timeRestrictionForInterferenceMeasurements Time domain measurement restriction for interference measurements. Corresponds to L1 parameter 'MeasRestrictionConfig-time-interference' (see 38.214, section 5.2.1.1)

PortIndexFor8Ranks field descriptions
portIndex8 Port-Index configuration for up to rank 8. If present, the network configures port indexes for at least one of the ranks.
portIndex4 Port-Index configuration for up to rank 4. If present, the network configures port indexes for at least one of the ranks.
portIndex2 Port-Index configuration for up to rank 2. If present, the network configures port indexes for at least one of the ranks.
portIndex1 Port-Index configuration for rank 1.

PUCCH-CSI-Resource field descriptions
pucch-Resource PUCCH resource for the associated uplink BWP. Only PUCCH-Resource of format 2, 3 and 4 is supported. The actual PUCCH-Resource is configured in *PUCCH-Config* and referred to by its ID.

– *CSI-ReportConfigId*

The IE *CSI-ReportConfigId* is used to identify one *CSI-ReportConfig*.

CSI-ReportConfigId information element

```
-- ASN1START
-- TAG-CSI-REPORTCONFIGID-START

CSI-ReportConfigId ::=              INTEGER (0..maxNrofCSI-ReportConfigurations-1)

-- TAG-CSI-REPORTCONFIGID-STOP
-- ASN1STOP
```

– *CSI-ResourceConfig*

The IE *CSI-ResourceConfig* defines a group of one or more *NZP-CSI-RS-ResourceSet*, *CSI-IM-ResourceSet* and/or *CSI-SSB-ResourceSet*.

CSI-ResourceConfig information element

```
-- ASN1START
-- TAG-CSI-RESOURCECONFIG-START

CSI-ResourceConfig ::=              SEQUENCE {
    csi-ResourceConfigId                CSI-ResourceConfigId,
    csi-RS-ResourceSetList              CHOICE {
        nzp-CSI-RS-SSB                      SEQUENCE {
            nzp-CSI-RS-ResourceSetList          SEQUENCE (SIZE (1..maxNrofNZP-CSI-RS-ResourceSetsPerConfig)) OF NZP-CSI-RS-ResourceSetId OPTIONAL,
            csi-SSB-ResourceSetList             SEQUENCE (SIZE (1..maxNrofCSI-SSB-ResourceSetsPerConfig)) OF CSI-SSB-ResourceSetIdOPTIONAL
        },
        csi-IM-ResourceSetList              SEQUENCE (SIZE (1..maxNrofCSI-IM-ResourceSetsPerConfig)) OF CSI-IM-ResourceSetId
    },

    bwp-Id                              BWP-Id,
    resourceType                        ENUMERATED { aperiodic, semiPersistent, periodic },
    ...
}

-- TAG-CSI-RESOURCECONFIGTOADDMOD-STOP
-- ASN1STOP
```

CSI-ResourceConfig field descriptions
bwp-Id The DL BWP which the CSI-RS associated with this CSI-ResourceConfig are located in. Corresponds to L1 parameter 'BWP-Info' (see 38.214, section 5.2.1.2
csi-ResourceConfigId Used in CSI-ReportConfig to refer to an instance of CSI-ResourceConfig
csi-RS-ResourceSetList Contains up to maxNrofNZP-CSI-RS-ResourceSetsPerConfig resource sets if ResourceConfigType is 'aperiodic' and 1 otherwise. Corresponds to L1 parameter 'ResourceSetConfigList' (see 38.214, section 5.2.1.3.1)
csi-SSB-ResourceSetList List of SSB resources used for beam measurement and reporting in a resource set Corresponds to L1 parameter 'resource-config-SS-list' (see 38,214, section FFS_Section)
resourceType Time domain behavior of resource configuration. Corresponds to L1 parameter 'ResourceConfigType' (see 38.214, section 5.2.2.3.5)

– *CSI-ResourceConfigId*

The IE *CSI-ResourceConfigId* is used to identify a CSI-ResourceConfig.

CSI-ResourceConfigId information element

```
-- ASN1START
-- TAG-CSI-RESOURCECONFIGID-START

CSI-ResourceConfigId ::=            INTEGER (0..maxNrofCSI-ResourceConfigurations-1)

-- TAG-CSI-RESOURCECONFIGID-STOP
-- ASN1STOP
```

– *CSI-ResourcePeriodicityAndOffset*

The IE *CSI-ResourcePeriodicityAndOffset* is used to configure a periodicity and a corresponding offset for periodic and semi-persistent CSI resources, and for periodic and semi-persistent reporting on PUCCH. both, the periodicity and the offset are given in number of slots. The periodicity value slots4 corresponds to 4 slots, slots5 corresponds to 5 slots, and so on.

CSI-ResourcePeriodicityAndOffset information element

```
-- ASN1START
-- TAG-CSI-RESOURCEPERIODICITYANDOFFSET-START

CSI-ResourcePeriodicityAndOffset ::=    CHOICE {
    slots4                              INTEGER (0..3),
    slots5                              INTEGER (0..4),
    slots8                              INTEGER (0..7),
    slots10                             INTEGER (0..9),
    slots16                             INTEGER (0..15),
    slots20                             INTEGER (0..19),
    slots32                             INTEGER (0..31),
    slots40                             INTEGER (0..39),
```

```
    slots64                             INTEGER (0..63),
    slots80                             INTEGER (0..79),
    slots160                            INTEGER (0..159),
    slots320                            INTEGER (0..319),
    slots640                            INTEGER (0..639)
}

-- TAG-CSI-RESIYRCEPERIODICITYANDOFFSET-STOP
-- ASN1STOP
```

– *CSI-RS-ResourceConfigMobility*

The IE *CSI-RS-ResourceConfigMobility* is used to configure CSI-RS based RRM measurements.

CSI-RS-ResourceConfigMobility information element

```
-- ASN1START
-- TAG-CSI-RS-RESOURCECONFIGMOBILITY-START

CSI-RS-ResourceConfigMobility ::=   SEQUENCE {
    subcarrierSpacing                   SubcarrierSpacing,
    csi-RS-CellList-Mobility            SEQUENCE (SIZE (1..maxNrofCSI-RS-CellsRRM)) OF CSI-RS-CellMobility,
    ...
}

CSI-RS-CellMobility ::=             SEQUENCE {
    cellId                              PhysCellId,
    csi-rs-MeasurementBW                SEQUENCE {
        nrofPRBs                            ENUMERATED { size24, size48, size96, size192, size264},
        startPRB                            INTEGER(0..2169)
    },
    density                             ENUMERATED {d1,d3}                                          OPTIONAL,
    csi-rs-ResourceList-Mobility        SEQUENCE (SIZE (1..maxNrofCSI-RS-ResourcesRRM)) OF CSI-RS-Resource-Mobility
}

CSI-RS-Resource-Mobility ::=        SEQUENCE {
    csi-RS-Index                        CSI-RS-Index,
    slotConfig                          CHOICE {
        ms4                                 INTEGER (0..31),
        ms5                                 INTEGER (0..39),
        ms10                                INTEGER (0..79),
        ms20                                INTEGER (0..159),
        ms40                                INTEGER (0..319)
    },
    associatedSSB                       SEQUENCE {
        ssb-Index                           SSB-Index,
        isQuasiColocated                    BOOLEAN
    }                                                                                               OPTIONAL, -- Need R
    frequencyDomainAllocation           CHOICE {
        row1                                BIT STRING (SIZE (4)),
        row2                                BIT STRING (SIZE (12))
    },
    firstOFDMSymbolInTimeDomain         INTEGER (0..13),
    sequenceGenerationConfig            INTEGER (0..1023),
```

```
    ...
}

CSI-RS-Index ::=                    INTEGER (0..maxNrofCSI-RS-ResourcesRRM-1)

-- TAG-CSI-RS-RESOURCECONFIGMOBILITY-STOP
-- ASN1STOP
```

CSI-RS-CellMobility field descriptions
csi-rs-ResourceList-Mobility List of CSI-RS resources for mobility. The maximum number of CSI-RS resources that can be configured per frequency layer depends on the configuration of *associatedSSB* (see 38.214, section 5.1.6.1.3).
density Frequency domain density for the 1-port CSI-RS for L3 mobility Corresponds to L1 parameter 'Density' (see FFS_Spec, section FFS_Section).
nrofPRBs Allowed size of the measurement BW in PRBs Corresponds to L1 parameter 'CSI-RS-measurementBW-size' (see FFS_Spec, section FFS_Section).
startPRB Starting PRB index of the measurement bandwidth Corresponds to L1 parameter 'CSI-RS-measurement-BW-start' (see FFS_Spec, section FFS_Section) FFS_Value: Upper edge of value range unclear in RAN1.

CSI-RS-ResourceConfigMobility field descriptions
csi-RS-CellList-Mobility List of cells
subcarrierSpacing Subcarrier spacing of CSI-RS. Only the values 15, 30 or 60 kHz (<6GHz), 60 or 120 kHz (>6GHz) are applicable. Corresponds to L1 parameter 'Numerology' (see 38.211, section FFS_Section).

CSI-RS-Resource-Mobility field descriptions
associatedSSB If this field is present, the UE may base the timing of the CSI-RS resource indicated in *CSI-RS-Resource-Mobility* on the timing of the cell indicated by the *cellId* in the *CSI-RS-CellMobility*. In this case,the UE is not required to monitor that CSI-RS resource if the UE can't detect the SS/PBCH block indicated by this *associatedSSB*and*cellId*. If this field is absent, the UE shall base the timing of the CSI-RS resource indicated in *CSI-RS-Resource-Mobility*on the timing of the serving cell. In this case, the UE is required to measure the CSI-RS resource even if SS/PBCH block(s) with *cellId*in the *CSI-RS-CellMobility*are not detected. CSI-RS resources with and without *associatedSSB* may be configured in accordance with the rules in 38.214, section 5.1.6.1.3.
csi-RS-Index CSI-RS resource index associated to the CSI-RS resource to be measured (and used for reporting).
firstOFDMSymbolInTimeDomain Time domain allocation within a physical resource block. The field indicates the first OFDM symbol in the PRB used for CSI-RS. Parameter l0 in 38.211, section 7.4.1.5.3. Value 2 is supported only when DL-DMRS-typeA-pos equals 3.
frequencyDomainAllocation Frequency domain allocation within a physical resource block in accordance with 38.211, section 7.4.1.5.3 including table 7.4.1.5.2-1. The number of bits that may be set to one depend on the chosen row in that table. For the choice "other", the row can be determined from the parmeters below and from the number of bits set to 1 in frequencyDomainAllocation.
isQuasiColocated The CSI-RS resource is either QCL'ed not QCL'ed with the associated SSB in spatial parameters Corresponds to L1 parameter 'QCLed-SSB' (see FFS_Spec, section FFS_Section).
sequenceGenerationConfig Scrambling ID for CSI-RS (see 38.211, section 7.4.1.5.2).
slotConfig Indicates the CSI-RS periodicity (in milliseconds) and for each periodicity the offset (in number of slots). When subcarrierSpacingCSI-RS is set to 15kHZ, the maximum offset values for periodicities ms4/ms5/ms10/ms20/ms40 are 3/4/9/19/39 slots. When subcarrierSpacingCSI-RS is set to 30kHZ, the maximum offset values for periodicities ms4/ms5/ms10/ms20/ms40 are 7/9/19/39/79 slots. When subcarrierSpacingCSI-RS is set to 60kHZ, the maximum offset values for periodicities ms4/ms5/ms10/ms20/ms40 are 15/19/39/79/159 slots. When subcarrierSpacingCSI-RS is set 120kHZ, the maximum offset values for periodicities ms4/ms5/ms10/ms20/ms40 are 31/39/79/159/319 slots.

– *CSI-RS-ResourceMapping*

The IE *CSI-RS-ResourceMapping* is used to configure the resource element mapping of a CSI-RS resource in time- and frequency domain.

CSI-RS-ResourceMapping information element

```
-- ASN1START
-- TAG-CSI-RS-RESOURCEMAPPING-START

CSI-RS-ResourceMapping ::=          SEQUENCE {
    frequencyDomainAllocation           CHOICE {
        row1                                BIT STRING (SIZE (4)),
        row2                                BIT STRING (SIZE (12)),
        row4                                BIT STRING (SIZE (3)),
        other                               BIT STRING (SIZE (6))
    },
    nrofPorts                           ENUMERATED {p1,p2,p4,p8,p12,p16,p24,p32},
    firstOFDMSymbolInTimeDomain         INTEGER (0..13),
    firstOFDMSymbolInTimeDomain2        INTEGER (2..12)                                                 OPTIONAL,   -- Need R
    cdm-Type                            ENUMERATED {noCDM, fd-CDM2, cdm4-FD2-TD2, cdm8-FD2-TD4},
    density                             CHOICE {
```

```
        dot5                                ENUMERATED {evenPRBs, oddPRBs},
        one                                 NULL,
        three                               NULL,
        spare                               NULL
    },
    freqBand                            CSI-FrequencyOccupation,
    ...
}

-- TAG-CSI-RS-RESOURCEMAPPING-STOP
-- ASN1STOP
```

CSI-RS-ResourceMapping field descriptions
cdm-Type CDM type (see 38.214, section 5.2.2.3.1)
density Density of CSI-RS resource measured in RE/port/PRB. Corresponds to L1 parameter 'CSI-RS-Density' (see 38.211, section 7.4.1.5.3). Values 0.5 (*dot5*), 1 (one) and 3 (three) are allowed for X=1, values 0.5 (*dot5*) and 1 (one) are allowed for X=2, 16, 24 and 32, value 1 (one) is allowed for X=4, 8, 12. For density = 1/2, includes 1 bit indication for RB level comb offset indicating whether odd or even RBs are occupied by CSI-RS.
firstOFDMSymbolInTimeDomain2 Time domain allocation within a physical resource block. Parameter l1 in 38.211, section 7.4.1.5.3.
firstOFDMSymbolInTimeDomain Time domain allocation within a physical resource block. The field indicates the first OFDM symbol in the PRB used for CSI-RS. Parameter l0 in 38.211, section 7.4.1.5.3. Value 2 is supported only when DL-DMRS-typeA-pos equals 3.
freqBand Wideband or partial band CSI-RS. Corresponds to L1 parameter 'CSI-RS-FreqBand' (see 38.214, section 5.2.2.3.1)
frequencyDomainAllocation Frequency domain allocation within a physical resource block in accordance with 38.211, section 7.4.1.5.3. The applicable row number in table 7.4.1.5.3-1 is determined by the frequencyDomainAllocation for rows 1, 2 and 4, and for other rows by matching the values in the column Ports, Density and CDMtype in table 7.4.1.5.3-1 with the values of nrofPorts, cdm-Type and density below and, when more than one column has the 3 values matching, by selecting the row where the column (k bar, l bar) in table 7.4.1.5.3-2 has indexes for k ranging from 0 to 2*n-1 where n is the number of bits set to 1 in frequencyDomainAllocation.
nrofPorts Number of ports (see 38.214, section 5.2.2.3.1)

– *CSI-SemiPersistentOnPUSCH-TriggerStateList*

The *CSI-SemiPersistentOnPUSCH-TriggerStateList* IE is used to configure the UE with list of trigger states for semi-persistent reporting of channel state information on L1. . See also 38.214, section 5.2.

***CSI-SemiPersistentOnPUSCH-TriggerStateList* information element**

```
-- ASN1START
-- TAG-CSI-SEMIPERSISTENTONPUSCHTRIGGERSTATELIST-START

CSI-SemiPersistentOnPUSCH-TriggerStateList ::=  SEQUENCE(SIZE (1..maxNrOfSemiPersistentPUSCH-Triggers)) OF CSI-SemiPersistentOnPUSCH-TriggerState

CSI-SemiPersistentOnPUSCH-TriggerState ::=      SEQUENCE {
```

```
    associatedReportConfigInfo                  CSI-ReportConfigId,
    ...
}


-- TAG-CSI-SEMIPERSISTENTONPUSCHTRIGGERSTATELIST-STOP
-- ASN1STOP
```

– *CSI-SSB-ResourceSetId*

The IE *CSI-SSB-ResourceSetId* is used to identify one SS/PBCH block resource set.

CSI-SSB-ResourceId information element

```
-- ASN1START
-- TAG-CSI-SSB-RESOURCESETID-START

CSI-SSB-ResourceSetId ::=           INTEGER (0..maxNrofCSI-SSB-ResourceSets-1)

-- TAG-CSI-SSB-RESOURCESETID-STOP
-- ASN1STOP
```

– *CSI-SSB-ResourceSet*

The IE *CSI-SSB-ResourceSet* is used to configure one SS/PBCH block resource set which refers to SS/PBCH as indicated in *ServingCellConfigCommon*.

CSI-SSB-ResourceSet information element

```
-- ASN1START
-- TAG-CSI-SSB-RESOURCESET-START

CSI-SSB-ResourceSet ::=             SEQUENCE {
    csi-SSB-ResourceSetId               CSI-SSB-ResourceSetId,
    csi-SSB-ResourceList                SEQUENCE (SIZE(1..maxNrofCSI-SSB-ResourcePerSet)) OF SSB-Index,
    ...
}

-- TAG-CSI-SSB-RESOURCESET-STOP
-- ASN1STOP
```

– *DMRS-DownlinkConfig*

The IE *DMRS-DownlinkConfig* is used to configure downlink demodulation reference signals for PDSCH.

DMRS-DownlinkConfig information element

```
-- ASN1START
```

```
-- TAG-DMRS-DOWNLINKCONFIG-START

DMRS-DownlinkConfig ::=             SEQUENCE {
    dmrs-Type                           ENUMERATED {type2}                                  OPTIONAL,   -- Need S
    dmrs-AdditionalPosition             ENUMERATED {pos0, pos1, pos3}                       OPTIONAL,   -- Need R
    maxLength                           ENUMERATED {len2}                                   OPTIONAL,   -- Need S
    scramblingID0                       INTEGER (0..65535)                                  OPTIONAL,   -- Need S
    scramblingID1                       INTEGER (0..65535)                                  OPTIONAL,   -- Need S
    phaseTrackingRS                     SetupRelease { PTRS-DownlinkConfig  }               OPTIONAL,   -- Need M
    ...
}

-- TAG-DMRS-DOWNLINKCONFIG-STOP
-- ASN1STOP
```

DMRS-DownlinkConfig field descriptions
dmrs-AdditionalPosition Position for additional DM-RS in DL, see Table 7.4.1.1.2-4 in 38.211. The four values represent the cases of 1+0, 1+1, 1+1+1. 1+1+1+1 non-adjacent OFDM symbols for DL. If the field is absent, the UE applies the value pos2.
dmrs-Type Selection of the DMRS type to be used for DL (see 38.211, section 7.4.1.1.1). If the field is absent, the UE uses DMRS type 1.
maxLength The maximum number of OFDM symbols for DL front loaded DMRS. 'len1' corresponds to value 1. 'len2 corresponds to value 2. If the field is absent, the UE applies value len1. Corresponds to L1 parameter 'DL-DMRS-max-len' (see 38.214, section 5.1)
phaseTrackingRS Configures downlink PTRS. If absent of released, the UE assumes that downlink PTRS are not present. See 38.214 section 5.1.6.3
scramblingID0 DL DMRS scrambling initalization Corresponds to L1 parameter 'n_SCID 0' (see 38.211, section 7.4.1). When the field is absent the UE applies the value Physical cell ID (physCellId) configured for this serving cell."
scramblingID1 DL DMRS scrambling initalization. Corresponds to L1 parameter 'n_SCID 1' (see 38.211, section 7.4.1). When the field is absent the UE applies the value (physCellId) configured for this serving cell.

– *DMRS-UplinkConfig*

The IE *DMRS-UplinkConfig* is used to configure uplink demodulation reference signals for PUSCH.

DMRS-UplinkConfig information element

```
-- ASN1START
-- TAG-DMRS-UPLINKCONFIG-START

DMRS-UplinkConfig ::=               SEQUENCE {
    dmrs-Type                           ENUMERATED {type2}                                  OPTIONAL,   -- Need S
    dmrs-AdditionalPosition             ENUMERATED {pos0, pos1, pos3}                       OPTIONAL,   -- Need R
    phaseTrackingRS                     SetupRelease { PTRS-UplinkConfig }                  OPTIONAL,   -- Need M
    maxLength                           ENUMERATED {len2}                                   OPTIONAL,   -- Need S
```

```
    transformPrecodingDisabled                          SEQUENCE {
        scramblingID0                       INTEGER (0..65535)                          OPTIONAL,   -- Need S
        scramblingID1                       INTEGER (0..65535)                          OPTIONAL,   -- Need S
        ...
    }                                                                                   OPTIONAL,   -- Need R
    transformPrecodingEnabled                               SEQUENCE {
        nPUSCH-Identity                     INTEGER(0..1007)                            OPTIONAL,   -- Need S
        disableSequenceGroupHopping         ENUMERATED {disabled}                       OPTIONAL,   -- Need S
        sequenceHoppingEnabled              ENUMERATED {enabled}                        OPTIONAL,   -- Need S
        ...
    }                                                                                   OPTIONAL,   -- Need R
    ...
}

-- TAG-DMRS-UPLINKCONFIG-STOP
-- ASN1STOP
```

DMRS-UplinkConfig field descriptions
disabled DMRS related parameters for Cyclic Prefix OFDM
disableSequenceGroupHopping Sequence-group hopping for PUSCH can be disabled for a certain UE despite being enabled on a cell basis. For DFT-s-OFDM DMRS when the field is absent, the UE considers group hopping to be enabled. Corresponds to L1 parameter 'Disable-sequence-group-hopping-Transform-precoding' (see 38.211, section FFS_Section)
dmrs-AdditionalPosition Position for additional DM-RS in UL. Corresponds to L1 parameter 'UL-DMRS-add-pos' (see Table 7.4.1.1.2-4 in 38.211) The four values represent the cases of 1+0, 1+1, 1+1+1. 1+1+1+1 non-adjacent OFDM symbols for UL. If the field is absent, the UE applies the value pos2.
dmrs-Type Selection of the DMRS type to be used for UL (see section 38.211, section 6.4.1.1.3) If the field is absent, the UE uses DMRS type 1.
enabled DMRS related parameters for DFT-s-OFDM (Transform Precoding)
maxLength The maximum number of OFDM symbols for UL front loaded DMRS. 'len1' corresponds to value 1. 'len2 corresponds to value 2. If the field is absent, the UE applies value len1. Corresponds to L1 parameter 'UL-DMRS-max-len' (see 38.214, section 6.4.1.1.2)
nPUSCH-Identity Parameter: N_ID^(PUSCH) for DFT-s-OFDM DMRS. If the value is absent or released, the UE uses the Physical cell ID. Corresponds to L1 parameter 'nPUSCH-Identity-Transform precoding' (see 38.211, section FFS_Section)
phaseTrackingRS Configures uplink PTRS (see 38.211, section x.x.x.x) FFS_Ref
scramblingID0 UL DMRS scrambling initalization for CP-OFDM Corresponds to L1 parameter 'n_SCID 0' (see 38.214, section 6.4.1.1.2) When the field is absent the UE applies the value Physical cell ID (physCellId)
scramblingID1 UL DMRS scrambling initalization for CP-OFDM. Corresponds to L1 parameter 'n_SCID 1' (see 38.214, section 6.4.1.1.2) When the field is absent the UE applies the value Physical cell ID (physCellId)
sequenceHoppingEnabled Determines if sequence hopping is enabled or not. For DFT-s-OFDM DMRS. If the field is absent, the UE considers sequence hopping to be disabled. Corresponds to L1 parameter 'Sequence-hopping-enabled-Transform-precoding' (see 38.211, section FFS_Section)

– *DownlinkConfigCommon*

The IE *DownlinConfigCommon* provides common downlink parameters of a cell.

DownlinkConfigCommon information element

```
-- ASN1START
-- TAG-DOWNLINK-CONFIG-COMMON-START

DownlinkConfigCommon ::=        SEQUENCE {
    frequencyInfoDL                 FrequencyInfoDL                                 OPTIONAL,   -- Cond InterFreqHOAndServCellAdd
    initialDownlinkBWP              BWP-DownlinkCommon                              OPTIONAL,   -- Cond ServCellAdd
    ...
}

-- TAG-DOWNLINK-CONFIG-COMMON-STOP
-- ASN1STOP
```

***DownlinkConfigCommon* field descriptions**
frequencyInfoDL Basic parameters of a downlink carrier and transmission thereon
initialUplinkBWP The initial downlink BWP configuration for a SpCell (PCell of MCG or SCG).

Conditional Presence	Explanation
InterFreqHOAndServCellAdd	This field is mandatory present for inter-frequency handover, and upon serving cell (PSCell/SCell) addition. Otherwise, the field is optionally present, Need M.
ServCellAdd	This field is mandatory present upon serving cell addition (for PSCell and SCell). It is optionally present, Need M otherwise.

– *DownlinkPreemption*

The IE *DownlinkPreemption* is used to configure the UE to monitor PDCCH for the INT-RNTI (interruption).

DownlinkPreemption information element

```
-- ASN1START
-- TAG-DOWNLINKPREEMPTION-START

DownlinkPreemption ::=              SEQUENCE {
    int-RNTI                            RNTI-Value,
    timeFrequencySet                    ENUMERATED {set0, set1},
    dci-PayloadSize                     INTEGER (0..maxINT-DCI-PayloadSize),
    int-ConfigurationPerServingCell     SEQUENCE (SIZE (1..maxNrofServingCells)) OF INT-ConfigurationPerServingCell,
    ...
}
```

```
INT-ConfigurationPerServingCell ::= SEQUENCE {
    servingCellId                       ServCellIndex,
    positionInDCI                       INTEGER (0..maxINT-DCI-PayloadSize-1)
}

-- TAG-DOWNLINKPREEMPTION-STOP
-- ASN1STOP
```

DownlinkPreemption field descriptions
dci-PayloadSize Total length of the DCI payload scrambled with INT-RNTI. Corresponds to L1 parameter 'INT-DCI-payload-length' (see 38.213, section 11.2)
int-ConfigurationPerServingCell Indicates (per serving cell) the position of the 14 bit INT values inside the DCI payload. Corresponds to L1 parameter 'INT-cell-to-INT' and 'cell-to-INT' (see 38.213, section 11.2)
int-RNTI RNTI used for indication pre-emption in DL. Corresponds to L1 parameter 'INT-RNTI', where "INT" stands for "interruption" (see 38.213, section 10)
timeFrequencySet Set selection for DL-preemption indication. Corresponds to L1 parameter 'int-TF-unit' (see 38.213, section 10.1) The set determines how the UE interprets the DL preemption DCI payload.

INT-ConfigurationPerServingCell field descriptions
positionInDCI Starting position (in number of bit) of the 14 bit INT value applicable for this serving cell (servingCellId) within the DCI payload. Must be multiples of 14 (bit). Corresponds to L1 parameter 'INT-values' (see 38.213, section 11.2)

– *DRB-Identity*

The IE *DRB-Identity* is used to identify a DRB used by a UE.

DRB-Identity information elements

```
-- ASN1START
-- TAG-DRB-IDENTITY-START

DRB-Identity ::=                    INTEGER (1..32)

-- TAG-DRB-IDENTITY-STOP
-- ASN1STOP
```

– *EUTRA-MBSFN-SubframeConfigList*

The IE *EUTRA-MBSFN-SubframeConfigList* is used to define an E-UTRA MBSFN subframe pattern (for the purpose of NR rate matching).

EUTRA-MBSFN-SubframeConfigList information element

```
-- ASN1START
-- TAG-EUTRA-MBSFN-SUBFRAMECONFIGLIST-START

EUTRA-MBSFN-SubframeConfigList ::=  SEQUENCE (SIZE (1..maxMBSFN-Allocations)) OF EUTRA-MBSFN-SubframeConfig

EUTRA-MBSFN-SubframeConfig ::=      SEQUENCE {
    radioframeAllocationPeriod          ENUMERATED {n1, n2, n4, n8, n16, n32},
    radioframeAllocationOffset          INTEGER (0..7),
    subframeAllocation                  CHOICE {
        oneFrame                            BIT STRING (SIZE(6)),
        fourFrames                          BIT STRING (SIZE(24))
    },
    subframeAllocation-v1430            CHOICE {
        oneFrame-v1430                      BIT STRING (SIZE(2)),
        fourFrames-v1430                    BIT STRING (SIZE(8))
    }                                                                                   OPTIONAL,   -- Need R
    ...
}

-- TAG-EUTRA-MBSFN-SUBFRAMECONFIGLIST-STOP
-- ASN1STOP
```

EUTRA-MBSFN-SubframeConfig field descriptions
fourFrames-v1430 Field as defined in MBSFN-SubframeConfig in 36.331
fourFrames Field as defined in MBSFN-SubframeConfig in 36.331
oneFrame-v1430 Field as defined in MBSFN-SubframeConfig in 36.331
oneFrame Field as defined in MBSFN-SubframeConfig in 36.331
radioframeAllocationOffset Field as defined in MBSFN-SubframeConfig in 36.331
radioframeAllocationPeriod Field as defined in MBSFN-SubframeConfig in 36.331
subframeAllocation Field as defined in MBSFN-SubframeConfig in 36.331

– *FilterCoefficient*

The IE *FilterCoefficient* specifies the measurement filtering coefficient. Value *fc0* corresponds to k = 0, *fc1* corresponds to k = 1, and so on.

FilterCoefficient information element

```
-- ASN1START
-- TAG-FILTERCOEFFICIENT-START
```

```
FilterCoefficient ::=               ENUMERATED { fc0, fc1, fc2, fc3, fc4, fc5, fc6, fc7, fc8, fc9, fc11, fc13, fc15, fc17, fc19, spare1, ...}

-- TAG-FILTERCOEFFICIENT-STOP
-- ASN1STOP
```

Editor's Note: Values should be checked.

– *FreqBandIndicatorNR*

The IE *FreqBandIndicatorNR* is used to convey an NR frequency band number as defined in 38.101.

FreqBandIndicatorNR information element

```
-- ASN1START
-- TAG-FREQBANDINDICATORNR-START

FreqBandIndicatorNR ::=             INTEGER (1..1024)

-- TAG-FREQBANDINDICATORNR-STOP
-- ASN1STOP
```

– FrequencyInfoDL

The IE *FrequencyInfoDL* provides basic parameters of a downlink carrier and transmission thereon.

FrequencyInfoDL information element

```
-- ASN1START
-- TAG-FREQUENCY-INFO-DL-START

FrequencyInfoDL ::=                 SEQUENCE {
    absoluteFrequencySSB                ARFCN-ValueNR                                                   OPTIONAL,   -- Cond SpCellAdd
    frequencyBandList                   MultiFrequencyBandListNR,
    absoluteFrequencyPointA             ARFCN-ValueNR,
    scs-SpecificCarrierList             SEQUENCE (SIZE (1..maxSCSs)) OF SCS-SpecificCarrier,
    ...
}

-- TAG-FREQUENCY-INFO-UL-STOP
-- ASN1STOP
```

FrequencyInfoDL field descriptions
absoluteFrequencyPointA Absolute frequency position of the reference resource block (Common RB 0). Its lowest subcarrier is also known as Point A. Note that the lower edge of the actual carrier is not defined by this field but rather in the scs-SpecificCarrierList. Corresponds to L1 parameter 'offset-ref-low-scs-ref-PRB' (see 38.211, section FFS_Section)
absoluteFrequencySSB Frequency of the SSB to be used for this serving cell. The frequency provided in this field identifies the position of resource element RE=#0 (subcarrier #0) of resource block RB#10 of the SS block. The cell-defining SSB of the PCell is always on the sync raster. Frequencies are considered to be on the sync raster if they are also identifiable with a GSCN value (see 38.101). If the field is absent, the SSB related parameters should be absent, e.g. ssb-PositionsInBurst, ssb-periodicityServingCell and subcarrierSpacing in ServingCellConfigCommon IE. If the field is absent, the UE obtains timing reference from the SpCell. This is only supported in case the Scell is in the same frequency band as the SpCell.
frequencyBandList List of one or multiple frequency bands to which this carrier(s) belongs. Multiple values are only supported in system information but not when the FrequencyInfoDL is provided in dedicated signalling (HO or S(p)Cell addition).
scs-SpecificCarrierList A set of carriers for different subcarrier spacings (numerologies). Defined in relation to Point A. Corresponds to L1 parameter 'offset-pointA-set' (see 38.211, section FFS_Section)

Conditional Presence	Explanation
SpCellAdd	The field is mandatory present if this *FrequencyInfoDL* is for SpCell. Otherwise the field is optionally present, Need R.

– *FrequencyInfoUL*

The IE *FrequencyInfoUL* provides basic parameters of an uplink carrier and transmission thereon.

FrequencyInfoUL information element

```
-- ASN1START
-- TAG-FREQUENCY-INFO-UL-START

FrequencyInfoUL ::=                 SEQUENCE {
    frequencyBandList                   MultiFrequencyBandListNR                                    OPTIONAL,   -- Cond FDD-OrSUL
    absoluteFrequencyPointA             ARFCN-ValueNR                                               OPTIONAL,   -- Cond FDD-OrSUL
    scs-SpecificCarrierList             SEQUENCE (SIZE (1..maxSCSs)) OF SCS-SpecificCarrier,
    additionalSpectrumEmission          AdditionalSpectrumEmission                                  OPTIONAL,   -- Need S
    p-Max                               P-Max                                                       OPTIONAL,   -- Need S
    frequencyShift7p5khz                ENUMERATED {true}                                           OPTIONAL,   -- Cond FDD-OrSUL-Optional
    ...
}

-- TAG-FREQUENCY-INFO-UL-STOP
-- ASN1STOP
```

FrequencyInfoUL field descriptions
absoluteFrequencyPointA Absolute frequency of the reference resource block (Common RB 0). Its lowest subcarrier is also known as Point A. Note that the lower edge of the actual carrier is not defined by this field but rather in the scs-SpecificCarrierList. Corresponds to L1 parameter 'offset-ref-low-scs-ref-PRB' (see 38.211, section FFS_Section)
additionalSpectrumEmission The additional spectrum emission requirements to be applied by the UE on this uplink. If the field is absent, the UE applies the value FFS_RAN4. (see FFS_section, section FFS_Section)
frequencyBandList List of one or multiple frequency bands to which this carrier(s) belongs. Multiple values are only supported in system information but not when the FrequencyInfoDL is provided in dedicated signalling (HO or S(p)Cell addition).
frequencyShift7p5khz Enable the NR UL transmission with a 7.5KHz shift to the LTE raster. If the field is absent, the frequency shift is disabled.
p-Max FFS_Definition. Corresponds to parameter FFS_RAN4. (see FFS_Spec, section FFS_Section) If the field is absent, the UE applies the value FFS_RAN4.
scs-SpecificCarrierList A set of carriers for different subcarrier spacings (numerologies). Defined in relation to Point A. Corresponds to L1 parameter 'offset-pointA-set' (see 38.211, section FFS_Section)

Conditional Presence	Explanation
FDD-OrSUL	The field is mandatory present if this FrequencyInfoUL is for the paired UL for a DL (defined in a FrequencyInfoDL) or if this FrequencyInfoUL is for a supplementary uplink (SUL). It is absent otherwise (if this FrequencyInfoUL is for an unpaired UL (TDD).
FDD-OrSUL-Optional	The field is optionally present, Need R, if this FrequencyInfoUL is for the paired UL for a DL (defined in a FrequencyInfoDL) or if this FrequencyInfoUL is for a supplementary uplink (SUL). It is absent otherwise.

– *Hysteresis*

The IE *Hysteresis* is a parameter used within the entry and leave condition of an event triggered reporting condition. The actual value is field value * 0.5 dB.

Hysteresis information element

```
-- ASN1START

Hysteresis ::=                  INTEGER (0..30)

-- ASN1STOP
```

Editor's Note: Values should be checked.

- *LogicalChannelConfig*

The IE *LogicalChannelConfig* is used to configure the logical channel parameters.

LogicalChannelConfig information element

```
-- ASN1START
-- TAG-LOGICAL-CHANNEL-CONFIG-START

LogicalChannelConfig ::=            SEQUENCE {
    ul-SpecificParameters               SEQUENCE {
        priority                            INTEGER (1..16),
        prioritisedBitRate                  ENUMERATED {kBps0, kBps8, kBps16, kBps32, kBps64, kBps128, kBps256, kBps512,
                                            kBps1024, kBps2048, kBps4096, kBps8192, kBps16384, kBps32768, kBps65536, infinity},
        bucketSizeDuration                  ENUMERATED {ms5, ms10, ms20, ms50, ms100, ms150, ms300, ms500, ms1000,
                                                        spare7, spare6, spare5, spare4, spare3,spare2, spare1},

        allowedServingCells                 SEQUENCE (SIZE (1..maxNrofServingCells-1)) OF ServCellIndex           OPTIONAL,   -- Need R
        allowedSCS-List                     SEQUENCE (SIZE (1..maxSCSs)) OF SubcarrierSpacing                   OPTIONAL,   -- Need R
        maxPUSCH-Duration                   ENUMERATED { ms0p02, ms0p04, ms0p0625, ms0p125, ms0p25, ms0p5, spare2, spare1 }
                                                                                                                OPTIONAL,   -- Need R
        configuredGrantType1Allowed         ENUMERATED {true}                                                   OPTIONAL,   -- Need R

        logicalChannelGroup                 INTEGER (0..maxLCG-ID)                                              OPTIONAL,   -- Need R
        schedulingRequestID                 SchedulingRequestId                                                 OPTIONAL,   -- Need R
        logicalChannelSR-Mask               BOOLEAN,
        logicalChannelSR-DelayTimerApplied  BOOLEAN,
        ...
    }                                                                                                           OPTIONAL,   -- Cond UL

    ...
}

-- TAG-LOGICAL-CHANNEL-CONFIG-STOP
-- ASN1STOP
```

LogicalChannelConfig field descriptions
allowedSCS-List If present, UL MAC SDUs from this logical channel can only be mapped to the indicated numerology. Otherwise, UL MAC SDUs from this logical channel can be mapped to any configured numerology. Corresponds to 'allowedSCS-List' as specified in TS 38.321 [3].
allowedServingCells If present, UL MAC SDUs from this logical channel can only be mapped to the serving cells indicated in this list. Otherwise, UL MAC SDUs from this logical channel can be mapped to any configured serving cell of this cell group. Corresponds to 'allowedServingCells' in TS 38.321 [3].
bucketSizeDuration Value in ms. ms5 corresponds to 5ms, ms10 corresponds to 10ms, and so on.
configuredGrantType1Allowed If present, UL MAC SDUs from this logical channel can be transmitted on a configured grant type 1. Corresponds to 'configuredGrantType1Allowed' in TS 38.321 [3].
logicalChannelGroup ID of the logical channel group, as specified in TS 38.321 [3], which the logical channel belongs to.
logicalChannelSR-Mask Indicates whether SR masking is configured for this logical channel.
logicalChannelSR-DelayTimerApplied Indicates whether to apply the delay timer for SR transmission for this logical channel. Set to FALSE if *logicalChannelSR-DelayTimer* is not included in *BSR-Config*.
maxPUSCH-Duration If present, UL MAC SDUs from this logical channel can only be transmitted using uplink grants that result in a PUSCH duration shorter than or equal to the the duration indicated by this field. Otherwise, UL MAC SDUs from this logical channel can be transmitted using an uplink grant resulting in any PUSCH duration. Corresponds to "maxPUSCH-Duration' in TS 38.321 [3].
priority Logical channel priority, as specified in TS 38.321 [3].
prioritisedBitRate Value in kiloBytes/s. 0kBps corresponds to 0, 8kBps corresponds to 8 kiloBytes/s,16 kBps corresponds to 16 kiloBytes/s, and so on. For SRBs, the value can only be set to infinity.
schedulingRequestId If present, it indicates the scheduling request configuration applicable for this logical channel, as specified in TS 38.321 [3].

Conditional Presence	Explanation
UL	The field is mandatory present for a logical channel with uplink if it serves DRB. It is optionally present for a logical channel with uplink if it serves an SRB. otherwise it is not present.

– *LogicalChannelIdentity*

The IE *LogicalChannelIdentity* is used to identify one logical channel (*LogicalChannelConfig*) and the corresponding RLC bearer (*RLC-BearerConfig*).

LogicalChannelIdentity information element

```
-- ASN1START
-- TAG-LOGICALCHANNELIDENTITY-START

LogicalChannelIdentity ::=          INTEGER (1..maxLC-ID)

-- TAG-LOGICALCHANNELIDENTITY-STOP
```

```
-- ASN1STOP
```

– *MAC-CellGroupConfig*

The IE *MAC-CellGroupConfig* is used to configure MAC parameters for a cell group, including DRX.

MAC-CellGroupConfig information element

```
-- ASN1START
-- TAG-MAC-CELL-GROUP-CONFIG-START

MAC-CellGroupConfig ::=             SEQUENCE {
    drx-Config                          SetupRelease { DRX-Config }                                 OPTIONAL, -- Need M
    schedulingRequestConfig             SchedulingRequestConfig                                     OPTIONAL, -- Need M
    bsr-Config                          BSR-Config                                                  OPTIONAL, -- Need M
    tag-Config                          TAG-Config                                                  OPTIONAL, -- Need M
    phr-Config                          SetupRelease { PHR-Config }                                 OPTIONAL, -- Need M
    skipUplinkTxDynamic             BOOLEAN,
    ...
}

DRX-Config ::=                      SEQUENCE {
    drx-onDurationTimer                 CHOICE {
                                            subMilliSeconds INTEGER (1..31),
                                            milliSeconds    ENUMERATED {
                                                ms1, ms2, ms3, ms4, ms5, ms6, ms8, ms10, ms20, ms30, ms40, ms50, ms60,
                                                ms80, ms100, ms200, ms300, ms400, ms500, ms600, ms800, ms1000, ms1200,
                                                ms1600, spare8, spare7, spare6, spare5, spare4, spare3, spare2, spare1 }
                                            },
    drx-InactivityTimer                 ENUMERATED {
                                            ms0, ms1, ms2, ms3, ms4, ms5, ms6, ms8, ms10, ms20, ms30, ms40, ms50, ms60, ms80,
                                            ms100, ms200, ms300, ms500, ms750, ms1280, ms1920, ms2560, spare9, spare8,
                                            spare7, spare6, spare5, spare4, spare3, spare2, spare1},
    drx-HARQ-RTT-TimerDL                INTEGER (0..56),
    drx-HARQ-RTT-TimerUL                INTEGER (0..56),
    drx-RetransmissionTimerDL           ENUMERATED {
                                            sl0, sl1, sl2, sl4, sl6, sl8, sl16, sl24, sl33, sl40, sl64, sl80, sl96, sl112, sl128,
                                            sl160, sl320, spare15, spare14, spare13, spare12, spare11, spare10, spare9,
                                            spare8, spare7, spare6, spare5, spare4, spare3, spare2, spare1},
    drx-RetransmissionTimerUL           ENUMERATED {
                                            sl0, sl1, sl2, sl4, sl6, sl8, sl16, sl24, sl33, sl40, sl64, sl80, sl96, sl112, sl128,
                                            sl160, sl320, spare15, spare14, spare13, spare12, spare11, spare10, spare9,
                                            spare8, spare7, spare6, spare5, spare4, spare3, spare2, spare1 },
    drx-LongCycleStartOffset            CHOICE {
        ms10                                INTEGER(0..9),
        ms20                                INTEGER(0..19),
        ms32                                INTEGER(0..31),
        ms40                                INTEGER(0..39),
        ms60                                INTEGER(0..59),
        ms64                                INTEGER(0..63),
        ms70                                INTEGER(0..69),
        ms80                                INTEGER(0..79),
```

```
        ms128                               INTEGER(0..127),
        ms160                               INTEGER(0..159),
        ms256                               INTEGER(0..255),
        ms320                               INTEGER(0..319),
        ms512                               INTEGER(0..511),
        ms640                               INTEGER(0..639),
        ms1024                              INTEGER(0..1023),
        ms1280                              INTEGER(0..1279),
        ms2048                              INTEGER(0..2047),
        ms2560                              INTEGER(0..2559),
        ms5120                              INTEGER(0..5119),
        ms10240                             INTEGER(0..10239)
    },
    -- FFS need for finer offset granulary
    -- FFS need for shorter values for long and short cycles
    shortDRX                            SEQUENCE {
        drx-ShortCycle                      ENUMERATED  {
                                                ms2, ms3, ms4, ms5, ms6, ms7, ms8, ms10, ms14, ms16, ms20, ms30, ms32,
                                                ms35, ms40, ms64, ms80, ms128, ms160, ms256, ms320, ms512, ms640, spare9,
                                                spare8, spare7, spare6, spare5, spare4, spare3, spare2, spare1 },
        drx-ShortCycleTimer                 INTEGER (1..16)
    }                                                                                                   OPTIONAL,   -- Need R
    drx-SlotOffset                      INTEGER (0..31)

}

PHR-Config ::=                      SEQUENCE {
    phr-PeriodicTimer                   ENUMERATED {sf10, sf20, sf50, sf100, sf200,sf500, sf1000, infinity},
    phr-ProhibitTimer                   ENUMERATED {sf0, sf10, sf20, sf50, sf100,sf200, sf500, sf1000},
    phr-Tx-PowerFactorChange            ENUMERATED {dB1, dB3, dB6, infinity},
    multiplePHR                         BOOLEAN,
    phr-Type2SpCell                     BOOLEAN,
    phr-Type2OtherCell                  BOOLEAN,
    phr-ModeOtherCG                     ENUMERATED {real, virtual},
    ...
}


TAG-Config ::=                      SEQUENCE {
    tag-ToReleaseList                   SEQUENCE (SIZE (1..maxNrofTAGs)) OF TAG-Id                      OPTIONAL,   -- Need N
    tag-ToAddModList                    SEQUENCE (SIZE (1..maxNrofTAGs)) OF TAG                 OPTIONAL -- Need N
}

TAG ::=                     SEQUENCE {
    tag-Id                              TAG-Id,
    timeAlignmentTimer                  TimeAlignmentTimer,
    ...
}

TAG-Id ::=                          INTEGER (0..maxNrofTAGs-1)

TimeAlignmentTimer ::=              ENUMERATED {ms500, ms750, ms1280, ms1920, ms2560, ms5120, ms10240, infinity}

BSR-Config ::=                      SEQUENCE {
```

```
    periodicBSR-Timer                   ENUMERATED { sf1, sf5, sf10, sf16, sf20, sf32, sf40, sf64,
                                                     sf80, sf128, sf160, sf320, sf640, sf1280, sf2560, infinity },
    retxBSR-Timer                       ENUMERATED { sf10, sf20, sf40, sf80, sf160, sf320, sf640, sf1280, sf2560,
                                                     sf5120, sf10240, spare5, spare4, spare3, spare2, spare1},
    logicalChannelSR-DelayTimer         ENUMERATED { sf20, sf40, sf64, sf128, sf512, sf1024, sf2560, spare1}       OPTIONAL,   -- Need R
    ...
}

-- TAG-MAC-CELL-GROUP-CONFIG-STOP
-- ASN1STOP
```

***MAC-CellGroupConfig* field descriptions**
drx-Config Used to configure DRX as specified in TS 38.321 [3].
drx-HARQ-RTT-TimerDL Value in number of symbols.
drx-HARQ-RTT-TimerUL Value in number of symbols.
drx-InactivityTimer Value in multiple integers of 1ms. ms0 corresponds to 0, ms1 corresponds to 1ms, ms2 corresponds to 2ms, and so on.
drx-onDurationTimer Value in multiples of 1/32 ms (subMilliSeconds) or in ms (milliSecond). For the latter, ms1 corresponds to 1ms, ms2 corresponds to 2ms, and so on.
drx-LongCycleStartOffset *drx-LongCycle* in ms and *drx-StartOffset* in multiples of 1ms.
drx-RetransmissionTimerDL Value in number of slot lengths. sl1 corresponds to 1 slot, sl2 corresponds to 2 slots, and so on.
drx-RetransmissionTimerUL Value in number of slot lengths. sl1 corresponds to 1 slot, sl2 corresponds to 2 slots, and so on.
drx-ShortCycle Value in ms. ms1 corresponds to 1ms, ms2 corresponds to 2ms, and so on.
drx-ShortCycleTimer Value in multiples of *drx-ShortCycle*. A value of 1 corresponds to *drx-ShortCycle*, a value of 2 corresponds to 2 * *drx-ShortCycle* and so on.
drx-SlotOffset Value in 1/32 ms. Value 0 corresponds to 0ms, value 1 corresponds to 1/32ms, value 2 corresponds to 2/32ms, and so on.
logicalChannelSR-DelayTimer Value in number of subframes. sf1 corresponds to one subframe, sf2 corresponds to 2 subframes, and so on.
multiplePHR Indicates if power headroom shall be reported using the Single Entry PHR MAC control element or Multiple Entry PHR MAC control element defined in TS 38.321 [3]. True means to use Multiple Entry PHR MAC control element and False means to use the Single Entry PHR MAC control element defined in TS 38.321 [3].
periodicBSR-Timer Value in number of subframes. Value sf1 corresponds to 1 subframe, sf5 corresponds to 5 subframes and so on.
phr-Tx-PowerFactorChange Value in dB for PHR reporting as specified in TS 38.321 [3]. Value dB1 corresponds to 1 dB, dB3 corresponds to 3 dB and so on. The same value applies for each serving cell (although the associated functionality is performed independently for each cell).
phr-ModeOtherCG Indicates the mode (i.e. *real* or *virtual*) used for the PHR of the activated cells that are part of the other Cell Group (i.e. MCG or SCG), when DC is configured.
phr-PeriodicTimer Value in number of subframes for PHR reporting as specified in TS 38.321 [3]. sf10 corresponds to 10 subframes, sf20 corresonds to 20 subframes, and so on.
phr-ProhibitTimer Value in number of subframes for PHR reporting as specified in TS 38.321 [3]. sf0 corresponds to 0 subframe, sf10 corresponds to 10 subframes, sf20 corresponds to 20 subframes, and so on.
phr-Type2SpCell Indicates whether or not PHR type 2 is reported for the SpCell of the MAC entity. It is set to false in this release of the specification.
phr-Type2OtherCell Indicates whether or not PHR type 2 is reported for the SpCell of the other MAC entity or PUCCH SCells of the MAC entity.
retxBSR-Timer Value in number of subframes. Value sf10 corresponds to 10 subframes, sf20 corresponds to 20 subframes and so on.

***MAC-CellGroupConfig* field descriptions**
skipUplinkTxDynamic If configured, indicates whether the UE skips UL transmissions for an uplink grant other than a configured uplink grant if no data is available for transmission in the UE buffer as described in TS 38.321 [3]. FFS : configurable per SCell?
tag-ID Indicates the TAG of an SCell, see TS 38.321 [3]. Uniquely identifies the TAG within the scope of a Cell Group (i.e. MCG or SCG). If the field is not configured for an SCell, the SCell is part of the PTAG.
timeAlignmentTimer Value in ms of the *timeAlignmentTimer* for TAG with ID *tag-Id*, as specified in TS 38.321 [3].

– *MeasConfig*

The IE *MeasConfig* specifies measurements to be performed by the UE, and covers intra-frequency, inter-frequency and inter-RAT mobility as well as configuration of measurement gaps.

***MeasConfig* information element**

```
-- ASN1START
-- TAG-MEAS-CONFIG-START

MeasConfig ::=                  SEQUENCE {
    measObjectToRemoveList          MeasObjectToRemoveList                                  OPTIONAL,   -- Need N
    measObjectToAddModList          MeasObjectToAddModList                                  OPTIONAL,   -- Need N

    reportConfigToRemoveList        ReportConfigToRemoveList                                OPTIONAL,   -- Need N
    reportConfigToAddModList        ReportConfigToAddModList                                OPTIONAL,   -- Need N

    measIdToRemoveList              MeasIdToRemoveList                                      OPTIONAL,   -- Need N
    measIdToAddModList              MeasIdToAddModList                                      OPTIONAL,   -- Need N

    s-MeasureConfig                 CHOICE {
        ssb-RSRP                        RSRP-Range,
        csi-RSRP                        RSRP-Range
    }                                                                                       OPTIONAL,   -- Need M

    quantityConfig                  QuantityConfig                                          OPTIONAL,   -- Need M

    measGapConfig                   MeasGapConfig                                           OPTIONAL,   -- Need M
    measGapSharingConfig                MeasGapSharingConfig                                   OPTIONAL,   -- Need M
    ...
}

MeasObjectToRemoveList ::=          SEQUENCE (SIZE (1..maxNrofObjectId)) OF MeasObjectId

MeasIdToRemoveList ::=              SEQUENCE (SIZE (1..maxNrofMeasId)) OF MeasId

ReportConfigToRemoveList ::=        SEQUENCE (SIZE (1..maxReportConfigId)) OF ReportConfigId

-- TAG-MEAS-CONFIG-STOP
```

```
-- ASN1STOP
```

Editor's Note: FFS Whether UE speed based TTT scaling (e.g. speedStatePars) is supported in Rel-15 (not applicable for EN-DC).

Editor's Note: FFS Whether measScaleFactor (or equivalent) is supported in Rel-15 (not applicable for EN-DC).

Editor's Note: FFS How to support allowInterruptions in NR (RAN4 input needed) in Rel-15.

***MeasConfig* field descriptions**
measGapConfig Used to setup and release measurement gaps in NR.
measIdToAddModList List of measurement identities to add and/or modify.
measIdToRemoveList List of measurement identities to remove.
measObjectToAddModList List of measurement objects to add and/or modify.
measObjectToRemoveList List of measurement objects to remove.
reportConfigToAddModList List of measurement reporting configurations to add and/or modify
reportConfigToRemoveList List of measurement reporting configurations to remove.
s-MeasureConfig Threshold for NR SpCell RSRP measurement controlling when the UE is required to perform measurements on non-serving cells. Choice of *ssb-RSRP* corresponds to cell RSRP based on SS/PBCH block and choice of *csi-RSRP* corresponds to cell RSRP of CSI-RS. The UE is only required to perform measurements on non-serving cells when the SpCell RSRP is below that threshold.
MeasGapSharingConfig The IE MeasGapSharingConfig specifies the measurement gap sharing scheme

– *MeasGapConfig*

The IE *MeasGapConfig* specifies the measurement gap configuration and controls setup/ release of measurement gaps.

MeasGapConfig information element

```
-- ASN1START
--TAG-MEAS-GAP-CONFIG-START

MeasGapConfig ::=                   SEQUENCE {
    gapFR2                              SetupRelease { GapConfig }                                  OPTIONAL,   -- Need M
    ...
}
```

```
GapConfig ::=                       SEQUENCE {
    gapOffset                           INTEGER (0..159),
    mgl                                 ENUMERATED {ms1dot5, ms3, ms3dot5, ms4, ms5dot5, ms6},
    mgrp                                ENUMERATED {ms20, ms40, ms80, ms160},
    mgta                                ENUMERATED {ms0, ms0dot25, ms0dot5},
    ...
}

-- TAG-MEAS-GAP-CONFIG-STOP
-- ASN1STOP
```

***MeasGapConfig* field descriptions**
gapFR2 Indicates measurement gap configuration applies to FR2 only. The applicability of the measurement gap is according to Table 9.1.2-2 in TS 38.133 [14].
gapOffset Value *gapOffset* is the gap offset of the gap pattern with MGRP indicated in the field *mgrp*. The value range should be from 0 to *mgrp*-1.
mgl Value *mgl* is the measurement gap length in ms of the measurement gap. The applicability of the measurement gap is according to in Table 9.1.2-1 and Table 9.1.2-2 in TS 38.133 [14]. Value *ms1dot5* corresponds to 1.5ms, *ms3* corresponds to 3ms and so on.
mgrp Value *mgrp* is measurement gap repetition period in (ms) of the measurement gap. The applicability of the measurement gap is according to in Table 9.1.2-1 and Table 9.1.2-2 in TS 38.133 [14].
mgta Value *mgta* is the measurement gap timing advance in ms. The applicability of the measurement gap timing advance is according to section 9.1.2 of TS 38.133 [14]. Value *ms0* corresponds to 0 ms, *ms0dot25* corresponds to 0.25ms and *ms0dot5* corresponds to 0.5ms. For FR2, the network only configures 0 and 0.25ms.

– *MeasGapSharingConfig*

The IE *MeasGapSharingConfig* specifies the measurement gap sharing scheme and controls setup/ release of measurement gap sharing.

MeasGapSharingConfig information element

```
-- ASN1START
--TAG-MEAS-GAP-SHARING-CONFIG-START

MeasGapSharingConfig ::=        SEQUENCE {
    gapSharingFR2               SetupRelease { MeasGapSharingScheme }       OPTIONAL,   -- Need M
    ...
}

MeasGapSharingScheme ::=        ENUMERATED { scheme00, scheme01, scheme10, scheme11 }

--TAG-MEAS-GAP-SHARING-CONFIG-STOP
-- ASN1STOP
```

MeasGapSharingConfig field descriptions
gapSharingFR2
Indicates the measurement gaps sharing scheme, see TS 38.133 [14]. Value scheme00 corresponds to "00", value scheme01 corresponds to "01", and so on.

– *MeasId*

The IE *MeasId* is used to identify a measurement configuration, i.e., linking of a measurement object and a reporting configuration.

MeasId information element

```
-- ASN1START
-- TAG-MEAS-ID-START

MeasId ::=                          INTEGER (1..maxNrofMeasId)

-- TAG-MEAS-ID-STOP
-- ASN1STOP
```

– *MeasIdToAddModList*

The IE *MeasIdToAddModList* concerns a list of measurement identities to add or modify, with for each entry the measId, the associated *measObjectId* and the associated *reportConfigId*.

MeasIdToAddModList information element

```
-- ASN1START
-- TAG-MEAS-ID-TO-ADD-MOD-LIST-START

MeasIdToAddModList ::=              SEQUENCE (SIZE (1..maxNrofMeasId)) OF MeasIdToAddMod

MeasIdToAddMod ::=                  SEQUENCE {
    measId                              MeasId,
    measObjectId                        MeasObjectId,
    reportConfigId                      ReportConfigId
}

-- TAG-MEAS-ID-TO-ADD-MOD-LIST-STOP
-- ASN1STOP
```

– *MeasObjectEUTRA*

The IE *MeasObjectEUTRA* specifies information applicable for E-UTRA cells.

Editor's Note: FFS Details of *measObjectEUTRA* that can be configured via NR (not applicable for EN-DC).

– *MeasObjectId*

The IE *MeasObjectId* used to identify a measurement object configuration.

MeasObjectId information element

```
-- ASN1START
-- TAG-MEAS-OBJECT-ID-START

MeasObjectId ::=                    INTEGER (1..maxNrofObjectId)

-- TAG-MEAS-OBJECT-ID-STOP
-- ASN1STOP
```

– *MeasObjectNR*

The IE *MeasObjectNR* specifies information applicable for SS/PBCH block(s) intra/inter-frequency measurements or CSI-RS intra/inter-frequency measurements.

MeasObjectNR information element

```
-- ASN1START
-- TAG-MEAS-OBJECT-NR-START

MeasObjectNR ::=                    SEQUENCE {
    ssbFrequency                        ARFCN-ValueNR                                           OPTIONAL,   -- Cond SSBorAssociatedSSB
    ssbSubcarrierSpacing                    SubcarrierSpacing                                   OPTIONAL,   -- Cond SSBorAssociatedSSB
    smtc1                               SSB-MTC                                                 OPTIONAL,   -- Cond SSBorAssociatedSSB
    smtc2                               SSB-MTC2                                                OPTIONAL,   -- Cond IntraFreqConnected

    refFreqCSI-RS                       ARFCN-ValueNR                                               OPTIONAL,
    referenceSignalConfig               ReferenceSignalConfig,

    absThreshSS-BlocksConsolidation     ThresholdNR                                                 OPTIONAL,   -- Need R
    absThreshCSI-RS-Consolidation       ThresholdNR                                                 OPTIONAL,   -- Need R

    nrofSS-BlocksToAverage              INTEGER (2..maxNrofSS-BlocksToAverage)                      OPTIONAL,   -- Need R
    nrofCSI-RS-ResourcesToAverage       INTEGER (2..maxNrofCSI-RS-ResourcesToAverage)               OPTIONAL,   -- Need R

    quantityConfigIndex                 INTEGER (1..maxNrofQuantityConfig),

    offsetMO                            Q-OffsetRangeList,

    cellsToRemoveList                   PCI-List                                                    OPTIONAL,   -- Need N
    cellsToAddModList                   CellsToAddModList                                           OPTIONAL,   -- Need N

    blackCellsToRemoveList              PCI-RangeIndexList                                          OPTIONAL,   -- Need N
    blackCellsToAddModList              SEQUENCE (SIZE (1..maxNrofPCI-Ranges)) OF PCI-RangeElement  OPTIONAL,   -- Need N

    whiteCellsToRemoveList              PCI-RangeIndexList                                          OPTIONAL,   -- Need N
    whiteCellsToAddModList              SEQUENCE (SIZE (1..maxNrofPCI-Ranges)) OF PCI-RangeElement  OPTIONAL,   -- Need N
    ...
```

```
}

ReferenceSignalConfig::=            SEQUENCE {
    ssb-ConfigMobility                  SSB-ConfigMobility                                          OPTIONAL,   -- Need M
    csi-rs-ResourceConfigMobility       SetupRelease { CSI-RS-ResourceConfigMobility }              OPTIONAL -- Need M
}

SSB-ConfigMobility ::=              SEQUENCE {
    ssb-ToMeasure                           SetupRelease { SSB-ToMeasure }                          OPTIONAL,   -- Need M
    useServingCellTimingForSync             BOOLEAN,
    ss-RSSI-Measurement                         SS-RSSI-Measurement                             OPTIONAL,   -- Need M
    ...
}


Q-OffsetRangeList ::=               SEQUENCE {
    rsrpOffsetSSB                       Q-OffsetRange               DEFAULT dB0,
    rsrqOffsetSSB                       Q-OffsetRange               DEFAULT dB0,
    sinrOffsetSSB                       Q-OffsetRange               DEFAULT dB0,
    rsrpOffsetCSI-RS                    Q-OffsetRange               DEFAULT dB0,
    rsrqOffsetCSI-RS                    Q-OffsetRange               DEFAULT dB0,
    sinrOffsetCSI-RS                    Q-OffsetRange               DEFAULT dB0
}

SSB-ToMeasure ::=                   CHOICE {
    shortBitmap                         BIT STRING (SIZE (4)),
    mediumBitmap                        BIT STRING (SIZE (8)),
    longBitmap                          BIT STRING (SIZE (64))
}

ThresholdNR ::=                     SEQUENCE{
    thresholdRSRP                       RSRP-Range                  OPTIONAL,
    thresholdRSRQ                       RSRQ-Range                  OPTIONAL,
    thresholdSINR                       SINR-Range                  OPTIONAL
}

CellsToAddModList ::=               SEQUENCE (SIZE (1..maxNrofCellMeas)) OF CellsToAddMod

CellsToAddMod ::=                   SEQUENCE {
    physCellId                          PhysCellId,
    cellIndividualOffset                Q-OffsetRangeList
}



-- TAG-MEAS-OBJECT-NR-STOP
-- ASN1STOP
```

CellsToAddMod field descriptions
cellIndividualOffset Cell individual offsets applicable to a specific cell.
physCellId Physical cell identity of a cell in the cell list.

MeasObjectNR field descriptions
absThreshCSI-RS-Consolidation Absolute threshold for the consolidation of measurement results per CSI-RS resource(s) from L1 filter(s). The values above the threshold are used as input to the derivation of cell measurement results as described in 5.5.3.3 and the L3 filter(s) per CSI-RS resource as described in 5.5.3.2.
absThreshSS-BlocksConsolidation Absolute threshold for the consolidation of measurement results per SS/PBCH block(s) from L1 filter(s). The values above the threshold are used as input to the derivation of cell measurement results as described in 5.5.3.3and the L3 filter(s) per SS/PBCH block index as described in 5.5.3.2.
blackCellsToAddModList List of cells to add/modify in the black list of cells.
blackCellsToRemoveList List of cells to remove from the black list of cells.
cellsToAddModList List of cells to add/modify in the cell list.
cellsToRemoveList List of cells to remove from the cell list.
nrofCSInrofCSI-RS-ResourcesToAverage Indicates the maximum number of measurement results per beam based on CSI-RS resources to be averaged. The same value applies for each detected cell associated with this MeasObjectNR.
nrofSS-BlocksToAverage Indicates the maximum number of measurement results per beam based on SS/PBCH blocks to be averaged. The same value applies for each detected cell associated with this MeasObject.
offsetMO Offset values applicable to all measured cells with reference signal(s) indicated in this *MeasObjectNR*.
quantityConfigIndex Indicates the n-*th* element of *quantityConfigNR-List* provided in *MeasConfig*.
referenceSignalConfig RS configuration (e.g. SMTC window, CSI-RS resource, etc.)
refFreqCSI-RS Point A which is used for maping of CSI-RS to physical resources according to TS 38.211 section 7.4.1.5.3.
smtc1 Primary measurement timing configuration. Applicable for intra- and inter-frequency measurements.
smtc2 Secondary measurement timing confguration for SS corresponding to this MeasObjectNR with PCI listed in pci-List. For these SS, the periodicity is indicated by periodicity in smtc2 and the timing offset is equal to the offset indicated in periodicityAndOffset modulo periodicity. periodicity in smtc2 can only be set to a value stricty shorter than the periodicity indicated by periodicityAndOffset in smtc1 (e.g. if periodicityAndOffset indicates sf10, periodicity can only be set of sf5, if periodicityAndOffset indicates sf5, smtc2 cannot be configured).
ssbFrequency Indicates the frequency of the SS associated to this MeasObjectNR.
ssbSubcarrierSpacing Subcarrier spacing of SSB. Only the values 15 or 30 (<6GHz), 120 kHz or 240 kHz (>6GHz) are applicable.
whiteCellsToAddModList List of cells to add/modify in the white list of cells.
whiteCellsToRemoveList List of cells to remove from the white list of cells.

ReferenceSignalConfig field descriptions
csi-rs-ResourceConfigMobility CSI-RS resources to be used for CSI-RS based RRM measurements
ssb-ConfigMobility SSB configuration for mobility (nominal SSBs, timing configuration)

SSB-ConfigMobility field descriptions
endSymbol Within a slot that is configured for RSSI measurements (see *measurementSlots*) the UE measures the RSSI from symbol 0 to symbol *endSymbol*. This field identifies the entry in Table 5.1.3-1 in TS 38.215 which determines the actual end symbol.
measurementSlots Indicates the slots in which the UE can perform RSSI measurements. The length of the BIT STRING is equal to the number of slots in the configured SMTC window (determined by the *duration* and by the *subcarrierSpacing*). The first (left-most / most significant) bit in the bitmap corresponds to the first slot in the SMTC window, the second bit in the bitmap corresponds to the second slot in the SMTC window, and so on. The UE measures in slots for which the corresponding bit in the bitmap is set to 1.
ssb-ToMeasure The set of SS blocks to be measured within the SMTC measurement duration. Corresponds to L1 parameter 'SSB-measured' (see FFS_Spec, section FFS_Section) When the field is absent the UE measures on all SS-blocks FFS_CHECK: Is this IE placed correctly.
useServingCellTimingForSync For intra-frequency measurement this field indicates whether the UE can utilize serving cell timing to derive the index of SS block transmitted by neighbour cell. For inter-frequency measurements, this field indicates whether the UE may use the timing of any detected cell on that target frequency to derive the SSB index of all neighbour cells on that frequency.

SSB-ToMeasure field descriptions
longBitmap bitmap for above 6 GHz
mediumBitmap bitmap for 3-6 GHz
shortBitmap bitmap for sub 3 GHz

Editor's Note: FFS How to support CGI reporting and whether changes are required in MeasObjectNR (e.g. introduction of cellForWhichToReportCGI). Not applicable for EN-DC.

Editor's Note: FFS Whether alternative TTT is supported in Rel-15 (not applicable for EN-DC).

Editor's Note: FFS measCycleSCell. (not applicable for EN-DC)

Editor's Note: FFS reducedMeasPerformance (not applicable for EN-DC).

Conditional presence	Explanation
SSBorAssociatedSSB	This field is mandatory present if *ssb-ConfigMobility* is configured or *associatedSSB* is configured in at least one cell, otherwise, it is absent.
IntraFreqConnected	This field is optionally present in an intra-frequency measurement object and only if ssb-ConfigMobility is configured or associatedSSB is configured in at least one cell, otherwise, it is absent.

– *MeasObjectToAddModList*

The IE *MeasObjectToAddModList* concerns a list of measurement objects to add or modify.

MeasObjectToAddModList information element

```
-- ASN1START
-- TAG-MEAS-OBJECT-TO-ADD-MOD-LIST-START

MeasObjectToAddModList ::=                SEQUENCE (SIZE (1..maxNrofObjectId)) OF MeasObjectToAddMod

MeasObjectToAddMod ::=                    SEQUENCE {
    measObjectId                              MeasObjectId,
    measObject                                CHOICE {
        measObjectNR                              MeasObjectNR,
        ...
    }
}

-- TAG-MEAS-OBJECT-TO-ADD-MOD-LIST-STOP
-- ASN1STOP
```

– *MeasResults*

The IE *MeasResults* covers measured results for intra-frequency, inter-frequency, and inter-RAT mobility.

MeasResults information element

```
-- ASN1START
-- TAG-MEAS-RESULTS-START

MeasResults ::=                           SEQUENCE {
    measId                                    MeasId,
    measResultServingMOList                MeasResultServMOList,
    measResultNeighCells                      CHOICE {
        measResultListNR                          MeasResultListNR,
        ...
    }                                                                                   OPTIONAL,
    ...
}

MeasResultServMOList ::=                  SEQUENCE (SIZE (1..maxNrofServingCells)) OF MeasResultServMO
```

```
MeasResultServMO ::=                    SEQUENCE {
    servCellId                              ServCellIndex,
    measResultServingCell                   MeasResultNR,
    measResultBestNeighCell                 MeasResultNR                                    OPTIONAL,
    ...
}

MeasResultListNR ::=                    SEQUENCE (SIZE (1..maxCellReport)) OF MeasResultNR

MeasResultNR ::=                        SEQUENCE {
    physCellId                              PhysCellId                                      OPTIONAL,
    --FFS: Details of cgi info
    measResult                              SEQUENCE {
        cellResults                             SEQUENCE{
            resultsSSB-Cell                         MeasQuantityResults                     OPTIONAL,
            resultsCSI-RS-Cell                      MeasQuantityResults                     OPTIONAL
        },
        rsIndexResults                          SEQUENCE{
            resultsSSB-Indexes                      ResultsPerSSB-IndexList                 OPTIONAL,
            resultsCSI-RS-Indexes                   ResultsPerCSI-RS-IndexList              OPTIONAL
        }                                                                                   OPTIONAL
    },
    ...
}


MeasQuantityResults ::=             SEQUENCE {
    rsrp                                RSRP-Range                                  OPTIONAL,
    rsrq                                RSRQ-Range                                  OPTIONAL,
    sinr                                SINR-Range                                  OPTIONAL
}

ResultsPerSSB-IndexList::=              SEQUENCE (SIZE (1..maxNrofSSBs)) OF ResultsPerSSB-Index

ResultsPerSSB-Index ::=                 SEQUENCE {
    ssb-Index                               SSB-Index,
    ssb-Results                             MeasQuantityResults                 OPTIONAL
}

ResultsPerCSI-RS-IndexList::=               SEQUENCE (SIZE (1..maxNrofCSI-RS)) OF ResultsPerCSI-RS-Index

ResultsPerCSI-RS-Index ::=              SEQUENCE {
    csi-RS-Index                            CSI-RS-Index,
    csi-RS-Results                          MeasQuantityResults                 OPTIONAL
}

-- TAG-MEAS-RESULTS-STOP
-- ASN1STOP
```

MeasResultServFreq field descriptions
measResultBestNeighCell Measured results of the best detected neighbour cell on the corresponding serving frequency.

Editor's Note: FFS *locationInfo*.

***MeasResults* field descriptions**
csi-rs-Index CSI-RS resource index associated to the measurement information to be reported.
measId Identifies the measurement identity for which the reporting is being performed.
measResult Measured results of an NR cell.
measResultListNR List of measured results for the maximum number of reported best cells for an NR measurement identity.
measResultServingMOList Measured results of measured cells with reference signals indicated in the serving cell measurement objects including measurement results of SpCell, configured SCell(s) and best neighbouring cell within measured cells with reference signals indicated in on each serving cell measurement object.
resultsCSI-RS-Indexes List of measurement information per CSI-RS resource index of an NR cell.
resultsSSB-Indexes List of measurement information per SS/PBCH index of an NR cell.
resultsCSI-RS-Cell Cell level measurement results (e.g. RSRP, RSRQ, SINR) to be reported derived from CSI-RS measurements.
resultsSSB-Cell Cell level measurement results (e.g. RSRP, RSRQ, SINR) to be reported derived on SS/PBCH block measurements.
rsrp Measured SS-RSRP or CSI-RSRP resultsas defined in TS 38.215 [9], either per NR cell from the L1 filter(s) or per (SS/PBCH)/(CSI-RS) index as specified in 5.5.3.3a.
rsrq Measured SS-RSRQ or CSI-RSRQ results as defined in TS 38.215 [9], either per NR cell from the L1 filter(s) or per (SS/PBCH)/(CSI-RS) index as specified in 5.5.3.3a.
sinr Measured SS-SINR or CSI-SINR results as defined in TS 38.215 [9], either per NR cell from the L1 filter(s) or per (SS/PBCH)/(CSI-RS) index as specified in 5.5.3.3a.
ssb-Index SS/PBCH block index associated to the measurement information to be reported.

– *MeasResultSCG-Failure*

The IE *MeasResultSCG-Failure* is used to provide information regarding failures detected by the UE in case of EN-DC.

MeasResultSCG-Failure information element

```
-- ASN1START
-- TAG-MEAS-RESULT-SCG-FAILURE-START
```

```
MeasResultSCG-Failure ::=           SEQUENCE {
    measResultPerMOList                     MeasResultList2NR,
    ...
}


MeasResultList2NR ::=               SEQUENCE (SIZE (1..maxFreq)) OF MeasResult2NR

MeasResult2NR ::=                   SEQUENCE {
    ssbFrequency                        ARFCN-ValueNR                           OPTIONAL,
    refFreqCSI-RS                       ARFCN-ValueNR                           OPTIONAL,
    measResultServingCell               MeasResultNR                            OPTIONAL,
    measResultNeighCellListNR           MeasResultListNR
}

-- TAG-MEAS-RESULT-SCG-FAILURE-STOP
-- ASN1STOP
```

– *MeasResult*CellList*SFTD*

The IE *MeasResultCellListSFTD* consists of SFN and radio frame boundary difference between the PCell and an NR cell as specified in TS 38.215 [9] and TS 38.133 [14].

MeasResultCellListSFTD information element

```
-- ASN1START
-- TAG-MEASRESULT-CELL-LIST-SFTD-START

MeasResultCellListSFTD ::=          SEQUENCE (SIZE (1..maxCellSFTD)) OF MeasResultCellSFTD

MeasResultCellSFTD ::=              SEQUENCE {
    physCellId                          PhysCellId,
    sfn-OffsetResult                    INTEGER (0..1023),
    frameBoundaryOffsetResult           INTEGER (-30720..30719),
    rsrp-Result                         RSRP-Range                      OPTIONAL
}

-- TAG-MEASRESULT-CELL-LIST-SFTD-STOP
-- ASN1STOP
```

***MeasResultSFTD* field descriptions**
sfn-OffsetResult Indicates the SFN difference between the PCell and the NR cell as an integer value according to TS 38.215 [9].
frameBoundaryOffsetResult Indicates the frame boundary difference between the PCell and the NR cell as an integer value according to TS 38.215 [9].

– *MultiFrequencyBandListNR*

The IE *MultiFrequencyBandListNR* is used to configure a list of one or multiple NR frequency bands.

MultiFrequencyBandListNR information element

```
-- ASN1START
-- TAG-MULTIFREQUENCYBANDLISTNR-START

MultiFrequencyBandListNR ::=        SEQUENCE (SIZE (1..maxNrofMultiBands)) OF FreqBandIndicatorNR

-- TAG-MULTIFREQUENCYBANDLISTNR-STOP
-- ASN1STOP
```

– *NZP-CSI-RS-Resource*

The IE *NZP-CSI-RS-Resource* is used to configure Non-Zero-Power (NZP) CSI-RStransmitted in the cell where the IE is included, which the UE may be configured to measure on (see 38.214, section 5.2.2.3.1).

NZP-CSI-RS-Resource information element

```
-- ASN1START
-- TAG-NZP-CSI-RS-RESOURCE-START

NZP-CSI-RS-Resource ::=             SEQUENCE {
    nzp-CSI-RS-ResourceId               NZP-CSI-RS-ResourceId,
    resourceMapping                     CSI-RS-ResourceMapping,
    powerControlOffset                  INTEGER(-8..15),
    powerControlOffsetSS                ENUMERATED {db-3, db0, db3, db6}                    OPTIONAL,   -- Need R
    scramblingID                        ScramblingId,
    periodicityAndOffset                CSI-ResourcePeriodicityAndOffset                    OPTIONAL,   -- Cond PeriodicOrSemiPersistent
    qcl-InfoPeriodicCSI-RS              TCI-StateId                                         OPTIONAL,   -- Cond Periodic
    ...
}

-- TAG-NZP-CSI-RS-RESOURCE-STOP
-- ASN1STOP
```

NZP-CSI-RS-Resource field descriptions
periodicityAndOffset Periodicity and slot offset *sl1* corresponds to a periodicity of 1 slot, *sl2* to a periodicity of two slots, and so on. The corresponding offset is also given in number of slots. Corresponds to L1 parameter 'CSI-RS-timeConfig' (see 38.214, section 5.2.2.3.1)
powerControlOffset Power offset of NZP CSI-RS RE to PDSCH RE. Value in dB. Corresponds to L1 parameter Pc (see 38.214, sections 5.2.2.3.1 and 4.1)
powerControlOffsetSS Power offset of NZP CSI-RS RE to SS RE. Value in dB. Corresponds to L1 parameter 'Pc_SS' (see 38.214, section 5.2.2.3.1)
qcl-InfoPeriodicCSI-RS For a target periodic CSI-RS, contains a reference to one TCI-State in TCI-States for providing the QCL source and QCL type. For periodic CSI-RS, the source can be SSB or another periodic-CSI-RS. Refers to the TCI-State which has this value for tci-StateId and is defined in *tci-StatesToAddModList* in the *PDSCH-Config* included in the *BWP-Downlink* corresponding to the serving cell and to the DL BWP to which the resource belong to. Corresponds to L1 parameter 'QCL-Info-PeriodicCSI-RS' (see 38.214, section 5.2.2.3.1)
resourceMapping OFDM symbol location(s) in a slot and subcarrier occupancy in a PRB of the CSI-RS resource
scramblingID Scrambling ID (see 38.214, section 5.2.2.3.1)

Conditional Presence	Explanation
Periodic	The field is optionally present, Need M, for periodic NZP-CSI-RS-Resources (as indicated in CSI-ResourceConfig). The field is absent otherwise
PeriodicOrSemiPersistent	The field is mandatory present, Need M, for periodic and semi-persistent NZP-CSI-RS-Resources (as indicated in CSI-ResourceConfig). The field is absent otherwise.

– *NZP-CSI-RS-ResourceId*

The IE *NZP-CSI-RS-ResourceId* is used to identify one NZP-CSI-RS-Resource.

NZP-CSI-RS-ResourceId information element

```
-- ASN1START
-- TAG-NZP-CSI-RS-RESOURCEID-START

NZP-CSI-RS-ResourceId ::=           INTEGER (0..maxNrofNZP-CSI-RS-Resources-1)

-- TAG-NZP-CSI-RS-RESOURCEID-STOP
-- ASN1STOP
```

– *NZP-CSI-RS-ResourceSet*

The IE *NZP-CSI-RS-ResourceSet* is a set of Non-Zero-Power (NZP) CSI-RS resources (their IDs) and set-specific parameters.

NZP-CSI-RS-ResourceSet information element

```
-- ASN1START
```

```
-- TAG-NZP-CSI-RS-RESOURCESET-START
NZP-CSI-RS-ResourceSet ::=          SEQUENCE {
    nzp-CSI-ResourceSetId               NZP-CSI-RS-ResourceSetId,
    nzp-CSI-RS-Resources                SEQUENCE (SIZE (1..maxNrofNZP-CSI-RS-ResourcesPerSet)) OF NZP-CSI-RS-ResourceId,
    repetition                          ENUMERATED { on, off }                                  OPTIONAL,
    aperiodicTriggeringOffset           INTEGER(0..4)                                           OPTIONAL,   -- Need S
    trs-Info                            ENUMERATED {true}                                       OPTIONAL,   -- Need R
    ...
}

-- TAG-NZP-CSI-RS-RESOURCESET-STOP
-- ASN1STOP
```

NZP-CSI-RS-ResourceSet field descriptions
aperiodicTriggeringOffset Offset X between the slot containing the DCI that triggers a set of aperiodic NZP CSI-RS resources and the slot in which the CSI-RS resource set is transmitted. When the field is absent the UE applies the value 0. Corresponds to L1 parameter 'Aperiodic-NZP-CSI-RS-TriggeringOffset' (see 38,214, section FFS_Section)
nzp-CSI-RS-Resources NZP-CSI-RS-Resources assocaited with this NZP-CSI-RS resource set. Corresponds to L1 parameter 'CSI-RS-ResourceConfigList' (see 38.214, section 5.2). For CSI, there are at most 8 NZP CSI RS resources per resource set
repetition Indicates whether repetition is on/off. If set to set to 'OFF', the UE may not assume that the NZP-CSI-RS resources within the resource set are transmitted with the same downlink spatial domain transmission filter and with same NrofPorts in every symbol. Corresponds to L1 parameter 'CSI-RS-ResourceRep' (see 38.214, sections 5.2.2.3.1 and 5.1.6.1.2). Can only be configured for CSI-RS resource sets which are associated with CSI-ReportConfig with report of L1 RSRP or "no report"
trs-Info Indicates that the antenna port for all NZP-CSI-RS resources in the CSI-RS resource set is same. If the field is absent or released the UE applies the value "false". Corresponds to L1 parameter 'TRS-Info' (see 38.214, section 5.2.2.3.1)

– *NZP-CSI-RS-ResourceSetId*

The IE *NZP-CSI-RS-ResourceSetId* is used to identify one *NZP-CSI-RS-ResourceSet*.

NZP-CSI-RS-ResourceSetId information element

```
-- ASN1START
-- TAG-NZP-CSI-RS-RESOURCESETID-START

NZP-CSI-RS-ResourceSetId ::=        INTEGER (0..maxNrofNZP-CSI-RS-ResourceSets-1)

-- TAG-NZP-CSI-RS-RESOURCESETID-STOP
-- ASN1STOP
```

– *P-Max*

The IE *P-Max* is used to limit the UE's uplink transmission power on a carrier frequency, see TS 38.101 [14].

P-Max information element

```
-- ASN1START
-- TAG-P-MAX-START

P-Max ::=                           INTEGER (-30..33)

-- TAG-P-MAX-STOP
-- ASN1STOP
```

– *PCI-List*

The IE *PCI-List* concerns a list of physical cell identities, which may be used for different purposes.

PCI-List information element

```
-- ASN1START
-- TAG-PCI-LIST-START

PCI-List ::=                        SEQUENCE (SIZE (1..maxNrofCellMeas)) OF PhysCellId

-- TAG-PCI-LIST-STOP
-- ASN1STOP
```

– *PCI-Range*

The IE *PCI-Range* is used to encode either a single or a range of physical cell identities. The range is encoded by using a *start* value and by indicating the number of consecutive physical cell identities (including *start*) in the range. For fields comprising multiple occurrences of *PCI-Range*, the Network may configure overlapping ranges of physical cell identities.

PCI-Range information element

```
-- ASN1START
-- TAG-PCI-RANGE-START

PCI-Range ::=                       SEQUENCE {
    start                               PhysCellId,
    range                               ENUMERATED { n4, n8, n12, n16, n24, n32, n48, n64, n84,
                                                     n96, n128, n168, n252, n504, n1008, spare1}            OPTIONAL  -- Need S
}

-- TAG-PCI-RANGE-STOP
-- ASN1STOP
```

***PCI-Range* field descriptions**
range Indicates the number of physical cell identities in the range (including *start*). Value n4 corresponds with 4, n8 corresponds with 8 and so on. The UE shall apply value 1 in case the field is absent, in which case only the physical cell identity value indicated by *start* applies.
start Indicates the lowest physical cell identity in the range.

– *PCI-RangeElement*

The IE *PCI-RangeElement* is used to define a PCI-Range as part of a list (e.g. AddMod list).

PCI-RangeElement information element

```
-- ASN1START
-- TAG-PCI-RANGEELEMENT-START

PCI-RangeElement ::=                SEQUENCE {
    pci-RangeIndex                      PCI-RangeIndex,
    pci-Range                           PCI-Range
}

-- TAG-PCI-RANGEELEMENT-STOP
-- ASN1STOP
```

PCI-RangeElement field descriptions
pci-Range Physical cell identity or a range of physical cell identities.

– *PCI-RangeIndex*

The IE PCI-RangeIndex identifies a physical cell id range, which may be used for different purposes.

PCI-RangeIndex information element

```
-- ASN1START
-- TAG-PCI-RANGE-INDEX-START

PCI-RangeIndex ::=                  INTEGER (1..maxNrofPCI-Ranges)

-- TAG-PCI-RANGE-INDEX-STOP
-- ASN1STOP
```

– *PCI-RangeIndexList*

The IE *PCI-RangeIndexList* concerns a list of indexes of physical cell id ranges, which may be used for different purposes.

PCI-RangeIndexList information element

```
-- ASN1START
-- TAG-PCI-RANGE-INDEX-LIST-START

PCI-RangeIndexList ::=              SEQUENCE (SIZE (1..maxNrofPCI-Ranges)) OF PCI-RangeIndex

-- TAG-PCI-Range-INDEX-LIST-STOP
-- ASN1STOP
```

– *PDCCH-Config*

The *PDCCH-Config* IE is used to configure UE specific PDCCH parameters such as control resource sets (CORESET), search spaces and additional parameters for acquiring the PDCCH.

PDCCH-Config information element

```
-- ASN1START
-- TAG-PDCCH-CONFIG-START

PDCCH-Config ::=                    SEQUENCE {
    controlResourceSetToAddModList      SEQUENCE(SIZE (1..3)) OF ControlResourceSet                OPTIONAL,   -- Need N
    controlResourceSetToReleaseList     SEQUENCE(SIZE (1..3)) OF ControlResourceSetId              OPTIONAL,   -- Need N
    searchSpacesToAddModList            SEQUENCE(SIZE (1..10)) OF SearchSpace                      OPTIONAL,   -- Need N
    searchSpacesToReleaseList           SEQUENCE(SIZE (1..10)) OF SearchSpaceId                    OPTIONAL,   -- Need N
    downlinkPreemption                  SetupRelease { DownlinkPreemption }                        OPTIONAL,   -- Need M
    tpc-PUSCH                           SetupRelease { PUSCH-TPC-CommandConfig }                   OPTIONAL,   -- Need M
    tpc-PUCCH                           SetupRelease { PUCCH-TPC-CommandConfig }                   OPTIONAL,   -- Cond PUCCH-CellOnly
    tpc-SRS                             SetupRelease { SRS-TPC-CommandConfig}                      OPTIONAL,   -- Need M
    ...
}

-- TAG-PDCCH-CONFIG-STOP
-- ASN1STOP
```

PDCCH-Config field descriptions
controlResourceSetToAddModList List of UE specifically configured Control Resource Sets (CORESETs) to be used by the UE. The network configures at most 3 CORESETs per BWP per cell (including the initial CORESET).
downlinkPreemption Configuration of downlink preemtption indications to be monitored in this cell. Corresponds to L1 parameter 'Preemp-DL' (see 38.214, section 11.2) FFS_RAN1: LS R1-1801281 indicates this is "Per Cell (but association with each configured BWP is needed)" => Unclear, keep on BWP for now.
searchSpacesToAddModList List of UE specifically configured Search Spaces. The network configures at most 10 Search Spaces per BWP per cell (including the initial Search Space).
tpc-PUCCH Enable and configure reception of group TPC commands for PUCCH
tpc-PUSCH Enable and configure reception of group TPC commands for PUSCH
tpc-SRS Enable and configure reception of group TPC commands for SRS

Conditional Presence	Explanation
PUCCH-CellOnly	The field is optionally present, Need M, for the PDCCH-Config of an SpCells as well as for PUCCH SCells. The field is absent otherwise.

– *PDCCH-ConfigCommon*

The IE *PDCCH-ConfigCommon* is used to configure cell specific PDCCH parameters provided in SIB as well as during handover and PSCell/SCell addition.

***PDCCH-ConfigCommon* information element**

```
-- ASN1START
-- TAG-PDCCH-CONFIGCOMMON-START

PDCCH-ConfigCommon ::=              SEQUENCE {
    controlResourceSetZero              INTEGER (0..15)                                 OPTIONAL,   -- Cond InitialBWP-Only
    commonControlResourceSet            ControlResourceSet                            OPTIONAL,  -- Need R
    searchSpaceZero                     INTEGER (0..15)                                 OPTIONAL,   -- Cond InitialBWP-Only
    commonSearchSpace                   SEQUENCE (SIZE(1..4)) OF SearchSpace            OPTIONAL,   -- Need R
    searchSpaceSIB1                     SearchSpaceId                                   OPTIONAL,   -- Need R
    searchSpaceOtherSystemInformation   SearchSpaceId                                   OPTIONAL,   -- Need R
    pagingSearchSpace                   SearchSpaceId                                   OPTIONAL,   -- Need R
    ra-SearchSpace                      SearchSpaceId                                   OPTIONAL,   -- Need R
    ...
}

-- TAG-PDCCH-CONFIGCOMMON-STOP
-- ASN1STOP
```

PDCCH-ConfigCommon field descriptions
commonControlResourceSet An additional common control resource setwhich may be configured and used for RAR (see ra-SearchSpace). If the network configures this field, it uses a ControlResourceSetId other than 0 for this ControlResourceSet.
commonSearchSpace An additional common search space.
controlResourceSetZero Parameters of the common CORESET#0. The values are interpreted like the corresponding bits in MIB pdcch-ConfigSIB1. Even though this field is only configured in the initial BWP (BWP#0) the UE acquires the CORESET#0 irrespective of the currently active BWP as described in FFS_Spec, section FFS_Section).
pagingSearchSpace ID of the Search space for paging. Corresponds to L1 parameter 'paging-SearchSpace' (see 38.213, section 10) If the field is absent, the monitoring occasions are derived as described in 38.213, section 10.1 and section 13.
ra-SearchSpace ID of the Search space for random access procedure. Corresponds to L1 parameter 'ra-SearchSpace' (see 38.214?, section FFS_Section) If the field is absent, the monitoring occasions are derived as described in 38.213, section 10.1 and section 13.
searchSpaceOtherSystemInformation ID of the Search space for other system information, i.e., SIB2 and beyond. Corresponds to L1 parameter 'osi-SearchSpace' (see 38.213, section 10) If the field is absent, the monitoring occasions are derived as described in 38.213, section 10.1 and section 13.
searchSpaceSIB1 ID of the search space for SIB1 message. Corresponds to L1 parameter 'rmsi-SearchSpace' (see 38.213, section 10)
searchSpaceZero Parameters of the common SearchSpace#0. The values are interpreted like the corresponding bits in MIB pdcch-ConfigSIB1. Even though this field is only configured in the initial BWP (BWP#0) the UE acquires the SearchSpace#0 irrespective of the currently active BWP as described in FFS_Spec, section FFS_Section).

Conditional Presence	Explanation
InitialBWP-Only	The field is mandatory present in the PDCCH-ConfigCommon of the initial BWP (BWP#0). It is absent in other BWPs.

– *PDCCH-ServingCellConfig*

The IE *PDCCH-ServingCellConfig* is used to configure UE specific PDCCH parameters applicable across all bandwidth parts of a serving cell.

***PDCCH-ServingCellConfig* information element**

```
-- ASN1START
-- TAG-PDCCH-SERVINGCELLCONFIG-START

PDCCH-ServingCellConfig ::=         SEQUENCE {
    slotFormatIndicator                 SetupRelease { SlotFormatIndicator }                        OPTIONAL,   -- Need M
    ...
}

-- TAG-PDCCH-SERVINGCELLCONFIG-STOP
-- ASN1STOP
```

PDCCH-ServingCellConfig field descriptions
slotFormatIndicator
Configuration of Slot-Format-Indicators to be monitored in the correspondingly configured PDCCHs this serving cell.

– *PDCP-Config*

The IE *PDCP-Config* is used to set the configurable PDCP parameters for signalling and data radio bearers.

PDCP-Config information element

```
-- ASN1START
-- TAG-PDCP-CONFIG-START

PDCP-Config ::=         SEQUENCE {
    drb                     SEQUENCE {
        discardTimer            ENUMERATED {ms10, ms20, ms30, ms40, ms50, ms60, ms75, ms100, ms150, ms200, ms250, ms300, ms500, ms750, ms1500,
infinity}                                                   OPTIONAL, -- Cond Setup
        pdcp-SN-SizeUL          ENUMERATED {len12bits, len18bits}               OPTIONAL, -- Cond Setup2
        pdcp-SN-SizeDL          ENUMERATED {len12bits, len18bits}               OPTIONAL, -- Cond Setup2
        headerCompression       CHOICE {
            notUsed                 NULL,
            rohc                    SEQUENCE {
                maxCID                  INTEGER (1..16383)              DEFAULT 15,
                profiles                SEQUENCE {
                    profile0x0001           BOOLEAN,
                    profile0x0002           BOOLEAN,
                    profile0x0003           BOOLEAN,
                    profile0x0004           BOOLEAN,
                    profile0x0006           BOOLEAN,
                    profile0x0101           BOOLEAN,
                    profile0x0102           BOOLEAN,
                    profile0x0103           BOOLEAN,
                    profile0x0104           BOOLEAN
                },
                drb-ContinueROHC            ENUMERATED { true }                                     OPTIONAL -- Need R
            },
            uplinkOnlyROHC          SEQUENCE {
                maxCID                  INTEGER (1..16383)              DEFAULT 15,
                profiles                SEQUENCE {
                    profile0x0006           BOOLEAN
                },
                drb-ContinueROHC            ENUMERATED { true }                                     OPTIONAL -- Need R
            },
            ...
        },
        integrityProtection     ENUMERATED { enabled }                                              OPTIONAL,   -- Cond ConnectedTo5GC
        statusReportRequired    ENUMERATED { true }                                                 OPTIONAL,   -- Cond Rlc-AM
        outOfOrderDelivery      ENUMERATED { true }                                               OPTIONAL -- Need R
    }                                                                                                   OPTIONAL,   -- Cond DRB
    moreThanOneRLC          SEQUENCE {
        primaryPath             SEQUENCE {
```

```
            cellGroup               CellGroupId                                     OPTIONAL, -- Need R
            logicalChannel          LogicalChannelIdentity                          OPTIONAL  -- Need R
        },
        ul-DataSplitThreshold   UL-DataSplitThreshold                               OPTIONAL, -- Cond SplitBearer
        pdcp-Duplication            BOOLEAN                                             OPTIONAL -- Need R
    }                                                                                           OPTIONAL, -- Cond MoreThanOneRLC

    t-Reordering                ENUMERATED {
                                    ms0, ms1, ms2, ms4, ms5, ms8, ms10, ms15, ms20, ms30, ms40, ms50, ms60, ms80, ms100, ms120, ms140, ms160,
ms180, ms200, ms220,
                                    ms240, ms260, ms280, ms300, ms500, ms750, ms1000, ms1250, ms1500, ms1750, ms2000, ms2250, ms2500, ms2750,
                                    ms3000, spare28, spare27, spare26, spare25, spare24, spare23, spare22, spare21, spare20,
                                    spare19, spare18, spare17, spare16, spare15, spare14, spare13, spare12, spare11, spare10, spare09,
                                    spare08, spare07, spare06, spare05, spare04, spare03, spare02, spare01 }     OPTIONAL, -- Need S


    ...
}

UL-DataSplitThreshold ::= ENUMERATED {
                                        b0, b100, b200, b400, b800, b1600, b3200, b6400, b12800, b25600, b51200, b102400, b204800,
                                        b409600, b819200, b1228800, b1638400, b2457600, b3276800, b4096000, b4915200, b5734400,
                                        b6553600, infinity, spare8, spare7, spare6, spare5, spare4, spare3, spare2, spare1}

-- TAG-PDCP-CONFIG-STOP
-- ASN1STOP
```

***PDCP-Config* field descriptions**
discardTimer Value in ms of *discardTimer* specified in TS 38.323 [5]. Value ms50 corresponds to 50 ms, ms100 corresponds to 100 ms and so on.
drb-ContinueROHC Indicates whether the PDCP entity continues or resets the ROHC header compression protocol during PDCP re-establishment. This field is configured only in case of reconfiguration with sync where the PDCP termination point is not changed.
headerCompression If rohc is configured, the UE shall apply the configured ROHC profile(s) in both uplink and downlink. If uplinkOnlyROHC is configured, the UE shall apply the configure ROHC profile(s) in uplink (there is no header compression in downlink). ROHC can be configured for any bearer type. ROHC should be configured at reconfiguration involving PDCP re-establishment if the RB was previously configured with ROHC. Header compression should not be configured when out-of-order delivery is allowed for PDCP SDUs.
integrityProtection Indicates whether or not integrity protection is configured for this radio bearer. The value of integrityProtection for a DRB can only be changed using reconfiguration with sync. FFS: text to indicate where to find the key.
maxCID Indicates the value of the MAX_CID parameter as specified in TS 38.323 [5] FFS: need to specify something with respect to UE capabilities.
moreThanOneRLC FFS / TODO: Handle more than two secondary cell groups
outOfOrderDelivery Indicates whether or not *outOfOrderDelivery* specified in TS 38.323 [5] is configured. Out-of-order delivery is configured only when the radio bearer is established
pdcp-Duplication Indicates whether or not uplink duplication status at the time of receiving this IE is configured and activated as specified in TS 38.323 [5]. The presence of this field indicates whether duplication is configured. The value of this field, when the field is present, indicates whether duplication is activated. The value of this field is always TRUE, when configured for a SRB.
pdcp-SN-Size PDCP sequence number size, 12 or 18 bits.
primaryPath Indicates the cell group ID and LCID of the primary RLC entity as specified in TS 38.323 clause 5.2.1 for UL data tranmission when more than one RLC entity is associated with the PDCP entity. In this version of the specification, only cell group ID corresponding to MCG is supported for SRBs.
pdcp-SN-Size PDCP sequence number size, 12 or 18 bits.
statusReportRequired For AM DRBs, indicates whether the DRB is configured to send a PDCP status report in the uplink, as specified in TS 38.323 [5]. For UL DRBs, the value shall be ignored by the UE.
t-Reordering Value in ms of t-Reordering specified in TS 38.323 [5]. Value ms0 corresponds to 0ms, value ms20 corresponds to 20ms, value ms40 corresponds to 40ms, and so on. When the field is absent the UE applies the value *infinity*.
ul-DataSplitThreshold Parameter specified in TS 38.323 [5]. Value b0 corresponds to 0 bits, value b100 corresponds to 100 bits, value b200 corresponds to 200 bits, and so on.

Conditional presence	Explanation
DRB	This field is mandatory present when the corresponding DRB is being set up, not present for SRBs. Otherwise this field is optionally present, need M.
MoreThanOneRLC	This field is mandatory present upon RRC reconfiguration with setup of a PDCP entity for a radio bearer with more than one associated logical channel and upon RRC reconfiguration with the association of an additional logical channel to the PDCP entity. Upon RRC reconfiguration when a PDCP entity is associated with multiple logical channels, this field is optionally present need M. Otherwise, this field is absent and all its included parameters are released.
Rlc-AM	For RLC AM, the field is optionally present, need R. Otherwise, the field is not present.
Setup	The field is mandatory present in case of radio bearer setup. Otherwise the field is optionally present, need M.
SplitBearer	The field is optional present, need M, n case of radio bearer with more than one associated RLC mapped to different cell groups. If the field is absent when the split bearer is configured for the radio bearer first time, then the default value *infinity* is applied.
ConnectedTo5GC	The field is optionally present, need R, if EN-DC is not configured, and absent if EN-DC is configured.
Setup2	This field is mandatory present in case for radio bearer setup for RLC-AM and RLC-UM. This field is optionally present in case for handover and reestablishment for for RLC-UM..Otherwise, ths field is not present.

– *PDSCH-Config*

The *PDSCH-Config* IE is used to configure the UE specific PDSCH parameters.

PDSCH-Config information element

```
-- ASN1START
-- TAG-PDSCH-CONFIG-START

PDSCH-Config ::=                    SEQUENCE {
    dataScramblingIdentityPDSCH         INTEGER (0..1023)                                       OPTIONAL,
    dmrs-DownlinkForPDSCH-MappingTypeA  SetupRelease { DMRS-DownlinkConfig }                    OPTIONAL,   -- Need M
    dmrs-DownlinkForPDSCH-MappingTypeB  SetupRelease { DMRS-DownlinkConfig }                    OPTIONAL,   -- Need M

    tci-StatesToAddModList              SEQUENCE (SIZE(1..maxNrofTCI-States)) OF TCI-State      OPTIONAL,   -- Need N
    tci-StatesToReleaseList             SEQUENCE (SIZE(1..maxNrofTCI-States)) OF TCI-StateId    OPTIONAL,   -- Need N
    vrb-ToPRB-Interleaver               ENUMERATED {n2, n4}                                     OPTIONAL,   -- Need S
    resourceAllocation                  ENUMERATED { resourceAllocationType0, resourceAllocationType1, dynamicSwitch},
    pdsch-TimeDomainAllocationList      SetupRelease { PDSCH-TimeDomainResourceAllocationList }     OPTIONAL,   -- Need M
    pdsch-AggregationFactor             ENUMERATED { n2, n4, n8 }                               OPTIONAL,   -- Need S
    rateMatchPatternToAddModList        SEQUENCE (SIZE (1..maxNrofRateMatchPatterns)) OF RateMatchPattern   OPTIONAL,   -- Need N
    rateMatchPatternToReleaseList       SEQUENCE (SIZE (1..maxNrofRateMatchPatterns)) OF RateMatchPatternId    OPTIONAL,   -- Need N
    rateMatchPatternGroup1              RateMatchPatternGroup       OPTIONAL,   -- Need R
    rateMatchPatternGroup2              RateMatchPatternGroup       OPTIONAL,   -- Need R

    rbg-Size                            ENUMERATED {config1, config2},
    mcs-Table                           ENUMERATED {qam256, spare1}                             OPTIONAL,   -- Need S
    maxNrofCodeWordsScheduledByDCI      ENUMERATED {n1, n2}                                     OPTIONAL,   -- Need R

    prb-BundlingType                    CHOICE {
        staticBundling                      SEQUENCE {
            bundleSize                          ENUMERATED { n4, wideband }                     OPTIONAL    -- Need S
        },
        dynamicBundling                     SEQUENCE {
```

```
            bundleSizeSet1                          ENUMERATED { n4, wideband, n2-wideband, n4-wideband }       OPTIONAL,   -- Need S
            bundleSizeSet2                          ENUMERATED { n4, wideband }                                 OPTIONAL    -- Need S
        }
    },
    zp-CSI-RS-ResourceToAddModList                  SEQUENCE (SIZE (1..maxNrofZP-CSI-RS-Resources)) OF ZP-CSI-RS-Resource     OPTIONAL, -- Need N
    zp-CSI-RS-ResourceToReleaseList                 SEQUENCE (SIZE (1..maxNrofZP-CSI-RS-Resources)) OF ZP-CSI-RS-ResourceId      OPTIONAL, -- Need
N
    aperiodic-ZP-CSI-RS-ResourceSetsToAddModList    SEQUENCE (SIZE (1..maxNrofZP-CSI-RS-ResourceSets)) OF ZP-CSI-RS-ResourceSet  OPTIONAL, -- Need
N
    aperiodic-ZP-CSI-RS-ResourceSetsToReleaseList   SEQUENCE (SIZE (1..maxNrofZP-CSI-RS-ResourceSets)) OF ZP-CSI-RS-ResourceSetId OPTIONAL,
                                                                                                                    -- Need N
    sp-ZP-CSI-RS-ResourceSetsToAddModList   SEQUENCE (SIZE (1..maxNrofZP-CSI-RS-ResourceSets)) OF ZP-CSI-RS-ResourceSet          OPTIONAL, -- Need
N
    sp-ZP-CSI-RS-ResourceSetsToReleaseList  SEQUENCE (SIZE (1..maxNrofZP-CSI-RS-ResourceSets)) OF ZP-CSI-RS-ResourceSetId     OPTIONAL, -- Need N
    p-ZP-CSI-RS-ResourceSet                 SetupRelease { ZP-CSI-RS-ResourceSet }                                  OPTIONAL, -- Need M
    ...
}
RateMatchPatternGroup ::=               SEQUENCE (SIZE (1..maxNrofRateMatchPatternsPerGroup)) OF CHOICE {  cellLevel
    RateMatchPatternId,
    bwpLevel                                RateMatchPatternId
}

-- TAG-PDSCH-CONFIG-STOP
-- ASN1STOP
```

PDSCH-Config field descriptions
aperiodic-ZP-CSI-RS-ResourceSetsToAddModList AddMod/Release lists for configuring aperiodically triggered zero-power CSI-RS resource sets. Each set contains a ZP-CSI-RS-ResourceSetId and the IDs of one or more ZP-CSI-RS-Resources (the actual resources are defined in the zp-CSI-RS-ResourceToAddModList). The network configures the UE with at most 3 aperiodic ZP-CSI-RS-ResourceSets and it uses only the ZP-CSI-RS-ResourceSetId 1 to 3. The network triggers a set by indicating its ZP-CSI-RS-ResourceSetId in the DCI payload. The DCI codepoint '01' triggers the resource set with ZP-CSI-RS-ResourceSetId 1, the DCI codepoint '10' triggers the resource set with ZP-CSI-RS-ResourceSetId 2, and the DCI codepoint '11' triggers the resource set with ZP-CSI-RS-ResourceSetId 3. Corresponds to L1 parameter ' ZP-CSI-RS-ResourceSetConfigList' (see 38.214, section FFS_Section)
dataScramblingIdentityPDSCH Identifer used to initalite data scrambling (c_init) for PDSCH. Corresponds to L1 parameter 'Data-scrambling-Identity' (see 38.211, section 7.3.1.1).
dmrs-DownlinkForPDSCH-MappingTypeA DMRS configuration for PDSCH transmissions using PDSCH mapping type A (chosen dynamically via PDSCH-TimeDomainResourceAllocation).
dmrs-DownlinkForPDSCH-MappingTypeB DMRS configuration for PDSCH transmissions using PDSCH mapping type B (chosen dynamically via PDSCH-TimeDomainResourceAllocation).
maxNrofCodeWordsScheduledByDCI Maximum number of code words that a single DCI may schedule. This changes the number of MCS/RV/NDI bits in the DCI message from 1 to 2.
mcs-Table Indicates which MCS table the UE shall use for PDSCH. Corresponds to L1 parameter 'MCS-Table-PDSCH' (see 38.214, section 5.1.3.1). If the field is absent the UE applies the value 64QAM.
pdsch-AggregationFactor Number of repetitions for data. Corresponds to L1 parameter 'aggregation-factor-DL' (see 38.214, section FFS_Section) When the field is absent the UE applies the value 1
pdsch-AllocationList List of time-domain configurations for timing of DL assignment to DL data. If configured, the values provided herein override the values received in corresponding PDSCH-ConfigCommon.
prb-BundlingType Indicates the PRB bundle type and bundle size(s). Corresponds to L1 parameter 'PRB_bundling' (see 38.214, section 5.1.2.3). If *dynamic* is chosen, the actual *bundleSizeSet1 or bundleSizeSet2* to use is indicated via DCI. Constraints on *bundleSize(Set)* setting depending on *vrb-ToPRB-Interleaver* and *rbg-Size* settings are described in TS 38.214 ([19], section 5.1.2.3). If a *bundleSize(Set)* value is absent, the UE applies the value *n2*.
p-ZP-CSI-RS-ResourceSet A set of periodically occurring ZP-CSI-RS-Resources (the actual resources are defined in the zp-CSI-RS-ResourceToAddModList). The network uses the ZP-CSI-RS-ResourceSetId=0 for this set.
rateMatchPatternGroup1 The IDs of a first group of RateMatchPatterns defined in PDSCH-Config -> rateMatchPatternToAddModList (BWP level) or in ServingCellConfig -> rateMatchPatternToAddModList (cell level). Corresponds to L1 parameter 'Resource-set-group-1'. (see 38.214, section FFS_Section)
rateMatchPatternGroup2 The IDs of a second group of RateMatchPatterns defined in PDSCH-Config -> rateMatchPatternToAddModList (BWP level) or in ServingCellConfig -> rateMatchPatternToAddModList (cell level). Corresponds to L1 parameter 'Resource-set-group-2'. (see 38.214, section FFS_Section)
rateMatchPatternToAddModList Resources patterns which the UE should rate match PDSCH around. The UE rate matches around the union of all resources indicated in the nexted bitmaps. Corresponds to L1 parameter 'Resource-set-BWP' (see 38.214, section 5.1.2.2.3) FFS: RAN1 indicates that there should be a set of patterns per cell and one per BWP => Having both seems unnecessary.
rbg-Size Selection between config 1 and config 2 for RBG size for PDSCH. Corresponds to L1 parameter 'RBG-size-PDSCH' (see 38.214, section 5.1.2.2.1)
resourceAllocation Configuration of resource allocation type 0 and resource allocation type 1 for non-fallback DCI Corresponds to L1 parameter 'Resouce-allocation-config' (see 38.214, section 5.1.2)

sp-ZP-CSI-RS-ResourceSetsToAddModList AddMod/Release lists for configuring aperiodically triggered zero-power CSI-RS resource sets. Each set contains a *ZP-CSI-RS-ResourceSetId* and the IDs of one or more *ZP-CSI-RS-Resources* (the actual resources are defined in the *zp-CSI-RS-ResourceToAddModList*). The network configures the UE with at most 3 aperiodic ZP-CSI-RS-ResourceSets and it uses only the ZP-CSI-RS-ResourceSetIds 1 to 3. The network triggers a set by indicating its *ZP-CSI-RS-ResourceSetId* in the DCI payload. The DCI codepoint '01' triggers the resource set with *ZP-CSI-RS-ResourceSetId* 1, the DCI codepoint '10' triggers the resource set with *ZP-CSI-RS-ResourceSetId* 2, and the DCI codepoint '11' triggers the resource set with *ZP-CSI-RS-ResourceSetId* 3. Corresponds to L1 parameter 'ZP-CSI-RS-ResourceSetConfigList' (see 38.214, section FFS_Section).
tci-StatesToAddModList A list of Transmission Configuration Indicator (TCI) states indicating a transmission configuration which includes QCL-relationships between the DL RSs in one RS set and the PDSCH DMRS ports (see 38.214, section 5.1.4)
vrb-ToPRB-Interleaver Interleaving unit configurable between 2 and 4 PRBs Corresponds to L1 parameter 'VRB-to-PRB-interleaver' (see 38.211, section 6.3.1.7). When the field is absent, the UE performs non-interleaved VRB-to-PRB mapping.
zp-CSI-RS-ResourceToAddModList A list of Zero-Power (ZP) CSI-RS resources used for PDSCH rate-matching. Corresponds to L1 parameter 'ZP-CSI-RS-ResourceConfigList' (see 38.214, section FFS_Section)

– *PDSCH-ConfigCommon*

The IE *PDSCH-ConfigCommon* is used to configure FFS

PDSCH-ConfigCommon information element

```
-- ASN1START
-- TAG-PDSCH-CONFIGCOMMON-START

PDSCH-ConfigCommon ::=                SEQUENCE {
    pdsch-TimeDomainAllocationList                PDSCH-TimeDomainResourceAllocationList       OPTIONAL,   -- Need R
    ...
}

-- TAG-PDSCH-CONFIGCOMMON-STOP
-- ASN1STOP
```

PDSCH-ConfigCommon field descriptions
pdsch-AllocationList List of time-domain configurations for timing of DL assignment to DL data

– *PDSCH-ServingCellConfig*

The IE *PDSCH-ServingCellConfig* is used to configure UE specific PDSCH parameters that are common across the UE's BWPs of one serving cell.

PDSCH-ServingCellConfig information element

```
-- ASN1START
-- TAG-PDSCH-SERVINGCELLCONFIG-START
```

```
PDSCH-ServingCellConfig ::=             SEQUENCE {
    codeBlockGroupTransmission              SetupRelease { PDSCH-CodeBlockGroupTransmission }               OPTIONAL,   -- Need M
    xOverhead                               ENUMERATED { xOh6, xOh12, xOh18 }                               OPTIONAL,   -- Need S
    nrofHARQ-ProcessesForPDSCH              ENUMERATED {n2, n4, n6, n10, n12, n16}                          OPTIONAL,   -- Need S
    pucch-Cell                              ServCellIndex                                                   OPTIONAL ,  -- Cond SCellAddOnly
    ...
}

PDSCH-CodeBlockGroupTransmission ::=    SEQUENCE {
    maxCodeBlockGroupsPerTransportBlock     ENUMERATED {n2, n4, n6, n8},
    codeBlockGroupFlushIndicator            BOOLEAN,
    ...
}

-- TAG-PDSCH-SERVINGCELLCONFIG-STOP
-- ASN1STOP
```

PDSCH-CodeBlockGroupTransmission field descriptions
codeBlockGroupFlushIndicator Indicates whether CBGFI for CBG based (re)transmission in DL is enabled (true). (see 38.212, section 7.3.1.2.2)
maxCodeBlockGroupsPerTransportBlock Maximum number of code-block-groups (CBGs) per TB. In case of multiple CW the maximum CBG is 4 (see 38.213, section 9.1.1)

PDSCH-ServingCellConfig field descriptions
codeBlockGroupTransmission Enables and configures code-block-group (CBG) based transmission (see 38.213, section 9.1.1)
nrofHARQ-ProcessesForPDSCH The number of HARQ processes to be used on the PDSCH of a serving cell. n2 corresponds to 2 HARQ processes, n4 to 4 HARQ processes and so on. If the field is absent, the UE uses 8 HARQ processes. Corresponds to L1 parameter 'number-HARQ-process-PDSCH' (see 38.214, section REF)
pucch-Cell The ID of the serving cell (of the same cell group) to use for PUCCH. If the field is absent, the UE sends the HARQ feedback on the PUCCH of the SpCell of this cell group.
xOverhead Accounts for overhead from CSI-RS, CORESET, etc. If the field is absent, the UE applies value xOh0. Corresponds to L1 parameter 'Xoh-PDSCH' (see 38.214, section 5.1.3.2)

Conditional Presence	Explanation
SCellAddOnly	It is optionally present, Need M, for SCells when adding a new SCell. The field is absent when reconfiguring SCells. The field is also absent for the SpCells.

– *PDSCH-TimeDomainResourceAllocationList*

The IE *PDSCH-TimeDomainResourceAllocation* is used to configure a time domain relation between PDCCH and PDSCH. The PDSCH-TimeDomainResourceAllocationList contains one or more of such PDSCH-TimeDomainResourceAllocations. The network indicates in the DL assignment which of the configued time domain allocations the UE

shall apply for that DL assignment. The UE determines the bit width of the DCI field based on the number of entries in the PDSCH-TimeDomainResourceAllocationList. Value 0 in the DCI field refers to the first element in this list, value 1 in the DCI field refers to the second element in this list, and so on.

PDSCH-TimeDomainResourceAllocationList information element

```
-- ASN1START
-- TAG-PDSCH-TIMEDOMAINRESOURCEALLOCATIONLIST-START


PDSCH-TimeDomainResourceAllocationList  ::= SEQUENCE (SIZE(1..maxNrofDL-Allocations)) OF PDSCH-TimeDomainResourceAllocation

PDSCH-TimeDomainResourceAllocation ::=  SEQUENCE {
    k0                                  INTEGER(0..32)                      OPTIONAL,   -- Need S
    mappingType                         ENUMERATED {typeA, typeB},
    startSymbolAndLength                INTEGER (0..127)
}

-- TAG-PDSCH-TIMEDOMAINRESOURCEALLOCATIONLIST-STOP
-- ASN1STOP
```

PDSCH-TimeDomainResourceAllocation field descriptions
k0 The *n1* corresponds to the value 1, *n2* corresponhds to value 2, and so on. Corresponds to L1 parameter 'K0' (see 38.214, section FFS_Section) When the field is absent the UE applies the value 0.
mappingType PDSCH mapping type. Corresponds to L1 parameter 'Mapping-type' (see 38.214, section FFS_Section)
startSymbolAndLength An index into a table/equation in RAN1 specs capturing valid combinations of start symbol and length (jointly encoded). Corresponds to L1 parameter 'Index-start-len' (see 38.214, section FFS_Section)

– *PhysCellId*

The *PhysCellId* identifies the physical cell identity (PCI).

PhysCellId information element

```
-- ASN1START
-- TAG-PHYS-CELL-ID-START

PhysCellId ::=                      INTEGER (0..1007)

-- TAG-PHYS-CELL-ID-STOP
-- ASN1STOP
```

– *PhysicalCellGroupConfig*

The IE *PhysicalCellGroupConfig* is used to configure cell-group specific L1 parameters.

PhysicalCellGroupConfig information element

```
-- ASN1START
-- TAG-PHYSICALCELLGROUPCONFIG-START

PhysicalCellGroupConfig ::=         SEQUENCE {
    harq-ACK-SpatialBundlingPUCCH       ENUMERATED {true}                                   OPTIONAL,   -- Need S
    harq-ACK-SpatialBundlingPUSCH       ENUMERATED {true}                                   OPTIONAL,   -- Need S
    p-NR                                P-Max                                               OPTIONAL,   -- Need R
    pdsch-HARQ-ACK-Codebook             ENUMERATED {semiStatic, dynamic},
    tpc-SRS-RNTI                        RNTI-Value                                          OPTIONAL,   -- Need R
    tpc-PUCCH-RNTI                      RNTI-Value                                          OPTIONAL,   -- Need R
    tpc-PUSCH-RNTI                      RNTI-Value                                          OPTIONAL,   -- Need R
    sp-CSI-RNTI                         RNTI-Value                                          OPTIONAL,   -- Cond SP-CSI-Report
    cs-RNTI                             SetupRelease { RNTI-Value }                         OPTIONAL,    -- Need R
    ...
}

-- TAG-PHYSICALCELLGROUPCONFIG-STOP
-- ASN1STOP
```

PhysicalCellGroupConfig field descriptions
cs-RNTI RNTI value for downlink SPS (see SPS-config) and uplink configured grant (see ConfiguredGrantConfig).
harq-ACK-SpatialBundlingPUCCH Enables spatial bundling of HARQ ACKs. It is configured per cell group (i.e. for all the cells within the cell group) for PUCCH reporting of HARQ-ACK. It is only applicable when more than 4 layers are possible to schedule. When the fidld is absent, the spatial bundling is disabled. Corresponds to L1 parameter 'HARQ-ACK-spatial-bundling' (see 38.213, section FFS_Section)
harq-ACK-SpatialBundlingPUSCH Enables spatial bundling of HARQ ACKs. It is configured per cell group (i.e. for all the cells within the cell group) for PUSCH reporting of HARQ-ACK. It is only applicable when more than 4 layers are possible to schedule. When the fidld is absent, the spatial bundling is disabled. Corresponds to L1 parameter 'HARQ-ACK-spatial-bundling' (see 38.213, section FFS_Section)
p-NR The maximum transmit power to be used by the UE in this NR cell group.
pdsch-HARQ-ACK-Codebook The PDSCH HARQ-ACK codebook is either semi-static or dynamic. This is applicable to both CA and none CA operation. Corresponds to L1 parameter 'HARQ-ACK-codebook' (see 38.213, section FFS_Section)
sp-CSI-RNTI RNTI for Semi-Persistent CSI reporting on PUSCH (see CSI-ReportConfig). Corresponds to L1 parameter 'SPCSI-RNTI' (see 38.214, section 5.2.1.5.2)
tpc-PUCCH-RNTI RNTI used for PUCCH TPC commands on DCI. Corresponds to L1 parameter 'TPC-PUCCH-RNTI' (see 38.213, section 10).
tpc-PUSCH-RNTI RNTI used for PUSCH TPC commands on DCI. Corresponds to L1 parameter 'TPC-PUSCH-RNTI' (see 38.213, section 10)
tpc-SRS-RNTI RNTI used for SRS TPC commands on DCI. Corresponds to L1 parameter 'TPC-SRS-RNTI' (see 38.213, section 10)

Conditional Presence	Explanation
SP-CSI-Report	The field is mandatory present, Need M, when at least one *CSI-ReportConfig* with *reportConfigType* set to *semiPersistentOnPUSCH* is configured; otherwise it is optionally present, need M.

– *PRB-Id*

The *PRB-Id* indentifies a Physical Resource Block (PRB) position within a carrier.

PRB-Id information element

```
-- ASN1START
-- TAG-PRB-ID-START

PRB-Id ::=                          INTEGER (0..maxNrofPhysicalResourceBlocks-1)

-- TAG-PRB-ID-STOP
-- ASN1STOP
```

– *PTRS-DownlinkConfig*

The IE *PTRS-DownlinkConfig* is used to configure downlink phase tracking reference signals (PTRS) (see 38.214 section5.1.6.3)

PTRS-DownlinkConfig information element

```
-- ASN1START
-- TAG-PTRS-DOWNLINKCONFIG-START

PTRS-DownlinkConfig ::=             SEQUENCE {
    frequencyDensity                    SEQUENCE (SIZE (2)) OF INTEGER (1..276)                     OPTIONAL,   -- Need S
    timeDensity                         SEQUENCE (SIZE (3)) OF INTEGER (0..29)                      OPTIONAL,   -- Need S
    epre-Ratio                      INTEGER (0..3)                                                OPTIONAL,   -- Need S
    resourceElementOffset               ENUMERATED { offset01, offset10, offset11 }                 OPTIONAL,   -- Need S
    ...
}

-- TAG-PTRS-DOWNLINKCONFIG-STOP
-- ASN1STOP
```

PTRS-DownlinkConfig field descriptions
epre-Ratio EPRE ratio between PTRS and PDSCH. Value 0 correspond to the codepoint "00" in table 4.1-2. Value 1 corresponds to codepoint "01" If the field is not provided, the UE applies value 0. Corresponds to L1 parameter 'DL-PTRS-EPRE-ratio' (see 38.214, section 4.1)
frequencyDensity Presence and frequency density of DL PT-RS as a function of Scheduled BW If the field is absent, the UE uses K_PT-RS = 2. Corresponds to L1 parameter 'DL-PTRS-frequency-density-table' (see 38.214, section 5.1)
resourceElementOffset Indicates the subcarrier offset for DL PTRS. If the field is absent, the UE applies the value offset00. Corresponds to L1 parameter 'DL-PTRS-RE-offset' (see 38.214, section 5.1.6.3)
timeDensity Presence and time density of DL PT-RS as a function of MCS. The value 29 is only applicable for MCS Table 5.1.3.1-1 (38.214) If the field is absent, the UE uses L_PT-RS = 1. Corresponds to L1 parameter 'DL-PTRS-time-density-table' (see 38.214, section 5.1)

– *PTRS-UplinkConfig*

The IE *PTRS-UplinkConfig* is used to configure uplink Phase-Tracking-Reference-Signals (PTRS).

PTRS-UplinkConfig information element

```
-- ASN1START
-- TAG-PTRS-UPLINKCONFIG-START

PTRS-UplinkConfig ::=               SEQUENCE {
```

```
    modeSpecificParameters                  CHOICE {
        cp-OFDM                                 SEQUENCE {
            frequencyDensity                        SEQUENCE (SIZE (2)) OF INTEGER (1..276)         OPTIONAL,   -- Need S
            timeDensity                             SEQUENCE (SIZE (3)) OF INTEGER (0..29)          OPTIONAL,   -- Need S
            maxNrofPorts                            ENUMERATED {n1, n2},
            resourceElementOffset                   ENUMERATED {offset01, offset10, offset11 }      OPTIONAL,   -- Need S
            ptrs-Power                              ENUMERATED {p00, p01, p10, p11}
        },
        dft-S-OFDM                              SEQUENCE {
            sampleDensity                       SEQUENCE (SIZE (5)) OF INTEGER (1..276),
            timeDensityTransformPrecoding       ENUMERATED {d2}                                     OPTIONAL -- Need S
        }
    }                                                                                               OPTIONAL,   -- Need M
    ...
}

-- TAG-PTRS-UPLINKCONFIG-STOP
-- ASN1STOP
```

PTRS-UplinkConfig field descriptions
cp-OFDM Configuration of UL PTRS for CP-OFDM
dft-S-OFDM Configuration of UL PTRS for DFT-S-OFDM.
frequencyDensity Presence and frequency density of UL PT-RS for CP-OFDM waveform as a function of scheduled BW If the field is absent, the UE uses K_PT-RS = 2. Corresponds to L1 parameter 'UL-PTRS-frequency-density-table' (see 38.214, section 6.1)
maxNrofPorts The maximum number of UL PTRS ports for CP-OFDM. Corresponds to L1 parameter 'UL-PTRS-ports' (see 38.214, section 6.2.3.1)
ptrs-Power UL PTRS power boosting factor per PTRS port. Corresponds to L1 parameter 'UL-PTRS-power' (see 38.214, section 6.1, table 6.2.3-5)
resourceElementOffset Indicates the subcarrier offset for UL PTRS for CP-OFDM. Corresponds to L1 parameter 'UL-PTRS-RE-offset' (see 38.214, section 6.1)
sampleDensity Sample density of PT-RS for DFT-s-OFDM, pre-DFT, indicating a set of thresholds T={NRBn,n=0,1,2,3,4}, that indicates dependency between presence of PT-RS and scheduled BW and the values of X and K the UE should use depending on the scheduled BW according to the table in 38.214 FFS_Section. Corresponds to L1 parameter 'UL-PTRS-pre-DFT-density' (see 38.214, section 6.1, 6.2.3-3)
timeDensity Presence and time density of UL PT-RS for CP-OFDM waveform as a function of MCS If the field is absent, the UE uses L_PT-RS = 1. Corresponds to L1 parameter 'UL-PTRS-time-density-table' (see 38.214, section 6.1)
timeDensityTransformPrecoding Time density (OFDM symbol level) of PT-RS for DFT-s-OFDM. If the field is absent, the UE applies value d1. Corresponds to L1 parameter 'UL-PTRS-time-density-transform-precoding' (see 38.214, section 6.1)

– *PUCCH-Config*

The IE *PUCCH-Config* is used to configure UE specific PUCCH parameters (per BWP).

PUCCH-Config information element

```
-- ASN1START
-- TAG-PUCCH-CONFIG-START

PUCCH-Config ::=                        SEQUENCE {
    resourceSetToAddModList                 SEQUENCE (SIZE (1..maxNrofPUCCH-ResourceSets)) OF PUCCH-ResourceSet          OPTIONAL,   -- Need N
    resourceSetToReleaseList                SEQUENCE (SIZE (1..maxNrofPUCCH-ResourceSets)) OF PUCCH-ResourceSetId        OPTIONAL,   -- Need N

    resourceToAddModList                    SEQUENCE (SIZE (1..maxNrofPUCCH-Resources)) OF PUCCH-Resource            OPTIONAL,   -- Need N
    resourceToReleaseList                   SEQUENCE (SIZE (1..maxNrofPUCCH-Resources)) OF PUCCH-ResourceId              OPTIONAL,   -- Need N

    format1                                 SetupRelease { PUCCH-FormatConfig }                                      OPTIONAL,   -- Need M
    format2                                 SetupRelease { PUCCH-FormatConfig }                                      OPTIONAL,   -- Need M
    format3                                 SetupRelease { PUCCH-FormatConfig }                                      OPTIONAL,   -- Need M
    format4                                 SetupRelease { PUCCH-FormatConfig }                                      OPTIONAL,   -- Need M

    schedulingRequestResourceToAddModList   SEQUENCE (SIZE (1..maxNrofSR-Resources)) OF SchedulingRequestResourceConfig     OPTIONAL, -- Need N
    schedulingRequestResourceToReleaseList  SEQUENCE (SIZE (1..maxNrofSR-Resources)) OF SchedulingRequestResourceId      OPTIONAL, -- Need N

    multi-CSI-PUCCH-ResourceList            SEQUENCE (SIZE (1..2)) OF PUCCH-ResourceId                               OPTIONAL,-- Need M
    dl-DataToUL-ACK                         SEQUENCE (SIZE (1..8)) OF INTEGER (0..15)                                   OPTIONAL,   -- Need M

    spatialRelationInfoToAddModList         SEQUENCE (SIZE (1..maxNrofSpatialRelationInfos)) OF PUCCH-SpatialRelationInfo OPTIONAL,   -- Need N
    spatialRelationInfoToReleaseList        SEQUENCE (SIZE (1..maxNrofSpatialRelationInfos)) OF PUCCH-SpatialRelationInfoId OPTIONAL,   -- Need N

    pucch-PowerControl                      PUCCH-PowerControl                                                       OPTIONAL,   -- Need M
    ...
}

PUCCH-FormatConfig ::=                  SEQUENCE {
    interslotFrequencyHopping               ENUMERATED {enabled}                                                 OPTIONAL,   -- Need R
    additionalDMRS                          ENUMERATED {true}                                                    OPTIONAL,   -- Need R
    maxCodeRate                             PUCCH-MaxCodeRate                                                    OPTIONAL,   -- Need R
    nrofSlots                               ENUMERATED {n2,n4,n8}                                                OPTIONAL,   -- Need S
    pi2BPSK                                 ENUMERATED {enabled}                                                 OPTIONAL,   -- Need R
    simultaneousHARQ-ACK-CSI                ENUMERATED {true}                                                    OPTIONAL -- Need R
}

PUCCH-MaxCodeRate ::=                   ENUMERATED {zeroDot08, zeroDot15, zeroDot25, zeroDot35, zeroDot45, zeroDot60, zeroDot80}

PUCCH-SpatialRelationInfo ::=           SEQUENCE {
    pucch-SpatialRelationInfoId             PUCCH-SpatialRelationInfoId,
    servingCellId                           ServCellIndex                                   OPTIONAL,  -- Need S
    referenceSignal                         CHOICE {
        ssb-Index                               SSB-Index,
        csi-RS-Index                            NZP-CSI-RS-ResourceId,
        srs                                     SEQUENCE {
                                                    resource                        SRS-ResourceId,
                                                    uplinkBWP                       BWP-Id
                                                }
    },
    pucch-PathlossReferenceRS-Id            PUCCH-PathlossReferenceRS-Id,
    p0-PUCCH-Id                             P0-PUCCH-Id,
```

```
    closedLoopIndex                         ENUMERATED { i0, i1 }
}

PUCCH-SpatialRelationInfoId ::=         INTEGER (1..maxNrofSpatialRelationInfos)

-- A set with one or more PUCCH resources
PUCCH-ResourceSet ::=                   SEQUENCE {
    pucch-ResourceSetId                     PUCCH-ResourceSetId,
    resourceList                    SEQUENCE (SIZE (1..maxNrofPUCCH-ResourcesPerSet)) OF PUCCH-ResourceId,
    maxPayloadMinus1                        INTEGER (4..256)                                    OPTIONAL -- Need R
}

PUCCH-ResourceSetId ::=                 INTEGER (0..maxNrofPUCCH-ResourceSets-1)

PUCCH-Resource ::=                      SEQUENCE {
    pucch-ResourceId                        PUCCH-ResourceId,
    startingPRB                             PRB-Id,
    intraSlotFrequencyHopping               ENUMERATED { enabled }                              OPTIONAL,   -- Need R
    secondHopPRB                            PRB-Id                                              OPTIONAL,   -- Need R
    format                                  CHOICE {
        format0                                 PUCCH-format0,                                  -- Cond InFirstSetOnly
        format1                                 PUCCH-format1,                                  -- Cond InFirstSetOnly
        format2                                 PUCCH-format2,                                  -- Cond NotInFirstSet
        format3                                 PUCCH-format3,                                  -- Cond NotInFirstSet
        format4                                 PUCCH-format4                                   -- Cond NotInFirstSet
    }
}

PUCCH-ResourceId ::=                    INTEGER (0..maxNrofPUCCH-Resources-1)


PUCCH-format0 ::=                           SEQUENCE {
    initialCyclicShift                          INTEGER(0..11),
    nrofSymbols                                 INTEGER (1..2),
    startingSymbolIndex                         INTEGER(0..13)
}

PUCCH-format1 ::=                           SEQUENCE {
    initialCyclicShift                          INTEGER(0..11),
    nrofSymbols                                 INTEGER (4..14),
    startingSymbolIndex                         INTEGER(0..10),
    timeDomainOCC                               INTEGER(0..6)
}

PUCCH-format2 ::=                           SEQUENCE {
    nrofPRBs                                    INTEGER (1..16),
    nrofSymbols                                 INTEGER (1..2),
    startingSymbolIndex                         INTEGER(0..13)
}

PUCCH-format3 ::=                           SEQUENCE {
    nrofPRBs                                    INTEGER (1..16),
    nrofSymbols                                 INTEGER (4..14),
    startingSymbolIndex                         INTEGER(0..10)
```

```
}

PUCCH-format4 ::=                       SEQUENCE {
    nrofSymbols                             INTEGER (4..14),
    occ-Length                              ENUMERATED {n2,n4},
    occ-Index                               ENUMERATED {n0,n1,n2,n3},
    startingSymbolIndex                     INTEGER(0..10)
}

-- TAG-PUCCH-CONFIG-STOP
-- ASN1STOP
```

PUCCH-Config field descriptions
dl-DataToUL-ACK List of timing for given PDSCH to the DL ACK. In this version of the specification only the values [0..8] are applicable. Corresponds to L1 parameter 'Slot-timing-value-K1' (see TS 38.213, section FFS_Section).
format1 Parameters that are common for all PUCCH resources of format 1.
format2 Parameters that are common for all PUCCH resources of format 2.
format3 Parameters that are common for all PUCCH resources of format 3.
format4. Parameters that are common for all PUCCH resources of format 4
resourceSetToAddModList Lists for adding and releasing PUCCH resource sets (see TS 38.213, section 9.2).
resourceToAddModList Lists for adding and releasing PUCCH resources applicable for the UL BWP and serving cell in which the PUCCH-Config is defined. The resources defined herein are referred to from other parts of the configuration to determine which resource the UE shall use for which report.
spatialRelationInfoToAddModList Configuration of the spatial relation between a reference RS and PUCCH. Reference RS can be SSB/CSI-RS/SRS. If the list has more than one element, MAC-CE selects a single element (see TS 38.321, section FFS_Section and TS 38.213, section 9.2.2).

PUCCH-format3 field descriptions
nrofPRBs The supported values are 1,2,3,4,5,6,8,9,10,12,15 and 16.

PUCCH-FormatConfig field descriptions
additionalDMRS Enabling 2 DMRS symbols per hop of a PUCCH Format 3 or 4 if both hops are more than X symbols when FH is enabled (X=4). Enabling 4 DMRS sybmols for a PUCCH Format 3 or 4 with more than 2X+1 symbols when FH is disabled (X=4). The field is not applicable for format 1 and 2. See TS 38.213, section 9.2.2.
interslotFrequencyHopping Enabling inter-slot frequency hopping when PUCCH Format 1, 3 or 4 is repetead over multiple slots. The field is not applicable for format 2. See TS 38.213, section 9.2.6.
maxCodeRate Max coding rate to determine how to feedback UCI on PUCCH for format 2, 3 or 4. The field is not applicable for format 1. See TS 38.213, section 9.2.5.
nrofSlots Number of slots with the same PUCCH F1, F3 or F4. When the field is absent the UE applies the value n1. The field is not applicable for format 2. See TS 38.213, section 9.2.6.
pi2BPSK Enabling pi/2 BPSK for UCI symbols instead of QPSK for PUCCH. The field is not applicable for format 1 and 2. See TS 38.213, section 9.2.5.
simultaneousHARQ-ACK-CSI Enabling simultaneous transmission of CSI and HARQ-ACK feedback with or without SR with PUCCH Format 2, 3 or 4. See TS 38.213, section 9.2.5. When the field is absent the UE applies the value OFF The field is not applicable for format 1.

PUCCH-Resource field descriptions
format Selection of the PUCCH format (format 0 - 4) and format-specific parameters, see TS 38.213, section 9.2.
intraSlotFrequencyHopping See TS 38.213, section 9.2.1.
secondHopPRB Index of starting PRB for second hop of PUCCH in case of FH. This value is appliable for intra-slot frequency hopping. Ssee TS 38.213, section 9.2.1.

PUCCH-ResourceSet field descriptions
maxPayloadMinus1 Maximum number of payload bits minus 1 that the UE may transmit using this PUCCH resource set. In a PUCCH occurrence, the UE chooses the first of its PUCCH-ResourceSet which supports the number of bits that the UE wants to transmit. The field is not present in the first set (Set0) since the maximum Size of Set0 is specified to be 3 bit. The field is not present in the last configured set since the UE derives its maximum payload size as specified in 38.213. This field can take integer values that are multiples of 4. Corresponds to L1 parameter 'N_2' or 'N_3' (see TS 38.213, section 9.2).
resourceList PUCCH resources of format0 and format1 are only allowed in the first PUCCH resource set, i.e., in a PUCCH-ResourceSet with pucch-ResourceSetId = 0. This set may contain between 1 and 32 resources. PUCCH resources of format2, format3 and format4 are only allowed in a PUCCH-ResourceSet with pucch-ResourceSetId > 0. If present, these sets contain between 1 and 8 resources each. The UE chooses a PUCCH-Resource from this list as speciied in TS 38.213, section 9.2.3. Note that this list contains only a list of resource IDs. The actual resources are configured in PUCCH-Config.

– *PUCCH-ConfigCommon*

The *PUCCH-ConfigCommon* IE is used to configure the cell specific PUCCH parameters.

***PUCCH-ConfigCommon* information element**

```
-- ASN1START
```

```
-- TAG-PUCCH-CONFIGCOMMON-START

PUCCH-ConfigCommon ::=              SEQUENCE {
    pucch-ResourceCommon                INTEGER (0..15)                                                 OPTIONAL,   -- Need R
    pucch-GroupHopping                  ENUMERATED { neither, enable, disable },
    hoppingId                           INTEGER (0..1024)                                                  OPTIONAL,   -- Need R
    p0-nominal                          INTEGER (-202..24)                                                 OPTIONAL,   -- Need R
    ...
}

-- TAG-PUCCH-CONFIGCOMMON-STOP
-- ASN1STOP
```

PUCCH-ConfigCommon field descriptions
hoppingId Cell-Specific scrambling ID for group hoppping and sequence hopping if enabled. Corresponds to L1 parameter 'HoppingID' (see 38.211, section 6.3.2.2)
p0-nominal Power control parameter P0 for PUCCH transmissions. Value in dBm. Only even values (step size 2) allowed. Corresponds to L1 parameter 'p0-nominal-pucch' (see 38.213, section 7.2)
pucch-GroupHopping Configuration of group- and sequence hopping for all the PUCCH formats 0, 1, 3 and 4. "neither" implies neither group or sequence hopping is enabled. "enable" enables group hopping and disables sequence hopping. "disable" disables group hopping and enables sequence hopping. Corresponds to L1 parameter 'PUCCH-GroupHopping' (see 38.211, section 6.4.1.3)
pucch-ResourceCommon An entry into a 16-row table where each row configures a set of cell-specific PUCCH resources/parameters. The UE uses those PUCCH resources during initial access on the initial uplink BWP. Once the network provides a dedicated PUCCH-Config for that bandwidth part the UE applies that one instead of the one provided in this field. Corresponds to L1 parameter 'PUCCH-resource-common' (see 38.213, section 9.2)

– *PUCCH-PathlossReferenceRS-Id*

The IE *PUCCH-PathlossReferenceRS-Id* is an ID for a referemce signal (RS) configured as PUCCH pathloss reference. It corresponds to L1 parameter 'pucch-pathlossreference-index' (see 38.213, section 7.2).

PUCCH-PathlossReferenceRS-Id information element

```
-- ASN1START
-- TAG-PUCCH-PATHLOSSREFERENCERS-ID-START

PUCCH-PathlossReferenceRS-Id ::=            INTEGER (0..maxNrofPUCCH-PathlossReferenceRSs-1)

-- TAG-PUCCH-PATHLOSSREFERENCERS-ID-STOP
-- ASN1STOP
```

– *PUCCH-PowerControl*

The IE *PUCCH-PowerControl* is used to configure FFS

PUCCH-PowerControl information element

```
-- ASN1START
-- TAG-PUCCH-POWERCONTROL-START
PUCCH-PowerControl ::=              SEQUENCE {
    deltaF-PUCCH-f0                     INTEGER (-16..15)                                                   OPTIONAL,   -- Need R
    deltaF-PUCCH-f1                     INTEGER (-16..15)                                                   OPTIONAL,   -- Need R
    deltaF-PUCCH-f2                     INTEGER (-16..15)                                                   OPTIONAL,   -- Need R
    deltaF-PUCCH-f3                     INTEGER (-16..15)                                                   OPTIONAL,   -- Need R
    deltaF-PUCCH-f4                     INTEGER (-16..15)                                                   OPTIONAL,   -- Need R
    p0-Set                              SEQUENCE (SIZE (1..maxNrofPUCCH-P0-PerSet)) OF P0-PUCCH             OPTIONAL, -- Need M
    pathlossReferenceRSs                SEQUENCE (SIZE (1..maxNrofPUCCH-PathlossReferenceRSs)) OF PUCCH-PathlossReferenceRS OPTIONAL, -- Need M
    twoPUCCH-PC-AdjustmentStates        ENUMERATED {twoStates}                                              OPTIONAL, -- Need S
    ...
}

P0-PUCCH ::=                            SEQUENCE {
    p0-PUCCH-Id                             P0-PUCCH-Id,
    p0-PUCCH-Value                          INTEGER (-16..15)
}

P0-PUCCH-Id ::=                         INTEGER (1..8)

PUCCH-PathlossReferenceRS ::=               SEQUENCE {
    pucch-PathlossReferenceRS-Id            PUCCH-PathlossReferenceRS-Id,
    referenceSignal                         CHOICE {
        ssb-Index                               SSB-Index,
        csi-RS-Index                            NZP-CSI-RS-ResourceId
    }
}

-- TAG-PUCCH-POWERCONTROL-STOP
-- ASN1STOP
```

P0-PUCCH field descriptions
p0-PUCCH-Value P0 value for PUCCH with 1dB step size.

PUCCH-PowerControl field descriptions
deltaF-PUCCH-f0 deltaF for PUCCH format 0 with 1dB step size (see 38.213, section 7.2)
deltaF-PUCCH-f1 deltaF for PUCCH format 1 with 1dB step size (see 38.213, section 7.2)
deltaF-PUCCH-f2 deltaF for PUCCH format 2 with 1dB step size (see 38.213, section 7.2)
deltaF-PUCCH-f3 deltaF for PUCCH format 3 with 1dB step size (see 38.213, section 7.2)
deltaF-PUCCH-f4 deltaF for PUCCH format 4 with 1dB step size (see 38.213, section 7.2)
p0-Set A set with dedicated P0 values for PUCCH, i.e., {P01, P02,... }. Corresponds to L1 parameter 'p0-pucch-set' (see 38.213, section 7.2)
pathlossReferenceRSs A set of Reference Signals (e.g. a CSI-RS config or a SSblock) to be used for PUCCH pathloss estimation. Up to maxNrofPUCCH-PathlossReference-RSs may be configured FFS_CHECK: Is it possible not to configure it at all? What does the UE use then? Any SSB? Corresponds to L1 parameter 'pucch-pathlossReference-rs-config' (see 38.213, section 7.2)
twoPUCCH-PC-AdjustmentStates Number of PUCCH power control adjustment states maintained by the UE (i.e., g(i)). If the field is present (n2) the UE maintains two power control states (i.e., g(i,0) and g(i,1)). If the field is absent, it applies one (i.e., g(i,0)). Corresponds to L1 parameter 'num-pucch-pcadjustment-states' (see 38.213, section 7.2)

– *PUCCH-TPC-CommandConfig*

The IE *PUCCH-TPC-CommandConfig* is used to configure the UE for extracting TPC commands for PUCCH from a group-TPC messages on DCI.

***PUCCH-TPC-CommandConfig* information element**

```
-- ASN1START
-- TAG-PUCCH-TPC-COMMANDCONFIG-START

PUCCH-TPC-CommandConfig ::=             SEQUENCE {
    tpc-IndexPCell                          INTEGER (1..15)                                 OPTIONAL,  -- Cond PDCCH-OfSpcell
    tpc-IndexPUCCH-SCell                    INTEGER (1..15)                                 OPTIONAL,  -- Cond PDCCH-ofSpCellOrPUCCH-Scell
    ...
}

-- TAG-PUCCH-TPC-COMMANDCONFIG-STOP
-- ASN1STOP
```

PUCCH-TPC-CommandConfig field descriptions
tpc-IndexPCell An index determining the position of the first bit of TPC command (applicable to the SpCell) inside the DCI format 2-2 payload.
tpc-IndexPUCCH-SCell An index determining the position of the first bit of TPC command (applicable to the PUCCH SCell) inside the DCI format 2-2 payload.

Conditional Presence	Explanation
PDCCH-OfSpcell	The field is mandatory present, need R, if the *PUCCH-TPC-CommandConfig* is provided in the *PDCCH-Config* for the SpCell. Otherwise, the field is absent.
PDCCH-ofSpCellOrPUCCH-Scell	The field is mandatory present, need R, if the *PUCCH-TPC-CommandConfig* is provided in the *PDCCH-Config* for the PUCCH-SCell. The field is optionally present, need R, if the UE is configured with a PUCCH SCell in this cell group and if the *PUCCH-TPC-CommandConfig* is provided in the *PDCCH-Config* for the SpCell. Otherwise, the field is absent.

– *PUSCH-Config*

The IE *PUSCH-Config* is used to configure the UE specific PUSCH parameters applicable to a particular BWP.

PUSCH-Config information element

```
-- ASN1START
-- TAG-PUSCH-CONFIG-START

PUSCH-Config ::=                    SEQUENCE {
    dataScramblingIdentityPUSCH         INTEGER (0..1023)                                       OPTIONAL,   -- Need M
    txConfig                            ENUMERATED {codebook, nonCodebook}                    OPTIONAL,   -- Need S
    dmrs-UplinkForPUSCH-MappingTypeA    SetupRelease { DMRS-UplinkConfig }                      OPTIONAL,   -- Need M
    dmrs-UplinkForPUSCH-MappingTypeB    SetupRelease { DMRS-UplinkConfig }                      OPTIONAL,   -- Need M

    pusch-PowerControl                  PUSCH-PowerControl                                      OPTIONAL, -- Need M
    frequencyHopping                    ENUMERATED {mode1, mode2}                               OPTIONAL,   -- Need S
    frequencyHoppingOffsetLists         SEQUENCE (SIZE (1..4)) OF INTEGER (1.. maxNrofPhysicalResourceBlocks-1)   OPTIONAL,   -- Need M
    resourceAllocation                  ENUMERATED { resourceAllocationType0, resourceAllocationType1, dynamicSwitch},
    pusch-TimeDomainAllocationList      SetupRelease { PUSCH-TimeDomainResourceAllocationList }          OPTIONAL,   -- Need M
    pusch-AggregationFactor             ENUMERATED { n2, n4, n8 }                           OPTIONAL,   -- Need S
    mcs-Table                           ENUMERATED {qam256, spare1}                            OPTIONAL,   -- Need S
    mcs-TableTransformPrecoder          ENUMERATED {qam256, spare1}                         OPTIONAL,   -- Need S
    transformPrecoder                   ENUMERATED {enabled, disabled}                      OPTIONAL,   -- Need S
    codebookSubset                      ENUMERATED {fullyAndPartialAndNonCoherent, partialAndNonCoherent,
                                                    nonCoherent}                                OPTIONAL,   -- Cond codebookBased
    maxRank                             INTEGER (1..4)                                      OPTIONAL,   -- Cond codebookBased
    rbg-Size                            ENUMERATED { config2}                                  OPTIONAL,   -- Need S
    uci-OnPUSCH                         SetupRelease { UCI-OnPUSCH}                       OPTIONAL, -- Need M
    tp-pi2BPSK                          ENUMERATED {enabled}                                OPTIONAL,   -- Need S
```

```
    ...
}

UCI-OnPUSCH ::=                         SEQUENCE {
    betaOffsets                             CHOICE {
            dynamic                             SEQUENCE (SIZE (4)) OF BetaOffsets,
            semiStatic                          BetaOffsets
    }                                                                                   OPTIONAL, -- Need M
    scaling                                 ENUMERATED { f0p5, f0p65, f0p8, f1 }
}

-- TAG-PUSCH-CONFIG-STOP
-- ASN1STOP
```

PUSCH-Config field descriptions
codebookSubset Subset of PMIs addressed by TPMI, where PMIs are those supported by UEs with maximum coherence capabilities Corresponds to L1 parameter 'ULCodebookSubset' (see 38.211, section 6.3.1.5).
dataScramblingIdentityPUSCH Identifer used to initalite data scrambling (c_init) for both PUSCH. Corresponds to L1 parameter 'Data-scrambling-Identity' (see 38.211, section 6.3.1.1).
dmrs-UplinkForPUSCH-MappingTypeA DMRS configuration for PUSCH transmissions using PUSCH mapping type A (chosen dynamically via PUSCH-TimeDomainResourceAllocation).
dmrs-UplinkForPUSCH-MappingTypeB DMRS configuration for PUSCH transmissions using PUSCH mapping type B (chosen dynamically via PUSCH-TimeDomainResourceAllocation).
frequencyHopping Configures one of two supported frequency hopping mode. If not configured, frequency hopping is not configured. Corresponds to L1 parameter 'Frequency-hopping-PUSCH' (see 38.214, section 6).
frequencyHoppingOffsetLists Set of frequency hopping offsets used when frequency hopping is enabled for granted transmission (not msg3) and type 2 Corresponds to L1 parameter 'Frequency-hopping-offsets-set' (see 38.214, section 6.3).
maxRank Subset of PMIs addressed by TRIs from 1 to ULmaxRank. Corresponds to L1 parameter 'ULmaxRank' (see 38.211, section 6.3.1.5).
mcs-Table Indicates which MCS table the UE shall use for PUSCH without transform precoder Corresponds to L1 parameter 'MCS-Table-PUSCH' (see 38.214, section 6.1.4) If the field is absent the UE applies the value 64QAM
mcs-TableTransformPrecoder Indicates which MCS table the UE shall use for PUSCH with transform precoding Corresponds to L1 parameter 'MCS-Table-PUSCH-transform-precoding' (see 38.214, section 6.1.4) If the field is absent the UE applies the value 64QAM
pusch-AggregationFactor Number of repetitions for data. Corresponds to L1 parameter 'aggregation-factor-UL' (see 38.214, section FFS_Section). If the field is absent the UE applies the value 1.
pusch-AllocationList List of time domain allocations for timing of UL assignment to UL data. If configured, the values provided herein override the values received in corresponding PUSCH-ConfigCommon.
rbg-Size Selection between config 1 and config 2 for RBG size for PUSCH. When the field is absent the UE applies the value config1. Corresponds to L1 parameter 'RBG-size-PUSCH' (see 38.214, section 6.1.2.2.1).
resourceAllocation Configuration of resource allocation type 0 and resource allocation type 1 for non-fallback DCI Corresponds to L1 parameter 'Resouce-allocation-config' (see 38.214, section 6.1.2).
tp-pi2PBSK Enables pi/2-BPSK modulation with transform precoding if the field is present and disables it otherwise.
transformPrecoder The UE specific selection of transformer precoder for PUSCH. When the field is absent the UE applies the value msg3-tp. Corresponds to L1 parameter 'PUSCH-tp' (see 38.211, section 6.3.1.4).
txConfig Whether UE uses codebook based or non-codebook based transmission. Corresponds to L1 parameter 'ulTxConfig' (see 38.214, section 6.1.1). If the field is absent, the UE transmits PUSCH on one antenna port, see 38.214, section 6.1.1.
uci-OnPUSCH Selection between and configuration of dynamic and semi-static beta-offset. If the field is absent or released, the UE applies the value 'semiStatic' and the BetaOffsets according to FFS [BetaOffsets and/or section 9.x.x). Corresponds to L1 parameter 'UCI-on-PUSCH' (see 38.213, section 9.3).

UCI-OnPUSCH field descriptions
scaling Indicates a scaling factor to limit the number of resource elements assigned to UCI on PUSCH. Value f0p5 corresponds to 0.5, value f0p65 corresponds to 0.65, and so on. Corresponds to L1 parameter 'uci-on-pusch-scaling' (see 38.212, section 6.3).

Conditional Presence	Explanation
codebookBased	The field is mandatory present if *txConfig* is set to codebook and absent otherwise.

– *PUSCH-ConfigCommon*

The IE *PUSCH-ConfigCommon* IE is used to configure the cell specific PUSCH parameters.

***PUSCH-Config* information element**

```
-- ASN1START
-- TAG-PUSCH-CONFIGCOMMON-START

PUSCH-ConfigCommon ::=                  SEQUENCE {
    groupHoppingEnabledTransformPrecoding   ENUMERATED {enabled}                                    OPTIONAL,   -- Need R
    pusch-TimeDomainAllocationList          PUSCH-TimeDomainResourceAllocationList  OPTIONAL,   -- Need R
    msg3-DeltaPreamble                      INTEGER (-1..6)                                         OPTIONAL,   -- Need R
    p0-NominalWithGrant                     INTEGER (-202..24)                                      OPTIONAL,   -- Need R
    ...
}

-- TAG-PUSCH-CONFIGCOMMON-STOP
-- ASN1STOP
```

PUSCH-ConfigCommon field descriptions
groupHoppingEnabledTransformPrecoding Sequence-group hopping can be enabled or disabled by means of this cell-specific parameter. Corresponds to L1 parameter 'Group-hopping-enabled-Transform-precoding' (see 38.211, section FFS_Section) This field is Cell specific
msg3-DeltaPreamble Power offset between msg3 and RACH preamble transmission. Actual value = field value * 2 [dB]. Corresponds to L1 parameter 'Delta-preamble-msg3' (see 38.213, section 7.1)
p0-NominalWithGrant P0 value for PUSCH with grant (except msg3). Value in dBm. Only even values (step size 2) allowed. Corresponds to L1 parameter 'p0-nominal-pusch-withgrant' (see 38.213, section 7.1) This field is cell specific
pusch-AllocationList List of time domain allocations for timing of UL assignment to UL data

– *PUSCH-PowerControl*

The IE *PUSCH-PowerControl* is used to configure UE specific power control parameter for PUSCH.

PUSCH-PowerControl information element

```
-- ASN1START
-- TAG-PUSCH-POWERCONTROL-START

PUSCH-PowerControl ::=              SEQUENCE {
    tpc-Accumulation                    ENUMERATED { disabled }                                                 OPTIONAL,   -- Need S
    msg3-Alpha                          Alpha                                                                   OPTIONAL,   -- Need S
    p0-NominalWithoutGrant              INTEGER (-202..24)                                                      OPTIONAL,   -- Need M,
    p0-AlphaSets                        SEQUENCE (SIZE (1..maxNrofP0-PUSCH-AlphaSets)) OF P0-PUSCH-AlphaSet       OPTIONAL,   -- Need M,
    pathlossReferenceRSToAddModList     SEQUENCE (SIZE (1..maxNrofPUSCH-PathlossReferenceRSs)) OF PUSCH-PathlossReferenceRS
                                                                                                                OPTIONAL,   -- Need N
    pathlossReferenceRSToReleaseList    SEQUENCE (SIZE (1..maxNrofPUSCH-PathlossReferenceRSs)) OF PUSCH-PathlossReferenceRS-Id
                                                                                                                OPTIONAL,   -- Need N
    twoPUSCH-PC-AdjustmentStates        ENUMERATED {twoStates}                                                  OPTIONAL, -- Need S
    deltaMCS                            ENUMERATED {enabled}                                                    OPTIONAL, -- Need S
    sri-PUSCH-MappingToAddModList       SEQUENCE (SIZE (1..maxNrofSRI-PUSCH-Mappings)) OF SRI-PUSCH-PowerControl OPTIONAL, -- Need N
    sri-PUSCH-MappingToReleaseList      SEQUENCE (SIZE (1..maxNrofSRI-PUSCH-Mappings)) OF SRI-PUSCH-PowerControlId OPTIONAL -- Need N
}

-- A set of p0-pusch and alpha used for PUSCH with grant. 'PUSCH beam indication' (if present) gives the index of the set to
-- be used for a particular PUSCH transmission.
-- FFS_CHECK: Is the ”PUSCH beam indication” in DCI which schedules the PUSCH? If so, clarify in field description
-- Corresponds to L1 parameter 'p0-pusch-alpha-set' (see 38.213, section 7.1)
P0-PUSCH-AlphaSet ::=               SEQUENCE {
    p0-PUSCH-AlphaSetId                 P0-PUSCH-AlphaSetId,
    p0                                  INTEGER (-16..15)                                                       OPTIONAL,
    alpha                               Alpha                                                                   OPTIONAL -- Need S
}

-- ID for a P0-PUSCH-AlphaSet. Corresponds to L1 parameter 'p0alphasetindex' (see 38.213, section 7.1)
P0-PUSCH-AlphaSetId ::=             INTEGER (0..maxNrofP0-PUSCH-AlphaSets-1)

-- A reference signal (RS) configured as pathloss reference signal for PUSCH power control
-- Corresponds to L1 parameter 'pusch-pathlossReference-rs' (see 38.213, section 7.1)
PUSCH-PathlossReferenceRS ::=       SEQUENCE {
    pusch-PathlossReferenceRS-Id        PUSCH-PathlossReferenceRS-Id,
    referenceSignal                     CHOICE {
        ssb-Index                           SSB-Index,
        csi-RS-Index                        NZP-CSI-RS-ResourceId
    }
}

-- ID for a referemce signal (RS) configured as PUSCH pathloss reference
-- Corresponds to L1 parameter 'pathlossreference-index' (see 38.213, section 7.1)
-- FFS_CHECK: Is this ID used anywhere except inside the PUSCH-PathlossReference-RS itself?
PUSCH-PathlossReferenceRS-Id ::=    INTEGER (0..maxNrofPUSCH-PathlossReferenceRSs-1)
```

```
-- A set of PUSCH power control parameters associated with one SRS-ResourceIndex (SRI)
SRI-PUSCH-PowerControl ::=          SEQUENCE {
    sri-PUSCH-PowerControlId            SRI-PUSCH-PowerControlId,
    sri-PUSCH-PathlossReferenceRS-Id    PUSCH-PathlossReferenceRS-Id,
    sri-P0-PUSCH-AlphaSetId             P0-PUSCH-AlphaSetId,
    sri-PUSCH-ClosedLoopIndex           ENUMERATED { i0, i1 }
}

SRI-PUSCH-PowerControlId ::=        INTEGER (0..maxNrofSRI-PUSCH-Mappings-1)

-- A set of beta-offset values
BetaOffsets ::=                     SEQUENCE {
    betaOffsetACK-Index1                INTEGER(0..31)                                  OPTIONAL, -- Need S
    betaOffsetACK-Index2                INTEGER(0..31)                                  OPTIONAL, -- Need S
    betaOffsetACK-Index3                INTEGER(0..31)                                  OPTIONAL, -- Need S
    betaOffsetCSI-Part1-Index1          INTEGER(0..31)                                  OPTIONAL, -- Need S
    betaOffsetCSI-Part1-Index2          INTEGER(0..31)                                  OPTIONAL, -- Need S
    betaOffsetCSI-Part2-Index1          INTEGER(0..31)                                  OPTIONAL, -- Need S
    betaOffsetCSI-Part2-Index2          INTEGER(0..31)                                  OPTIONAL -- Need S
}

-- TAG-PUSCH-POWERCONTROL-STOP
-- ASN1STOP
```

BetaOffsets field descriptions
betaOffsetACK-Index1 Up to 2 bits HARQ-ACK. Corresponds to L1 parameter 'betaOffset-ACK-Index-1' (see 38.213, section 9.3) When the field is absent the UE applies the value 11
betaOffsetACK-Index2 Up to 11 bits HARQ-ACK. Corresponds to L1 parameter 'betaOffset-ACK-Index-2' (see 38.213, section 9.3) When the field is absent the UE applies the value 11
betaOffsetACK-Index3 Above 11 bits HARQ-ACK. Corresponds to L1 parameter 'betaOffset-ACK-Index-3' (see 38.213, section 9.3) When the field is absent the UE applies the value 11
betaOffsetCSI-Part1-Index1 Up to 11 bits of CSI part 1 bits. Corresponds to L1 parameter 'betaOffset-CSI-part-1-Index-1' (see 38.213, section 9.3) When the field is absent the UE applies the value 13
betaOffsetCSI-Part1-Index2 Above 11 bits of CSI part 1 bits. Corresponds to L1 parameter 'betaOffset-CSI-part-1-Index-2' (see 38.213, section 9.3) When the field is absent the UE applies the value 13
betaOffsetCSI-Part2-Index1 Up to 11 bits of CSI part 2 bits. Corresponds to L1 parameter 'betaOffset-CSI-part-2-Index-1' (see 38.213, section 9.3) When the field is absent the UE applies the value 13
betaOffsetCSI-Part2-Index2 Above 11 bits of CSI part 2 bits. Corresponds to L1 parameter 'betaOffset-CSI-part-2-Index-2' (see 38.213, section 9.3) When the field is absent the UE applies the value 13

P0-PUSCH-AlphaSet field descriptions
alpha alpha value for PUSCH with grant (except msg3) (see 38.213, section 7.1) When the field is absent the UE applies the value 1
p0 P0 value for PUSCH with grant (except msg3) in steps of 1dB. Corresponds to L1 parameter 'p0-pusch' (see 38,213, section 7.1)

PUSCH-PowerControl field descriptions
deltaMCS Indicates whether to apply dela MCS. When the field is absent, the UE applies Ks = 0 in delta_TFC formula for PUSCH. Corresponds to L1 parameter 'deltaMCS-Enabled' (see 38.213, section 7.1)
msg3-Alpha Dedicated alpha value for msg3 PUSCH. Corresponds to L1 parameter 'alpha-ue-pusch-msg3' (see 38.213, section 7.1) When the field is absent the UE applies the value 1.
p0-AlphaSets configuration {p0-pusch,alpha} sets for PUSCH (except msg3), i.e., { {p0,alpha,index1}, {p0,alpha,index2},...}. Corresponds to L1 parameter 'p0-push-alpha-setconfig' (see 38,213, section 7.1)
p0-NominalWithoutGrant P0 value for UL grant-free/SPS based PUSCH. Value in dBm. Only even values (step size 2) allowed. Corresponds to L1 parameter 'p0-nominal-pusch-withoutgrant' (see 38.213, section 7.1)
pathlossReferenceRSToAddModList A set of Reference Signals (e.g. a CSI-RS config or a SSblock) to be used for PUSCH path loss estimation. Up to maxNrofPUSCH-PathlossReferenceRSs may be configured when 'PUSCH beam indication' is present (FFS: in DCI???). Otherwise, there may be only one entry. Corresponds to L1 parameter 'pusch-pathlossReference-rs-config' (see 38.213, section 7.1)
sri-PUSCH-MappingToAddModList A list of SRI-PUSCH-PowerControl elements among which one is selected by the SRI field in DCI. Corresponds to L1 parameter 'SRI-PUSCHPowerControl-mapping' (see 38.213, section 7.1)
tpc-Accumulation If enabled, UE applies TPC commands via accumulation. If not enabled, UE applies the TPC command without accumulation. If the field is absent, TPC accumulation is enabled. Corresponds to L1 parameter 'Accumulation-enabled' (see 38.213, section 7.1)
twoPUSCH-PC-AdjustmentStates Number of PUSCH power control adjustment states maintained by the UE (i.e., fc(i)). If the field is present (n2) the UE maintains two power control states (i.e., fc(i,1) and fc(i,2)). If the field is absent, it applies one (i.e., fc(i,1)). Corresponds to L1 parameter 'num-pusch-pcadjustment-states' (see 38.213, section 7.1)

SRI-PUSCH-PowerControl field descriptions
sri-P0-PUSCH-AlphaSetId The ID of a P0-PUSCH-AlphaSet as configured in p0-AlphaSets in PUSCH-PowerControl.
sri-PUSCH-ClosedLoopIndex The index of the closed power control loop associated with this SRI-PUSCH-PowerControl
sri-PUSCH-PathlossReferenceRS-Id The ID of PUSCH-PathlossReferenceRS as configured in the pathlossReferenceRSToAddModList in PUSCH-PowerControl.
sri-PUSCH-PowerControlId The ID of this SRI-PUSCH-PowerControl configuration. It is used as the codepoint (payload) in the SRI DCI field.

– *PUSCH-ServingCellConfig*

The IE *PUSCH-ServingCellConfig* is used to configure UE specific PUSCH parameters that are common across the UE's BWPs of one serving cell.

PUSCH-ServingCellConfig information element

```
-- ASN1START
-- TAG-PUSCH-SERVINGCELLCONFIG-START
```

```
PUSCH-ServingCellConfig ::=             SEQUENCE {
    codeBlockGroupTransmission              SetupRelease { PUSCH-CodeBlockGroupTransmission }                   OPTIONAL,   -- Need M
    rateMatching                            ENUMERATED {limitedBufferRM}                                        OPTIONAL,   -- Need S
    xOverhead                               ENUMERATED {xoh6, xoh12, xoh18}                                     OPTIONAL,   -- Need S
    ...
}

PUSCH-CodeBlockGroupTransmission ::=    SEQUENCE {
    maxCodeBlockGroupsPerTransportBlock     ENUMERATED {n2, n4, n6, n8},
    ...
}

-- TAG-PUSCH-SERVINGCELLCONFIG-STOP
-- ASN1STOP
```

PUSCH-CodeBlockGroupTransmission field descriptions
maxCodeBlockGroupsPerTransportBlock Maximum number of code-block-groups (CBGs) per TB (see 38.xxx, section x.x.x, FFS_Ref) For 2 codewords, only the values { n2, n4 } are valid.

PUSCH-ServingCellConfig field descriptions
codeBlockGroupTransmission Enables and configures code-block-group (CBG) based transmission (see 38.214, section FFS_Section)
rateMatching Enables LBRM (Limited buffer rate-matching). When the field is absent the UE applies FBRM (Full buffer rate-matchingLBRM). Corresponds to L1 parameter 'LBRM-FBRM-selection' (see 38.212, section 5.4.2)
xOverhead Accounts for overhead from CSI-RS, CORESET, etc. If the field is absent, the UE applies the value 'xoh0'. Corresponds to L1 parameter 'Xoh-PUSCH' (see 38.214, section 5.1.3.2)

– *PUSCH-TimeDomainResourceAllocationList*

The IE *PUSCH-TimeDomainResourceAllocation* is used to configure a time domain relation between PDCCH and PUSCH. PUSCH-TimeDomainResourceAllocationList contains one or more of such PUSCH-TimeDomainResourceAllocations. The network indicates in the UL grant which of the configued time domain allocations the UE shall apply for that UL grant. The UE determines the bit width of the DCI field based on the number of entries in the PUSCH-TimeDomainResourceAllocationList. Value 0 in the DCI field refers to the first element in this list, value 1 in the DCI field refers to the second element in this list, and so on.

***PUSCH-TimeDomainResourceAllocation* information element**

```
-- ASN1START
-- TAG-PUSCH-TIMEDOMAINRESOURCEALLOCATIONLIST-START

PUSCH-TimeDomainResourceAllocationList ::=  SEQUENCE (SIZE(1..maxNrofUL-Allocations)) OF PUSCH-TimeDomainResourceAllocation

PUSCH-TimeDomainResourceAllocation ::=  SEQUENCE {
    k2                                      INTEGER(0..32)          OPTIONAL,   -- Need S
    mappingType                             ENUMERATED {typeA, typeB},
```

```
    startSymbolAndLength                    INTEGER (0..127)
}

-- TAG-PUSCH-TIMEDOMAINRESOURCEALLOCATIONLIST-STOP
-- ASN1STOP
```

PUSCH-TimeDomainResourceAllocationList field descriptions
k2 Corresponds to L1 parameter 'K2' (see 38.214, section FFS_Section) When the field is absent the UE applies the value 1 when PUSCH SCS is 15/30KHz; 2 when PUSCH SCS is 60KHz and 3 when PUSCH SCS is 120KHz.
mappingType Mapping type. Corresponds to L1 parameter 'Mapping-type' (see 38.214, section FFS_Section)
startSymbolAndLength An index into a table/equation in RAN1 specs capturing valid combinations of start symbol and length (jointly encoded) Corresponds to L1 parameter 'Index-start-len' (see 38.214, section FFS_Section)

– *PUSCH-TPC-CommandConfig*

The IE *PUSCH-TPC-CommandConfig* is used to configure the UE for extracting TPC commands for PUSCH from a group-TPC messages on DCI.

***PUSCH-TPC-CommandConfig* information element**

```
-- ASN1START
-- TAG-PUSCH-TPC-COMMANDCONFIG-START

PUSCH-TPC-CommandConfig ::=         SEQUENCE {
    tpc-Index                           INTEGER (1..15)                                 OPTIONAL,   -- Cond SUL
    tpc-IndexSUL                        INTEGER (1..15)                                 OPTIONAL,   -- Cond SUL-Only
    targetCell                          ServCellIndex                                   OPTIONAL,   -- Need S
    ...
}

-- TAG-PUSCH-TPC-COMMANDCONFIG-STOP
-- ASN1STOP
```

PUSCH-TPC-CommandConfig field descriptions
targetCell The serving cell to which the acquired power control commands are applicable. If the value is absent, the UE applies the TPC commands to the serving cell on which the command has been received.
tpc-Index An index determining the position of the first bit of TPC command inside the DCI format 2-2 payload.
tpc-IndexSUL An index determining the position of the first bit of TPC command inside the DCI format 2-2 payload.

Conditional Presence	Explanation
SUL-Only	The field is optionally present, Need R, if this serving cell is configured with a supplementary uplink (SUL). It is absent otherwise.
SUL	The field is optionally present, Need R, if this serving cell is configured with a supplementary uplink (SUL). It is mandatory present otherwise.

– *Q-OffsetRange*

The IE *Q-OffsetRange* is used to indicate a cell, beam or measurement object specific offset to be applied when evaluating candidates for cell re-selection or when evaluating triggering conditions for measurement reporting. The value in dB. Value dB-24 corresponds to -24 dB, dB-22 corresponds to -22 dB and so on.

Q-OffsetRange information element

```
-- ASN1START

Q-OffsetRange ::=                   ENUMERATED {
                                                dB-24, dB-22, dB-20, dB-18, dB-16, dB-14,
                                                dB-12, dB-10, dB-8, dB-6, dB-5, dB-4, dB-3,
                                                dB-2, dB-1, dB0, dB1, dB2, dB3, dB4, dB5,
                                                dB6, dB8, dB10, dB12, dB14, dB16, dB18,
                                                dB20, dB22, dB24}

-- ASN1STOP
```

Editor's Note: FFS Confirm the exact values that are supported.

– *QuantityConfig*

The IE *QuantityConfig* specifies the measurement quantities and layer 3 filtering coefficients for NR and inter-RAT measurements.

QuantityConfig information element

```
-- ASN1START
-- TAG-QUANTITY-CONFIG-START


QuantityConfig ::=                  SEQUENCE {
    quantityConfigNR-List               SEQUENCE (SIZE (1..maxNrofQuantityConfig)) OF QuantityConfigNR       OPTIONAL,   -- Need M
    ...
}

QuantityConfigNR::=                 SEQUENCE {
    quantityConfigCell                  QuantityConfigRS,
    quantityConfigRS-Index              QuantityConfigRS                                                    OPTIONAL -- Need M
}

QuantityConfigRS ::=                SEQUENCE {
    ssb-FilterConfig                    FilterConfig,
```

```
    cs-RS-FilterConfig                FilterConfig
}

FilterConfig ::=                    SEQUENCE {
    filterCoefficientRSRP             FilterCoefficient                              DEFAULT fc4,
    filterCoefficientRSRQ             FilterCoefficient                              DEFAULT fc4,
    filterCoefficientRS-SINR          FilterCoefficient                              DEFAULT fc4
}

-- TAG-QUANTITY-CONFIG-STOP
-- ASN1STOP
```

QuantityConfigNR field descriptions
quantityConfigCell Specifies L3 filter configurations for cell measurement results for the configurable RS Types (e.g. SS/PBCH block and CSI-RS) and the configurable measurement quantities (e.g. RSRP, RSRQ and SINR).
quantityConfigRS-Index Specifies L3 filter configurations for measurement results per RS index for the configurable RS Types (e.g. SS/PBCH block and CSI-RS) and the configurable measurement quantities (e.g. RSRP, RSRQ and SINR).

QuantityConfigRS field descriptions
cs-RS-FilterConfig CSI-RS basedL3 filter configurations: Specifies L3 filter configurations for CSI-RSRP, CSI-RSRQ and CSI-SINR measurement results from the L1 filter(s), as defined in 38.215 [9].
ssb-FilterConfig SS Block based L3 filter configurations: Specifies L3 filter configurations for SS-RSRP, SS-RSRQ and SS-SINR measurement results from the L1 filter(s), as defined in 38.215 [9].

– *RACH-ConfigCommon*

The *RACH-ConfigCommon* IE is used to specify the cell specific random-access parameters.

***RACH-ConfigCommon* information element**

```
-- ASN1START
-- TAG-RACH-CONFIG-COMMON-START

RACH-ConfigCommon ::=               SEQUENCE {
    rach-ConfigGeneric          RACH-ConfigGeneric,
    totalNumberOfRA-Preambles           INTEGER (1..63)                                                 OPTIONAL,   -- Need S
    ssb-perRACH-OccasionAndCB-PreamblesPerSSB   CHOICE {
        oneEighth                               ENUMERATED {n4,n8,n12,n16,n20,n24,n28,n32,n36,n40,n44,n48,n52,n56,n60,n64},
        oneFourth                               ENUMERATED {n4,n8,n12,n16,n20,n24,n28,n32,n36,n40,n44,n48,n52,n56,n60,n64},
        oneHalf                                 ENUMERATED {n4,n8,n12,n16,n20,n24,n28,n32,n36,n40,n44,n48,n52,n56,n60,n64},
        one                                     ENUMERATED {n4,n8,n12,n16,n20,n24,n28,n32,n36,n40,n44,n48,n52,n56,n60,n64},
        two                                     ENUMERATED {n4,n8,n12,n16,n20,n24,n28,n32},
        four                                    INTEGER (1..16),
```

```
        eight                                   INTEGER (1..8),
        sixteen                                 INTEGER (1..4)
    }                                                                                   OPTIONAL,   -- Need M

    groupBconfigured                    SEQUENCE {
        ra-Msg3SizeGroupA                   ENUMERATED { b56, b144, b208, b256, b282, b480, b640,
                                                         b800, b1000, spare7, spare6, spare5, spare4, spare3, spare2, spare1},
        messagePowerOffsetGroupB            ENUMERATED { minusinfinity, dB0, dB5, dB8, dB10, dB12, dB15, dB18},
        numberOfRA-PreamblesGroupA          INTEGER (1..64)
    }                                                                                   OPTIONAL,   -- Need R
    ra-ContentionResolutionTimer            ENUMERATED { sf8, sf16, sf24, sf32, sf40, sf48, sf56, sf64},
    rsrp-ThresholdSSB                       RSRP-Range                                  OPTIONAL,   -- Need R
    rsrp-ThresholdSSB-SUL                   RSRP-Range                                  OPTIONAL,   -- Cond SUL
    prach-RootSequenceIndex                 CHOICE {
        l839                                    INTEGER (0..837),
        l139                                    INTEGER (0..137)
    },
    msg1-SubcarrierSpacing                  SubcarrierSpacing                           OPTIONAL,   --Need S
    restrictedSetConfig                     ENUMERATED {unrestrictedSet, restrictedSetTypeA, restrictedSetTypeB},
    msg3-transformPrecoding                 ENUMERATED {enabled}                        OPTIONAL,   -- Need R
    ...
}

-- TAG-RACH-CONFIG-COMMON-STOP
-- ASN1STOP
```

RACH-ConfigCommon field descriptions
messagePowerOffsetGroupB Threshold for preamble selection. Value in dB. Value minusinfinity corresponds to –infinity. Value dB0 corresponds to 0 dB, dB5 corresponds to 5 dB and so on. (see FFS_Spec, section FFS_Section)
msg1-SubcarrierSpacing Subcarrier spacing of PRACH. Only the values 15 or 30 kHz (<6GHz), 60 or 120 kHz (>6GHz) are applicable. Corresponds to L1 parameter 'prach-Msg1SubcarrierSpacing' (see 38.211, section FFS_Section). If absent, the UE applies the SCS as derived from the *prach-ConfigurationIndex* in *RACH-ConfigGeneric* (see 38.211, section XXX).
msg3-transformPrecoding Indicates to a UE whether transform precoding is enabled for Msg3 transmission. Absence indicates that it is disabled. Corresponds to L1 parameter 'msg3-tp' (see 38.213, section 8.1)
numberOfRA-PreamblesGroupA The number of CB preambles per SSB in group A. This determines implicitly the number of CB preambles per SSB available in group B. (see 38.321, section 5.1.1). The setting should be consistent with the setting of *ssb-perRACH-OccasionAndCB-PreamblesPerSSB*.
prach-RootSequenceIndex PRACH root sequence index. Corresponds to L1 parameter 'PRACHRootSequenceIndex' (see 38.211, section 6.3.3.1). The value range depends on whether L=839 or L=139
ra-ContentionResolutionTimer The initial value for the contention resolution timer (see 38.321, section 5.1.5). Value *ms8* corresponds to 8 ms, value *ms16* corresponds to 16 ms, and so on.
ra-Msg3SizeGroupA Transport Blocks size threshold in bit below which the UE shall use a contention based RA premable of group A. (see 38.321, section 5.1.2)
rach-ConfigGeneric Generic RACH parameters
restrictedSetConfig Configuration of an unrestricted set or one of two types of restricted sets, see 38.211 6.3.3.1
rsrp-ThresholdSSB UE may select the SS block and corresponding PRACH resource for path-loss estimation and (re)transmission based on SS blocks that satisfy the threshold (see 38.213, section REF)
rsrp-ThresholdSSB-SUL The UE selects SUL carrier to perform random access based on this threshold (see TS 38.321, section 5.1.1).
ssb-perRACH-OccasionAndCB-PreamblesPerSSB Number of SSBs per RACH occasion (L1 parameter 'SSB-per-rach-occasion') and the number of Contention Based preambles per SSB (L1 parameter 'CB-preambles-per-SSB'). The total number of CB preambles in a RACH occasion is given by CB-preambles-per-SSB * max(1,SSB-per-rach-occasion).
totalNumberOfRA-Preambles Total number of preambles used for contention based and contention free random access, excluding preambles used for other purposes (e.g. for SI request). If the field is absent, the UE may use all 64 preambles for RA.

Conditional Presence	Explanation
SUL	The field is mandatory present in *initialUplinkBWP* in *supplementaryUplink*; otherwise, the field is absent.

– *RACH-ConfigGeneric*

The *RACH-ConfigGeneric* IE is used to specify the cell specific random-access parameters both for regular random access as well as for beam failure recovery.

RACH-ConfigGeneric information element

```
-- ASN1START
```

```
-- TAG-RACH-CONFIG-GENERIC-START

RACH-ConfigGeneric ::=              SEQUENCE {
    prach-ConfigurationIndex            INTEGER (0..255),
    msg1-FDM                            ENUMERATED {one, two, four, eight},
    msg1-FrequencyStart                 INTEGER (0..maxNrofPhysicalResourceBlocks-1),
    zeroCorrelationZoneConfig           INTEGER(0..15),
    preambleReceivedTargetPower         INTEGER (-202..-60),
    preambleTransMax                    ENUMERATED {n3, n4, n5, n6, n7, n8, n10, n20, n50, n100, n200},
    powerRampingStep                    ENUMERATED {dB0, dB2, dB4, dB6},
    ra-ResponseWindow                   ENUMERATED {sl1, sl2, sl4, sl8, sl10, sl20, sl40, sl80},
    ...
}

-- TAG-RACH-CONFIG-GENERIC-STOP
-- ASN1STOP
```

RACH-ConfigGeneric field descriptions
msg1-FDM The number of PRACH transmission occasions FDMed in one time instance. Corresponds to L1 parameter 'prach-FDM' (see 38.211, section FFS_Section)
msg1-FrequencyStart Offset of lowest PRACH transmission occasion in frequency domain with respective to PRB 0. The value is configured so that the corresponding RACH resource is entirely within the bandwidth of the UL BWP. Corresponds to L1 parameter 'prach-frequency-start' (see 38,211, section FFS_Section)
powerRampingStep Power ramping steps for PRACH (see 38.321,5.1.3)
prach-ConfigurationIndex PRACH configuration index. Corresponds to L1 parameter 'PRACHConfigurationIndex' (see 38.211, section 6.3.3.2)
preambleReceivedTargetPower The target power level at the network receiver side (see 38.213, section 7.4, 38.321, section 5.1.2, 5.1.3). Only multiples of 2 dBm may be chosen (e.g. -202, -200, -198, ...).
preambleTransMax Max number of RA preamble transmission perfomed before declaring a failure (see 38.321, section 5.1.4, 5.1.5)
ra-ResponseWindow Msg2 (RAR) window length in number of slots. The network configures a value lower than or euqal to 10 ms (see 38.321, section 5.1.4)
zeroCorrelationZoneConfig N-CS configuration, see Table 6.3.3.1-3 in 38.211

– *RACH-ConfigDedicated*

The IE *RACH-ConfigDedicated* is used to specify the dedicated random access parameters.

RACH-ConfigDedicated information element

```
-- ASN1START
-- TAG-RACH-CONFIG-DEDICATED-START

-- FFS_Standlone: resources for msg1-based on-demand SI request

RACH-ConfigDedicated ::=        SEQUENCE {
```

```
    cfra                            CFRA                                                                    OPTIONAL,   -- Need N
    ra-Prioritization               RA-Prioritization                                                             OPTIONAL,   -- Need N
    ...
}

CFRA ::=                    SEQUENCE {
    occasions                       SEQUENCE {
        rach-ConfigGeneric              RACH-ConfigGeneric,
        ssb-perRACH-Occasion            ENUMERATED {oneEighth, oneFourth, oneHalf, one, two, four, eight, sixteen} OPTIONAL -- Cond SSB-CFRA
    }                                                                                                             OPTIONAL,   -- Need S
    resources                       CHOICE {
        ssb                             SEQUENCE {
            ssb-ResourceList                SEQUENCE (SIZE(1..maxRA-SSB-Resources)) OF CFRA-SSB-Resource,
            ra-ssb-OccasionMaskIndex        INTEGER (0..15)
        },
        csirs                           SEQUENCE {
            csirs-ResourceList              SEQUENCE (SIZE(1..maxRA-CSIRS-Resources)) OF CFRA-CSIRS-Resource,
            rsrp-ThresholdCSI-RS            RSRP-Range
        }
    },
    ...
}

CFRA-SSB-Resource ::=           SEQUENCE {
    ssb                             SSB-Index,
    ra-PreambleIndex                INTEGER (0..63),
    ...
}

CFRA-CSIRS-Resource ::=         SEQUENCE {
    csi-RS                          CSI-RS-Index,
    ra-OccasionList                 SEQUENCE (SIZE(1..maxRA-OccasionsPerCSIRS)) OF INTEGER (0..maxRA-Occasions-1),
    ra-PreambleIndex                INTEGER (0..63),
    ...
}

-- TAG-RACH-CONFIG-DEDICATED-STOP
-- ASN1STOP
```

CFRA-CSIRS-Resource field descriptions
csi-RS The ID of a CSI-RS resource defined in the measurement object associated with this serving cell.
ra-OccasionList RA occasions that the UE shall use when performing CF-RA upon selecting the candidate beam identified by this CSI-RS.
ra-PreambleIndex The RA preamble index to use in the RA occasions assoicated with this CSI-RS.

CFRA field descriptions
ra-ssb-OccasionMaskIndex Explicitly signalled PRACH Mask Index for RA Resource selection in TS 36.321. The mask is valid for all SSB resources signalled in ssb-ResourceList
rach-ConfigGeneric Configuration of contention free random access occasions for CFRA.
ssb-perRACH-Occasion Number of SSBs per RACH occasion (L1 parameter 'SSB-per-rach-occasion').

CFRA-SSB-Resource field descriptions
ra-PreambleIndex The preamble index that the UE shall use when performing CF-RA upon selecting the candidate beams identified by this SSB.
ssb The ID of an SSB transmitted by this serving cell.

RACH-ConfigDedicated field descriptions
cfra Parameters for contention free random access to a given target cell. If the field is absent, the UE performs contention based random access.
ra-prioritization Parameters which apply for prioritized random access procedure to a given target cell (see 38.321, section 5.1.1).

Conditional Presence	Explanation
SSB-CFRA	The field is mandatory present if the field resources in CFRA is set to ssb; otherwise it is not present.

– *RA-Prioritization*

The IE *RA-Prioritization* is used to configure prioritized random access.

***RA-Prioritization* information element**

```
-- ASN1START
-- TAG-RA-PRIORITIZATION-START

RA-Prioritization ::=           SEQUENCE {
    powerRampingStepHighPriority        ENUMERATED {dB0, dB2, dB4, dB6},
    scalingFactorBI                 ENUMERATED {zero, dot25, dot5, dot75}                       OPTIONAL,   -- Need R
    ...
}

-- TAG-RA-PRIORITIZATION-STOP
-- ASN1STOP
```

RA-Prioritization field descriptions
powerRampingStepHighPrioritiy Power ramping step applied for prioritized random access procedure.
scalingFactorBI Scaling factor for the backoff indicator (BI) for the prioritized random access procedure. (see 38,321, section 5.1.4). Value *zero* corresponds to 0, value *dot25* corresponds to 0.25 and so on.

– *RadioBearerConfig*

The IE *RadioBearerConfig* is used to add, modify and release signalling and/or data radio bearers. Specifically, this IE carries the parameters for PDCP and, if applicable, SDAP entities for the radio bearers.

***RadioBearerConfig* information element**

```
-- ASN1START
-- TAG-RADIO-BEARER-CONFIG-START

RadioBearerConfig ::=                   SEQUENCE {
    srb-ToAddModList                        SRB-ToAddModList                                OPTIONAL,   -- Need N
    srb3-ToRelease                          ENUMERATED{true}                                OPTIONAL,   -- Need N
    drb-ToAddModList                        DRB-ToAddModList                                OPTIONAL,   -- Need N
    drb-ToReleaseList                       DRB-ToReleaseList                               OPTIONAL,   -- Need N
    securityConfig                          SecurityConfig                                  OPTIONAL,   -- Need M
    ...
}

SRB-ToAddModList ::=                    SEQUENCE (SIZE (1..2)) OF SRB-ToAddMod
SRB-ToAddMod ::=                        SEQUENCE {
    srb-Identity                            SRB-Identity,
    reestablishPDCP                         ENUMERATED{true}                                OPTIONAL,   -- Need N
    discardOnPDCP                           ENUMERATED{true}                                OPTIONAL,   -- Need N
    pdcp-Config                             PDCP-Config                                     OPTIONAL,   -- Cond PDCP
    ...
}


DRB-ToAddModList ::=                    SEQUENCE (SIZE (1..maxDRB)) OF DRB-ToAddMod
DRB-ToAddMod ::=                        SEQUENCE {
    cnAssociation                           CHOICE {
        eps-BearerIdentity                      INTEGER (0..15),                            -- EPS-DRB-Setup
        sdap-Config                             SDAP-Config                                 -- 5GC
    }                                       OPTIONAL, -- Cond DRBSetup
    drb-Identity                            DRB-Identity,
    reestablishPDCP                         ENUMERATED{true}                                OPTIONAL,   -- Need N
    recoverPDCP                             ENUMERATED{true}                                OPTIONAL,   -- Need N
    pdcp-Config                             PDCP-Config                                     OPTIONAL,   -- Cond PDCP
    ...
}
DRB-ToReleaseList ::=                   SEQUENCE (SIZE (1..maxDRB)) OF DRB-Identity

SecurityConfig ::=                      SEQUENCE {
```

```
    securityAlgorithmConfig                 SecurityAlgorithmConfig                         OPTIONAL,   -- Cond RBTermChange
    keyToUse                                ENUMERATED{keNB, s-KgNB}                        OPTIONAL,   -- Cond RBTermChange
    ...
}

-- TAG-RADIO-BEARER-CONFIG-STOP
-- ASN1STOP
```

DRB-ToAddMod field descriptions
cnAssociation Indicates if the bearer is associated with the eps-bearerIdentity (when connected to EPC) or sdap-Config (when connected to 5GC).
drb-Identity In case of DC, the DRB identity is unique within the scope of the UE, i.e. an MCG DRB cannot use the same value as a split DRB. For a split DRB the same identity is used for the MCG and SCG parts of the configuration.
eps-BearerIdentity The EPS bearer ID determines the EPS bearer when NR connects to EPC using EN-DC
reestablishPDCP may only be set if the cell groups of all linked logical channels are reset or released Indicates that PDCP should be re-established. Network sets this to TRUE whenever the security key used for this radio bearer changes.
sdap-Config The SDAP configuration determines how to map QoS flows to DRBs when NR connects to the 5GC

RadioBearerConfig field descriptions
securityConfig Indicates the security algorithm and key to use for the signalling and data radio bearers configured with the list in this radioBearerConfig When the field is not included, the UE shall continue to use the currently configured keyToUse and security algorithm for the radio bearers reconfigured with the lists in this radioBearerConfig.
srb3-ToRelease Release SRB3. SRB3 release can only be done at SCG release and reconfiguration with sync.

SecurityConfig field descriptions
keyToUse Indicates if the bearers configured with the list in this radioBearerConfig is using KeNB or S-KgNB for deriving ciphering and/or integrity protection keys. Network should not configure SRB1 and SRB2 with S-KgNB and SRB3 with KeNB. When the field is not included, the UE shall continue to use the currently configured keyToUse for the radio bearers reconfigured with the lists in this radioBearerConfig.
securityAlgorithmConfig Indicates the security algorithm for the signalling and data radio bearers configured with the list in this radioBearerConfig. When the field is not included, the UE shall continue to use the currently configured security algorithm for the radio bearers reconfigured with the lists in this radioBearerConfig.

SRB-ToAddMod field descriptions
reestablishPDCP may only be set if the cell groups of all linked logical channels are reset or released
srb-Identity Value 1 is applicable for SRB1 only. Value 2 is applicable for SRB2 only. Value 3 is applicable for SRB3 only.

Conditional Presence	Explanation
RBTermChange	The field is mandatory present in case of set up of signalling and data radio bearer and change of termination point for the radio bearer between MN and SN. It is optionally present otherwise, Need S.
PDCP	The field is mandatory present if the corresponding DRB is being setup or corresponding RB is reconfigured with NR PDCP; otherwise the field is optionally present, need M.
DRBSetup	The field is mandatory present if the corresponding DRB is being setup; otherwise the field is optionally present, need M.

– *RadioLinkMonitoringConfig*

The *RadioLinkMonitoringConfig* IE is used to configure radio link monitoring for detection of beam- and/or cell radio link failure. See also 38.321, section 5.1.1.

RadioLinkMonitoringConfig information element

```
-- ASN1START
-- TAG-RADIOLINKMONITORINGCONFIG-START

RadioLinkMonitoringConfig ::=       SEQUENCE {
    failureDetectionResourcesToAddModList   SEQUENCE (SIZE(1..maxNrofFailureDetectionResources)) OF RadioLinkMonitoringRS OPTIONAL,   -- Need N
    failureDetectionResourcesToReleaseList  SEQUENCE (SIZE(1..maxNrofFailureDetectionResources)) OF RadioLinkMonitoringRS-Id OPTIONAL,-- Need N
    beamFailureInstanceMaxCount             ENUMERATED {n1, n2, n3, n4, n5, n6, n8, n10}                          OPTIONAL,   -- Need S
    beamFailureDetectionTimer               ENUMERATED {pbfd1, pbfd2, pbfd3, pbfd4, pbfd5, pbfd6, pbfd8, pbfd10}      OPTIONAL,   -- Need R
    ...
}

RadioLinkMonitoringRS ::=           SEQUENCE {
    radioLinkMonitoringRS-Id                RadioLinkMonitoringRS-Id,
    purpose                             ENUMERATED {beamFailure, rlf, both},
    detectionResource                   CHOICE {
        ssb-Index                           SSB-Index,
        csi-RS-Index                        NZP-CSI-RS-ResourceId
    },
    ...
}

-- TAG-RADIOLINKMONITORINGCONFIG-STOP
-- ASN1STOP
```

RadioLinkMonitoringConfig field descriptions
beamFailureDetectionTimer Timer for beam failure detection (see 38.321, section FFS_Section). See also the BeamFailureRecoveryConfig IE. Value in number of "periods of Beam Failure Detection" Reference Signal. Value pbfd1 corresponds to 1 period of Beam Failure Detection Reference Signal, value pbfd2 corresponds to 2 periods of Beam Failure Detection Reference Signal and so on. When the network reconfigures this field, the UE resets on-going *beamFailureDetectionTimer* and the counter related to *beamFailureInstanceMaxCount*.
beamFailureInstanceMaxCount This field determines after how many beam failure events the UE triggers beam failure recovery (see 38.321, section 5.17). Value n1 corresponds to 1 beam failure instance, n2 corresponds to 2 beam failure instances and so on. When the network reconfigures this field, the UE resets on-going*beamFailureDetectionTimer* and the counter related to *beamFailureInstanceMaxCount*. If the field is absent, the UE does not trigger beam failure recovery.
failureDetectionResourcesToAddModList A list of reference signals for detecting beam failure and/or cell level radio link failure (RLF). The network configures at most two detectionResources per BWP for the purpose "beamFailure" or "both". If no RSs are provided for the purpose of beam failure detection, the UE performs beam monitoring based on the activated TCI-State for PDCCH. However, if the activated TCI state refers to an aperiodic or semi-persistent CSI-RS, the gNB configures the failure detection resources explicitly (FFS_RAN1: TBC by RAN1). If no RSs are provided in this list at all (neither for Cell- nor for Beam-RLM), the UE performs also Cell-RLM based on the activated TCI-State of PDCCH (FFS_RAN1: TBC by RAN1). When the RS(s) for RLF is reconfigured by the network, the UE resets T310 and the counters related to N310 and N311. When the RS(s) for beam failure detection (BFD) is reconfigured by the network, the UE resets the on-going *beamFailureDetectionTimer* and the counter related to *beamFailureInstanceMaxCount*.

RadioLinkMonitoringRS field descriptions
detectionResource A reference signal that the UE shall use for radio link monitoring.
purpose Determines whether the UE shall monitor the associated reference signal for the purpose of cell- and/or beam failure detection.

– *RadioLinkMonitoringRSId*

The IE *RadioLinkMonitoringRSId* is used to identify one *RadioLinkMonitoringRS*.

RadioLinkMonitoringRSId information element

```
-- ASN1START
-- TAG-RADIOLINKMONITORINGRSID-START

RadioLinkMonitoringRS-Id ::=            INTEGER (0..maxNrofFailureDetectionResources-1)

-- TAG-RADIOLINKMONITORINGRSID-STOP
-- ASN1STOP
```

– *RateMatchPattern*

The IE *RateMatchPattern* is used to configure one rate matching pattern for PDSCH. Corresponds to L1 IE 'rate-match-PDSCH-resource-set', see 38.214, section FFS_Section.

RateMatchPattern information element

```
-- ASN1START
```

```
-- TAG-RATEMATCHPATTERN-START

RateMatchPattern ::=                SEQUENCE {
    rateMatchPatternId                  RateMatchPatternId,

    patternType                         CHOICE {
        bitmaps                             SEQUENCE {
            resourceBlocks                      BIT STRING (SIZE (275)),
            symbolsInResourceBlock              CHOICE {
                oneSlot                             BIT STRING (SIZE (14)),
                twoSlots                            BIT STRING (SIZE (28))
            },
            periodicityAndPattern               CHOICE {
                n2                                  BIT STRING (SIZE (2)),
                n4                                  BIT STRING (SIZE (4)),
                n5                                  BIT STRING (SIZE (5)),
                n8                                  BIT STRING (SIZE (8)),
                n10                                 BIT STRING (SIZE (10)),
                n20                                 BIT STRING (SIZE (20)),
                n40                                 BIT STRING (SIZE (40))
            }                                                                   OPTIONAL,   -- Need S
            ...
        },
        controlResourceSet              ControlResourceSetId
    },
    subcarrierSpacing               SubcarrierSpacing                           OPTIONAL,   -- Cond CellLevel
    mode                            ENUMERATED { dynamic, semiStatic },
    ...
}

-- TAG-RATEMATCHPATTERN-STOP
-- ASN1STOP
```

RateMatchPattern field descriptions
controlResourceSet This ControlResourceSet us used as a PDSCH rate matching pattern, i.e., PDSCH reception rate matches around it.
mode FFS_Description, FFS_Section
periodicityAndPattern A time domain repetition pattern. at which the symbolsInResourceBlock pattern recurs. This slot pattern repeats itself continuously. Absence of this field indicates the value n1, i.e., the symbolsInResourceBlock recurs every 14 symbols. Corresponds to L1 parameter 'rate-match-PDSCH-bitmap3' (see 38.214, section FFS_Section)
resourceBlocks A resource block level bitmap in the frequency domain. It indicates the PRBs to which the symbolsInResourceBlock bitmap applies. Corresponds to L1 parameter 'rate-match-PDSCH-bitmap1' (see 38.214, section FFS_Section) FFS_ASN1: Consider multiple options with different number of bits (for narrower carriers)
subcarrierSpacing The SubcarrierSpacing for this resource pattern. If the field is absent, the UE applies the SCS of the associcated BWP. The value kHz15 corresponds to μ=0, kHz30 to μ=1, and so on. Only the values 15 or 30 kHz (<6GHz), 60 or 120 kHz (>6GHz) are applicable. Corresponds to L1 parameter 'resource-pattern-scs' (see 38.214, section FFS_Section)
symbolsInResourceBlock A symbol level bitmap in time domain. It indicates (FFS: with a bit set to true) the symbols which the UE shall rate match around. This pattern recurs (in time domain) with the configured periodicityAndOffset. Corresponds to L1 parameter 'rate-match-PDSCH-bitmap2' (see 38.214, section FFS_Section)

Conditional Presence	Explanation
CellLevel	The field is mandatory present if the RateMatchPattern is defined on cell level. The field is absent when the RateMatchPattern is defined on BWP level. If the RateMatchPattern is defined on BWP level, the UE applies the SCS of the BWP.

– *RateMatchPatternId*

The IE *RateMatchPatternId* identifies one RateMatchMattern. Corresponds to L1 parameter 'resource-set-index' (see 38.214, section 5.1.2.2.3)

RateMatchPatternId information element

```
-- ASN1START
-- TAG-RATEMATCHPATTERNID-START

RateMatchPatternId ::=              INTEGER (0..maxNrofRateMatchPatterns-1)

-- TAG-RATEMATCHPATTERNID-STOP
-- ASN1STOP
```

– *RateMatchPatternLTE-CRS*

The IE *RateMatchPatternLTE-CRS* is used to configure a pattern to rate match around LTE CRS.

RateMatchPatternLTE-CRS information element

```
-- ASN1START
-- TAG-RATEMATCHPATTERNLTE-CRS-START

RateMatchPatternLTE-CRS ::=         SEQUENCE {
    carrierFreqDL                       INTEGER (0..16383),
    carrierBandwidthDL                  ENUMERATED {n6, n15, n25, n50, n75, n100, spare2, spare1},
    mbsfn-SubframeConfigList            EUTRA-MBSFN-SubframeConfigList                                  OPTIONAL,   -- Need M
    nrofCRS-Ports                       ENUMERATED {n1, n2, n4},
    v-Shift                             ENUMERATED {n0, n1, n2, n3, n4, n5}
}

-- TAG-RATEMATCHPATTERNLTE-CRS-STOP
-- ASN1STOP
```

RateMatchPatternLTE-CRS field descriptions
carrierBandwidthDL BW of the LTE carrier in numbewr of PRBs. Corresponds to L1 parameter 'BW' (see 38.214, section 5.1.4)
carrierFreqDL Center of the LTE carrier. Corresponds to L1 parameter 'center-subcarrier-location' (see 38.214, section 5.1.4)
mbsfn-SubframeConfigList LTE MBSFN subframe configuration. Corresponds to L1 parameter 'MBSFN-subframconfig' (see 38.214, section 5.1.4) FFS_ASN1: Import the LTE MBSFN-SubframeConfigList
nrofCRS-Ports Number of LTE CRS antenna port to rate-match around. Corresponds to L1 parameter 'rate-match-resources-numb-LTE-CRS-antenna-port' (see 38.214, section 5.1.4)
v-Shift Shifting value v-shift in LTE to rate match around LTE CRS Corresponds to L1 parameter 'rate-match-resources-LTE-CRS-v-shift' (see 38.214, section 5.1.4)

– *ReportConfigId*

The IE *ReportConfigId* is used to identify a measurement reporting configuration.

ReportConfigId information element

```
-- ASN1START
-- TAG-REPORT-CONFIG-ID-START

ReportConfigId ::=                      INTEGER (1..maxReportConfigId)

-- TAG-REPORT-CONFIG-ID-STOP
-- ASN1STOP
```

– *ReportConfigNR*

The IE *ReportConfigNR* specifies criteria for triggering of an NR measurement reporting event. Measurement reporting events are based on cell measurement results, which can either be derived based on SS/PBCH block or CSI-RS. These events are labelled AN with N equal to 1, 2 and so on.

Event A1: Serving becomes better than absolute threshold;

Event A2: Serving becomes worse than absolute threshold;

Event A3: Neighbour becomes amount of offset better than PCell/PSCell;

Event A4: Neighbour becomes better than absolute threshold;

Event A5: PCell/PSCell becomes worse than absolute threshold1 AND Neighbour becomes better than another absolute threshold2.

Event A6: Neighbour becomes amount of offset better than SCell.

ReportConfigNR information element

```
-- ASN1START
-- TAG-REPORT-CONFIG-START

ReportConfigNR ::=                          SEQUENCE {
    reportType                                  CHOICE {
        periodical                                  PeriodicalReportConfig,
        eventTriggered                              EventTriggerConfig,
-- reportCGI is to be completed before the end of Rel-15.
        ...
    }
}

-- FFS / TODO: Consider separating trgger configuration (trigger, periodic, ...) from report configuration.
-- Current structure allows easier definiton of new events and new report types e.g. CGI, etc.
EventTriggerConfig ::=                      SEQUENCE {
    eventId                                     CHOICE {
        eventA1                                     SEQUENCE {
            a1-Threshold                                MeasTriggerQuantity,
            reportOnLeave                               BOOLEAN,
            hysteresis                                  Hysteresis,
            timeToTrigger                               TimeToTrigger
        },
        eventA2                                     SEQUENCE {
            a2-Threshold                                MeasTriggerQuantity,
            reportOnLeave                               BOOLEAN,
            hysteresis                                  Hysteresis,
            timeToTrigger                               TimeToTrigger
        },
        eventA3                                     SEQUENCE {
            a3-Offset                                   MeasTriggerQuantityOffset,
            reportOnLeave                               BOOLEAN,
            hysteresis                                  Hysteresis,
```

```
            timeToTrigger                       TimeToTrigger,
            useWhiteCellList                    BOOLEAN
        },
        eventA4                             SEQUENCE {
            a4-Threshold                        MeasTriggerQuantity,
            reportOnLeave                       BOOLEAN,
            hysteresis                          Hysteresis,
            timeToTrigger                       TimeToTrigger,
            useWhiteCellList                    BOOLEAN
        },
        eventA5                             SEQUENCE {
            a5-Threshold1                       MeasTriggerQuantity,
            a5-Threshold2                       MeasTriggerQuantity,
            reportOnLeave                       BOOLEAN,
            hysteresis                          Hysteresis,
            timeToTrigger                       TimeToTrigger,
            useWhiteCellList                    BOOLEAN
        },
        eventA6                             SEQUENCE {
            a6-Offset                           MeasTriggerQuantityOffset,
            reportOnLeave                       BOOLEAN,
            hysteresis                          Hysteresis,
            timeToTrigger                       TimeToTrigger,
            useWhiteCellList                    BOOLEAN
        },
        ...
    },

    rsType                              NR-RS-Type,

    reportInterval                      ReportInterval,
    reportAmount                        ENUMERATED {r1, r2, r4, r8, r16, r32, r64, infinity},

    reportQuantityCell                  MeasReportQuantity,
    maxReportCells                      INTEGER (1..maxCellReport),

    reportQuantityRsIndexes             MeasReportQuantity                              OPTIONAL,   -- Need R
    maxNrofRSIndexesToReport            INTEGER (1..maxNrofIndexesToReport)             OPTIONAL,   -- Need R
    includeBeamMeasurements             BOOLEAN,
    reportAddNeighMeas                  ENUMERATED {setup}                              OPTIONAL,   -- Need R
    ...

}

PeriodicalReportConfig ::=          SEQUENCE {
    rsType                              NR-RS-Type,

    reportInterval                      ReportInterval,
    reportAmount                        ENUMERATED {r1, r2, r4, r8, r16, r32, r64, infinity},

    reportQuantityCell                  MeasReportQuantity,
    maxReportCells                      INTEGER (1..maxCellReport),

    reportQuantityRsIndexes             MeasReportQuantity                              OPTIONAL,   -- Need R
```

```
    maxNrofRsIndexesToReport                INTEGER (1..maxNrofIndexesToReport)                 OPTIONAL,   -- Need R
    includeBeamMeasurements                 BOOLEAN,
    useWhiteCellList                        BOOLEAN,
    ...

}

NR-RS-Type ::=                              ENUMERATED {ssb, csi-rs}

MeasTriggerQuantity ::=                     CHOICE {
    rsrp                                        RSRP-Range,
    rsrq                                        RSRQ-Range,
    sinr                                        SINR-Range
}

MeasTriggerQuantityOffset ::=               CHOICE {
    rsrp                                        INTEGER (-30..30),
    rsrq                                        INTEGER (-30..30),
    sinr                                        INTEGER (-30..30)
}


MeasReportQuantity ::=                      SEQUENCE {
    rsrp                                        BOOLEAN,
    rsrq                                        BOOLEAN,
    sinr                                        BOOLEAN
}


-- TAG-REPORT-CONFIG-START
-- ASN1STOP
```

EventTriggerConfig field descriptions
a3-Offset/a6-Offset
Offset value(s) to be used in NR measurement report triggering condition for event a3/a6.The actual value is field value * 0.5 dB.
aN-ThresholdM
Threshold value associated to the selected trigger quantity (e.g. RSRP, RSRQ, SINR) per RS Type (e.g. SS/PBCH block, CSI-RS) to be used in NR measurement report triggering condition for event number aN. If multiple thresholds are defined for event number aN, the thresholds are differentiated by M. The network configures aN-Threshold1 only for events A1, A2, A4, A5 and a5-Threshold2 only for event A5.
eventId
Choice of NR event triggered reporting criteria.
maxNrofRsIndexesToReport
Max number of measurement information per RS index to include in the measurement report for A1-A6 events.
maxReportCells
Max number of non-serving cells to include in the measurement report.
reportAddNeighMeas
Indicates that the UE shall includes the best neighbour cells per serving frequency.
reportAmount
Number of measurement reports applicable for *eventTriggered* as well as for *periodical* report types
reportOnLeave
Indicates whether or not the UE shall initiate the measurement reporting procedure when the leaving condition is met for a cell in cellsTriggeredList, as specified in 5.5.4.1.
reportQuantityCell
The cell measurement quantities to be included in the measurement report.
reportQuantityRsIndexes
Indicates which measurement information per RS index the UE shall include in the measurement report.
timeToTrigger
Time during which specific criteria for the event needs to be met in order to trigger a measurement report.
useWhiteCellList
Indicates whether only the cells included in the white-list of the associated measObject are applicable as specified in 5.5.4.1.

PeriodicalReportConfig field descriptions
maxNrofRsIndexesToReport
Max number of measurement information per RS index to include in the measurement report for A1-A6 events.
maxReportCells
Max number of non-serving cells to include in the measurement report.
reportAmount
Number of measurement reports applicable for *eventTriggered* as well as for *periodical* report types
reportQuantityCell
The cell measurement quantities to be included in the measurement report.
reportQuantityRsIndexes
Indicates which measurement information per RS index the UE shall include in the measurement report.
useWhiteCellList
Indicates whether only the cells included in the white-list of the associated measObject are applicable as specified in 5.5.4.1.

– *ReportConfigToAddModList*

The IE *ReportConfigToAddModList* concerns a list of reporting configurations to add or modify.

ReportConfigToAddModList information element

```
-- ASN1START
-- TAG-REPORT-CONFIG-TO-ADD-MOD-LIST-START

ReportConfigToAddModList ::=        SEQUENCE (SIZE (1..maxReportConfigId)) OF ReportConfigToAddMod

ReportConfigToAddMod ::=            SEQUENCE {
    reportConfigId                      ReportConfigId,
    reportConfig                        CHOICE {
        reportConfigNR                      ReportConfigNR,
        ...
    }
}

-- TAG- REPORT-CONFIG-TO-ADD-MOD-LIST-STOP
-- ASN1STOP
```

– *ReportInterval*

The *ReportInterval* indicates the interval between periodical reports. The *ReportInterval* is applicable if the UE performs periodical reporting (i.e. when *reportAmount* exceeds 1), for *triggerTypeevent* as well as for *triggerTypeperiodical*. Value ms120 corresponds to 120 ms, ms240 corresponds to 240 ms and so on, while value min1 corresponds to 1 min, min6 corresponds to 6 min and so on.

***ReportInterval* information element**

```
-- ASN1START

ReportInterval ::=                  ENUMERATED { ms120, ms240, ms480, ms640, ms1024, ms2048, ms5120, ms10240, ms20480, ms40960,
                                                 min1, min6, min12, min30 }

-- ASN1STOP
```

– *RLC-BearerConfig*

The IE *RLC-BearerConfig* is used to configure FFS

***RLC-BearerConfig* information element**

```
-- ASN1START
-- TAG-RLC-BEARERCONFIG-START

RLC-BearerConfig ::=                    SEQUENCE {
    logicalChannelIdentity                  LogicalChannelIdentity,
```

```
    servedRadioBearer                       CHOICE {
        srb-Identity                            SRB-Identity,
        drb-Identity                            DRB-Identity
    }                                                                       OPTIONAL,   -- Cond LCH-SetupOnly

    reestablishRLC                          ENUMERATED {true}               OPTIONAL,   -- Need R
    rlc-Config                              RLC-Config                      OPTIONAL,   -- Cond LCH-Setup

    mac-LogicalChannelConfig                LogicalChannelConfig            OPTIONAL,   -- Cond LCH-Setup
    ...
}

-- TAG-RLC-BEARERCONFIG-STOP
-- ASN1STOP
```

RLC-BearerConfig field descriptions
logicalChannelIdentity
ID used commonly for the MAC logical channel and for the RLC bearer.
servedRadioBearer
Associates the RLC Bearer with an SRB or a DRB. The UE shall deliver DL RLC SDUs received via the RLC entity of this RLC bearer to the PDCP entity of the servedRadioBearer. Furthermore, the UE shall advertise and deliver uplink PDCP PDUs of the uplink PDCP entity of the servedRadioBearer to the uplink RLC entity of this RLC bearer unless the uplink scheduling restrictions ('moreThanOneRLC' in PDCP-Config and the restrictions in LogicalChannelConfig) forbid it to do so.

– *RLC-Config*

The IE *RLC-Config* is used to specify the RLC configuration of SRBs and DRBs.

RLC-Config information element

```
-- ASN1START
-- TAG-RLC-CONFIG-START

RLC-Config ::=                      CHOICE {
    am                                  SEQUENCE {
        ul-AM-RLC                           UL-AM-RLC,
        dl-AM-RLC                           DL-AM-RLC
    },
    um-Bi-Directional                   SEQUENCE {
        ul-UM-RLC                           UL-UM-RLC,
        dl-UM-RLC                           DL-UM-RLC
    },
    um-Uni-Directional-UL               SEQUENCE {
        ul-UM-RLC                           UL-UM-RLC
    },
    um-Uni-Directional-DL               SEQUENCE {
        dl-UM-RLC                           DL-UM-RLC
    },
    ...
}
```

```
UL-AM-RLC ::=                   SEQUENCE {
    sn-FieldLength                  SN-FieldLengthAM                                OPTIONAL,   -- Cond Reestab
    t-PollRetransmit                T-PollRetransmit,
    pollPDU                         PollPDU,
    pollByte                        PollByte,
    maxRetxThreshold                ENUMERATED { t1, t2, t3, t4, t6, t8, t16, t32 }
}

DL-AM-RLC ::=                   SEQUENCE {
    sn-FieldLength                  SN-FieldLengthAM                                OPTIONAL,   -- Cond Reestab
    t-Reassembly                    T-Reassembly,
    t-StatusProhibit                T-StatusProhibit
}

UL-UM-RLC ::=                   SEQUENCE {
    sn-FieldLength                  SN-FieldLengthUM                                OPTIONAL    -- Cond Reestab
}

DL-UM-RLC ::=                   SEQUENCE {
    sn-FieldLength                  SN-FieldLengthUM                                OPTIONAL,   -- Cond Reestab
    t-Reassembly                    T-Reassembly
}

T-PollRetransmit ::=            ENUMERATED {
                                    ms5, ms10, ms15, ms20, ms25, ms30, ms35,
                                    ms40, ms45, ms50, ms55, ms60, ms65, ms70,
                                    ms75, ms80, ms85, ms90, ms95, ms100, ms105,
                                    ms110, ms115, ms120, ms125, ms130, ms135,
                                    ms140, ms145, ms150, ms155, ms160, ms165,
                                    ms170, ms175, ms180, ms185, ms190, ms195,
                                    ms200, ms205, ms210, ms215, ms220, ms225,
                                    ms230, ms235, ms240, ms245, ms250, ms300,
                                    ms350, ms400, ms450, ms500, ms800, ms1000,
                                    ms2000, ms4000, spare5, spare4, spare3,
                                    spare2, spare1}


PollPDU ::=                     ENUMERATED {
                                    p4, p8, p16, p32, p64, p128, p256, p512, p1024, p2048, p4096, p6144, p8192, p12288, p16384, p20480,
                                    p24576, p28672, p32768, p40960, p49152, p57344, p65536, infinity, spare8, spare7, spare6, spare5, spare4,
                                    spare3, spare2, spare1}

PollByte ::=                    ENUMERATED {
                                    kB1, kB2, kB5, kB8, kB10, kB15, kB25, kB50, kB75,
                                    kB100, kB125, kB250, kB375, kB500, kB750, kB1000,
                                    kB1250, kB1500, kB2000, kB3000, kB4000, kB4500,
                                    kB5000, kB5500, kB6000, kB6500, kB7000, kB7500,
                                    mB8, mB9, mB10, mB11, mB12, mB13, mB14, mB15,
                                    mB16, mB17, mB18, mB20, mB25, mB30, mB40, infinity,
                                    spare20, spare19, spare18, spare17, spare16,
                                    spare15, spare14, spare13, spare12, spare11,
                                    spare10, spare9, spare8, spare7, spare6, spare5,
                                    spare4, spare3, spare2, spare1}
```

```
T-Reassembly ::=                ENUMERATED {
                                    ms0, ms5, ms10, ms15, ms20, ms25, ms30, ms35,
                                    ms40, ms45, ms50, ms55, ms60, ms65, ms70,
                                    ms75, ms80, ms85, ms90, ms95, ms100, ms110,
                                    ms120, ms130, ms140, ms150, ms160, ms170,
                                    ms180, ms190, ms200, spare1}

T-StatusProhibit ::=            ENUMERATED {
                                    ms0, ms5, ms10, ms15, ms20, ms25, ms30, ms35,
                                    ms40, ms45, ms50, ms55, ms60, ms65, ms70,
                                    ms75, ms80, ms85, ms90, ms95, ms100, ms105,
                                    ms110, ms115, ms120, ms125, ms130, ms135,
                                    ms140, ms145, ms150, ms155, ms160, ms165,
                                    ms170, ms175, ms180, ms185, ms190, ms195,
                                    ms200, ms205, ms210, ms215, ms220, ms225,
                                    ms230, ms235, ms240, ms245, ms250, ms300,
                                    ms350, ms400, ms450, ms500, ms800, ms1000,
                                    ms1200, ms1600, ms2000, ms2400, spare2, spare1}

SN-FieldLengthUM ::=            ENUMERATED {size6, size12}
SN-FieldLengthAM ::=            ENUMERATED {size12, size18}

-- TAG-RLC-CONFIG-STOP
-- ASN1STOP
```

***RLC-Config*field descriptions**
maxRetxThreshold Parameter for RLC AM in TS 38.322 [4]. Value t1 corresponds to 1 retransmission, t2 to 2 retransmissions and so on.
pollByte Parameter for RLC AM in TS 38.322 [4]. Value kB25 corresponds to 25 kBytes, kB50 to 50 kBytes and so on. infinity corresponds to an infinite amount of kBytes.
pollPDU Parameter for RLC AM in TS 38.322 [4]. Value p4 corresponds to 4 PDUs, p8 to 8 PDUs and so on. infinity corresponds to an infinite number of PDUs.
sn-FieldLength Indicates the RLC SN field size, see TS 38.322 [4], in bits. Value size6 means 6 bits, size12 means 12 bits, size18 means 18 bits. The value of sn-FieldLength for a DRB shall be changed only using reconfiguration with sync.
t-PollRetransmit Timer for RLC AM inTS 38.322 [4], in milliseconds. Value ms5 means 5ms, ms10 means 10ms and so on.
t-Reassembly Timer for reassembly in TS 38.322 [4], in milliseconds. Value ms0 means 0ms, ms5 means 5ms and so on.
t-StatusProhibit Timer for status reporting in TS 38.322 [4], in milliseconds. Value ms0 means 0ms, ms5 means 5ms and so on.

Conditional Presence	Explanation
Reestab	The field is mandatory present at bearer setup. It is optionally present, need M, at RLC re-establishment. Otherwise it is not present.

– *RLF-TimersAndConstants*

Editor's Note: FFS / TODO: Insert the RLF timers and related functionality. Check what is needed for EN-DC.

The *RLF-TimersAndConstants* IE is used to configure UE specific timers and constants.

RLF-TimersAndConstants information element

```
-- ASN1START
-- TAG-RLF-TIMERS-AND-CONSTANTS-START

RLF-TimersAndConstants ::=          SEQUENCE {
    t310                                ENUMERATED {ms0, ms50, ms100, ms200, ms500, ms1000, ms2000, ms4000, ms6000},
    n310                                ENUMERATED {n1, n2, n3, n4, n6, n8, n10, n20},
    n311                                ENUMERATED {n1, n2, n3, n4, n5, n6, n8, n10},
    ...
}

-- TAG-RLF-TIMERS-AND-CONSTANTS-STOP
-- ASN1STOP
```

RLF-TimersAndConstants field descriptions
n3xy Constants are described in section 7.3. n1 corresponds with 1, n2 corresponds to 2 and so on.
t3xy Timers are described in section 7.1. Value ms0 corresponds with 0 ms, ms50 corresponds to 50 ms and so on.

– *RNTI-Value*

The *RNTI-Value* IE represents a Radio Network Temporary Identity.

RNTI-Value information element

```
-- ASN1START
-- TAG-RNTI-VALUE-START

RNTI-Value ::=                      INTEGER (0..65535)

-- TAG-RNTI-VALUE-STOP
-- ASN1STOP
```

– *RSRP-Range*

The IE *RSRP-Range* specifies the value range used in RSRP measurements and thresholds. Integer value for RSRP measurements according to mapping table in TS 38.133 [14].

RSRP-Range information element

```
-- ASN1START
-- TAG-RSRP-RANGE-START

RSRP-Range ::=                      INTEGER(0..127)

-- TAG-RSRP-RANGE-STOP
-- ASN1STOP
```

– *RSRQ-Range*

The IE *RSRQ-Range* specifies the value range used in RSRQ measurements and thresholds. Integer value for RSRQ measurements is according to mapping table in TS 38.133 [14].

RSRQ-Range information element

```
-- ASN1START
-- TAG-RSRQ-RANGE-START

RSRQ-Range ::=                      INTEGER(0..127)

-- TAG-RSRQ-RANGE-STOP
-- ASN1STOP
```

– *SCellIndex*

The IE *SCellIndex* concerns a short identity, used to identify an SCell. The value range is shared across the Cell Groups.

SCellIndex information element

```
-- ASN1START
-- TAG-SCELL-INDEX-START

SCellIndex ::=                      INTEGER (1..31)

-- TAG-SCELL-INDEX-STOP
-- ASN1STOP
```

– *SchedulingRequestConfig*

The IE *SchedulingRequestConfig* is used to configure the parameters, for the dedicated scheduling request (SR) resources.

SchedulingRequestConfig information element

```
-- ASN1START
-- TAG-SCHEDULING-REQUEST-CONFIG-START
```

```
SchedulingRequestConfig ::=         SEQUENCE {
    schedulingRequestToAddModList       SEQUENCE (SIZE (1..maxNrofSR-ConfigPerCellGroup)) OF SchedulingRequestToAddMod    OPTIONAL, -- Need N
    schedulingRequestToReleaseList      SEQUENCE (SIZE (1..maxNrofSR-ConfigPerCellGroup)) OF SchedulingRequestId      OPTIONAL  -- Need N
}

SchedulingRequestToAddMod ::=       SEQUENCE {
    schedulingRequestId     SchedulingRequestId,

    sr-ProhibitTimer                    ENUMERATED {ms1, ms2, ms4, ms8, ms16, ms32, ms64, ms128}                  OPTIONAL,   -- Need S
    sr-TransMax                         ENUMERATED { n4, n8, n16, n32, n64, spare3, spare2, spare1}
}



-- TAG-SCHEDULING-REQUEST-CONFIG-STOP
-- ASN1STOP
```

***SchedulingRequestConfig* field descriptions**
schedulingRequestToAddModList List of Scheduling Request configurations to add or modify.
schedulingRequestToReleaseList List of Scheduling Request configurations to release
sr-ConfigIndex Used to modify a SR configuration and to indicate, in LogicalChannelConfig, the SR configuration to which a logical channel is mapped.
sr-ProhibitTimer Timer for SR transmission on PUCCH in TS 38.321 [3]. Value in ms. ms1 corresponds to 1ms, ms2 corresponds to 2ms, and so on. When the field is absent, the UE applies the value 0.
sr-TransMax Maximum number of SR transmissions as described in 38.321 [3]. n4 corresponds to 4, n8 corresponds to 8, and so on.

– *SchedulingRequestId*

The IE *SchedulingRequestId* is used to identify a Scheduling Request instance in the MAC layer.

SchedulingRequestId information element

```
-- ASN1START
-- TAG-SCHEDULINGREQUESTID-START

SchedulingRequestId ::=             INTEGER (0..7)

-- TAG-SCHEDULINGREQUESTID-STOP
-- ASN1STOP
```

– *SchedulingRequestResourceConfig*

The IE *SchedulingRequestResourceConfig* determines physical layer resources on PUCCH where the UE may send the dedicated scheduling request (D-SR) (see 38.213, section 9.2.2).

SchedulingRequestResourceConfig information element

```
-- ASN1START
-- TAG-SCHEDULING-REQUEST-RESOURCE-CONFIG-START

SchedulingRequestResourceConfig ::=     SEQUENCE {
    schedulingRequestResourceId             SchedulingRequestResourceId,
    schedulingRequestID                     SchedulingRequestId,
    periodicityAndOffset                    CHOICE {
        sym2                                    NULL,
        sym6or7                                 NULL,
        sl1                                     NULL,                       -- Recurs in every slot
        sl2                                     INTEGER (0..1),
        sl4                                     INTEGER (0..3),
        sl5                                     INTEGER (0..4),
        sl8                                     INTEGER (0..7),
        sl10                                    INTEGER (0..9),
        sl16                                    INTEGER (0..15),
        sl20                                    INTEGER (0..19),
        sl40                                    INTEGER (0..39),
        sl80                                    INTEGER (0..79),
        sl160                                   INTEGER (0..159),
        sl320                                   INTEGER (0..319),
        sl640                                   INTEGER (0..639)
    }                                                                                   OPTIONAL,   -- Need M
    resource                                PUCCH-ResourceId                            OPTIONAL -- Need M
}

-- TAG-SCHEDULING-REQUEST-RESOURCE-CONFIG-STOP
-- ASN1STOP
```

SchedulingRequestResourceConfig field descriptions
periodicityAndOffset SR periodicity and offset in number of slots. Corresponds to L1 parameter 'SR-periodicity' and 'SR-offset' (see 38.213, section 9.2.2) The following periodicities may be configured depending on the chosen subcarrier spacing: SCS = 15 kHz: 2sym, 7sym, 1sl, 2sl, 4sl, 5sl, 8sl, 10sl, 16sl, 20sl, 40sl, 80sl SCS = 30 kHz: 2sym, 7sym, 1sl, 2sl, 4sl, 8sl, 10sl, 16sl, 20sl, 40sl, 80sl, 160sl SCS = 60 kHz: 2sym, 7sym/6sym, 1sl, 2sl, 4sl, 8sl, 16sl, 20sl, 40sl, 80sl, 160sl, 320sl SCS = 120 kHz: 2sym, 7sym, 1sl, 2sl, 4sl, 8sl, 16sl, 40sl, 80sl, 160sl, 320sl, sl640 sym6or7 corresponds to 6 symbols if extended cyclic prefix and a SCS of 60 kHz are configured, otherwise it corresponds to 7 symbols. For periodicities sym2, sym7 and sl1 the UE assumes an offset of 0 slots.
resource ID of the PUCCH resource in which the UE shall send the scheduling request. The actual PUCCH-Resource is configured in PUCCH-Config of the same UL BWP and serving cell as this SchedulingRequestResourceConfig. The network configures a PUCCH-Resource of PUCCH-format0 or PUCCH-format1 (other formats not supported). Corresponds to L1 parameter 'SR-resource' (see 38.213, section 9.2.2)
schedulingRequestID The ID of the SchedulingRequestConfig that uses this scheduling request resource.

– *SchedulingRequestResourceId*

The IE *SchedulingRequestResourceId* is used to identify scheduling request resources on PUCCH.

SchedulingRequestResourceId information element

```
-- ASN1START
-- TAG-SCHEDULINGREQUESTRESOURCEID-START

SchedulingRequestResourceId ::=     INTEGER (1..maxNrofSR-Resources)

-- TAG-SCHEDULINGREQUESTRESOURCEID-STOP
-- ASN1STOP
```

– *ScramblingId*

The IE *ScramblingID* is used for scrambling channels and reference signals.

```
-- ASN1START
-- TAG-SCRAMBLING-ID-START

ScramblingId ::=                    INTEGER (0..1023)

-- TAG-SCRAMBLING-ID-STOP
-- ASN1STOP
```

– *SCS-SpecificCarrier*

The IE *SCS-SpecificCarrier* provides parameters determining the location and width of the actual carrier. It is defined specifically for a numerology (subcarrier spacing (SCS)) and in relation (frequency offset) to Point A.

```
-- ASN1START
-- TAG-SCS-SPECIFIC-CARRIER-START

SCS-SpecificCarrier ::=             SEQUENCE {
    offsetToCarrier                     INTEGER (0..2199),
    subcarrierSpacing                   SubcarrierSpacing,
    carrierBandwidth                    INTEGER (1..maxNrofPhysicalResourceBlocks),
    ...
}

-- TAG-SCS-SPECIFIC-CARRIER-STOP
-- ASN1STOP
```

SCS-SpecificCarrier field descriptions
carrierBandwidth Width of this carrier in number of PRBs (using the subcarrierSpacing defined for this carrier) Corresponds to L1 parameter 'BW' (see 38.211, section FFS_Section)
offsetToCarrier Offset in frequency domain between Point A (lowest subcarrier of common RB 0) and the lowest usable subcarrier on this carrier in number of PRBs (using the subcarrierSpacing defined for this carrier). The maximum value corresponds to 275*8-1. Corresponds to L1 parameter 'offset-pointA-low-scs' (see 38.211, section FFS_Section)
subcarrierSpacing Subcarrier spacing of this carrier. It is used to convert the offsetToCarrier into an actual frequency. Only the values 15 or 30 kHz (<6GHz), 60 or 120 kHz (>6GHz) are applicable. The network configures all SCSs of configured BWPs configured in this serving cell. Corresponds to L1 parameter 'ref-scs' (see 38.211, section FFS_Section)

Conditional Presence	Explanation
OnePerServCell	This field must be present for exactly one SCS-SpecificCarrier of a serving cell.

– *SDAP-Config*

The IE *SDAP-Config* is used to set the configurable SDAP parameters for a data radio bearer. All configured instances of SDAP-Config with the same value of pdu-Session correspond to the same SDAP entity as specified in TS 37.324 [FFS_Ref].

SDAP-Config information element

```
-- ASN1START
-- TAG-SDAP-CONFIG-START

SDAP-Config ::=                     SEQUENCE {
    pdu-Session                         PDU-SessionID,
    sdap-HeaderDL                       ENUMERATED {present, absent},
```

```
    sdap-HeaderUL                       ENUMERATED {present, absent},
    defaultDRB                          BOOLEAN,
    mappedQoS-FlowsToAdd                SEQUENCE (SIZE (1..maxNrofQFIs)) OF QFI                         OPTIONAL, -- Need N
    mappedQoS-FlowsToRelease            SEQUENCE (SIZE (1..maxNrofQFIs)) OF QFI                         OPTIONAL, -- Need N
    ...
}

QFI ::=                             INTEGER (0..maxQFI)

PDU-SessionID ::=                   INTEGER (0..255)

-- TAG-SDAP-CONFIG-STOP
-- ASN1STOP
```

SDAP-Config field descriptions
defaultDRB Indicates whether or not this is the default DRB for this PDU session. Among all configured instances of *SDAP-Config* with the same value of *pdu-Session*, this field shall be set to TRUE in at most one instance of SDAP-Config and to FALSE in all other instances.
mappedQoS-FlowsToAdd Indicates the list of QFIs of QoS flows of the PDU session to be additionally mapped to this DRB. A QFI value can be included at most once in all configured instances of *SDAP-Config* with the same value of *pdu-Session*.
mappedQoS-FlowsToRelease Indicates the list of QFIs of QoS flows of the PDU session to be released from existing QoS flow to DRB mapping of this DRB.
pdu-Session Identity of the PDU session whose QoS flows are mapped to the DRB
sdap-HeaderUL Indicates whether or not a SDAP header is present for UL data on this DRB.
sdap-HeaderDL Indicates whether or not a SDAP header is present for DL data on this DRB.

– *SearchSpace*

The IE *SearchSpace* defines how/where to search for PDCCH candidates. Each search space is associated with one *ControlResourceSet*.

SearchSpace information element

```
-- ASN1START
-- TAG-SEARCHSPACE-START

SearchSpace ::=                         SEQUENCE {
    searchSpaceId                           SearchSpaceId,
    controlResourceSetId                    ControlResourceSetId                                    OPTIONAL,   -- Cond SetupOnly
    monitoringSlotPeriodicityAndOffset      CHOICE {
        sl1                                     NULL,
        sl2                                     INTEGER (0..1),
        sl4                                     INTEGER (0..3),
        sl5                                     INTEGER (0..4),
        sl8                                     INTEGER (0..7),
```

```
        sl10                                INTEGER (0..9),
        sl16                                INTEGER (0..15),
        sl20                                INTEGER (0..19),
        sl40                                INTEGER (0..39),
        sl80                                INTEGER (0..79),
        sl160                               INTEGER (0..159),
        sl320                               INTEGER (0..319),
        sl640                               INTEGER (0..639),
        sl1280                              INTEGER (0..1279),
        sl2560                              INTEGER (0..2559)
    }                                                                       OPTIONAL,   -- Cond Setup
    duration                            INTEGER (2..2559)                   OPTIONAL,   -- Need R
    monitoringSymbolsWithinSlot         BIT STRING (SIZE (14))              OPTIONAL,   -- Cond Setup
    nrofCandidates                      SEQUENCE {
        aggregationLevel1                   ENUMERATED {n0, n1, n2, n3, n4, n5, n6, n8},
        aggregationLevel2                   ENUMERATED {n0, n1, n2, n3, n4, n5, n6, n8},
        aggregationLevel4                   ENUMERATED {n0, n1, n2, n3, n4, n5, n6, n8},
        aggregationLevel8                   ENUMERATED {n0, n1, n2, n3, n4, n5, n6, n8},
        aggregationLevel16                  ENUMERATED {n0, n1, n2, n3, n4, n5, n6, n8}
    }                                                                       OPTIONAL,   -- Cond Setup
    searchSpaceType                     CHOICE {
        common                              SEQUENCE {
            dci-Format0-0-AndFormat1-0          SEQUENCE {
                ...
            }                                                               OPTIONAL,   -- Need R
            dci-Format2-0                       SEQUENCE {
                nrofCandidates-SFI                  SEQUENCE {
                    aggregationLevel1                   ENUMERATED {n1, n2} OPTIONAL,   -- Need R
                    aggregationLevel2                   ENUMERATED {n1, n2} OPTIONAL,   -- Need R
                    aggregationLevel4                   ENUMERATED {n1, n2} OPTIONAL,   -- Need R
                    aggregationLevel8                   ENUMERATED {n1, n2} OPTIONAL,   -- Need R
                    aggregationLevel16                  ENUMERATED {n1, n2} OPTIONAL -- Need R
                },
                ...
            }                                                               OPTIONAL,   -- Need R
            dci-Format2-1                       SEQUENCE {
                ...
            }                                                               OPTIONAL,   -- Need R
            dci-Format2-2                       SEQUENCE {
                ...
            }                                                               OPTIONAL,   -- Need R
            dci-Format2-3                       SEQUENCE {
                monitoringPeriodicity               ENUMERATED {n1, n2, n4, n5, n8, n10, n16, n20 }     OPTIONAL,   -- Cond Setup
                nrofPDCCH-Candidates                ENUMERATED {n1, n2},
                ...
            }                                                               OPTIONAL -- Need R
        },
        ue-Specific                         SEQUENCE {
            dci-Formats                         ENUMERATED {formats0-0-And-1-0, formats0-1-And-1-1},
            ...
        }
    }                                                                       OPTIONAL -- Cond Setup
}
```

```
-- TAG-SEARCHSPACE-STOP
-- ASN1STOP
```

SearchSpace field descriptions
common Configures this search space as common search space (CSS) and DCI formats to monitor.
controlResourceSetId The CORESET applicable for this SearchSpace. Value 0 identifies the common CORESET configured in MIB and in ServingCellConfigCommon Values 1..maxNrofControlResourceSets-1 identify CORESETs configured by dedicated signalling
dci-Format0-0-AndFormat1-0 If configured, the UE monitors the DCI formats 0_0 and 1_0 with CRC scrambled by C-RNTI, CS-RNTI (if configured), SP-CSI-RNTI (if configured), RA-RNTI, TC-RNTI, P-RNTI, SI-RNTI
dci-Format2-0 If configured, UE monitors the DCI format format 2_0 with CRC scrambled by SFI-RNTI
dci-Format2-1 If configured, UE monitors the DCI format format 2_1 with CRC scrambled by INT-RNTI
dci-Format2-2 If configured, UE monitors the DCI format 2_2 with CRC scrambled by TPC-PUSCH-RNTI or TPC-PUCCH-RNTI
dci-Format2-3 If configured, UE monitors the DCI format 2_3 with CRC scrambled by TPC-SRS-RNTI
dci-Formats Indicates whether the UE monitors in this USS for DCI formats 0-0 and 1-0 or for formats 0-1 and 1-1.
duration Number of consecutive slots that a SearchSpace lasts in every occasion, i.e., upon every period as given in the periodicityAndOffset. If the field is absent, the UE applies the value 1 slot. The maximum valid duration is periodicity-1 (periodicity as given in the monitoringSlotPeriodicityAndOffset).
monitoringPeriodicity Monitoring periodicity of SRS PDCCH in number of slots for DCI format 2-3. Corresponds to L1 parameter 'SRS-monitoring-periodicity' (see 38.212, 38.213, section 7.3.1, 11.3)
monitoringSlotPeriodicityAndOffset Slots for PDCCH Monitoring configured as periodicity and offset. Corresponds to L1 parameters 'Montoring-periodicity-PDCCH-slot' and 'Montoring-offset-PDCCH-slot' (see 38.213, section 10)
monitoringSymbolsWithinSlot Symbols for PDCCH monitoring in the slots configured for PDCCH monitoring (see monitoringSlotPeriodicityAndOffset). The most significant (left) bit represents the first OFDM in a slot. The least significant (right) bit represents the last symbol. Corresponds to L1 parameter 'Montoring-symbols-PDCCH-within-slot' (see 38.213, section 10)
nrofCandidates-SFI The number of PDCCH candidates specifically for format 2-0 for the configured aggregation level. If an aggregation level is absent, the UE does not search for any candidates with that aggregation level. Corresponds to L1 parameters 'SFI-Num-PDCCH-cand' and 'SFI-Aggregation-Level' (see 38.213, section 11.1.1).
nrofCandidates Number of PDCCH candidates per aggregation level. Corresponds to L1 parameter 'Aggregation-level-1' to 'Aggregation-level-8'. The number of candidates and aggregation levels configured here applies to all formats unless a particular value is specified or a format-specific value is provided (see inside searchSpaceType). (see 38.213, section 10)
nrofPDCCH-Candidates The number of PDCCH candidates for DCI format 2-3 for the configured aggregation level. Corresponds to L1 parameter 'SRS-Num-PDCCH-cand' (see 38.212, 38.213, section 7.3.1, 11.3)
searchSpaceId Identity of the search space. SearchSpaceId = 0 identifies the SearchSpace configured via PBCH (MIB) or ServingCellConfigCommon. The searchSpaceId is unique among the BWPs of a Serving Cell.
searchSpaceType Indicates whether this is a common search space (present) or a UE specific search space as well as DCI formats to monitor for.

ue-Specific Configures this search space as UE specific search space (USS). The UE monitors the DCI format with CRC scrambled by C-RNTI, CS-RNTI (if configured), TC-RNTI (if a certain condition is met), and SP-CSI-RNTI (if configured)

Conditional Presence	Explanation
Setup	This field is mandatory present upon creation of a new SearchSpace. It is optionally present, Need M, otherwise.
SetupOnly	This field is mandatory present upon creation of a new SearchSpace. It is absent otherwise.

– *SearchSpaceId*

The IE *SearchSpaceId* is used to identify Search Spaces. The search space with the *SearchSpaceId* = 0 identifies the search space configured via PBCH (MIB) and in ServingCellConfigCommon. The number of Search Spaces per BWP is limited to 10 including the initial Search Space.

SearchSpaceId information element

```
-- ASN1START
-- TAG-SEARCHSPACEID-START

SearchSpaceId ::=                   INTEGER (0..maxNrofSearchSpaces-1)

-- TAG-SEARCHSPACEID-STOP
-- ASN1STOP
```

– *SecurityAlgorithmConfig*

The IE *SecurityAlgorithmConfig* is used to configure AS integrity protection algorithm (SRBs) and AS ciphering algorithm (SRBs and DRBs).

SecurityAlgorithmConfig information element

```
-- ASN1START
-- TAG-SECURITY-ALGORITHM-CONFIG-START

SecurityAlgorithmConfig ::=         SEQUENCE {
    cipheringAlgorithm                  CipheringAlgorithm,
    integrityProtAlgorithm              IntegrityProtAlgorithm          OPTIONAL,   -- Need R
    ...
}

IntegrityProtAlgorithm ::=          ENUMERATED {
                                        nia0, nia1, nia2, nia3, spare4, spare3,
                                        spare2, spare1, ...}

CipheringAlgorithm ::=              ENUMERATED {
                                        nea0, nea1, nea2, nea3, spare4, spare3,
                                        spare2, spare1, ...}

-- TAG-SECURITY-ALGORITHM-CONFIG-STOP
```

```
-- ASN1STOP
```

***SecurityAlgorithmConfig* field descriptions**
cipheringAlgorithm Indicates the ciphering algorithm to be used for SRBs and DRBs, as specified in TS 33.501 [11]. The algorithms nea0-nea3 are identical to the LTE algorithms eea0-3. For EN-DC, the algorithms configured for bearers using KeNB shall be the same as for all bearers using KeNB and the algorithms configured for bearers using KgNB shall be the same as for all bearers using KgNB.
integrityProtAlgorithm For EN-DC, this IE indicates the integrity protection algorithm to be used for SRBs, as specified in TS 33.501 [11]. The algorithms nia0-nia3 is identical to the LTE algorithms eia0-3. For EN-DC, the algorithms configured for SRBs using KeNB shall be the same as for all SRBs using KeNB and the algorithms configured for bearers using KgNB shall be the same as for all bearers using KgNB. The network does not configure *nia0* for SRB3

– *ServCellIndex*

The IE *ServCellIndex* concerns a short identity, used to identify a serving cell (i.e. the PCell, the PSCell or an SCell). Value 0 applies for the PCell, while the *SCellIndex* that has previously been assigned applies for SCells.

ServCellIndex information element

```
-- ASN1START
-- TAG-SERV-CELL-INDEX-START

ServCellIndex ::=                   INTEGER (0..maxNrofServingCells-1)

-- TAG-SERV-CELL-INDEX-STOP
-- ASN1STOP
```

– *ServingCellConfig*

The *ServingCellConfig* IE is used to configure (add or modify) the UE with a serving cell, which may be the SpCell or an SCell of an MCG or SCG. The parameters herein are mostly UE specific but partly also cell specific (e.g. in additionally configured bandwidth parts).

ServingCellConfig information element

```
-- ASN1START
-- TAG-SERVING-CELL-CONFIG-START

ServingCellConfig ::=               SEQUENCE {
    tdd-UL-DL-ConfigurationDedicated    TDD-UL-DL-ConfigDedicated                                   OPTIONAL,   -- Cond TDD

    initialDownlinkBWP                  BWP-DownlinkDedicated                                       OPTIONAL,   -- Cond ServCellAdd
    downlinkBWP-ToReleaseList           SEQUENCE (SIZE (1..maxNrofBWPs)) OF BWP-Id                  OPTIONAL,   -- Need N
    downlinkBWP-ToAddModList            SEQUENCE (SIZE (1..maxNrofBWPs)) OF BWP-Downlink            OPTIONAL,   -- Need N
    firstActiveDownlinkBWP-Id           BWP-Id                                                      OPTIONAL,   -- Cond SyncAndCellAdd
    bwp-InactivityTimer                 ENUMERATED { ms2, ms3, ms4, ms5, ms6, ms8, ms10, ms20, ms30,
                                                     ms40,ms50, ms60, ms80, ms100, ms200, ms300, ms500,
```

```
                                        ms750, ms1280, ms1920, ms2560, spare10, spare9, spare8,
                                        spare7, spare6, spare5, spare4, spare3, spare2, spare1 } OPTIONAL,   -- Need R
    defaultDownlinkBWP-Id               BWP-Id                                                   OPTIONAL,   -- Need S

    uplinkConfig                        UplinkConfig                                             OPTIONAL,   -- Cond ServCellAdd-UL
    supplementaryUplink                 UplinkConfig                                             OPTIONAL,   -- Cond ServCellAdd-SUL

    pdcch-ServingCellConfig             SetupRelease { PDCCH-ServingCellConfig }                 OPTIONAL,   -- Need M
    pdsch-ServingCellConfig             SetupRelease { PDSCH-ServingCellConfig }                 OPTIONAL,   -- Need M
    csi-MeasConfig                      SetupRelease { CSI-MeasConfig }                          OPTIONAL,   -- Need M
    sCellDeactivationTimer              ENUMERATED { ms20, ms40, ms80, ms160, ms200, ms240,
                                        ms320, ms400, ms480, ms520, ms640, ms720,
                                        ms840, ms1280, spare2,spare1}               OPTIONAL,   -- Cond ServingCellWithoutPUCCH
    crossCarrierSchedulingConfig        CrossCarrierSchedulingConfig                             OPTIONAL,   -- Need M
    tag-Id                              TAG-Id,
    ue-BeamLockFunction                 ENUMERATED {enabled}                                     OPTIONAL,   -- Need R
    pathlossReferenceLinking            ENUMERATED {pCell, sCell}                                OPTIONAL,   -- Cond SCellOnly
    servingCellMO                       MeasObjectId                                             OPTIONAL,   -- Cond MeasObject
    ...
}

UplinkConfig ::=                    SEQUENCE {
    initialUplinkBWP                    BWP-UplinkDedicated                                      OPTIONAL,   -- Cond ServCellAdd
    uplinkBWP-ToReleaseList             SEQUENCE (SIZE (1..maxNrofBWPs)) OF BWP-Id               OPTIONAL,   -- Need N
    uplinkBWP-ToAddModList              SEQUENCE (SIZE (1..maxNrofBWPs)) OF BWP-Uplink           OPTIONAL,   -- Need N
    firstActiveUplinkBWP-Id             BWP-Id                                                   OPTIONAL,   -- Cond SyncAndCellAdd

    pusch-ServingCellConfig             SetupRelease { PUSCH-ServingCellConfig }                 OPTIONAL,   -- Need M
    carrierSwitching                    SetupRelease { SRS-CarrierSwitching }                    OPTIONAL,   -- Need M
    ...
}

-- TAG-SERVING-CELL-CONFIG-STOP
-- ASN1STOP
```

ServingCellConfig field descriptions
bwp-InactivityTimer The duration in ms after which the UE falls back to the default Bandwidth Part. (see 38.321, section 5.15) The value 0.5 ms is only applicable for carriers >6 GHz. When the network releases the timer configuration, the UE stops the timer without swithching to the default BWP.
crossCarrierSchedulingConfig Indicates whether this SCell is cross-carrier scheduled by another serving cell.
defaultDownlinkBWP-Id Corresponds to L1 parameter 'default-DL-BWP'. The initial bandwidth part is referred to by BWP-Id = 0. ID of the downlink bandwidth part to be used upon expiry of txxx. This field is UE specific. When the field is absent the UE uses the the initial BWP as default BWP. (see 38.211, 38.213, section 12 and 38.321, section 5.15)
downlinkBWP-ToAddModList List of additional downlink bandwidth parts to be added or modified. (see 38.211, 38.213, section 12).
downlinkBWP-ToReleaseList List of additional downlink bandwidth parts to be released. (see 38.211, 38.213, section 12).
firstActiveDownlinkBWP-Id If configured for an SpCell, this field contains the ID of the DL BWP to be activated upon performing the reconfiguration in which it is received. If the field is absent, the RRC reconfiguration does not impose a BWP switch (corresponds to L1 parameter 'active-BWP-DL-Pcell'). If configured for an SCell, this field contains the ID of the downlink bandwidth part to be used upon MAC-activation of an SCell. The initial bandwidth part is referred to by BWP-Id = 0.
initialDownlinkBWP The dedicated (UE-specific) configuration for the initial downlink bandwidth-part.
pathlossReferenceLinking Indicates whether UE shall apply as pathloss reference either the downlink of PCell or of SCell that corresponds with this uplink (see 38.213, section 7)
pdsch-ServingCellConfig PDSCH releated parameters that are not BWP-specific.
sCellDeactivationTimer SCell deactivation timer in TS 38.321 [3]. If the field is absent, the UE applies the value infinity.
servingCellMO *measObjectId* of the *MeasObjectNR* in *MeasConfig* which is associated to the serving cell. For this *MeasObjectNR*, the following relationship applies between this MeasObjectNR and *frequencyInfoDL* in *ServingCellConfigCommon* of the serving cell: if *ssbFrequency* is configured, its value is the same aslike the *absoluteFrequencySSB* and if *csi-rs-ResourceConfigMobility* is configured, the value of its *subcarrierSpacing* is present in one entry of the *scs-SpecificCarrierList*, *csi-RS-CellList-Mobility* includes an entry corresponding to the serving cell (with *cellId* equal to *physCellId* in *ServingCellConfigCommon*) and the frequency range indicated by the *csi-rs-MeasurementBW* of the entry in *csi-RS-CellList-Mobility* is included in the frequency range indicated by in the entry of the *scs-SpecificCarrierList*.
tag-Id Timing Advance Group ID, as specified in TS 38.321 [3], which this cell belongs to.
ue-BeamLockFunction Enables the "UE beam lock function (UBF)", which disable changes to the UE beamforming configuration when in NR_RRC_CONNECTED. FFS: Parameter added preliminary based on RAN4 LS in R4-1711823. Decide where to place it (maybe ServingCellConfigCommon or in a BeamManagement IE??)

UplinkConfig field descriptions
carrierSwitching Includes parameters for configuration of carrier based SRS switching Corresponds to L1 parameter 'SRS-CarrierSwitching' (see 38,214, section FFS_Section)
firstActiveUplinkBWP-Id If configured for an SpCell, this field contains the ID of the DL BWP to be activated upon performing the reconfiguration in which it is received. If the field is absent, the RRC reconfiguration does not impose a BWP switch (corresponds to L1 parameter 'active-BWP-UL-Pcell'). If configured for an SCell, this field contains the ID of the uplink bandwidth part to be used upon MAC-activation of an SCell. The initial bandwidth part is referred to by BandiwdthPartId = 0.
initialUplinkBWP The dedicated (UE-specific) configuration for the initial uplink bandwidth-part.
pusch-ServingCellConfig PUSCH related parameters that are not BWP-specific.
uplinkBWP-ToReleaseList The additional bandwidth parts for uplink. In case of TDD uplink- and downlink BWP with the same bandwidthPartId are considered as a BWP pair and must have the same center frequency.

Conditional Presence	Explanation
MeasObject	This field is mandatory present for the SpCell, it is optionally present, Need R, for SCells.
SCellOnly	This field is optionally present, Need R, for SCells. It is absent otherwise.
ServCellAdd	This field is mandatory present upon serving cell addition (for PSCell and SCell). It is optionally present, Need M otherwise.
ServCellAdd-UL	This field is mandatory present upon serving cell addition (for PSCell and SCell) provided that the serving cell is configured with uplink. It is optionally present, Need M otherwise.
ServCellAdd-SUL	This field is mandatory present upon serving cell addition (for PSCell and SCell) provided that the serving cell is configured with a supplementary uplink. It is optionally present, Need M otherwise.
ServingCellWithoutPUCCH	This field is optionally present, Need S, for SCells except PUCCH SCells. It is absent otherwise.
SyncAndCellAdd	This field is mandatory present, Need N, for a SpCell upon reconfigurationWithSync (PCell handover, PSCell addition/change). The field is mandatory present, Need M, for an SCell upon addition. In all other cases the field is absent.
TDD	This field is optionally present, Need R, for TDD cells. It is absent otherwise.

– *ServingCellConfigCommon*

The *ServingCellConfigCommon* IE is used to configure cell specific parameters of a UE's serving cell. The IE contains parameters which a UE would typically acquire from SSB, MIB or SIBs when accessing the cell from IDLE. With this IE, the network provides this information in dedicated signalling when configuring a UE with a SCells or with an additional cell group (SCG). It also provides it for SpCells (MCG and SCG) upon reconfiguration with sync.

ServingCellConfigCommon information element

```
-- ASN1START
-- TAG-SERVING-CELL-CONFIG-COMMON-START

ServingCellConfigCommon ::=         SEQUENCE {
    physCellId                          PhysCellId                                      OPTIONAL, -- Cond HOAndServCellAdd,
    downlinkConfigCommon                DownlinkConfigCommon                            OPTIONAL, -- Cond InterFreqHOAndServCellAdd

    uplinkConfigCommon                  UplinkConfigCommon                              OPTIONAL, -- Cond ServCellAdd-UL
```

```
    supplementaryUplinkConfig               UplinkConfigCommon                              OPTIONAL, -- Cond ServCellAdd-SUL
    n-TimingAdvanceOffset               ENUMERATED { n0, n25600, n39936 }                      OPTIONAL,-- Need S
    ssb-PositionsInBurst                CHOICE {
        shortBitmap                         BIT STRING (SIZE (4)),
        mediumBitmap                        BIT STRING (SIZE (8)),
        longBitmap                          BIT STRING (SIZE (64))
    }                                                                                           OPTIONAL, -- Cond AbsFreqSSB
    ssb-periodicityServingCell          ENUMERATED { ms5, ms10, ms20, ms40, ms80, ms160, spare2, spare1 }    OPTIONAL,   -- Need S
    dmrs-TypeA-Position                 ENUMERATED {pos2, pos3},
    lte-CRS-ToMatchAround               SetupRelease { RateMatchPatternLTE-CRS }                        OPTIONAL,   -- Need M
    rateMatchPatternToAddModList        SEQUENCE (SIZE (1..maxNrofRateMatchPatterns)) OF RateMatchPattern    OPTIONAL, -- Need N
    rateMatchPatternToReleaseList       SEQUENCE (SIZE (1..maxNrofRateMatchPatterns)) OF RateMatchPatternId     OPTIONAL, -- Need N
    subcarrierSpacing                   SubcarrierSpacing                                       OPTIONAL, -- Need S
    tdd-UL-DL-ConfigurationCommon       TDD-UL-DL-ConfigCommon                                  OPTIONAL, -- Cond TDD
    ss-PBCH-BlockPower                  INTEGER (-60..50),
    ...
}


-- TAG-SERVING-CELL-CONFIG-COMMON-STOP
-- ASN1STOP
```

ServingCellConfigCommon field descriptions
dmrs-TypeA-Position Position of (first) DL DM-RS (see 38.211, section 7.4.1.1.1)
initialDownlinkBWP The initial downlink BWP configuration for a SpCell (PCell of MCG or SCG). The parameters provided herein should match the parameters configured by MIB and SIB1 of the serving cell.
longBitmap bitmap for above 6 GHz
lte-CRS-ToMatchAround Parameters to determine an LTE CRS pattern that the UE shall rate match around.
mediumBitmap bitmap for 3-6 GHz
n-TimingAdvanceOffset The N_TA-Offset to be applied for random access on this serving cell. If the field is absent, the UE applies the value defined for the duplex mode and frequency rangeof this serving cell. See 38.133, table 7.1.2-2.
rateMatchPatternToAddModList Resources patterns which the UE should rate match PDSCH around. The UE rate matches around the union of all resources indicated in the nested bitmaps. Rate match patterns defined here on cell level apply only to PDSCH of the same numerology. Corresponds to L1 parameter 'Resource-set-cekk' (see 38.214, section 5.1.2.2.3)
shortBitmap bitmap for sub 3 GHz
ss-PBCH-BlockPower TX power that the NW used for SSB transmission. The UE uses it to estimate the RA preamble TX power. (see 38.213, section 7.4)
ssb-periodicityServingCell The SSB periodicity in msec for the rate matching purpose. If the field is absent, the UE applies the value ms5. (see 38.211, section [7.4.3.1])
ssb-PositionsInBurst Indicates the time domain positions of the transmitted SS-blocks in an SS-burst. The first/ leftmost bit corresponds to SS/PBCH block index 0, the second bit corresponds to SS/PBCH block index 1, and so on. Value 0 in the bitmap indicates that the corresponding SS/PBCH block is not transmitted while value 1 indicates that the corresponding SS/PBCH block is transmitted. Corresponds to L1 parameter 'SSB-Transmitted' (see 38.213, section 4.1)
subcarrierSpacing Subcarrier spacing of SSB. Used only for non-initial access (e.g. SCells, PCell of SCG). If the field is absent the UE shall assume the default value of the band. Only the values 15 or 30 kHz (<6GHz), 120 or 240 kHz (>6GHz) are applicable.
tdd-UL-DL-ConfigurationCommon A cell-specific TDD UL/DL configuration, see 38.213, section 11.1.

Conditional Presence	Explanation
AbsFreqSSB	The field is absent when absoluteFrequencySSB in frequencyInfoDL is absent, oherwise the field is mandatory present.
HOAndServCellAdd	This field is mandatory present for inter-cell handover and upon serving cell (PSCell/SCell) addition. Otherwise, the field is absent, Need M.
InterFreqHOAndServCellAdd	This field is mandatory present for inter-frequency handover and upon serving cell (PSCell/SCell) addition. Otherwise, the field isoptionally present, Need M.
ServCellAdd	This field is mandatory present upon serving cell addition (for PSCell and SCell). It is optionally present, Need M otherwise.
ServCellAdd-UL	This field is mandatory present upon serving cell addition (for PSCell and SCell) provided that the serving cell is configured with uplink. It is optionally present, Need M otherwise.
ServCellAdd-SUL	This field is mandatory present upon serving cell addition (for PSCell and SCell) provided that the serving cell is configured with a supplementary uplink. It is optionally present, Need M otherwise.
TDD	The field is optionally present, Need R, for TDD cells; otherwise it is not present.

– *SINR-Range*

The IE *SINR-Range* specifies the value range used in SINR measurements and thresholds. Integer value for SINR measurements is according to mapping table in TS 38.133 [14].

SINR-Range information element

```
-- ASN1START
-- TAG-SINR-RANGE-START

SINR-Range ::=                    INTEGER (0..127)

-- TAG-SINR-RANGE-STOP
-- ASN1STOP
```

– *SlotFormatCombinationsPerCell*

The IE *SlotFormatCombinationsPerCell* is used to configure the SlotFormatCombinations applicable for one serving cell. Corresponds to L1 parameter 'cell-to-SFI' (see 38.213, section 11.1.1).

SlotFormatCombinationsPerCell information element

```
-- ASN1START
-- TAG-SLOTFORMATCOMBINATIONSPERCELL-START

SlotFormatCombinationsPerCell ::=   SEQUENCE {
    servingCellId                       ServCellIndex,
    subcarrierSpacing                   SubcarrierSpacing,
    subcarrierSpacing2                  SubcarrierSpacing                                                   OPTIONAL,   -- Need R
    slotFormatCombinations              SEQUENCE (SIZE (1..maxNrofSlotFormatCombinationsPerSet)) OF SlotFormatCombination OPTIONAL,
    positionInDCI                       INTEGER(0..maxSFI-DCI-PayloadSize-1)                                OPTIONAL,
    ...
}
```

```
SlotFormatCombination ::=           SEQUENCE {
    slotFormatCombinationId             SlotFormatCombinationId,
    slotFormats                         SEQUENCE (SIZE (1..maxNrofSlotFormatsPerCombination)) OF INTEGER (0..255)
}

SlotFormatCombinationId ::=         INTEGER (0..maxNrofSlotFormatCombinationsPerSet-1)

-- TAG-SLOTFORMATCOMBINATIONSPERCELL-STOP
-- ASN1STOP
```

SlotFormatCombination field descriptions
slotFormatCombinationId This ID is used in the DCI payload to dynamically select this SlotFormatCombination. Corresponds to L1 parameter 'SFI-index' (see 38.213, section FFS_Section)
slotFormats Slot formats that occur in consecutive slots in time domain order as listed here. The the slot formats are defined in 38.211, table 4.3.2-3 and numbered with 0..255.

SlotFormatCombinationsPerCell field descriptions
positionInDCI The (starting) position (bit) of the slotFormatCombinationId (SFI-Index) for this serving cell (servingCellId) within the DCI payload. Corresponds to L1 parameter 'SFI-values' (see 38.213, section FFS_Section)
servingCellId The ID of the serving cell for which the slotFormatCombinations are applicable
slotFormatCombinations A list with SlotFormatCombinations. Each SlotFormatCombination comprises of one or more SlotFormats (see 38.211, section 4.3.2). The total number of slotFormats in the slotFormatCombinations list does not exceed 512. FFS_CHECK: RAN1 indicates that the combinations could be of two different types... but they don't specify the second
subcarrierSpacing2 Reference subcarrier spacing for a Slot Format Combination on an FDD or SUL cell. Corresponds to L1 parameter 'SFI-scs2' (see 38.213, section FFS_Section). For FDD, subcarrierSpacing (SFI-scs) is the reference SCS for DL BWP and subcarrierSpacing2 (SFI-scs2) is the reference SCS for UL BWP. For SUL, subcarrierSpacing (SFI-scs) is the reference SCS for non-SUL carrier and subcarrierSpacing2 (SFI-scs2) is the reference SCS for SUL carrier. The network configures a value that is smaller than or equal to any SCS of configured BWPs of the serving cell that the command applies to. And the network configures a value that is smaller than or equal to the SCS of the serving cell which the UE monitors for SFI indications.
subcarrierSpacing Reference subcarrier spacing for this Slot Format Combination. The network configures a value that is smaller than or equal to any SCS of configured BWPs of the serving cell that the command applies to. And the network configures a value that is smaller than or equal to the SCS of the serving cell which the UE monitors for SFI indications. Corresponds to L1 parameter 'SFI-scs' (see 38.213, section FFS_Section)

– *SlotFormatIndicator*

The IE *SlotFormatIndicator* is used to configure monitoring a Group-Common-PDCCH for Slot-Format-Indicators (SFI).

***SlotFormatIndicator* information element**

```
-- ASN1START
-- TAG-SLOTFORMATINDICATOR-START
```

```
SlotFormatIndicator ::=         SEQUENCE {
    sfi-RNTI                        RNTI-Value,
    dci-PayloadSize                 INTEGER (1..maxSFI-DCI-PayloadSize),
    slotFormatCombToAddModList      SEQUENCE (SIZE(1..maxNrofAggregatedCellsPerCellGroup)) OF SlotFormatCombinationsPerCell OPTIONAL,   -- Need N
    slotFormatCombToReleaseList     SEQUENCE (SIZE(1..maxNrofAggregatedCellsPerCellGroup)) OF ServCellIndex             OPTIONAL,   -- Need N
    ...
}

-- TAG-SLOTFORMATINDICATOR-STOP
-- ASN1STOP
```

SlotFormatIndicator field descriptions
dci-PayloadSize Total length of the DCI payload scrambled with SFI-RNTI. Corresponds to L1 parameter 'SFI-DCI-payload-length' (see 38.213, section 11.1.1)
sfi-RNTI RNTI used for SFI on the given cell Corresponds to L1 parameter 'SFI-RNTI' (see 38.213, section 11.1.1)
slotFormatCombToAddModList A list of SlotFormatCombinations for the UE's serving cells. Corresponds to L1 parameter 'SFI-cell-to-SFI' (see 38.213, section 11.1.1)

– *SS-RSSI-Measurement*

The IE *SS-RSSI-Measurement* is used to configure RSSI measuremens based on synchronization reference signals.

SS-RSSI-Measurement information element

```
-- ASN1START
-- TAG-SS-RSSI-MEASUREMENT-START

SS-RSSI-Measurement ::=             SEQUENCE {
    measurementSlots                    BIT STRING (SIZE(1..80)),
    endSymbol                           INTEGER(0..3)
}

-- TAG-SS-RSSI-MEASUREMENT-STOP
-- ASN1STOP
```

– *SPS-Config*

Editor's Note: FFS: RAN1 indicated in the L1 table: "Note: Multiple configurations is possible, how many needs to be determined". RAN2 agreed that SPS can be used on Pcell and SCell... But each UE can use it on at most one serving cell of a cell group at a time. Are the ”multiple configuration” meant for one carrier? Does the UE then use several SPS-RNTIs?

The *SPS-Config* IE is used to configure downlink semi-persistent transmission. Downlink SPS may be configured on the PCell as well as on SCells. But it shall not be configured for more than one serving cell of a cell group at once.

SPS-Config information element

```
-- ASN1START
-- TAG-SPS-CONFIG-START

SPS-Config ::=                          SEQUENCE {
    periodicity                             ENUMERATED {ms10, ms20, ms32, ms40, ms64, ms80, ms128, ms160, ms320, ms640,
                                                        spare6, spare5, spare4, spare3, spare2, spare1},
    nrofHARQ-Processes                      INTEGER (1..8),
    n1PUCCH-AN                              PUCCH-ResourceId                                                OPTIONAL -- Need M
}

-- TAG-SPS-CONFIG-STOP
-- ASN1STOP
```

SPS-Config field descriptions
n1PUCCH-AN HARQ resource for PUCCH for DL SPS. The network configures the resource either as format0 or format1. The actual PUCCH-Resource is configured in PUCCH-Config and referred to by its ID. See 38.214, section FFS_Section.
nrofHARQ-Processes Number of configured HARQ processes for SPS DL. Corresponds to L1 parameter 'numberOfConfSPS-Processes' (see 38.214, section FFS_Section)
periodicity Periodicity for DL SPS Corresponds to L1 parameter 'semiPersistSchedIntervalDL' (see 38.214 and 38.321, section FFS_Section) FFS-Value: Support also shorter periodicities for DL?

– *SRB-Identity*

The IE SRB-Identity is used to identify a Signalling Radio Bearer (SRB) used by a UE.

```
-- ASN1START
-- TAG-SRB-IDENTITY-START

SRB-Identity ::=                    INTEGER (1..3)

-- TAG-SRB-IDENTITY-STOP
-- ASN1STOP
```

– *SRS-Config*

The *SRS-Config* IE is used to configure sounding reference signal transmissions. The configuration defines a list of SRS-Resources and a list of SRS-ResourceSets. Each resource set defines a set of SRS-Resources. The network triggers the transmission of the set of SRS-Resources using a configured aperiodicSRS-ResourceTrigger (L1 DCI).

SRS-Config information element

```
-- ASN1START
-- TAG-SRS-CONFIG-START
```

```
SRS-Config ::=                          SEQUENCE {
    srs-ResourceSetToReleaseList            SEQUENCE (SIZE(1..maxNrofSRS-ResourceSets)) OF SRS-ResourceSetId       OPTIONAL,   -- Need N
    srs-ResourceSetToAddModList             SEQUENCE (SIZE(1..maxNrofSRS-ResourceSets)) OF SRS-ResourceSet         OPTIONAL,   -- Need N

    srs-ResourceToReleaseList               SEQUENCE (SIZE(1..maxNrofSRS-Resources)) OF SRS-ResourceId            OPTIONAL,   -- Need N
    srs-ResourceToAddModList                SEQUENCE (SIZE(1..maxNrofSRS-Resources)) OF SRS-Resource           OPTIONAL,   -- Need N

    tpc-Accumulation                        ENUMERATED {disabled}                                              OPTIONAL,   -- Need S
    ...
}

SRS-ResourceSet ::=                     SEQUENCE {
    srs-ResourceSetId                       SRS-ResourceSetId,
    srs-ResourceIdList                      SEQUENCE (SIZE(1..maxNrofSRS-ResourcesPerSet)) OF SRS-ResourceId    OPTIONAL,   -- Cond Setup

    resourceType                            CHOICE {
        aperiodic                               SEQUENCE {
            aperiodicSRS-ResourceTrigger            INTEGER (1..maxNrofSRS-TriggerStates-1),
            csi-RS                                  NZP-CSI-RS-ResourceId                                  OPTIONAL,   -- Cond NonCodebook
            slotOffset                              INTEGER (1..32)                                        OPTIONAL,   -- Need S
            ...
        },
        semi-persistent                         SEQUENCE {
            associatedCSI-RS                        NZP-CSI-RS-ResourceId                                  OPTIONAL, -- Cond NonCodebook
            ...
        },
        periodic                                SEQUENCE {
            associatedCSI-RS                        NZP-CSI-RS-ResourceId                                  OPTIONAL, -- Cond NonCodebook
            ...
        }
    },
    usage                                   ENUMERATED {beamManagement, codebook, nonCodebook, antennaSwitching},
    alpha                                   Alpha                                                          OPTIONAL, -- Need S
    p0                                      INTEGER (-202..24)                                             OPTIONAL, -- Cond Setup
    pathlossReferenceRS                     CHOICE {
        ssb-Index                               SSB-Index,
        csi-RS-Index                            NZP-CSI-RS-ResourceId
    }                                                                                                      OPTIONAL, -- Need M
    srs-PowerControlAdjustmentStates        ENUMERATED { sameAsFci2, separateClosedLoop}                   OPTIONAL, -- Need S
    ...
}

SRS-ResourceSetId ::=                   INTEGER (0..maxNrofSRS-ResourceSets-1)

SRS-Resource ::=                        SEQUENCE {
    srs-ResourceId                          SRS-ResourceId,
    nrofSRS-Ports                           ENUMERATED {port1, ports2, ports4},
    ptrs-PortIndex                          ENUMERATED {n0, n1 }                                           OPTIONAL,   -- Need R
    transmissionComb                        CHOICE {
        n2                                      SEQUENCE {
            combOffset-n2                           INTEGER (0..1),
            cyclicShift-n2                          INTEGER (0..7)
        },
```

```
        n4                                      SEQUENCE {
            combOffset-n4                           INTEGER (0..3),
            cyclicShift-n4                          INTEGER (0..11)
        }
    },
    resourceMapping                         SEQUENCE {
        startPosition                           INTEGER (0..5),
        nrofSymbols                             ENUMERATED {n1, n2, n4},
        repetitionFactor                        ENUMERATED {n1, n2, n4}
    },
    freqDomainPosition                      INTEGER (0..67),
    freqDomainShift                         INTEGER (0..268),
    freqHopping                             SEQUENCE {
        c-SRS                                   INTEGER (0..63),
        b-SRS                                   INTEGER (0..3),
        b-hop                                   INTEGER (0..3)
    },
    groupOrSequenceHopping                  ENUMERATED { neither, groupHopping, sequenceHopping },
    resourceType                            CHOICE {
        aperiodic                               SEQUENCE {
            ...
        },
        semi-persistent                         SEQUENCE {
            periodicityAndOffset-sp                 SRS-PeriodicityAndOffset,
            ...
        },
        periodic                                SEQUENCE {
            periodicityAndOffset-p                  SRS-PeriodicityAndOffset,
            ...
        }
    },
    sequenceId                              BIT STRING (SIZE (10)),
    spatialRelationInfo                     SRS-SpatialRelationInfo                                 OPTIONAL,   -- Need R
    ...
}

SRS-SpatialRelationInfo ::=     SEQUENCE {
    servingCellId                       ServCellIndex                                   OPTIONAL,   -- Need S
    referenceSignal                     CHOICE {
        ssb-Index                           SSB-Index,
        csi-RS-Index                        NZP-CSI-RS-ResourceId,
        srs                                 SEQUENCE {
            resourceId                          SRS-ResourceId,
            uplinkBWP                           BWP-Id
        }
    }
}


SRS-ResourceId ::=                      INTEGER (0..maxNrofSRS-Resources-1)

SRS-PeriodicityAndOffset ::=            CHOICE {
    sl1                                     NULL,
    sl2                                     INTEGER(0..1),
```

```
    sl4                                     INTEGER(0..3),
    sl5                                     INTEGER(0..4),
    sl8                                     INTEGER(0..7),
    sl10                                    INTEGER(0..9),
    sl16                                    INTEGER(0..15),
    sl20                                    INTEGER(0..19),
    sl32                                    INTEGER(0..31),
    sl40                                    INTEGER(0..39),
    sl64                                    INTEGER(0..63),
    sl80                                    INTEGER(0..79),
    sl160                                   INTEGER(0..159),
    sl320                                   INTEGER(0..319),
    sl640                                   INTEGER(0..639),
    sl1280                                  INTEGER(0..1279),
    sl2560                                  INTEGER(0..2559)
}

-- TAG-SRS-CONFIG-STOP
-- ASN1STOP
```

SRS-Config field descriptions
tpc-Accumulation   If the field is absent, UE applies TPC commands via accumulation. If disabled, UE applies the TPC command without accumulation (this applies to SRS when a separate closed loop is configured for SRS) Corresponds to L1 parameter 'Accumulation-enabled-srs' (see 38,213, section 7.3)

SRS-Resource field descriptions
cyclicShift-n2 Cyclic shift configuration. Corresponds to L1 parameter 'SRS-CyclicShiftConfig' (see 38.214, section 6.2.1)
cyclicShift-n4 Cyclic shift configuration. Corresponds to L1 parameter 'SRS-CyclicShiftConfig' (see 38.214, section 6.2.1)
freqDomainPosition Parameter(s) defining frequency domain position and configurable shift to align SRS allocation to 4 PRB grid. Corresponds to L1 parameter 'SRS-FreqDomainPosition' (see 38.214, section 6.2.1)
freqHopping Includes parameters capturing SRS frequency hopping Corresponds to L1 parameter 'SRS-FreqHopping' (see 38.214, section 6.2.1)
groupOrSequenceHopping Parameter(s) for configuring group or sequence hopping Corresponds to L1 parameter 'SRS-GroupSequenceHopping' (see 38.211, section FFS_Section)
periodicityAndOffset-p Periodicity and slot offset for for this SRS resource. All values in "number of slots" sl1 corresponds to a periodicity of 1 slot, value sl2 corresponds to a periodicity of 2 slots, and so on. For each periodicity the corresponding offset is given in number of slots. For periodicity sl1 the offset is 0 slots. Corresponds to L1 parameter 'SRS-SlotConfig' (see 38.214, section 6.2.1)
periodicityAndOffset-sp Periodicity and slot offset for for this SRS resource. All values in "number of slots". sl1 corresponds to a periodicity of 1 slot, value sl2 corresponds to a periodicity of 2 slots, and so on. For each periodicity the corresponding offset is given in number of slots. For periodicity sl1 the offset is 0 slots. Corresponds to L1 parameter 'SRS-SlotConfig' (see 38.214, section 6.2.1)
ptrs-PortIndex The PTRS port index for this SRS resource for non-codebook based UL MIMO. This is only applicable when the corresponding PTRS-UplinkConfig is set to CP-OFDM. The ptrs-PortIndex configured here must be smaller than or equal to the maxNnrofPorts configured in the PTRS-UplinkConfig. Corresponds to L1 parameter 'UL-PTRS-SRS-mapping-non-CB' (see 38.214, section 6.1)
resourceMapping OFDM symbol location of the SRS resource within a slot including number of OFDM symbols (N = 1, 2 or 4 per SRS resource), startPosition (SRSSymbolStartPosition = 0..5; "0" refers to the last symbol, "1" refers to the second last symbol) and RepetitionFactor (r = 1, 2 or 4). Corresponds to L1 parameter 'SRS-ResourceMapping' (see 38.214, section 6.2.1 and 38.211, section 6.4.1.4). FFS: Apparently, RAN1 considers replacing these three fields by a table in RAN1 specs and a corresponding index in ASN.1?!
resourceType Time domain behavior of SRS resource configuration. Corresponds to L1 parameter 'SRS-ResourceConfigType' (see 38.214, section 6.2.1). For codebook based uplink transmission, the network configures SRS resources in the same resource set with the same time domain behavior on periodic, aperiodic and semi-persistent SRS. FFS: Add configuration parameters for the different SRS resource types?
sequenceId Sequence ID used to initialize psedo random group and sequence hopping. Corresponds to L1 parameter 'SRS-SequenceId' (see 38.214, section 6.2.1)
spatialRelationInfo Configuration of the spatial relation between a reference RS and the target SRS. Reference RS can be SSB/CSI-RS/SRS Corresponds to L1 parameter 'SRS-SpatialRelationInfo' (see 38.214, section 6.2.1)
transmissionComb Comb value (2 or 4) and comb offset (0..combValue-1). Corresponds to L1 parameter 'SRS-TransmissionComb' (see 38.214, section 6.2.1)

SRS-ResourceSet field descriptions
alpha alpha value for SRS power control. Corresponds to L1 parameter 'alpha-srs' (see 38.213, section 7.3) When the field is absent the UE applies the value 1
aperiodicSRS-ResourceTrigger The DCI "code point" upon which the UE shall transmit SRS according to this SRS resource set configuration. Corresponds to L1 parameter 'AperiodicSRS-ResourceTrigger' (see 38.214, section 6.1.1.2)
associatedCSI-RS ID of CSI-RS resource associated with this SRS resource set in non-codebook based operation. Corresponds to L1 parameter 'SRS-AssocCSIRS' (see 38.214, section 6.2.1)
csi-RS ID of CSI-RS resource associated with this SRS resource set. (see 38.214, section 6.1.1.2)
p0 P0 value for SRS power control. The value is in dBm. Only even values (step size 2) are allowed. Corresponds to L1 parameter 'p0-srs' (see 38.213, section 7.3)
pathlossReferenceRS A reference signal (e.g. a CSI-RS config or a SSblock) to be used for SRS path loss estimation. Corresponds to L1 parameter 'srs-pathlossReference-rs-config' (see 38.213, section 7.3)
slotOffset An offset in number of slots between the triggering DCI and the actual transmission of this SRS-ResourceSet. If the field is absent the UE applies no offset (value 0)
srs-PowerControlAdjustmentStates Indicates whether hsrs,c(i) = fc(i,1) or hsrs,c(i) = fc(i,2) (if twoPUSCH-PC-AdjustmentStates are configured) or serarate close loop is configured for SRS. This parameter is applicable only for Uls on which UE also transmits PUSCH. If absent or release, the UE applies the value sameAs-Fci1 Corresponds to L1 parameter 'srs-pcadjustment-state-config' (see 38.213, section 7.3)
srs-ResourceIdList The IDs of the SRS-Resources used in this SRS-ResourceSet
srs-ResourceSetId The ID of this resource set. It is unique in the context of the BWP in which the parent SRS-Config is defined.
usage Indicates if the SRS resource set is used for beam management vs. used for either codebook based or non-codebook based transmission. Corresponds to L1 parameter 'SRS-SetUse' (see 38.214, section 6.2.1)

Conditional Presence	Explanation
Setup	This field is mandatory present upon configuration of SRS-ResourceSet or SRS-Resource and optional (Need M) otherwise
NonCodebook	This field is optionally present, Need M, in case of non-codebook based transmission, otherwise the field is absent.

– *SRS-CarrierSwitching*

The IE *SRS-CarrierSwitching* is used to configure FFS

***SRS-CarrierSwitching* information element**

```
-- ASN1START
-- TAG-SRS-CARRIERSWITCHING-START
SRS-CarrierSwitching ::=            SEQUENCE {
    srs-SwitchFromServCellIndex         INTEGER (0..31)                                         OPTIONAL,   -- Cond Setup
    srs-SwitchFromCarrier               ENUMERATED {sUL, nUL},
    srs-TPC-PDCCH-Group                 CHOICE {
```

```
        typeA                           SEQUENCE (SIZE (1..32)) OF SRS-TPC-PDCCH-Config,
        typeB                           SRS-TPC-PDCCH-Config
    }                                                                                   OPTIONAL,   -- Cond Setup
    monitoringCells                 SEQUENCE (SIZE (1..maxNrofServingCells)) OF ServCellIndex   OPTIONAL,   -- Cond Setup
    ...
}

-- One trigger configuration for SRS-Carrier Switching. (see 38.212, 38.213, section 7.3.1, 11.3)
SRS-TPC-PDCCH-Config ::=            SEQUENCE {
    srs-CC-SetIndexlist                 SEQUENCE (SIZE(1..4)) OF SRS-CC-SetIndex        OPTIONAL -- Cond Setup
}

SRS-CC-SetIndex ::=                 SEQUENCE {
    cc-SetIndex                         INTEGER (0..3)                                  OPTIONAL,   -- Cond Setup
    cc-IndexInOneCC-Set                 INTEGER (0..7)                                  OPTIONAL -- Cond Setup
}

-- TAG-SRS-CARRIERSWITCHING-STOP
-- ASN1STOP
```

SRS-CC-SetIndex field descriptions
cc-IndexInOneCC-Set Indicates the CC index in one CC set for Type A (see 38.212, 38.213, section 7.3.1, 11.3)
cc-SetIndex Indicates the CC set index for Type A associated (see 38.212, 38.213, section 7.3.1, 11.3)

SRS-CarrierSwitching field descriptions
monitoringCells A set of serving cells for monitoring PDCCH conveying SRS DCI format with CRC scrambled by TPC-SRS-RNTI Corresponds to L1 parameter 'SRS-monitoring-cells' (see 38.212, 38.213, section 7.3.1, 11.3)
srs-SwitchFromServCellIndex Indicates the serving cell whose UL transmission may be interrupted during SRS transmission on a PUSCH-less cell. During SRS transmission on a PUSCH-less cell, the UE may temporarily suspend the UL transmission on a serving cell with PUSCH in the same CG to allow the PUSCH-less cell to transmit SRS. (see 38.214, section 6.2.1.3)
srs-TPC-PDCCH-Group Network configures the UE with either typeA-SRS-TPC-PDCCH-Group or typeB-SRS-TPC-PDCCH-Group, if any.
typeA Type A trigger configuration for SRS transmission on a PUSCH-less SCell. Corresponds to L1 parameter 'typeA-SRS-TPC-PDCCH-Group' (see 38.212, 38.213, section 7.3.1, 11.3)
typeB Type B trigger configuration for SRS transmission on a PUSCH-less SCell. Corresponds to L1 parameter 'typeB-SRS-TPC-PDCCH-Config' (see 38.212, 38.213, section 7.3.1, 11.3)

SRS-TPC-PDCCH-Config field descriptions
srs-CC-SetIndexlist A list of pairs of [cc-SetIndex; cc-IndexInOneCC-Set] (see 38.212, 38.213, section 7.3.1, 11.3)

Conditional Presence	Explanation
Setup	This field is mandatory present upon configuration of SRS-CarrierSwitching or SRS-TPC-PDCCH-Config and optional (Need M) otherwise

– *SRS-TPC-CommandConfig*

The IE SRS-TPC-CommandConfig is used to configure the UE for extracting TPC commands for SRS from a group-TPC messages on DCI

SRS-TPC-CommandConfig information element

```
-- ASN1START
-- TAG-SRS-TPC-COMMANDCONFIG-START

SRS-TPC-CommandConfig ::=               SEQUENCE {
    startingBitOfFormat2-3                  INTEGER (1..31)                                 OPTIONAL,   -- Cond Setup
    fieldTypeFormat2-3                      INTEGER (0..1)                                  OPTIONAL,   -- Cond Setup
    ...
}

-- TAG-SRS-TPC-COMMANDCONFIG-STOP
-- ASN1STOP
```

SRS-TPC-CommandConfig field descriptions
fieldTypeFormat2-3 The type of a field within the group DCI with SRS request fields (optional), which indicates how many bits in the field are for SRS request (0 or 2). Note that for Type A, there is a common SRS request field for all SCells in the set, but each SCell has its own TPC command bits. See TS 38.212. (see 38.212, 38.213, section 7.3.1, 11.3)
startingBitOfFormat2-3 The starting bit position of a block within the group DCI with SRS request fields (optional) and TPC commands (see 38.212, 38.213, section 7.3.1, 11.3).

– *SSB-Index*

The IE *SSB-Index* identifies an SS-Block within an SS-Burst. See FFS_Ref, section FFS_Section.

SSB-Index information element

```
-- ASN1START
-- TAG-SSB-INDEX-START
```

```
SSB-Index ::=                       INTEGER (0..63)

-- TAG-SSB-INDEX-STOP
-- ASN1STOP
```

– *SSB-MTC*

The IE *SSB-MTC* is used to configure measurement timing configurations, i.e., timing occasions at which the UE measures SSBs.

SSB-MTC information element

```
-- ASN1START
-- TAG-SSB-MTC-START

SSB-MTC ::=                             SEQUENCE {
    periodicityAndOffset                    CHOICE {
        sf5                                 INTEGER (0..4),
        sf10                                    INTEGER (0..9),
        sf20                                    INTEGER (0..19),
        sf40                                    INTEGER (0..39),
        sf80                                    INTEGER (0..79),
        sf160                               INTEGER (0..159)
    },
    duration                                ENUMERATED { sf1, sf2, sf3, sf4, sf5 }
}

SSB-MTC2 ::=                        SEQUENCE {
    pci-List                            SEQUENCE (SIZE (1..maxNrofPCIsPerSMTC)) OF PhysCellId               OPTIONAL,   -- Need M
    periodicity                         ENUMERATED {sf5, sf10, sf20, sf40, sf80, spare3, spare2, spare1}
}

-- TAG-SSB-MTC-STOP
-- ASN1STOP
```

***SSB-MTC* field descriptions**
duration Duration of the measurement window in which to receive SS/PBCH blocks. It is given in number of subframes (see 38.213, section 4.1)
periodicityAndOffset Periodicity and offset of the measurement window in which to receive SS/PBCH blocks. Periodicity and offset are given in number of subframes. FFS_FIXME: This does not match the L1 parameter table! They seem to intend an index to a hidden table in L1 specs. (see 38.213, section REF): Periodicity for the given PCIs. Timing offset and Duration as provided in smtc1.

***SSB-MTC2* field descriptions**
pci-List PCIs that are known to follow this SMTC.

– *SubcarrierSpacing*

The *SubcarrierSpacing* IE determines the subcarrier spacing. Restrictions applicable for certain frequencies, channels or signals are clarified in the fields that use this IE.

SubcarrierSpacing information element

```
-- ASN1START
-- TAG-SUBCARRIER-SPACING-START

SubcarrierSpacing ::=               ENUMERATED {kHz15, kHz30, kHz60, kHz120, kHz240, spare3, spare2, spare1}

-- TAG-SUBCARRIER-SPACING-STOP
-- ASN1STOP
```

– *TCI-State*

The *TCI-State* IE associates one or two DL reference signals with a corresponding quasi-colocation (QCL) type.

TCI-State information element

```
-- ASN1START
-- TAG-TCI-STATE-START

TCI-State ::=                       SEQUENCE {
    tci-StateId                         TCI-StateId,
    qcl-Type1                           QCL-Info,
    qcl-Type2                           QCL-Info                                                OPTIONAL,   -- Need R
    ...
}

QCL-Info ::=                        SEQUENCE {
    cell                                ServCellIndex                                           OPTIONAL,   -- Need R
    bwp-Id                              BWP-Id                                                  OPTIONAL, -- Cond CSI-RS-Indicated
    referenceSignal                     CHOICE {
        csi-rs                              NZP-CSI-RS-ResourceId,
        ssb                                 SSB-Index
    },
    qcl-Type                            ENUMERATED {typeA, typeB, typeC, typeD},
    ...
}

-- TAG-TCI-STATE-STOP
-- ASN1STOP
```

QCL-Info field descriptions
bwp-Id The DL BWP which the RS is located in.
cell The carrier which the RS is located in. If the field is absent, it applies to the serving cell in which the TCI-State is configured. The RS can be located on a serving cell other than the serving cell in which the TCI-State is configured only if the qcl-Type is configured as typeD. See TS 38.214 section 5.1.5.
referenceSignal Reference signal with which quasi-collocation information is provided as specified in TS 38.3214 subclause 5.1.5.
qcl-Type QCL type as specified in TS 38.214 subclause 5.1.5.

Conditional Presence	Explanation
CSI-RS-Indicated	This field is mandatory present if *csi-rs* or *csi-RS-for-tracking* is included, absent otherwise

– *TCI-StateId*

The IE *TCI-StateId* is used to identify one *TCI-State* configuration.

TCI-StateId information element

```
-- ASN1START
-- TAG-TCI-STATEID-START

TCI-StateId ::=                     INTEGER (0..maxNrofTCI-States-1)

-- TAG-TCI-STATEID-STOP
-- ASN1STOP
```

– *TDD-UL-DL-Config*

The *TDD-UL-DL-Config* IEs determines the Uplink/Downlink TDD configuration. There are both, UE- and cell specific IEs.

TDD-UL-DL-Config information element

```
-- ASN1START
-- TAG-TDD-UL-DL-CONFIG-START

TDD-UL-DL-ConfigCommon ::=          SEQUENCE {
    referenceSubcarrierSpacing          SubcarrierSpacing,
    pattern1                            TDD-UL-DL-Pattern,
    pattern2                            TDD-UL-DL-Pattern                                   OPTIONAL, -- Need R
    ...
}

TDD-UL-DL-Pattern ::=               SEQUENCE {
```

```
    dl-UL-TransmissionPeriodicity       ENUMERATED {ms0p5, ms0p625, ms1, ms1p25, ms2, ms2p5, ms5, ms10},
    nrofDownlinkSlots                   INTEGER (0..maxNrofSlots),
    nrofDownlinkSymbols                 INTEGER (0..maxNrofSymbols-1),
    nrofUplinkSlots                     INTEGER (0..maxNrofSlots),
    nrofUplinkSymbols                   INTEGER (0..maxNrofSymbols-1),
    ...
}

TDD-UL-DL-ConfigDedicated ::=       SEQUENCE {
    slotSpecificConfigurationsToAddModList      SEQUENCE (SIZE (1..maxNrofSlots)) OF TDD-UL-DL-SlotConfig            OPTIONAL, -- Need N
    slotSpecificConfigurationsToreleaseList     SEQUENCE (SIZE (1..maxNrofSlots)) OF TDD-UL-DL-SlotIndex             OPTIONAL, -- Need N
    ...
}

TDD-UL-DL-SlotConfig ::=            SEQUENCE {
    slotIndex                           TDD-UL-DL-SlotIndex,
    symbols                             CHOICE {
        allDownlink                         NULL,
        allUplink                           NULL,
        explicit                            SEQUENCE {
            nrofDownlinkSymbols                 INTEGER (1..maxNrofSymbols-1)                                   OPTIONAL,   -- Need S
            nrofUplinkSymbols                   INTEGER (1..maxNrofSymbols-1)                                   OPTIONAL -- Need S
        }
    }
}

TDD-UL-DL-SlotIndex ::=             INTEGER (0..maxNrofSlots-1)

-- TAG-TDD-UL-DL-CONFIG-STOP
-- ASN1STOP
```

TDD-UL-DL-ConfigCommon field descriptions
referenceSubcarrierSpacing
Reference SCS used to determine the time domain boundaries in the UL-DL pattern which must be common across all subcarrier specific carriers, i.e., independent of the actual subcarrier spacing using for data transmission. Only the values 15, 30 or 60 kHz (<6GHz) and 60 or 120 kHz (>6GHz) are applicable. The network configures a not larger than any SCS of configured BWPs for the serving cell. Corresponds to L1 parameter 'reference-SCS' (see 38.211, section FFS_Section)

TDD-UL-DL-Pattern field descriptions
dl-UL-TransmissionPeriodicity Periodicity of the DL-UL pattern, see 38.211, section FFS_Section.
nrofDownlinkSlots Number of consecutive full DL slots at the beginning of each DL-UL pattern, see 38.213, Table 4.3.2-1. In this release, the maximum value for this field is 80.
nrofDownlinkSymbols Number of consecutive DL symbols in the beginning of the slot following the last full DL slot (as derived from nrofDownlinkSlots). The value 0 indicates that there is no partial-downlink slot. (see 38.211¨3, section FFS_Section).
nrofUplinkSlots Number of consecutive full UL slots at the end of each DL-UL pattern, see 38.213, Table 4.3.2-1. In this release, the maximum value for this field is 80.
nrofUplinkSymbols Number of consecutive UL symbols in the end of the slot preceding the first full UL slot (as derived from nrofUplinkSlots). The value 0 indicates that there is no partial-uplink slot. (see 38.213, section FFS_Section)

TDD-UL-DL-ConfigDedicated field descriptions
slotSpecificConfigurationsToAddModList The slotSpecificConfiguration allows overriding UL/DL allocations provided in tdd-UL-DL-configurationCommon.

TDD-UL-DL-SlotConfig field descriptions
nrofDownlinkSymbols Number of consecutive DL symbols in the beginning of the slot identified by slotIndex. If the field is absent the UE assumes that there are no leading DL symbols. (see 38.213, section FFS_Section)
nrofUplinkSymbols Number of consecutive UL symbols in the end of the slot identified by slotIndex. If the field is absent the UE assumes that there are no trailing UL symbols. (see 38.213, section FFS_Section)
slotIndex Identifies a slot within a dl-UL-TransmissionPeriodicity (given in tdd-UL-DL-configurationCommon)
symbols The direction (downlink or uplink) for the symbols in this slot. "allDownlink" indicates that all symbols in this slot are used for downlink; "allUplink" indicates that all symbols in this slot are used for uplink; "explicit" indicates explicitly how many symbols in the beginning and end of this slot are allocated to downlink and uplink, respectively.

– *TimeToTrigger*

The IE *TimeToTrigger* specifies the value range used for time to trigger parameter, which concerns the time during which specific criteria for the event needs to be met in order to trigger a measurement report. Value ms0 corresponds to 0 ms and behaviour as specified in 7.1.2 applies, ms40 corresponds to 40 ms, and so on.

TimeToTrigger information element

```
-- ASN1START

TimeToTrigger ::=                   ENUMERATED {
                                        ms0, ms40, ms64, ms80, ms100, ms128, ms160, ms256,
                                        ms320, ms480, ms512, ms640, ms1024, ms1280, ms2560,
                                        ms5120}
```

```
-- ASN1STOP
```

Editor's Note: Values should be checked.

– *UplinkConfigCommon*

The IE *UplinkConfigCommon* provides common uplink parameters of a cell.

UplinkConfigCommon information element

```
-- ASN1START
-- TAG-UPLINK-CONFIG-COMMON-START

UplinkConfigCommon ::=              SEQUENCE {
    frequencyInfoUL                     FrequencyInfoUL                                 OPTIONAL,   -- Cond InterFreqHOAndServCellAddAndSIB1
    initialUplinkBWP                        BWP-UplinkCommon                                OPTIONAL,   -- Cond ServCellAddAndSIB1
    timeAlignmentTimerCommon                TimeAlignmentTimer
}

-- TAG-UPLINK-CONFIG-COMMON-STOP
-- ASN1STOP
```

***UplinkConfigCommon* field descriptions**
frequencyInfoUL Absolute uplink frequency configuration and subcarrier specific virtual carriers.
initialUplinkBWP The initial uplink BWP configuration for a SpCell (PCell of MCG or SCG). Corresponds to L1 parameter 'initial-UL-BWP'. (see 38.331, section FFS_Section).

Conditional Presence	Explanation
InterFreqHOAndServCellAddAndSIB1	This field is mandatory present for inter-frequency handover, SIB1 and upon serving cell (PSCell/SCell) addition. Otherwise, the field isoptionally present, Need M.
ServCellAddAndSIB1	This field is mandatory present for SIB1 and upon serving cell addition (for PSCell and SCell). It is optionally present, Need M otherwise.

– *ZP-CSI-RS-Resource*

The IE *ZP-CSI-RS-Resource* is used to configure a Zero-Power (ZP) CSI-RS resource. Corresponds to L1 parameter 'ZP-CSI-RS-ResourceConfig' (see 38.214, section 5.1.4.2).

***ZP-CSI-RS-Resource* information element**

```
-- ASN1START
-- TAG-ZP-CSI-RS-RESOURCE-START
```

```
ZP-CSI-RS-Resource ::=              SEQUENCE {
    zp-CSI-RS-ResourceId                ZP-CSI-RS-ResourceId,
    resourceMapping                     CSI-RS-ResourceMapping,
    periodicityAndOffset                CSI-ResourcePeriodicityAndOffset                        OPTIONAL, --Cond PeriodicOrSemiPersistent
    ...
}

ZP-CSI-RS-ResourceId ::=            INTEGER (0..maxNrofZP-CSI-RS-Resources-1)

-- TAG-ZP-CSI-RS-RESOURCE-STOP
-- ASN1STOP
```

ZP-CSI-RS-Resource field descriptions
periodicityAndOffset Periodicity and slot offset for periodic/semi-persistent ZP-CSI-RS. Corresponds to L1 parameter 'ZP-CSI-RS-timeConfig' (see 38.214, section 5.1.4.2)
resourceMapping OFDM symbol and subcarrier occupancy of the ZP-CSI-RS resource within a slot
zp-CSI-RS-ResourceId ZP CSI-RS resource configuration ID. Corresponds to L1 parameter 'ZP-CSI-RS-ResourceConfigId' (see 38.214, section 5.1.4.2)

– *ZP-CSI-RS-ResourceSet*

The IE *ZP-CSI-RS-ResourceSet* refers to a set of *ZP-CSI-RS-Resources* using their *ZP-CSI-RS-ResourceIds*. It corresponds to the L1 parameter '*ZP-CSI-RS-ResourceSetConfigList*'.

***ZP-CSI-RS-ResourceSet* information element**

```
-- ASN1START
-- TAG-ZP-CSI-RS-RESOURCESET-START

ZP-CSI-RS-ResourceSet ::=           SEQUENCE {
    zp-CSI-RS-ResourceSetId             ZP-CSI-RS-ResourceSetId,
    zp-CSI-RS-ResourceIdList            SEQUENCE (SIZE(1..maxNrofZP-CSI-RS-ResourcesPerSet)) OF ZP-CSI-RS-ResourceId,
    ...
}

-- TAG-ZP-CSI-RS-RESOURCESET-STOP
-- ASN1STOP
```

ZP-CSI-RS-ResourceSet field descriptions
zp-CSI-RS-ResourceIdList The list of ZP-CSI-RS-ResourceId identifying the ZP-CSI-RS-Resource elements belonging to this set.

– *ZP-CSI-RS-ResourceSetId*

The IE *ZP-CSI-RS-ResourceSetId* identifies a *ZP-CSI-RS-ResourceSet*.

***ZP-CSI-RS-ResourceSetId* information element**

```
-- ASN1START
-- TAG-ZP-CSI-RS-RESOURCESETID-START

ZP-CSI-RS-ResourceSetId ::=                     INTEGER (0..maxNrofZP-CSI-RS-ResourceSets-1)

-- TAG-ZP-CSI-RS-RESOURCESETID-STOP
-- ASN1STOP
```

6.3.3 UE capability information elements

– *AccessStratumRelease*

The IE *AccessStratumRelease* indicates the release supported by the UE.

***AccessStratumRelease* information element**

```
-- ASN1START
-- TAG-ACCESSSTRATUMRELEASE-START

AccessStratumRelease ::= ENUMERATED {
                            rel15, spare7, spare6, spare5, spare4, spare3, spare2, spare1, ... }

-- TAG-ACCESSSTRATUMRELEASE-STOP
-- ASN1STOP
```

– *BandCombinationList*

The IE *BandCombinationList* contains a list of NR CA and/or MR-DC band combinations (also including DL only or UL only band).

***BandCombinationList* information element**

```
-- ASN1START
-- TAG-BANDCOMBINATIONLIST-START

BandCombinationList ::=         SEQUENCE (SIZE (1..maxBandComb)) OF BandCombination

BandCombination ::=                 SEQUENCE {
    bandList                                SEQUENCE (SIZE (1..maxSimultaneousBands)) OF BandParameters,
    featureSetCombination               FeatureSetCombinationId,

    ca-ParametersEUTRA                  CA-ParametersEUTRA                  OPTIONAL,
    ca-ParametersNR                     CA-ParametersNR                     OPTIONAL,
```

```
    mrdc-Parameters                     MRDC-Parameters                     OPTIONAL,
    supportedBandwidthCombinationSet        BIT STRING (SIZE (1..32))           OPTIONAL
}


BandParameters ::=                  CHOICE {
    eutra                           SEQUENCE {
        bandEUTRA                       FreqBandIndicatorEUTRA,
        ca-BandwidthClassDL-EUTRA       CA-BandwidthClassEUTRA              OPTIONAL,
        ca-BandwidthClassUL-EUTRA       CA-BandwidthClassEUTRA              OPTIONAL
    },
    nr                              SEQUENCE {
        bandNR                          FreqBandIndicatorNR,
        ca-BandwidthClassDL-NR          CA-BandwidthClassNR                 OPTIONAL,
        ca-BandwidthClassUL-NR          CA-BandwidthClassNR                 OPTIONAL
    }
}


-- TAG-BANDCOMBINATIONLIST-STOP
-- ASN1STOP
```

– *CA-BandwidthClassNR*

```
-- ASN1START
-- TAG-CA-BANDWIDTHCLASSNR-START

CA-BandwidthClassNR ::= ENUMERATED {a, b, c, d, e, f, g, h, i, j, k, l, m, n, o, p, q, ...}

-- TAG-CA-BANDWIDTHCLASSNR-STOP
-- ASN1STOP
```

– *CA-BandwidthClassEUTRA*

```
-- ASN1START
-- TAG-CA-BANDWIDTHCLASSEUTRA-START

CA-BandwidthClassEUTRA ::=  ENUMERATED {a, b, c, d, e, f, ...}

-- TAG-CA-BANDWIDTHCLASSEUTRA-STOP
-- ASN1STOP
```

– *CA-ParametersNR*

The IE *CA-ParametersNR* is contains carrier aggregation related capabilities that are defined per band combination.

***CA-ParametersNR* information element**

```
-- ASN1START
-- TAG-CA-PARAMETERSNR-START

CA-ParametersNR ::= SEQUENCE {
    multipleTimingAdvances              ENUMERATED {supported}      OPTIONAL,
    parallelTxSRS-PUCCH-PUSCH           ENUMERATED {supported}      OPTIONAL,
    parallelTxPRACH-SRS-PUCCH-PUSCH     ENUMERATED {supported}      OPTIONAL,
    simultaneousRxTxInterBandCA         ENUMERATED {supported}      OPTIONAL,
    simultaneousRxTxSUL                 ENUMERATED {supported}      OPTIONAL,
    diffNumerologyAcrossPUCCH-Group     ENUMERATED {supported}      OPTIONAL,
    diffNumerologyWithinPUCCH-Group     ENUMERATED {supported}      OPTIONAL,
    supportedNumberTAG                  ENUMERATED {n2, n3, n4}     OPTIONAL,
    ...
}

-- TAG-CA-PARAMETERSNR-STOP
-- ASN1STOP
```

– *CA-ParametersEUTRA*

The IE *CA-ParameterEUTRA* contains the EUTRA part of band combination parameters for a given MR-DC band combination.

NOTE: If an additional EUTRA band combonation parameters are defined in TS 36.331 [10], which are supported for MR-DC, they will be defined here as well.

```
-- ASN1START
-- TAG-CA-PARAMETERSEUTRA-START

CA-ParametersEUTRA ::=  SEQUENCE {
    multipleTimingAdvance               ENUMERATED {supported}                  OPTIONAL,
    simultaneousRx-Tx                   ENUMERATED {supported}                  OPTIONAL,
    supportedNAICS-2CRS-AP              BIT STRING (SIZE (1..8))                OPTIONAL,
    additionalRx-Tx-PerformanceReq      ENUMERATED {supported}                  OPTIONAL,
    ue-CA-PowerClass-N                  ENUMERATED {class2}                     OPTIONAL,
    ...
}

-- TAG-CA-PARAMETERSEUTRA-STOP
-- ASN1STOP
```

– *FeatureSetCombination*

The IE FeatureSetCombination is a two dimensional matrix of FeatureSet entries.

Each FeatureSetsPerBand contains a list of feature sets applicable to the carrier(s) of one band entry of the associated band combination. Across the associated bands, the UE shall support the combination of FeatureSets at the same position in the FeatureSetsPerBand. All FeatureSetsPerBand in one FeatureSetCombination must have the same number of entries.

The number of FeatureSetsPerBand in the FeatureSetCombination must be equal to the number of band entries in an associated band combination. The first FeatureSetPerBand applies to the first band entry of the band combination, and so on.

Each FeatureSet contains either a pair of NR- or EUTRA feature set IDs for UL and DL.

In case of NR, the actual feature sets for UL and DL are defined in the FeatureSets IE and referred to from here by their ID, i.e., their position in the featureSetsUplink / featureSetsDownlink list in the FeatureSet IE.

In case of EUTRA, the feature sets referred to from this list are defined in TS 36.331 and conveyed as part of the UE-EUTRA-Capability container. The FeatureSetUL-Id-r15 and FeatureSetDL-Id-r15 in the EUTRA feature sets correspond to the FeatureSetEUTRA-DownlinkId and FeatureSetEUTRA-UplinkId, respectively.

The FeatureSetUplink and FeatureSetDownlink referred to from the FeatureSet comprise, among other information, a set of FeatureSetUplinkPerCC-Id:s and FeatureSetDownlinkPerCC-Id:s. The number of these per-CC IDs determines the number of carriers that the UE is able to aggregate contiguously in frequency domain in the corresponding band. The number of FeatureSetUplink-Id:s/DownlinkPerCC-Id:s shall not exceed the number of carrier supported according to the BWC indicated in the associated BandCombination, if present.

FeatureSetCombination information element

```
-- ASN1START
-- TAG-FEATURESETCOMBINATION-START

FeatureSetCombination ::=   SEQUENCE (SIZE (1..maxSimultaneousBands)) OF FeatureSetsPerBand

FeatureSetsPerBand ::=      SEQUENCE (SIZE (1..maxFeatureSetsPerBand)) OF FeatureSet

FeatureSet ::=                  CHOICE {
    eutra                           SEQUENCE {
        downlinkSetEUTRA                FeatureSetEUTRA-DownlinkId,
        uplinkSetEUTRA                  FeatureSetEUTRA-UplinkId
    },
    nr                              SEQUENCE {
        downlinkSetNR                   FeatureSetDownlinkId,
        uplinkSetNR                     FeatureSetUplinkId
    }
}

-- ASN1STOP
-- TAG-FEATURESETCOMBINATION-STOP
```

– *FeatureSetCombinationId*

The IE *FeatureSetCombinationId* identifies a FeatureSetCombination. The *FeatureSetCombinationId* of a *FeatureSetCombination* is the position of the *FeatureSetCombination* in the featureSetCombinations list (in *UE-NR-Capability* or *UE-MRDC-Capability*).

FeatureSetCombinationId information element

```
-- ASN1START
-- TAG-FEATURESET-COMBINATION-ID-START
```

```
FeatureSetCombinationId ::=                INTEGER (0.. maxFeatureSetCombinations)

-- TAG-FEATURESET-COMBINATION-ID-STOP
-- ASN1STOP
```

– *FeatureSetDownlink*

The IE *FeatureSetDownlink* indicates a set of features that the UE supports on the carriers corresponding to one band entry in a band combination.

FeatureSetDownlink information element

```
-- ASN1START
-- TAG-FEATURESETDOWNLINK-START

FeatureSetDownlink ::=              SEQUENCE {
    featureSetListPerDownlinkCC         SEQUENCE (SIZE (1..maxNrofServingCells)) OF FeatureSetDownlinkPerCC-Id,

    intraBandFreqSeparationDL               FreqSeparationClass                                          OPTIONAL,
    scalingFactor                           ENUMERATED {f0p4, f0p75, f0p8}                              OPTIONAL,
    crossCarrierSchedulingDL-OtherSCS       ENUMERATED {supported}                                      OPTIONAL,
    scellWithoutSSB                         ENUMERATED {supported}                                      OPTIONAL,
    csi-RS-MeasSCellWithoutSSB              ENUMERATED {supported}                                      OPTIONAL,
    srs-AssocCSI-RS                         ENUMERATED {supported}                                      OPTIONAL,
    type1-3-CSS                             ENUMERATED {supported}                                      OPTIONAL,
    pdcchMonitoringAnyOccasions             ENUMERATED {withoutDCI-Gap, withDCI-Gap}                    OPTIONAL,
    pdcchMonitoringAnyOccasionsWithSpanGap  ENUMERATED {supported}                                      OPTIONAL,
    ue-SpecificUL-DL-Assignment             ENUMERATED {supported}                                      OPTIONAL,
    searchSpaceSharingCA-DL                 ENUMERATED {supported}                                      OPTIONAL,
    timeDurationForQCL                      SEQUENCE {
        scs-60kHz                               ENUMERATED {s7, s14, s28}                               OPTIONAL,
        sch-120kHz                              ENUMERATED {s14, s28}                                   OPTIONAL
    }                                                                                                   OPTIONAL,
    pdsch-DifferentTB-PerSlot               SEQUENCE {
        scs-15kHz                               ENUMERATED {upto2, upto4, upto7}                        OPTIONAL,
        scs-30kHz                               ENUMERATED {upto2, upto4, upto7}                        OPTIONAL,
        scs-60kHz                               ENUMERATED {upto2, upto4, upto7}                        OPTIONAL,
        scs-120kHz                              ENUMERATED {upto2, upto4, upto7}                        OPTIONAL
    }                                                                                                   OPTIONAL,
    csi-RS-IM-ReceptionForFeedback          CSI-RS-IM-ReceptionForFeedback                              OPTIONAL,
    typeI-SinglePanelCodebookList           SEQUENCE (SIZE (1.. maxNrofCodebooks)) OF TypeI-SinglePanelCodebook  OPTIONAL,
    typeI-MultiPanelCodebookList            SEQUENCE (SIZE (1.. maxNrofCodebooks)) OF TypeI-MultiPanelCodebook     OPTIONAL,
    typeII-CodebookList                     SEQUENCE (SIZE (1.. maxNrofCodebooks)) OF TypeII-Codebook           OPTIONAL,
    typeII-CodebookPortSelectionList        SEQUENCE (SIZE (1.. maxNrofCodebooks)) OF TypeII-CodebookPortSelection  OPTIONAL

}

CSI-RS-IM-ReceptionForFeedback ::=  SEQUENCE {
    maxNumberNZP-CSI-RS-PerCC               INTEGER (1..32),
    maxNumberPortsAcrossNZP-CSI-RS-PerCC        ENUMERATED {p2, p4, p8, p12, p16, p24, p32, p40, p48, p56, p64, p72, p80,
                                                            p88, p96, p104, p112, p120, p128, p136, p144, p152, p160, p168,
                                                            p176, p184, p192, p200, p208, p216, p224, p232, p240, p248, p256},
```

```
    maxNumberCS-IM-PerCC                            ENUMERATED {n1, n2, n4, n8, n16, n32},
    maxNumberSimultaneousCSI-RS-ActBWP-AllCC        ENUMERATED {n5, n6, n7, n8, n9, n10, n12, n14, n16, n18, n20, n22, n24, n26,
                                                                n28, n30, n32, n34, n36, n38, n40, n42, n44, n46, n48, n50, n52,
                                                                n54, n56, n58, n60, n62, n64},
    totalNumberPortsSimultaneousCSI-RS-ActBWP-AllCC ENUMERATED {p8, p12, p16, p24, p32, p40, p48, p56, p64, p72, p80,
                                                                p88, p96, p104, p112, p120, p128, p136, p144, p152, p160, p168,
                                                                p176, p184, p192, p200, p208, p216, p224, p232, p240, p248, p256}
}

TypeI-SinglePanelCodebook ::=       SEQUENCE {
    maxNumberTxPortsPerResource         ENUMERATED {p2, p4, p8, p12, p16, p24, p32},
    maxNumberResources                  INTEGER (1..64),
    totalNumberTxPorts                  INTEGER (2..256),
    supportedCodebookMode               ENUMERATED {mode1, mode1AndMode2},
    maxNumberCSI-RS-PerResourceSet      INTEGER (1..8)
}

TypeI-MultiPanelCodebook ::=        SEQUENCE {
    maxNumberTxPortsPerResource         ENUMERATED {p8, p16, p32},
    maxNumberResources                  INTEGER (1..64),
    totalNumberTxPorts                  INTEGER (2..256),
    supportedCodebookMode               ENUMERATED {mode1, mode2, both},
    supportedNumberPanels               ENUMERATED {n2, n4},
    maxNumberCSI-RS-PerResourceSet      INTEGER (1..8)
}

TypeII-Codebook ::=                 SEQUENCE {
    maxNumberTxPortsPerResource         ENUMERATED {p4, p8, p12, p16, p24, p32},
    maxNumberResources                  INTEGER (1..64),
    totalNumberTxPorts                  INTEGER (2..256),
    parameterLx                         INTEGER (2..4),
    amplitudeScalingType                ENUMERATED {wideband, widebandAndSubband},
    amplitudeSubsetRestriction          ENUMERATED {supported}                          OPTIONAL,
    maxNumberCSI-RS-PerResourceSet      INTEGER (1..8)
}

TypeII-CodebookPortSelection ::=    SEQUENCE {
    maxNumberTxPortsPerResource         ENUMERATED {p4, p8, p12, p16, p24, p32},
    maxNumberResources                  INTEGER (1..64),
    totalNumberTxPorts                  INTEGER (2..256),
    parameterLx                         INTEGER (2..4),
    amplitudeScalingType                ENUMERATED {wideband, widebandAndSubband},
    maxNumberCSI-RS-PerResourceSet      INTEGER (1..8)
}

-- TAG-FEATURESETDOWNLINK-STOP
-- ASN1STOP
```

FeatureSetDownlink field descriptions
featureSetListPerDownlinkCC Indicates which features the UE supports on the individual carriers of the feature set (and hence of a band entry that refer to the feature set). The UE shall hence include as many FeatureSetDownlinkPerCC-Id in this list as the number of carriers it supports according to the ca-bandwidthClassDL. The order of the elements in this list is not relevant, i.e., the network may configure any of the carriers in accordance with any of the FeatureSetDownlinkPerCC-Id in this list.

– *FeatureSetDownlinkId*

The IE *FeatureSetDownlinkId* identifies a downlink feature set. The *FeatureSetDownlinkId* of a *FeatureSetDownlink* is the index position of the *FeatureSetDownlink* in the *featureSetsDownlink* list in the *FeatureSets* IE. The first element in that list is referred to by *FeatureSetDownlinkId* = 1. The *FeatureSetDownlinkId=0* is not used by an actual *FeatureSetDownlink* but means that the UE does not support a carrier in this band of a band combination.

FeatureSetDownlinkId information element

```
-- ASN1START
-- TAG-FEATURESET-DOWNLINK-ID-START

FeatureSetDownlinkId ::=                INTEGER (0..maxDownlinkFeatureSets)

-- TAG-FEATURESET-DOWNLINK-ID-STOP
-- ASN1STOP
```

– *FeatureSetEUTRA-DownlinkId*

The IE *FeatureSetEUTRA-DownlinkId* identifies a downlink feature set in EUTRA. The *FeatureSetEUTRA-DownlinkId=0* is used when the UE does not support a carrier in this band of a band combination.

FeatureSetEUTRA-DownlinkId information element

```
-- ASN1START
-- TAG-FEATURESET-EUTRA-DOWNLINK-ID-START

FeatureSetEUTRA-DownlinkId ::=              INTEGER (0..maxEUTRA-DL-FeatureSets)

-- TAG-FEATURESET-EUTRA-DOWNLINK-ID-STOP
-- ASN1STOP
```

– *FeatureSetDownlinkPerCC*

The IE *FeatureSetDownlinkPerCC* indicates a set of features that the UE supports on the corresponding carrier of one band entry of a band combination.

FeatureSetDownlinkPerCC information element

```
-- ASN1START
-- TAG-FEATURESETDOWNLINKPERCC-START
```

```
FeatureSetDownlinkPerCC ::=     SEQUENCE {
    supportedSubcarrierSpacingDL    SubcarrierSpacing,
    supportedBandwidthDL            SupportedBandwidth,
    channelBW-90mhz                 ENUMERATED {supported}                                  OPTIONAL,
    maxNumberMIMO-LayersPDSCH           MIMO-LayersDL                                       OPTIONAL,
    supportedModulationOrderDL          ModulationOrder                                     OPTIONAL
}

-- TAG-FEATURESETDOWNLINKPERCC-STOP
-- ASN1STOP
```

– *FeatureSetDownlinkPerCC-Id*

The IE *FeatureSetDownlinkPerCC-Id* identifies a set of features applicable to one carrier of a feature set. The *FeatureSetDownlinkPerCC-Id* of a *FeatureSetDownlinkPerCC* is the index position of the *FeatureSetDownlinkPerCC* in the *featureSetsDownlinkPerCC*. The first element in the list is referred to by *FeatureSetDownlinkPerCC-Id* = 1, and so on.

FeatureSetDownlinkPerCC-Id information element

```
-- ASN1START
-- TAG-FEATURESET-DOWNLINK-PER-CC-ID-START

FeatureSetDownlinkPerCC-Id ::=          INTEGER (1..maxPerCC-FeatureSets)

-- TAG-FEATURESET-DOWNLINK-PER-CC-ID-STOP
-- ASN1STOP
```

– *FeatureSetUplink*

The IE *FeatureSetUplink* is used to indicate the features that the UE supports on the carriers corresponding to one band entry in a band combination.

FeatureSetUplink information element

```
-- ASN1START
-- TAG-FEATURESETUPLINK-START

FeatureSetUplink ::=                    SEQUENCE {
    featureSetListPerUplinkCC               SEQUENCE (SIZE (1.. maxNrofServingCells)) OF FeatureSetUplinkPerCC-Id,
    scalingFactor                       ENUMERATED {f0p4, f0p75, f0p8}              OPTIONAL,
    crossCarrierSchedulingUL-OtherSCS   ENUMERATED {supported}                      OPTIONAL,
    intraBandFreqSeparationUL               FreqSeparationClass                 OPTIONAL,
    searchSpaceSharingCA-UL             ENUMERATED {supported}                      OPTIONAL,
    srs-TxSwitch                        SRS-TxSwitch                                OPTIONAL,
    supportedSRS-Resources              SRS-Resources                               OPTIONAL,
    twoPUCCH-Group                      ENUMERATED {supported}                      OPTIONAL,
    dynamicSwitchSUL                    ENUMERATED {supported}                      OPTIONAL,
    pusch-DifferentTB-PerSlot           SEQUENCE {
        scs-15kHz                           ENUMERATED {upto2, upto4, upto7}            OPTIONAL,
        scs-30kHz                           ENUMERATED {upto2, upto4, upto7}            OPTIONAL,
```

```
        scs-60kHz                           ENUMERATED {upto2, upto4, upto7}           OPTIONAL,
        scs-120kHz                          ENUMERATED {upto2, upto4, upto7}           OPTIONAL
    }                                                                                  OPTIONAL,
    csi-ReportFramework                 CSI-ReportFramework                            OPTIONAL
}


CSI-ReportFramework ::=                 SEQUENCE {
    maxNumberPeriodicCSI-ReportPerBWP           INTEGER (1..4),
    maxNumberAperiodicCSI-ReportPerBWP          INTEGER (1..4),
    maxNumberSemiPersistentCSI-ReportPerBWP     INTEGER (0..4),
    simultaneousCSI-ReportsAllCC                    INTEGER (5..32)
}

-- TAG- FEATURESETUPLINK-STOP
-- ASN1STOP
```

FeatureSetUplink field descriptions
featureSetsPerUplinkCC Indicates which features the UE supports on the individual carriers of the feature set (and hence of a band entry that refer to the feature set). The UE shall hence include as many FeatureSetUplinkPerCC-Id in this list as the number of carriers it supports according to the ca-bandwidthClassUL. The order of the elements in this list is not relevant, i.e., the network may configure any of the carriers in accordance with any of the FeatureSetUplinkPerCC-Id in this list.

– *FeatureSetUplinkId*

The IE *FeatureSetUplinkId* identifies a downlink feature set. The *FeatureSetUplinkId* of a *FeatureSetUplink* is the index position of the *FeatureSetUplink* in the *featureSetsUplink* list in the *FeatureSets* IE. The first element in the list is referred to by *FeatureSetUplinkPerCC-Id* = 1, and so on.The *FeatureSetUplinkId =0* is not used by an actual *FeatureSetUplink* but means that the UE does not support a carrier in this band of a band combination.

***FeatureSetUplinkId* information element**

```
-- ASN1START
-- TAG-FEATURESET-UPLINK-ID-START

FeatureSetUplinkId ::=              INTEGER (0..maxUplinkFeatureSets)

-- TAG-FEATURESET-UPLINK-ID-STOP
-- ASN1STOP
```

– *FeatureSetEUTRA-UplinkId*

The IE *FeatureSetEUTRA-UplinkId* identifies an uplink feature set. The *FeatureSetEUTRA-UplinkId =0* is used when the UE does not support a carrier in this band of a band combination.

***FeatureSetEUTRA-UplinkId* information element**

```
-- ASN1START
```

```
-- TAG-FEATURESET-EUTRA-UPLINK-ID-START

FeatureSetEUTRA-UplinkId ::=                    INTEGER (0..maxEUTRA-UL-FeatureSets)

-- TAG-FEATURESET-EUTRA-UPLINK-ID-STOP
-- ASN1STOP
```

– *FeatureSetUplinkPerCC*

The IE *FeatureSetDownlinkPerCC* indicates a set of features that the UE supports on the corresponding carrier of one band entry of a band combination.

FeatureSetUplinkPerCC information element

```
-- ASN1START
-- TAG-FEATURESETUPLINKPERCC-START

FeatureSetUplinkPerCC ::=           SEQUENCE {
    supportedSubcarrierSpacingUL            SubcarrierSpacing,
    supportedBandwidthUL                    SupportedBandwidth,
    channelBW-90mhz                     ENUMERATED {supported}                  OPTIONAL,
    mimo-CB-PUSCH                       SEQUENCE {
        maxNumberMIMO-LayersCB-PUSCH        MIMO-LayersUL                       OPTIONAL,
        maxNumberSRS-ResourcePerSet         INTEGER (1..2)
    }                                                                           OPTIONAL,
    maxNumberMIMO-LayersNonCB-PUSCH     MIMO-LayersUL                           OPTIONAL,
    supportedModulationOrderUL          ModulationOrder                         OPTIONAL,
    simultaneousTxSUL-NonSUL            ENUMERATED {supported}                  OPTIONAL
}

-- TAG-FEATURESETUPLINKPERCC-STOP
-- ASN1STOP
```

– *FeatureSetUplinkPerCC-Id*

The IE *FeatureSetUplinkPerCC-Id* identifies a set of features applicable to one carrier of a feature set. The *FeatureSetUplinkPerCC-Id* of a *FeatureSetUplinkPerCC* is the index position of the *FeatureSetUplinkPerCC* in the *featureSetsUplinkPerCC*. The first element in the list is referred to by *FeatureSetUplinkPerCC-Id* = 1, and so on.

FeatureSetUplinkPerCC-Id information element

```
-- ASN1START
-- TAG-FEATURESET-UPLINK-PER-CC-ID-START

FeatureSetUplinkPerCC-Id ::=            INTEGER (1..maxPerCC-FeatureSets)

-- TAG-FEATURESET-UPLINK-PER-CC-ID-STOP
-- ASN1STOP
```

– *FeatureSets*

The IE *FeatureSets* is used to provide pools of downlink and uplink features sets. A *FeatureSetCombination* refers to the IDs of the feature set(s) that the UE supports in that *FeatureSetCombination*. The *BandCombination* entries in the *BandCombinationList* then indicate the ID of the *FeatureSetCombination* that the UE supports fot that band combination.

The entries in the lists in this IE are identified by their index position. For example, the *FeatureSetUplinkPerCC-Id* = 4 identifies the 4th element in the *featureSetsUplinkPerCC* list.

FeatureSets information element

```
-- ASN1START
-- TAG-FEATURESETS-START

FeatureSets ::= SEQUENCE {
    featureSetsDownlink                SEQUENCE (SIZE (1..maxDownlinkFeatureSets)) OF FeatureSetDownlink          OPTIONAL,
    featureSetsDownlinkPerCC           SEQUENCE (SIZE (1..maxPerCC-FeatureSets)) OF FeatureSetDownlinkPerCC       OPTIONAL,
    featureSetsUplink                  SEQUENCE (SIZE (1..maxUplinkFeatureSets)) OF FeatureSetUplink              OPTIONAL,
    featureSetsUplinkPerCC             SEQUENCE (SIZE (1..maxPerCC-FeatureSets)) OF FeatureSetUplinkPerCC         OPTIONAL,
    ...
}

-- ASN1STOP
-- TAG-FEATURESETS-STOP
```

– *FreqBandIndicatorEUTRA*

```
-- ASN1START
-- TAG-FREQ-BAND-INDICATOR-EUTRA-START

FreqBandIndicatorEUTRA ::=  INTEGER (1..maxBandsEUTRA)

-- TAG-FREQ-BAND-INDICATOR-EUTRA-STOP
-- ASN1STOP
```

– *FreqBandList*

The IE *FreqBandList* is used by the network to request NR CA and/or MR-DC band combinations for specific NR and/or E-UTRA frequency bands and/or up to a specific number of carriers and/or up to a specific aggregated bandwidths.

FreqBandList information element

```
-- ASN1START
-- TAG-FREQBANDLIST-START

FreqBandList ::=               SEQUENCE (SIZE (1..maxBandsMRDC)) OF FreqBandInformation

FreqBandInformation ::=        CHOICE {
```

```
    bandInformationEUTRA            FreqBandInformationEUTRA,
    bandInformationNR               FreqBandInformationNR
}

FreqBandInformationEUTRA ::=    SEQUENCE {
    bandEUTRA                       FreqBandIndicatorEUTRA,
    ca-BandwidthClassDL-EUTRA       CA-BandwidthClassEUTRA                  OPTIONAL,   -- Need N
    ca-BandwidthClassUL-EUTRA       CA-BandwidthClassEUTRA                  OPTIONAL    -- Need N
}

FreqBandInformationNR ::=       SEQUENCE {
    bandNR                          FreqBandIndicatorNR,
    maxBandwidthRequestedDL         AggregatedBandwith          OPTIONAL,   -- Need N
    maxBandwidthRequestedUL         AggregatedBandwith          OPTIONAL,   -- Need N
    maxCarriersRequestedDL          INTEGER (1.. maxNrofServingCells)       OPTIONAL,   -- Need N
    maxCarriersRequestedUL          INTEGER (1.. maxNrofServingCells)       OPTIONAL    -- Need N
}

AggregatedBandwith ::=          ENUMERATED {mhz50, mhz100, mhz150, mhz200, mhz250, mhz300, mhz350,
                                        mhz400, mhz450, mhz500, mhz550, mhz600, mhz650, mhz700, mhz750, mhz800}

-- TAG-FREQBANDLIST-STOP
-- ASN1STOP
```

– *FreqSeparationClass*

The IE *FreqSeparationClas*s is used for an intra-band non-contiguous CA band combination to indicate frequency separation between lower edge of lowest CC and upper edge of highest CC in a frequency band.

FreqSeparationClass information element

```
-- ASN1START
-- TAG-FREQSEPARATIONCLASS-START

FreqSeparationClass ::= ENUMERATED {c1, c2, c3, ...}

-- TAG-FREQSEPARATIONCLASS-STOP
-- ASN1STOP
```

– *MIMO-Layers*

```
-- ASN1START
-- TAG-MIMO-LAYERS-START

MIMO-LayersDL ::=   ENUMERATED {twoLayers, fourLayers, eightLayers}

MIMO-LayersUL ::=   ENUMERATED {oneLayer, twoLayers, fourLayers}

-- TAG-MIMO-LAYERS-STOP
-- ASN1STOP
```

– *ModulationOrder*

```
-- ASN1START
-- TAG-MODULATION-ORDER-START

ModulationOrder ::= ENUMERATED {bpsk-halfpi, bpsk, qpsk, qam16, qam64, qam256}

-- TAG-MODULATION-ORDER-STOP
-- ASN1STOP
```

– *MRDC-Parameters*

The IE *MRDC-Parameters* contains the band combination parameters specific to MR-DC for a given MR-DC band combination.

MRDC-Parameters information element

```
-- ASN1START
-- TAG-MRDC-PARAMETERS-START

MRDC-Parameters ::= SEQUENCE {
    singleUL-Transmission               ENUMERATED {supported}      OPTIONAL,
    dynamicPowerSharing                 ENUMERATED {supported}      OPTIONAL,
    tdm-Pattern                         ENUMERATED {supported}      OPTIONAL,
    ul-SharingEUTRA-NR                  ENUMERATED {tdm, fdm, both}     OPTIONAL,
    ul-SwitchingTimeEUTRA-NR            ENUMERATED {type1, type2}   OPTIONAL,
    simultaneousRxTxInterBandENDC       ENUMERATED {supported}      OPTIONAL,
    asyncIntraBandENDC                  ENUMERATED {supported}      OPTIONAL,
    ...
}

-- TAG-MRDC-PARAMETERS-STOP
-- ASN1STOP
```

– *RAT-Type*

The IE *RAT-Type* is used to indicate the radio access technology (RAT), including NR, of the requested/transferred UE capabilities.

RAT-Type information element

```
-- ASN1START
-- TAG-RAT-TYPE-START

RAT-Type ::= ENUMERATED {nr, eutra-nr, spare2, spare1, ...}

-- TAG-RAT-TYPE-STOP
-- ASN1STOP
```

– *SupportedBandwidth*

The IE *SupportedBandwidth* is used to indicate the maximum channel bandwidth supported by the UE on one carrier of a band of a band combination.

SupportedBandwidth information element

```
-- ASN1START
-- TAG-SUPPORTEDBANDWIDTH-START

SupportedBandwidth ::=      CHOICE {
    fr1                         ENUMERATED {mhz5, mhz10, mhz15, mhz20, mhz25, mhz30, mhz40, mhz50, mhz60, mhz80, mhz100},
    fr2                         ENUMERATED {mhz50, mhz100, mhz200, mhz400}
}

-- TAG-SUPPORTEDBANDWIDTH-STOP
-- ASN1STOP
```

– *UE-CapabilityRAT-ContainerList*

The IE *UE-CapabilityRAT-ContainerList* contains a list of radio access technology specific capability containers.

UE-CapabilityRAT-ContainerList information element

```
-- ASN1START
-- TAG-UE-CAPABILITY-RAT-CONTAINER-LIST-START

UE-CapabilityRAT-ContainerList ::=SEQUENCE (SIZE (0..maxRAT-CapabilityContainers)) OF UE-CapabilityRAT-Container

UE-CapabilityRAT-Container ::= SEQUENCE {
    rat-Type                            RAT-Type,
    ue-CapabilityRAT-Container          OCTET STRING
}

-- TAG-UE-CAPABILITY-RAT-CONTAINER-LIST-STOP
-- ASN1STOP
```

UE-CapabilityRAT-ContainerList field descriptions
ue-CapabilityRAT-Container
Container for the UE capabilities of the indicated RAT. The encoding is defined in the specification of each RAT:
For NR: the encoding of UE capabilities is defined in UE-NR-Capability.
For EUTRA-NR: the encoding of UE capabilities is defined in UE-MRDC-Capability

– *UE-MRDC-Capability*

The IE *UE-MRDC-Capability* is used to convey the UE Radio Access Capability Parameters for MR-DC, see TS 38.306 [yy].

UE-MRDC-Capability information element

```
-- ASN1START
-- TAG-UE-MRDC-CAPABILITY-START

UE-MRDC-Capability ::=  SEQUENCE {
    measParametersMRDC                  MeasParametersMRDC                  OPTIONAL,
    rf-ParametersMRDC                   RF-ParametersMRDC,
    generalParametersMRDC               GeneralParametersMRDC-XDD-Diff      OPTIONAL,
    fdd-Add-UE-MRDC-Capabilities        UE-MRDC-CapabilityAddXDD-Mode       OPTIONAL,
    tdd-Add-UE-MRDC-Capabilities        UE-MRDC-CapabilityAddXDD-Mode       OPTIONAL,
    fr1-Add-UE-MRDC-Capabilities        UE-MRDC-CapabilityAddFRX-Mode       OPTIONAL,
    fr2-Add-UE-MRDC-Capabilities        UE-MRDC-CapabilityAddFRX-Mode       OPTIONAL,
    featureSetCombinations              SEQUENCE (SIZE (1..maxFeatureSetCombinations)) OF FeatureSetCombination       OPTIONAL,
    lateNonCriticalExtension            OCTET STRING                        OPTIONAL,
    nonCriticalExtension                SEQUENCE {}                         OPTIONAL
}
UE-MRDC-CapabilityAddXDD-Mode ::=   SEQUENCE {
    measParametersMRDC-XDD-Diff     MeasParametersMRDC-XDD-Diff     OPTIONAL,
    generalParametersMRDC-XDD-Diff      GeneralParametersMRDC-XDD-Diff      OPTIONAL
}

UE-MRDC-CapabilityAddFRX-Mode ::=   SEQUENCE {
    measParametersMRDC-FRX-Diff     MeasParametersMRDC-FRX-Diff
}

GeneralParametersMRDC-XDD-Diff ::= SEQUENCE {
    splitSRB-WithOneUL-Path             ENUMERATED {supported}      OPTIONAL,
    splitDRB-withUL-Both-MCG-SCG        ENUMERATED {supported}      OPTIONAL,
    srb3                                ENUMERATED {supported}      OPTIONAL,
    ...
}

-- TAG-UE-MRDC-CAPABILITY-STOP
-- ASN1STOP
```

UE-MRDC-Capability field descriptions
featureSetCombinations A list of FeatureSetCombination:s for MR-DC. The FeatureSetDownlink:s and FeatureSetUplink:s referred to from these FeatureSetCombination:s are defined in the featureSets list in UE-NR-Capability.

– *RF-ParametersMRDC*

The IE *RF-ParametersMRDC* is used to convey RF related capabilities for MR-DC.

RF-ParametersMRDC information element

```
-- ASN1START
-- TAG-RF-PARAMETERSMRDC-START
```

```
RF-ParametersMRDC ::= SEQUENCE {
    supportedBandCombinationList        BandCombinationList                OPTIONAL,
    appliedFreqBandListFilter           FreqBandList                       OPTIONAL
}

-- TAG-RF-PARAMETERSMRDC-STOP
-- ASN1STOP
```

RF-ParametersMRDC field descriptions
appliedFreqBandListFilter In this field the UE mirrors the FreqBandList that the NW provided in the capability enquiry, if any. The UE filtered the band combinations in the supportedBandCombinationList in accordance with this appliedFreqBandListFilter.
supportedBandCombinationList A list of band combinations that the UE supports for MR-DC. The *FeatureSetCombinationId*:s in this list refer to the *FeatureSetCombination* entries in the *featureSetCombinations* list in the *UE-MRDC-Capability* IE.

– *MeasParametersMRDC*

The IE *MeasParametersMRDC* is used to configure FFS

***MeasParametersMRDC* information element**

```
-- ASN1START
-- TAG-MEASPARAMETERSMRDC-START

MeasParametersMRDC ::= SEQUENCE {
    measParametersMRDC-Common       MeasParametersMRDC-Common              OPTIONAL,
    measParametersMRDC-XDD-Diff     MeasParametersMRDC-XDD-Diff            OPTIONAL,
    measParametersMRDC-FRX-Diff     MeasParametersMRDC-FRX-Diff            OPTIONAL
}

MeasParametersMRDC-Common ::=   SEQUENCE {
    independentGapConfig            ENUMERATED {supported}             OPTIONAL
}

MeasParametersMRDC-XDD-Diff ::= SEQUENCE {
    sftd-MeasPSCell                 ENUMERATED {supported}             OPTIONAL,
    sftd-MeasNR-Cell                ENUMERATED {supported}             OPTIONAL
}

MeasParametersMRDC-FRX-Diff ::= SEQUENCE {
    simultaneousRxDataSSB-DiffNumerology    ENUMERATED {supported}     OPTIONAL
}

-- TAG-MEASPARAMETERSMRDC-STOP
-- ASN1STOP
```

– *UE-NR-Capability*

The IE *UE-NR-Capability* is used to convey the NR UE Radio Access Capability Parameters, see TS 38.306 [yy].

UE-NR-Capability information element

```
-- ASN1START
-- TAG-UE-NR-CAPABILITY-START

UE-NR-Capability ::= SEQUENCE {
    accessStratumRelease            AccessStratumRelease,
    pdcp-Parameters                 PDCP-Parameters,
    rlc-Parameters                  RLC-Parameters                      OPTIONAL,
    mac-Parameters                  MAC-Parameters                      OPTIONAL,
    phy-Parameters                  Phy-Parameters,
    rf-Parameters                   RF-Parameters,
    measParameters                  MeasParameters                      OPTIONAL,
    fdd-Add-UE-NR-Capabilities      UE-NR-CapabilityAddXDD-Mode         OPTIONAL,
    tdd-Add-UE-NR-Capabilities      UE-NR-CapabilityAddXDD-Mode         OPTIONAL,
    fr1-Add-UE-NR-Capabilities      UE-NR-CapabilityAddFRX-Mode         OPTIONAL,
    fr2-Add-UE-NR-Capabilities      UE-NR-CapabilityAddFRX-Mode         OPTIONAL,
    featureSets                     FeatureSets                         OPTIONAL,
    featureSetCombinations          SEQUENCE (SIZE (1..maxFeatureSetCombinations)) OF FeatureSetCombination        OPTIONAL,

    lateNonCriticalExtension        OCTET STRING                        OPTIONAL,
    nonCriticalExtension            SEQUENCE {}                         OPTIONAL
}

UE-NR-CapabilityAddXDD-Mode ::= SEQUENCE {
    phy-ParametersXDD-Diff          Phy-ParametersXDD-Diff          OPTIONAL,
    mac-ParametersXDD-Diff          MAC-ParametersXDD-Diff          OPTIONAL,
    measParametersXDD-Diff          MeasParametersXDD-Diff          OPTIONAL
}

UE-NR-CapabilityAddFRX-Mode ::= SEQUENCE {
    phy-ParametersFRX-Diff          Phy-ParametersFRX-Diff          OPTIONAL,
    measParametersFRX-Diff          MeasParametersFRX-Diff          OPTIONAL
}

-- TAG-UE-NR-CAPABILITY-STOP
-- ASN1STOP
```

UE-NR-Capability field descriptions
featureSetCombinations   A list of FeatureSetCombination:s for NR (not for MR-DC). The FeatureSetDownlink:s and FeatureSetUplink:s referred to from these FeatureSetCombination:s are defined in the featureSets list in UE-NR-Capability.

– *Phy-Parameters*

The IE *Phy-Parameters* is used to convey the physical layer capabilities.

Phy-Parameters information element

```
-- ASN1START
-- TAG-PHY-PARAMETERS-START

Phy-Parameters ::=  SEQUENCE {
    phy-ParametersCommon            Phy-ParametersCommon              OPTIONAL,
    phy-ParametersXDD-Diff          Phy-ParametersXDD-Diff            OPTIONAL,
    phy-ParametersFRX-Diff          Phy-ParametersFRX-Diff            OPTIONAL,
    phy-ParametersFR1               Phy-ParametersFR1                 OPTIONAL,
    phy-ParametersFR2               Phy-ParametersFR2                 OPTIONAL
}

Phy-ParametersCommon ::=    SEQUENCE {
    csi-RS-CFRA-ForHO                   ENUMERATED {supported}                  OPTIONAL,
    dynamicPRB-BundlingDL               ENUMERATED {supported}                  OPTIONAL,
    sp-CSI-ReportPUCCH                  ENUMERATED {supported}                  OPTIONAL,
    sp-CSI-ReportPUSCH                  ENUMERATED {supported}                  OPTIONAL,
    nzp-CSI-RS-IntefMgmt                ENUMERATED {supported}                  OPTIONAL,
    type2-SP-CSI-Feedback-LongPUCCH     ENUMERATED {supported}                  OPTIONAL,
    precoderGranularityCORESET          ENUMERATED {supported}                  OPTIONAL,
    dynamicHARQ-ACK-Codebook            ENUMERATED {supported}                  OPTIONAL,
    semiStaticHARQ-ACK-Codebook         ENUMERATED {supported}                  OPTIONAL,
    spatialBundlingHARQ-ACK             ENUMERATED {supported}                  OPTIONAL,
    dynamicBetaOffsetInd-HARQ-ACK-CSI   ENUMERATED {supported}                  OPTIONAL,
    pucch-Repetition-F1-3-4             ENUMERATED {supported}                  OPTIONAL,
    ra-Type0-PUSCH                      ENUMERATED {supported}                  OPTIONAL,
    dynamicSwitchRA-Type0-1-PDSCH       ENUMERATED {supported}                  OPTIONAL,
    dynamicSwitchRA-Type0-1-PUSCH       ENUMERATED {supported}                  OPTIONAL,
    pdsch-MappingTypeA                  ENUMERATED {supported}                  OPTIONAL,
    pdsch-MappingTypeB                  ENUMERATED {supported}                  OPTIONAL,
    interleavingVRB-ToPRB-PDSCH         ENUMERATED {supported}                  OPTIONAL,
    interSlotFreqHopping-PUSCH          ENUMERATED {supported}                  OPTIONAL,
    type1-PUSCH-RepetitionMultiSlots    ENUMERATED {supported}                  OPTIONAL,
    type2-PUSCH-RepetitionMultiSlots    ENUMERATED {supported}                  OPTIONAL,
    pusch-RepetitionMultiSlots          ENUMERATED {supported}                  OPTIONAL,
    pdsch-RepetitionMultiSlots          ENUMERATED {supported}                  OPTIONAL,
    downlinkSPS                         ENUMERATED {supported}                  OPTIONAL,
    configuredUL-GrantType1             ENUMERATED {supported}                  OPTIONAL,
    configuredUL-GrantType2             ENUMERATED {supported}                  OPTIONAL,
    pre-EmptIndication-DL               ENUMERATED {supported}                  OPTIONAL,
    cbg-TransIndication-DL              ENUMERATED {supported}                  OPTIONAL,
    cbg-TransIndication-UL              ENUMERATED {supported}                  OPTIONAL,
    cbg-FlushIndication-DL              ENUMERATED {supported}                  OPTIONAL,
    dynamicHARQ-ACK-CodeB-CBG-Retx-DL   ENUMERATED {supported}                  OPTIONAL,
    rateMatchingResrcSetSemi-Static     ENUMERATED {supported}                  OPTIONAL,
    rateMatchingResrcSetDynamic         ENUMERATED {supported}                  OPTIONAL,
    bwp-SwitchingDelay                  ENUMERATED {type1, type2}               OPTIONAL,
    ...
```

```
}

Phy-ParametersXDD-Diff ::=  SEQUENCE {
    dynamicSFI                          ENUMERATED {supported}                  OPTIONAL,
    twoPUCCH-F0-2-ConsecSymbols         ENUMERATED {supported}                  OPTIONAL,
    twoDifferentTPC-Loop-PUSCH          ENUMERATED {supported}                  OPTIONAL,
    twoDifferentTPC-Loop-PUCCH          ENUMERATED {supported}                  OPTIONAL,
    ...
}

Phy-ParametersFRX-Diff ::=  SEQUENCE {
    dynamicSFI                          ENUMERATED {supported}                  OPTIONAL,
    oneFL-DMRS-TwoAdditionalDMRS        BIT STRING (SIZE (2))                   OPTIONAL,
    twoFL-DMRS                          BIT STRING (SIZE (2))                   OPTIONAL,
    twoFL-DMRS-TwoAdditionalDMRS        BIT STRING (SIZE (2))                   OPTIONAL,
    oneFL-DMRS-ThreeAdditionalDMRS      BIT STRING (SIZE (2))                   OPTIONAL,
    supportedDMRS-TypeDL                ENUMERATED {type1, type2}               OPTIONAL,
    supportedDMRS-TypeUL                ENUMERATED {type1, type2}               OPTIONAL,
    semiOpenLoopCSI                     ENUMERATED {supported}                  OPTIONAL,
    csi-ReportWithoutPMI                ENUMERATED {supported}                  OPTIONAL,
    csi-ReportWithoutCQI                ENUMERATED {supported}                  OPTIONAL,
    onePortsPTRS                        BIT STRING (SIZE (2))                   OPTIONAL,
    twoPUCCH-F0-2-ConsecSymbols         ENUMERATED {supported}                  OPTIONAL,
    pucch-F2-WithFH                     ENUMERATED {supported}                  OPTIONAL,
    pucch-F3-WithFH                     ENUMERATED {supported}                  OPTIONAL,
    pucch-F4-WithFH                     ENUMERATED {supported}                  OPTIONAL,
    freqHoppingPUCCH-F0-2               ENUMERATED {notSupported}               OPTIONAL,
    freqHoppingPUCCH-F1-3-4             ENUMERATED {notSupported}               OPTIONAL,
    mux-SR-HARQ-ACK-CSI-PUCCH           ENUMERATED {supported}                  OPTIONAL,
    uci-CodeBlockSegmentation           ENUMERATED {supported}                  OPTIONAL,
    onePUCCH-LongAndShortFormat         ENUMERATED {supported}                  OPTIONAL,
    twoPUCCH-AnyOthersInSlot            ENUMERATED {supported}                  OPTIONAL,
    intraSlotFreqHopping-PUSCH          ENUMERATED {supported}                  OPTIONAL,
    pusch-LBRM                          ENUMERATED {supported}                  OPTIONAL,
    pdcch-BlindDetectionCA              ENUMERATED {supported}                  OPTIONAL,
    tpc-PUSCH-RNTI                      ENUMERATED {supported}                  OPTIONAL,
    tpc-PUCCH-RNTI                      ENUMERATED {supported}                  OPTIONAL,
    tpc-SRS-RNTI                        ENUMERATED {supported}                  OPTIONAL,
    absoluteTPC-Command                 ENUMERATED {supported}                  OPTIONAL,
    twoDifferentTPC-Loop-PUSCH          ENUMERATED {supported}                  OPTIONAL,
    twoDifferentTPC-Loop-PUCCH          ENUMERATED {supported}                  OPTIONAL,
    pusch-HalfPi-BPSK                   ENUMERATED {supported}                  OPTIONAL,
    pucch-F3-4-HalfPi-BPSK              ENUMERATED {supported}                  OPTIONAL,
    almostContiguousCP-OFDM-UL          ENUMERATED {supported}                  OPTIONAL ,
    sp-CSI-RS                           ENUMERATED {supported}                  OPTIONAL,
    sp-CSI-IM                           ENUMERATED {supported}                  OPTIONAL,
    tdd-MultiDL-UL-SwitchPerSlot        ENUMERATED {supported}                  OPTIONAL,
    multipleCORESET                     ENUMERATED {supported}                  OPTIONAL,
    ...
}

Phy-ParametersFR1 ::=   SEQUENCE {
    pdcchMonitoringSingleOccasion       ENUMERATED {supported}                  OPTIONAL,
    scs-60kHz                           ENUMERATED {supported}                  OPTIONAL,
```

```
    pdsch-256QAM-FR1                    ENUMERATED {supported}                  OPTIONAL,
    pdsch-RE-MappingFR1                 ENUMERATED {n10, n20}                   OPTIONAL,
    ...
}

Phy-ParametersFR2 ::=   SEQUENCE {
    calibrationGapPA                    ENUMERATED {supported}                  OPTIONAL,
    pdsch-RE-MappingFR2                 ENUMERATED {n6, n20}                    OPTIONAL,
    ...
}

-- TAG-PHY-PARAMETERS-STOP
-- ASN1STOP
```

– *RF-Parameters*

The IE *RF-Parameters* is used to convey RF-related capabilities for NR operation.

RF-Parameters information element

```
-- ASN1START
-- TAG-RF-PARAMETERS-START

RF-Parameters ::= SEQUENCE {
    supportedBandListNR             SEQUENCE (SIZE (1..maxBands)) OF BandNR,
    supportedBandCombinationList        BandCombinationList                 OPTIONAL,
    appliedFreqBandListFilter           FreqBandList                        OPTIONAL
}

BandNR ::=  SEQUENCE {
    bandNR                          FreqBandIndicatorNR,
    modifiedMPR-Behaviour           BIT STRING (SIZE (8))                   OPTIONAL,
    mimo-ParametersPerBand          MIMO-ParametersPerBand                  OPTIONAL,
    extendedCP                      ENUMERATED {supported}                  OPTIONAL,
    multipleTCI                     ENUMERATED {supported}                  OPTIONAL,
    bwp-WithoutRestriction          ENUMERATED {supported}                  OPTIONAL,
    bwp-SameNumerology                  ENUMERATED {upto2, upto4}           OPTIONAL,
    bwp-DiffNumerology                  ENUMERATED {upto4}                  OPTIONAL,
    crossCarrierSchedulingDL-SameSCS        ENUMERATED {supported}                  OPTIONAL,
    crossCarrierSchedulingUL-SameSCS        ENUMERATED {supported}                  OPTIONAL,
    pdsch-256QAM-FR2                ENUMERATED {supported}                  OPTIONAL,
    pusch-256QAM                    ENUMERATED {supported}                  OPTIONAL,
    ue-PowerClass                   ENUMERATED {pc2, pc3}               OPTIONAL,
    rateMatchingLTE-CRS             ENUMERATED {supported}                  OPTIONAL,
    ...
}

-- TAG-RF-PARAMETERS-STOP
-- ASN1STOP
```

RF-Parameters field descriptions
appliedFreqBandListFilter In this field the UE mirrors the FreqBandList that the NW provided in the capability enquiry, if any. The UE filtered the band combinations in the supportedBandCombinationList in accordance with this appliedFreqBandListFilter.
supportedBandCombinationList A list of band combinations that the UE supports for NR (without MR-DC). The *FeatureSetCombinationId*:s in this list refer to the *FeatureSetCombination* entries in the *featureSetCombinations* list in the *UE-NR-Capability* IE.

– *MIMO-ParametersPerBand*

The IE *MIMO-ParametersPerBand* is used to convey MIMO related parameters specific for a certain band (not per feature set or band combination).

MIMO-ParametersPerBand information element

```
-- ASN1START
-- TAG-MIMO-PARAMETERSPERBAND-START

MIMO-ParametersPerBand ::= SEQUENCE {
    tci-StatePDSCH                      SEQUENCE {
        maxNumberConfiguredTCIstatesPerCC   ENUMERATED {n4, n8, n16, n32, n64}                      OPTIONAL,
        maxNumberActiveTCI-PerBWP           ENUMERATED {n1, n2, n4, n8}                             OPTIONAL
    }                                                                                               OPTIONAL,
    additionalActiveTCI-StatePDCCH      ENUMERATED {supported}                                      OPTIONAL,
    pusch-TransCoherence                ENUMERATED {nonCoherent, partialNonCoherent, fullCoherent}  OPTIONAL,
    beamCorrespondence                  ENUMERATED {supported}                                      OPTIONAL,
    periodicBeamReport                  ENUMERATED {supported}                                      OPTIONAL,
    aperiodicBeamReport                 ENUMERATED {supported}                                      OPTIONAL,
    sp-BeamReportPUCCH                  ENUMERATED {supported}                                      OPTIONAL,
    sp-BeamReportPUSCH                  ENUMERATED {supported}                                      OPTIONAL,
    beamManagementSSB-CSI-RS            BeamManagementSSB-CSI-RS                                    OPTIONAL,
    maxNumberRxBeam                     INTEGER (2..8)                                              OPTIONAL,
    maxNumberRxTxBeamSwitchDL           SEQUENCE {
        scs-15kHz                           ENUMERATED {n4, n7, n14}                                OPTIONAL,
        scs-30kHz                           ENUMERATED {n4, n7, n14}                                OPTIONAL,
        scs-60kHz                           ENUMERATED {n4, n7, n14}                                OPTIONAL,
        scs-120kHz                          ENUMERATED {n4, n7, n14}                                OPTIONAL,
        scs-240kHz                          ENUMERATED {n4, n7, n14}                                OPTIONAL
    }                                                                                               OPTIONAL,
    maxNumberNonGroupBeamReporting      ENUMERATED {n1, n2, n4}                                     OPTIONAL,
    groupBeamReporting                  ENUMERATED {supported}                                      OPTIONAL,
    uplinkBeamManagement                SEQUENCE {
        maxNumberSRS-ResourcePerSet         ENUMERATED {n2, n4, n8, n16, n32},
        maxNumberSRS-ResourceSet            INTEGER (1..8)
    }                                                                                               OPTIONAL,
    maxNumberCSI-RS-BFR                 INTEGER (1..64)                                             OPTIONAL,
    maxNumberSSB-BFR                    INTEGER (1..64)                                             OPTIONAL,
    maxNumberCSI-RS-SSB-BFR             INTEGER (1..256)                                            OPTIONAL,
    twoPortsPTRS-DL                     ENUMERATED {supported}                                      OPTIONAL,
    twoPortsPTRS-UL                     ENUMERATED {supported}                                      OPTIONAL,
    supportedSRS-Resources          SRS-Resources                                                   OPTIONAL,
    srs-TxSwitch                    SRS-TxSwitch                                                    OPTIONAL,
```

```
    maxNumberSimultaneousSRS-PerCC      INTEGER (1..4)                                  OPTIONAL,
    beamReportTiming                    SEQUENCE {
        scs-15kHz                           ENUMERATED {sym2, sym4, sym8}               OPTIONAL,
        scs-30kHz                           ENUMERATED {sym4, sym8, sym14}              OPTIONAL,
        scs-60kHz                           ENUMERATED {sym8, sym14, sym28}             OPTIONAL,
        scs-120kHz                          ENUMERATED {sym14, sym28, sym56}            OPTIONAL
    }                                                                                   OPTIONAL,
    ptrs-DensityRecommendationSetDL     SEQUENCE {
        scs-15kHz                           PTRS-DensityRecommendationDL                OPTIONAL,
        scs-30kHz                           PTRS-DensityRecommendationDL                OPTIONAL,
        scs-60kHz                           PTRS-DensityRecommendationDL                OPTIONAL,
        scs-120kHz                          PTRS-DensityRecommendationDL                OPTIONAL
    }                                                                                   OPTIONAL,
    ptrs-DensityRecommendationSetUL     SEQUENCE {
        scs-15kHz                           PTRS-DensityRecommendationUL                OPTIONAL,
        scs-30kHz                           PTRS-DensityRecommendationUL                OPTIONAL,
        scs-60kHz                           PTRS-DensityRecommendationUL                OPTIONAL,
        scs-120kHz                          PTRS-DensityRecommendationUL                OPTIONAL
    }                                                                                   OPTIONAL,
    csi-RS-ForTracking                  CSI-RS-ForTracking                              OPTIONAL,
    aperiodicTRS                        ENUMERATED {supported}                          OPTIONAL,
    ...
}

BeamManagementSSB-CSI-RS ::=    SEQUENCE {
    maxNumberSSB-CSI-RS-ResourceOneTx   ENUMERATED {n8, n16, n32, n64},
    maxNumberSSB-CSI-RS-ResourceTwoTx   ENUMERATED {n0, n4, n8, n16, n32, n64},
    supportedCSI-RS-Density             ENUMERATED {one, three, oneAndThree}
}

CSI-RS-ForTracking ::=              SEQUENCE {
    burstLength                         INTEGER (1..2),
    maxSimultaneousResourceSetsPerCC    INTEGER (1..8),
    maxConfiguredResourceSetsPerCC      INTEGER (1..64),
    maxConfiguredResourceSetsAllCC      INTEGER (1..128)
}

PTRS-DensityRecommendationDL ::=    SEQUENCE {
    frequencyDensity1                   INTEGER (1..276),
    frequencyDensity2                   INTEGER (1..276),
    timeDensity1                        INTEGER (0..29),
    timeDensity2                        INTEGER (0..29),
    timeDensity3                        INTEGER (0..29)
}

PTRS-DensityRecommendationUL ::=    SEQUENCE {
    frequencyDensity1                   INTEGER (1..276),
    frequencyDensity2                   INTEGER (1..276),
    timeDensity1                        INTEGER (0..29),
    timeDensity2                        INTEGER (0..29),
    timeDensity3                        INTEGER (0..29),
    sampleDensity1                      INTEGER (1..276),
    sampleDensity2                      INTEGER (1..276),
    sampleDensity3                      INTEGER (1..276),
```

```
    sampleDensity4                      INTEGER (1..276),
    sampleDensity5                      INTEGER (1..276)
}

SRS-Resources ::=   SEQUENCE {
    maxNumberAperiodicSRS-PerBWP                    ENUMERATED {n1, n2, n4, n8, n16},
    maxNumberAperiodicSRS-PerBWP-PerSlot            INTEGER (1..6),
    maxNumberPeriodicSRS-PerBWP                     ENUMERATED {n1, n2, n4, n8, n16},
    maxNumberPeriodicSRS-PerBWP-PerSlot             INTEGER (1..6),
    maxNumberSemiPersitentSRS-PerBWP                ENUMERATED {n1, n2, n4, n8, n16},
    maxNumberSP-SRS-PerBWP-PerSlot                  INTEGER (1..6),
    maxNumberSRS-Ports-PerResource                  ENUMERATED {n1, n2, n4}
}

SRS-TxSwitch ::=    SEQUENCE {
    supportedSRS-TxPortSwitch           ENUMERATED {t1r2, t1r4, t2r4, t1r4-t2r4, tr-equal},
    txSwitchImpactToRx                  ENUMERATED {true}                                   OPTIONAL
}

-- ASN1STOP
-- TAG-MIMO-PARAMETERSPERBAND-STOP
```

– *PDCP-Parameters*

The IE *PDCP-Parameters* is used to convey capabilities related to PDCP.

PDCP-Parameters information element

```
-- ASN1START
-- TAG-PDCP-PARAMETERS-START

PDCP-Parameters ::= SEQUENCE {
    supportedROHC-Profiles  SEQUENCE {
        profile0x0000       BOOLEAN,
        profile0x0001       BOOLEAN,
        profile0x0002       BOOLEAN,
        profile0x0003       BOOLEAN,
        profile0x0004       BOOLEAN,
        profile0x0006       BOOLEAN,
        profile0x0101       BOOLEAN,
        profile0x0102       BOOLEAN,
        profile0x0103       BOOLEAN,
        profile0x0104       BOOLEAN
    },
    maxNumberROHC-ContextSessions   ENUMERATED {cs2, cs4, cs8, cs12, cs16, cs24, cs32, cs48, cs64,
                                                cs128, cs256, cs512, cs1024, cs16384, spare2, spare1},
    uplinkOnlyROHC-Profiles         ENUMERATED {supported}  OPTIONAL,
    continueROHC-Context                ENUMERATED {supported}  OPTIONAL,
    outOfOrderDelivery              ENUMERATED {supported}  OPTIONAL,
    shortSN                         ENUMERATED {supported}  OPTIONAL,
    ...
}
```

```
-- TAG-PDCP-PARAMETERS-STOP
-- ASN1STOP
```

– *RLC-Parameters*

The IE *RLC-Parameters* is used to convey capabilities related to RLC.

RLC-Parameters information element

```
-- ASN1START
-- TAG-RLC-PARAMETERS-START

RLC-Parameters ::= SEQUENCE {
    am-WithShortSN                  ENUMERATED {supported}  OPTIONAL,
    um-WithShortSN                  ENUMERATED {supported}  OPTIONAL,
    um-WIthLongSN                   ENUMERATED {supported}  OPTIONAL,
    ...
}

-- TAG-RLC-PARAMETERS-STOP
-- ASN1STOP
```

– *MAC-Parameters*

The IE *MAC-Parameters* is used to convey capabilities related to MAC.

MAC-Parameters information element

```
-- ASN1START
-- TAG-MAC-PARAMETERS-START

MAC-Parameters ::= SEQUENCE {
    mac-ParametersCommon            MAC-ParametersCommon    OPTIONAL,
    mac-ParametersXDD-Diff          MAC-ParametersXDD-Diff  OPTIONAL
}

MAC-ParametersCommon ::=    SEQUENCE {
    lcp-Restriction                 ENUMERATED {supported}  OPTIONAL,
    pucch-SpatialRelInfoMAC-CE      ENUMERATED {supported}  OPTIONAL,
    ...
}

MAC-ParametersXDD-Diff ::=  SEQUENCE {
    skipUplinkTxDynamic             ENUMERATED {supported}  OPTIONAL,
    logicalChannelSR-DelayTimer     ENUMERATED {supported}  OPTIONAL,
    longDRX-Cycle                   ENUMERATED {supported}  OPTIONAL,
    shortDRX-Cycle                  ENUMERATED {supported}  OPTIONAL,
    multipleSR-Configurations       ENUMERATED {supported}  OPTIONAL,
    multipleConfiguredGrants    ENUMERATED {supported}  OPTIONAL,
```

```
    ...
}

-- TAG-MAC-PARAMETERS-STOP
-- ASN1STOP
```

– *MeasParameters*

The IE *MeasParameters* is used to convey UE capabilities related to measurements for radio resource management (RRM) and radio link monitoring (RLM).

MeasParameters information element

```
-- ASN1START
-- TAG-MEASPARAMETERS-START

MeasParameters ::= SEQUENCE {
    measParametersCommon                MeasParametersCommon            OPTIONAL,
    measParametersXDD-Diff          MeasParametersXDD-Diff      OPTIONAL,
    measParametersFRX-Diff          MeasParametersFRX-Diff      OPTIONAL
}

MeasParametersCommon ::= SEQUENCE {
    supportedGapPattern             BIT STRING (SIZE (22))          OPTIONAL,
    ...
}

MeasParametersXDD-Diff ::=  SEQUENCE {
    intraAndInterF-MeasAndReport    ENUMERATED {supported}  OPTIONAL,
    eventA-MeasAndReport            ENUMERATED {supported}  OPTIONAL,
    ...
}

MeasParametersFRX-Diff ::=  SEQUENCE {
    ss-SINR-Meas                        ENUMERATED {supported}      OPTIONAL,
    csi-RSRP-AndRSRQ-MeasWithSSB        ENUMERATED {supported}      OPTIONAL,
    csi-RSRP-AndRSRQ-MeasWithoutSSB     ENUMERATED {supported}      OPTIONAL,
    csi-SINR-Meas                       ENUMERATED {supported}      OPTIONAL,
    csi-RS-RLM                          ENUMERATED {supported}      OPTIONAL,
    ...
}

-- TAG-UE-NR-CAPABILITY-STOP
-- ASN1STOP
```

6.3.4 Other information elements

– *RRC-TransactionIdentifier*

The IE *RRC-TransactionIdentifier* is used, together with the message type, for the identification of an RRC procedure (transaction).

***RRC-TransactionIdentifier* information element**

```
-- ASN1START
-- TAG-RRC-TRANSACTIONIDENTIFIER-START

RRC-TransactionIdentifier ::=       INTEGER (0..3)

-- TAG-RRC-TRANSACTIONIDENTIFIER-STOP
-- ASN1STOP
```

6.4 RRC multiplicity and type constraint values

– Multiplicity and type constraint definitions

```
-- ASN1START
-- TAG-MULTIPLICITY-AND-TYPE-CONSTRAINT-DEFINITIONS-START

maxBandComb                             INTEGER ::= 65536   -- Maximum number of DL band combinations

maxNrofServingCells                     INTEGER ::= 32      -- Max number of serving cells (SpCell + SCells) per cell group
maxNrofServingCells-1                   INTEGER ::= 31      -- Max number of serving cells (SpCell + SCells) per cell group minus 1
maxNrofAggregatedCellsPerCellGroup      INTEGER ::= 16
maxNrofSCells                           INTEGER ::= 31      -- Max number of secondary serving cells per cell group
maxNrofCellMeas                         INTEGER ::= 32      -- Maximum number of entries in each of the cell lists in a measurement object
maxNrofSS-BlocksToAverage               INTEGER ::= 16      -- Max number for the (max) number of SS blocks to average to determine cell
                                                            -- measurement
maxNrofCSI-RS-ResourcesToAverage            INTEGER ::= 16      -- Max number for the (max) number of CSI-RS to average to determine cell
                                                            -- measurement
maxNrofDL-Allocations                   INTEGER ::= 16      -- Maximum number of PDSCH time domain resource allocations

maxNrofSR-ConfigPerCellGroup                INTEGER ::= 8       -- Maximum number of SR configurations per cell group

maxLCG-ID                               INTEGER ::= 7       -- Maximum value of LCG ID
maxLC-ID                                INTEGER ::= 32      -- Maximum value of Logical Channel ID
maxNrofTAGs                             INTEGER ::= 4       -- Maximum number of Timing Advance Groups
maxNrofTAGs-1                           INTEGER ::= 3       -- Maximum number of Timing Advance Groups minus 1

maxNrofBWPs                             INTEGER ::= 4       -- Maximum number of BWPs per serving cell
maxNrofSymbols-1                        INTEGER ::= 13      -- Maximum index identifying a symbol within a slot (14 symbols, indexed from 0..13)
maxNrofSlots                            INTEGER ::= 320     -- Maximum number of slots in a 10 ms period
maxNrofSlots-1                          INTEGER ::= 319     -- Maximum number of slots in a 10 ms period minus 1

maxNrofPhysicalResourceBlocks           INTEGER ::= 275     -- Maximum number of PRBs
maxNrofPhysicalResourceBlocks-1         INTEGER ::= 274     -- Maximum number of PRBs minus 1
maxNrofPhysicalResourceBlocksPlus1      INTEGER ::= 276     -- Maximum number of PRBs plus 1
maxNrofControlResourceSets              INTEGER ::= 12      -- Max number of CoReSets configurable on a serving cell
maxNrofControlResourceSets-1            INTEGER ::= 11      -- Max number of CoReSets configurable on a serving cell minus 1
maxCoReSetDuration                      INTEGER ::= 3       -- Max number of OFDM symbols in a control resource set
maxNrofSearchSpaces                     INTEGER ::= 40      -- Max number of Search Spaces
maxNrofSearchSpaces-1                   INTEGER ::= 39      -- Max number of Search Spaces minus 1
maxSFI-DCI-PayloadSize                  INTEGER ::= 128     -- Max number payload of a DCI scrambled with SFI-RNTI
```

```
maxSFI-DCI-PayloadSize-1                INTEGER ::= 127     -- Max number payload of a DCI scrambled with SFI-RNTI minus 1
maxINT-DCI-PayloadSize                  INTEGER ::= 126     -- Max number payload of a DCI scrambled with INT-RNTI
maxINT-DCI-PayloadSize-1                INTEGER ::= 125     -- Max number payload of a DCI scrambled with INT-RNTI minus 1
maxNrofRateMatchPatterns                INTEGER ::= 4       -- Max number of rate matching patterns that may be configured
maxNrofRateMatchPatterns-1              INTEGER ::= 3       -- Max number of rate matching patterns that may be configured minus 1
maxNrofRateMatchPatternsPerGroup            INTEGER ::= 8       -- Max number of rate matching patterns that may be configured in one group

maxNrofCSI-ReportConfigurations         INTEGER ::= 48      -- Maximum number of report configurations
maxNrofCSI-ReportConfigurations-1       INTEGER ::= 47      -- Maximum number of report configurations minus 1

maxNrofCSI-ResourceConfigurations       INTEGER ::= 112     -- Maximum number of resource configurations
maxNrofCSI-ResourceConfigurations-1     INTEGER ::= 111     -- Maximum number of resource configurations minus 1

maxNrofAP-CSI-RS-ResourcesPerSet        INTEGER ::= 16
maxNrOfCSI-AperiodicTriggers            INTEGER ::= 128     -- Maximum number of triggers for aperiodic CSI reporting
maxNrofReportConfigPerAperiodicTrigger  INTEGER ::= 16      -- Maximum number of report configurations per trigger state for aperiodic reporting

maxNrofNZP-CSI-RS-Resources             INTEGER ::= 192     -- Maximum number of Non-Zero-Power (NZP) CSI-RS resources
maxNrofNZP-CSI-RS-Resources-1           INTEGER ::= 191     -- Maximum number of Non-Zero-Power (NZP) CSI-RS resources minus 1
maxNrofNZP-CSI-RS-ResourcesPerSet       INTEGER ::= 64      -- Maximum number of NZP CSI-RS resources per resource set
maxNrofNZP-CSI-RS-ResourceSets          INTEGER ::= 64      -- Maximum number of NZP CSI-RS resources per cell
maxNrofNZP-CSI-RS-ResourceSets-1        INTEGER ::= 63      -- Maximum number of NZP CSI-RS resources per cell minus 1
maxNrofNZP-CSI-RS-ResourceSetsPerConfig INTEGER ::= 16      -- Maximum number of resource sets per resource configuration
maxNrofNZP-CSI-RS-ResourcesPerConfig        INTEGER ::= 128     -- Maximum number of resources per resource configuration

maxNrofZP-CSI-RS-Resources              INTEGER ::= 32      -- Maximum number of Zero-Power (NZP) CSI-RS resources
maxNrofZP-CSI-RS-Resources-1            INTEGER ::= 31      -- Maximum number of Zero-Power (NZP) CSI-RS resources minus 1
maxNrofZP-CSI-RS-ResourceSets-1         INTEGER ::= 15
maxNrofZP-CSI-RS-ResourcesPerSet        INTEGER ::= 16
maxNrofZP-CSI-RS-ResourceSets           INTEGER ::= 16

maxNrofCSI-IM-Resources                 INTEGER ::= 32      -- Maximum number of CSI-IM resources. See CSI-IM-ResourceMax in 38.214.
maxNrofCSI-IM-Resources-1               INTEGER ::= 31      -- Maximum number of CSI-IM resources minus 1. See CSI-IM-ResourceMax in 38.214.
maxNrofCSI-IM-ResourcesPerSet           INTEGER ::= 8       -- Maximum number of CSI-IM resources per set. See CSI-IM-ResourcePerSetMax in 38.214
maxNrofCSI-IM-ResourceSets              INTEGER ::= 64      -- Maximum number of NZP CSI-IM resources per cell
maxNrofCSI-IM-ResourceSets-1            INTEGER ::= 63      -- Maximum number of NZP CSI-IM resources per cell minus 1
maxNrofCSI-IM-ResourceSetsPerConfig     INTEGER ::= 16      -- Maximum number of CSI IM resource sets per resource configuration

maxNrofCSI-SSB-ResourcePerSet           INTEGER ::= 64      -- Maximum number of SSB resources in a resource set
maxNrofCSI-SSB-ResourceSets             INTEGER ::= 64      -- Maximum number of CSI SSB resource sets per cell
maxNrofCSI-SSB-ResourceSets-1           INTEGER ::= 63      -- Maximum number of CSI SSB resource sets per cell minus 1
maxNrofCSI-SSB-ResourceSetsPerConfig    INTEGER ::= 1       -- Maximum number of CSI SSB resource sets per resource configuration

maxNrofFailureDetectionResources        INTEGER ::= 10      -- Maximum number of failure detection resources
maxNrofFailureDetectionResources-1      INTEGER ::= 9       -- Maximum number of failure detection resources minus 1

maxNrofObjectId                         INTEGER ::= 64      -- Maximum number of measurement objects
maxNrofPCI-Ranges                       INTEGER ::= 8       -- Maximum number of PCI ranges

maxNrofCSI-RS-ResourcesRRM              INTEGER ::= 96      -- Maximum number of CSI-RS resources for an RRM measurement object
maxNrofCSI-RS-ResourcesRRM-1            INTEGER ::= 95      -- Maximum number of CSI-RS resources for an RRM measurement object minus 1
maxNrofMeasId                           INTEGER ::= 64      -- Maximum number of configured measurements
maxNrofQuantityConfig                   INTEGER ::= 2       -- Maximum number of quantity configurations
maxNrofCSI-RS-CellsRRM                  INTEGER ::= 96      -- Maximum number of FFS
```

```
maxNrofSRS-ResourceSets                 INTEGER ::= 16      -- Maximum number of SRS resource sets in a BWP.
maxNrofSRS-ResourceSets-1               INTEGER ::= 15      -- Maximum number of SRS resource sets in a BWP minus 1.
maxNrofSRS-Resources                    INTEGER ::= 64      -- Maximum number of SRS resources in an SRS resource set.
maxNrofSRS-Resources-1                  INTEGER ::= 63      -- Maximum number of SRS resources in an SRS resource set minus 1.
maxNrofSRS-TriggerStates-1              INTEGER ::= 3       -- Maximum number of SRS trigger states minus 1, i.e., the largest code point.
maxRAT-CapabilityContainers             INTEGER ::= 8       -- Maximum number of interworking RAT containers (incl NR and MRDC)
maxSimultaneousBands                    INTEGER ::= 32      -- Maximum number of simultaneously aggregated bands


maxNrofSlotFormatCombinationsPerCell    INTEGER ::= 16      -- Maximum number of
maxNrofSlotFormatCombinationsPerSet     INTEGER ::= 512 -- Maximum number of Slot Format Combinations in a SF-Set.
maxNrofSlotFormatCombinationsPerSet-1   INTEGER ::= 511 -- Maximum number of Slot Format Combinations in a SF-Set minus 1.
maxNrofPUCCH-Resources                  INTEGER ::= 128
maxNrofPUCCH-Resources-1                INTEGER ::= 127
maxNrofPUCCH-ResourceSets               INTEGER ::= 4       -- Maximum number of PUCCH Resource Sets
maxNrofPUCCH-ResourceSets-1             INTEGER ::= 3       -- Maximum number of PUCCH Resource Sets minus 1.
maxNrofPUCCH-ResourcesPerSet            INTEGER ::= 32      -- Maximum number of PUCCH Resources per PUCCH-ResourceSet
maxNrofPUCCH-ResourcesPerSet-1          INTEGER ::= 31      -- Maximum number of PUCCH Resources per PUCCH-ResourceSet minus 1.
maxNrofPUCCH-P0-PerSet                  INTEGER ::= 8       -- Maximum number of P0-pucch present in a p0-pucch set
maxNrofPUCCH-PathlossReferenceRSs       INTEGER ::= 4       -- Maximum number of RSs used as pathloss reference for PUCCH power control.
maxNrofPUCCH-PathlossReferenceRSs-1     INTEGER ::= 3       -- Maximum number of RSs used as pathloss reference for PUCCH power control minus 1.

maxNrofP0-PUSCH-AlphaSets               INTEGER ::= 30      -- Maximum number of P0-pusch-alpha-sets (see 38,213, section 7.1)
maxNrofP0-PUSCH-AlphaSets-1             INTEGER ::= 29      -- Maximum number of P0-pusch-alpha-sets minus 1 (see 38,213, section 7.1)
maxNrofPUSCH-PathlossReferenceRSs       INTEGER ::= 4       -- Maximum number of RSs used as pathloss reference for PUSCH power control.
maxNrofPUSCH-PathlossReferenceRSs-1     INTEGER ::= 3       -- Maximum number of RSs used as pathloss reference for PUSCH power control minus 1.

maxBands                                INTEGER ::= 1024        -- Maximum number of supported bands in UE capability.
maxBandsMRDC                            INTEGER ::= 1280
maxBandsEUTRA                           INTEGER ::= 256
maxCellReport                           INTEGER ::= 8
maxDRB                                  INTEGER ::= 29          -- Maximum number of DRBs (that can be added in DRB-ToAddModLIst).
maxFreq                                 INTEGER ::= 8           -- Max number of non-serving frequencies in MeasResultSCG-Failure.
maxNrofCSI-RS                           INTEGER ::= 64
maxNrofCandidateBeams                   INTEGER ::= 16          -- Max number of PRACH-ResourceDedicatedBFR that in BFR config.
maxNrofPCIsPerSMTC                      INTEGER ::= 64          -- Maximun number of PCIs per SMTC.
maxNrofQFIs                             INTEGER ::= 64
maxNrOfSemiPersistentPUSCH-Triggers     INTEGER ::= 64          -- Maximum number of triggers for semi persistent reporting on PUSCH
maxNrofSR-Resources                     INTEGER ::= 8           -- Maximum number of SR resources per BWP in a cell.
maxNrofSlotFormatsPerCombination        INTEGER ::= 256
maxNrofSpatialRelationInfos             INTEGER ::= 8
maxNrofSRS-ResourcesPerSet              INTEGER ::= 16
maxNrofIndexesToReport                  INTEGER ::= 32
maxNrofSSBs                             INTEGER ::= 64          -- Maximum number of SSB resources in a resource set.
maxNrofSSBs-1                           INTEGER ::= 63          -- Maximum number of SSB resources in a resource set minus 1.

maxNrofTCI-StatesPDCCH                  INTEGER ::= 64
maxNrofTCI-States                       INTEGER ::= 64          -- Maximum number of TCI states.
maxNrofTCI-States-1                     INTEGER ::= 63          -- Maximum number of TCI states minus 1.
maxNrofUL-Allocations                   INTEGER ::= 16          -- Maximum number of PUSCH time domain resource allocations.
maxQFI                                  INTEGER ::= 63
maxRA-CSIRS-Resources                   INTEGER ::= 96
maxRA-OccasionsPerCSIRS                 INTEGER ::= 64          -- Maximum number of RA occasions for one CSI-RS
```

```
maxRA-Occasions-1                       INTEGER ::= 511         -- Maximum number of RA occasions in the system
maxRA-SSB-Resources                     INTEGER ::= 64
maxSCSs                                 INTEGER ::= 5
maxSecondaryCellGroups                  INTEGER ::= 3
maxNrofServingCellsEUTRA                INTEGER ::= 32
maxMBSFN-Allocations                    INTEGER ::= 8
maxNrofMultiBands                       INTEGER ::= 8
maxCellSFTD                             INTEGER ::= 3           -- Maximum number of cells for SFTD reporting
maxReportConfigId                       INTEGER ::= 64
maxNrofCodebooks                        INTEGER ::= 16          -- Maximum number of codebooks suppoted by the UE

maxNrofSRI-PUSCH-Mappings               INTEGER ::= 16
maxNrofSRI-PUSCH-Mappings-1             INTEGER ::= 15

maxDownlinkFeatureSets              INTEGER ::= 1024        -- (for NR DL) Total number of FeatureSets (size of the pool)
maxUplinkFeatureSets                INTEGER ::= 1024        -- (for NR UL) Total number of FeatureSets (size of the pool)
maxEUTRA-DL-FeatureSets             INTEGER ::= 256     -- (for EUTRA) Total number of FeatureSets (size of the pool)
maxEUTRA-UL-FeatureSets             INTEGER ::= 256     -- (for EUTRA) Total number of FeatureSets (size of the pool)
maxFeatureSetsPerBand               INTEGER ::= 128         -- (for NR) The number of feature sets associated with one band.
maxPerCC-FeatureSets                INTEGER ::= 1024        -- (for NR) Total number of CC-specific FeatureSets (size of the pool)
maxFeatureSetCombinations           INTEGER ::= 1024        -- (for MR-DC/NR)Total number of Feature set combinations (size of the pool)


-- Editor's Note: Targeted for completion in Sept 2018. Not used in EN-DC drop.
CellIdentity ::=                        ENUMERATED {ffsTypeAndValue}
ShortMAC-I ::=                          ENUMERATED {ffsTypeAndValue}

-- TAG-MULTIPLICITY-AND-TYPE-CONSTRAINT-DEFINITIONS-STOP
-- ASN1STOP
```

– End of NR-RRC-Definitions

```
-- ASN1START

END

-- ASN1STOP
```

7 Variables and constants

7.1 Timers

7.1.1 Timers (Informative)

Timer	Start	Stop	At expiry
T304	Reception of *RRCReconfiguration* message including *reconfigurationWithSync*	Successful completion of random access on the corresponding SpCell For T304 of SCG, upon SCG release	For T304 of SCG, inform network about the reconfiguration with sync failure by initiating the SCG failure information procedure as specified in 5.7.3.
T310	Upon detecting physical layer problems for the SpCell i.e. upon receiving N310 consecutive out-of-sync indications from lower layers.	Upon receiving N311 consecutive in-sync indications from lower layers for the SpCell, upon receiving RRCReconfiguration with *reconfigurationWithSync* for that cell group, and upon initiating the connection re-establishment procedure. Upon SCG release, if the T310 is kept in SCG.	If the T310 is kept in MCG: If security is not activated: go to RRC_IDLE else: initiate the connection re-establishment procedure. If the T310 is kept in SCG, Inform E-UTRAN/NR about the SCG radio link failure by initiating the SCG failure information procedure as specified in 5.7.3.
T311	Upon initiating the RRC connection re-establishment procedure	Selection of a suitable NR cell or a cell using another RAT.	Enter RRC_IDLE

7.1.2 Timer handling

When the UE applies zero value for a timer, the timer shall be started and immediately expire unless explicitly stated otherwise.

7.2 Counters

Counter	Reset	Incremented	When reaching max value

7.3 Constants

Constant	Usage
N310	Maximum number of consecutive "out-of-sync" indications for the PCell received from lower layers
N311	Maximum number of consecutive "in-sync" indications for the PCell received from lower layers

7.4 UE variables

NOTE: To facilitate the specification of the UE behavioural requirements, UE variables are represented using ASN.1. Unless explicitly specified otherwise, it is however up to UE implementation how to store the variables. The optionality of the IEs in ASN.1 is used only to indicate that the values may not always be available.

– *NR-UE-Variables*

This ASN.1 segment is the start of the NR UE variable definitions.

```
-- ASN1START

NR-UE-Variables DEFINITIONS AUTOMATIC TAGS ::=

BEGIN

IMPORTS
    MeasId,
    MeasIdToAddModList,
    MeasObjectToAddModList,
    PhysCellId,
    ReportConfigToAddModList,
    RSRP-Range,
    QuantityConfig,
    maxNrofCellMeas,
    maxNrofMeasId
FROM NR-RRC-Definitions;

-- ASN1STOP
```

– *VarMeasConfig*

The UE variable *VarMeasConfig* includes the accumulated configuration of the measurements to be performed by the UE, covering intra-frequency, inter-frequency and inter-RAT mobility related measurements.

VarMeasConfig UE variable

```
-- ASN1START
-- TAG-VAR-MEAS-CONFIG-START
```

```
VarMeasConfig ::=                   SEQUENCE {
    -- Measurement identities
    measIdList                          MeasIdToAddModList                  OPTIONAL,
    -- Measurement objects
    measObjectList                      MeasObjectToAddModList              OPTIONAL,
    -- Reporting configurations
    reportConfigList                    ReportConfigToAddModList            OPTIONAL,
    -- Other parameters
    quantityConfig                      QuantityConfig                      OPTIONAL,

    s-MeasureConfig                         CHOICE {
        ssb-RSRP                                RSRP-Range,
        csi-RSRP                                RSRP-Range
    }                                                                       OPTIONAL

}

-- TAG-VAR-MEAS-CONFIG-STOP
-- ASN1STOP
```

Editor's Note: FFS Revisit whether we really need *VarMeasConfig*.

– *VarMeasReportList*

The UE variable *VarMeasReportList* includes information about the measurements for which the triggering conditions have been met.

VarMeasReportList UE variable

```
-- ASN1START
-- TAG-VAR-MEAS-REPORT-START

VarMeasReportList ::=               SEQUENCE (SIZE (1..maxNrofMeasId)) OF VarMeasReport

VarMeasReport ::=                   SEQUENCE {
    -- List of measurement that have been triggered
    measId                              MeasId,
    cellsTriggeredList                  CellsTriggeredList              OPTIONAL,
    numberOfReportsSent                 INTEGER
}

CellsTriggeredList ::=              SEQUENCE (SIZE (1..maxNrofCellMeas)) OF CHOICE {
    physCellId                          PhysCellId,
--  Not needed for EN-DC.
    physCellIdEUTRA                     ENUMERATED {ffsTypeAndValue}
    }


-- TAG-VAR-MEAS-REPORT-STOP
-- ASN1STOP
```

– End of *NR-UE-Variables*

```
-- ASN1START

END

-- ASN1STOP
```

8 Protocol data unit abstract syntax

8.1 General

The RRC PDU contents in clause 6 and clause 10 are described using abstract syntax notation one (ASN.1) as specified in ITU-T Rec. X.680 [6] and X.681 [7]. Transfer syntax for RRC PDUs is derived from their ASN.1 definitions by use of Packed Encoding Rules, unaligned as specified in ITU-T Rec. X.691 [8].

The following encoding rules apply in addition to what has been specified in X.691:

- When a bit string value is placed in a bit-field as specified in 15.6 to 15.11 in X.691, the leading bit of the bit string value shall be placed in the leading bit of the bit-field, and the trailing bit of the bit string value shall be placed in the trailing bit of the bit-field;

NOTE: The terms 'leading bit' and 'trailing bit' are defined in ITU-T Rec. X.680. When using the 'bstring' notation, the leading bit of the bit string value is on the left, and the trailing bit of the bit string value is on the right.

- When decoding types constrained with the ASN.1 Contents Constraint ("CONTAINING"), automatic decoding of the contained type should not be performed because errors in the decoding of the contained type should not cause the decoding of the entire RRC message PDU to fail. It is recommended that the decoder first decodes the outer PDU type that contains the OCTET STRING or BIT STRING with the Contents Constraint, and then decodes the contained type that is nested within the OCTET STRING or BIT STRING as a separate step;

- When decoding a) RRC message PDUs, b) BIT STRING constrained with a Contents Constraint, or c) OCTET STRING constrained with a Contents Constraint, PER decoders are required to never report an error if there are extraneous zero or non-zero bits at the end of the encoded RRC message PDU, BIT STRING or OCTET STRING.

8.2 Structure of encoded RRC messages

An RRC PDU, which is the bit string that is exchanged between peer entities/across the radio interface contains the basic production as defined in X.691.

RRC PDUs shall be mapped to and from PDCP SDUs (in case of DCCH) or RLC SDUs (in case of PCCH, BCCH or CCCH) upon transmission and reception as follows:

- when delivering an RRC PDU as an PDCP SDU to the PDCP layer for transmission, the first bit of the RRC PDU shall be represented as the first bit in the PDCP SDU and onwards; and

- when delivering an RRC PDU as an RLC SDU to the RLC layer for transmission, the first bit of the RRC PDU shall be represented as the first bit in the RLC SDU and onwards; and

- upon reception of an PDCP SDU from the PDCP layer, the first bit of the PDCP SDU shall represent the first bit of the RRC PDU and onwards; and

- upon reception of an RLC SDU from the RLC layer, the first bit of the RLC SDU shall represent the first bit of the RRC PDU and onwards.

8.3 Basic production

The 'basic production' is obtained by applying UNALIGNED PER to the abstract syntax value (the ASN.1 description) as specified in X.691. It always contains a multiple of 8 bits.

8.4 Extension

The following rules apply with respect to the use of protocol extensions:

- A transmitter compliant with this version of the specification shall, unless explicitly indicated otherwise on a PDU type basis, set the extension part empty. Transmitters compliant with a later version may send non-empty extensions;

- A transmitter compliant with this version of the specification shall set spare bits to zero.

8.5 Padding

If the encoded RRC message does not fill a transport block, the RRC layer shall add padding bits. This applies to PCCH and BCCH.

Padding bits shall be set to 0 and the number of padding bits is a multiple of 8.

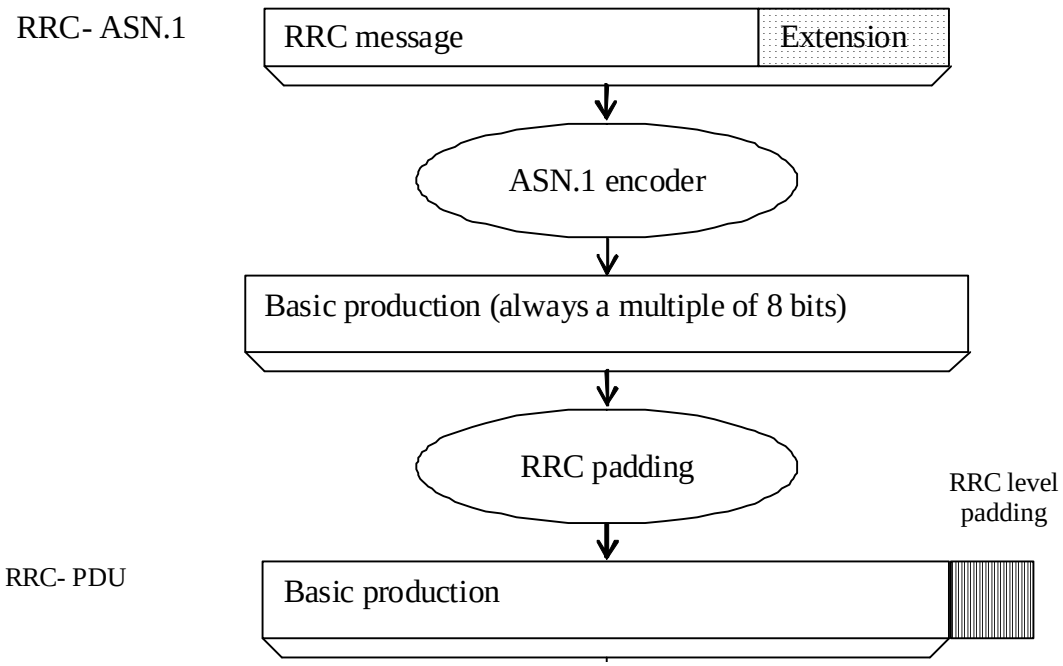


Figure 8.5-1: RRC level padding

9 Specified and default radio configurations

Specified and default configurations are configurations of which the details are specified in the standard. Specified configurations are fixed while default configurations can be modified using dedicated signalling.

Editor's Note: FFS / FIXME: Default configurations

9.1 Specified configurations

Editor's Note: FFS

9.1.1 Logical channel configurations

9.1.2 SRB configurations

9.1.2.1 SRB1/SRB1S

Parameters

Name	Value	Semantics description	Ver
RLC configuration			
logicalChannelIdentity	1		

9.1.2.2 SRB2/SRB2S

Parameters

Name	Value	Semantics description	Ver
RLC configuration			
logicalChannelIdentity	2		

9.1.2.3 SRB3

Parameters

Name	Value	Semantics description	Ver
RLC configuration			
logicalChannelIdentity	3		

9.2 Default radio configurations

9.2.1 SRB configurations

9.2.1.1 SRB1/SRB1S

Parameters (FFS)

Name	Value	Semantics description	Ver
PDCP-Config *>t-Reordering*	 *infinity*		
RLC-Config CHOICE	am		
ul-RLC-Config *>sn-FieldLength* *>t-PollRetransmit* *>pollPDU* *>pollByte* *>maxRetxThreshold*	 size12 ms45 infinity infinity t4		
dl-RLC-Config *>sn-FieldLength* *>t-Reassembly* *>t-StatusProhibit*	 size12 ms35 ms0		
LogicalChannelConfig			
>priority	1	Highest priority	
>prioritisedBitRate	infinity		
>bucketSizeDuration	N/A		
>allowedSubCarrierSpacing	FFS		
>allowedTiming	FFS		
>logicalChannelGroup	0		
>logicalChannelSR-DelayTimerApplied	false		

9.2.1.2 SRB2/SRB2S

Parameters (FFS)

Name	Value	Semantics description	Ver
PDCP-Config *>t-Reordering*	 *infinity*		
RLC-Config CHOICE	am		
ul-RLC-Config *>sn-FieldLength* *>t-PollRetransmit* *>pollPDU* *>pollByte* *>maxRetxThreshold*	 size12 ms45 infinity infinity t4		
dl-RLC-Config *>sn-FieldLength* *>t-Reassembly* *>t-StatusProhibit*	 size12 ms35 ms0		
LogicalChannelConfig			
>priority	3		
>prioritisedBitRate	infinity		
>bucketSizeDuration	N/A		
>allowedSubCarrierSpacing	FFS		
>allowedTiming	FFS		
>logicalChannelGroup	0		
>logicalChannelSR-DelayTimerApplied	false		

9.2.1.3 SRB3

Parameters (FFS)

Name	Value	Semantics description	Ver
PDCP-Config *>t-Reordering*	 *infinity*		
RLC-Config CHOICE	am		
ul-RLC-Config *>sn-FieldLength* *>t-PollRetransmit* *>pollPDU* *>pollByte* *>maxRetxThreshold*	 size12 ms45 infinity infinity t4		
dl-RLC-Config *>sn-FieldLength* *>t-Reassembly* *>t-StatusProhibit*	 size12 ms35 ms0		
LogicalChannelConfig			
>priority	1	Highest priority	
>prioritisedBitRate	infinity		
>bucketSizeDuration	N/A		
>allowedSubCarrierSpacing	FFS		
>allowedTiming	FFS		
>logicalChannelGroup	0		
>logicalChannelSR-DelayTimerApplied	false		

10 Generic error handling

10.1 General

The generic error handling defined in the subsequent sub-clauses applies unless explicitly specified otherwise e.g. within the procedure specific error handling.

The UE shall consider a value as not comprehended when it is set:

- to an extended value that is not defined in the version of the transfer syntax supported by the UE;

- to a spare or reserved value unless the specification defines specific behaviour that the UE shall apply upon receiving the concerned spare/reserved value.

The UE shall consider a field as not comprehended when it is defined:

- as spare or reserved unless the specification defines specific behaviour that the UE shall apply upon receiving the concerned spare/reserved field.

10.2 ASN.1 violation or encoding error

The UE shall:

1> when receiving an RRC message on the [BCCH] for which the abstract syntax is invalid [6]:

2> ignore the message.

NOTE: This section applies in case one or more fields is set to a value, other than a spare, reserved or extended value, not defined in this version of the transfer syntax. E.g. in the case the UE receives value 12 for a field defined as INTEGER (1..11). In cases like this, it may not be possible to reliably detect which field is in the error hence the error handling is at the message level.

10.3 Field set to a not comprehended value

The UE shall, when receiving an RRC message on any logical channel:

1> if the message includes a field that has a value that the UE does not comprehend:

2> if a default value is defined for this field:

3> treat the message while using the default value defined for this field;

2> else if the concerned field is optional:

3> treat the message as if the field were absent and in accordance with the need code for absence of the concerned field;

2> else:

3> treat the message as if the field were absent and in accordance with sub-clause 10.4.

10.4 Mandatory field missing

The UE shall:

1> if the message includes a field that is mandatory to include in the message (e.g. because conditions for mandatory presence are fulfilled) and that field is absent or treated as absent:

2> if the RRC message was received on DCCH or CCCH:

3> ignore the message;

2> else:

3> if the field concerns a (sub-field of) an entry of a list (i.e. a SEQUENCE OF):

4> treat the list as if the entry including the missing or not comprehended field was not present;

3> else if the field concerns a sub-field of another field, referred to as the 'parent' field i.e. the field that is one nesting level up compared to the erroneous field:

4> consider the 'parent' field to be set to a not comprehended value;

4> apply the generic error handling to the subsequent 'parent' field(s), until reaching the top nesting level i.e. the message level;

3> else (field at message level):

4> ignore the message.

NOTE 1: The error handling defined in these sub-clauses implies that the UE ignores a message with the message type or version set to a not comprehended value.

NOTE 2: The nested error handling for messages received on logical channels other than DCCH and CCCH applies for errors in extensions also, even for errors that can be regarded as invalid network operation e.g. the network not observing conditional presence.

The following ASN.1 further clarifies the levels applicable in case of nested error handling for errors in extension fields.

```
-- /example/ ASN1START

-- Example with extension addition group

ItemInfoList ::=                    SEQUENCE (SIZE (1..max)) OF ItemInfo

ItemInfo ::=                        SEQUENCE {
    itemIdentity                        INTEGER (1..max),
    field1                              Field1,
    field2                              Field2                  OPTIONAL,           -- Need N
    ...
    [[  field3-r9                       Field3-r9               OPTIONAL,           -- Cond Cond1
        field4-r9                       Field4-r9               OPTIONAL            -- Need N
    ]]
}

-- Example with traditional non-critical extension (empty sequence)

BroadcastInfoBlock1 ::=             SEQUENCE {
    itemIdentity                        INTEGER (1..max),
    field1                              Field1,
    field2                              Field2                  OPTIONAL,           -- Need N
    nonCriticalExtension                BroadcastInfoBlock1-v940-IEs    OPTIONAL
}

BroadcastInfoBlock1-v940-IEs::= SEQUENCE {
    field3-r9                           Field3-r9               OPTIONAL,           -- Cond Cond1
    field4-r9                           Field4-r9               OPTIONAL,           -- Need N
    nonCriticalExtension                SEQUENCE {}             OPTIONAL            -- Need S
}

-- ASN1STOP
```

The UE shall, apply the following principles regarding the levels applicable in case of nested error handling:

- an extension additon group is not regarded as a level on its own. E.g. in the ASN.1 extract in the previous, a error regarding the conditionality of *field3* would result in the entire itemInfo entry to be ignored (rather than just the extension addition group containing *field3* and *field4*);
- a traditional *nonCriticalExtension* is not regarded as a level on its own. E.g. in the ASN.1 extract in the previous, a error regarding the conditionality of *field3* would result in the entire *BroadcastInfoBlock1* to be ignored (rather than just the non critical extension containing *field3* and *field4*).

10.5 Not comprehended field

The UE shall, when receiving an RRC message on any logical channel:

1> if the message includes a field that the UE does not comprehend:

2> treat the rest of the message as if the field was absent.

NOTE: This section does not apply to the case of an extension to the value range of a field. Such cases are addressed instead by the requirements in section 10.3.

11 Radio information related interactions between network nodes

11.1 General

This section specifies RRC messages that are transferred between network nodes. These RRC messages may be transferred to or from the UE via another Radio Access Technology. Consequently, these messages have similar characteristics as the RRC messages that are transferred across the NR radio interface, i.e. the same transfer syntax and protocol extension mechanisms apply.

11.2 Inter-node RRC messages

11.2.1 General

This section specifies RRC messages that are sent either across the X2-, Xn- or the NG-interface, either to or from the gNB, i.e. a single 'logical channel' is used for all RRC messages transferred across network nodes. The information could originate from or be destined for another RAT.

```
-- ASN1START
-- TAG_NR-INTER-NODE-DEFINITIONS-START

NR-InterNodeDefinitions DEFINITIONS AUTOMATIC TAGS ::=

BEGIN

IMPORTS
    ARFCN-ValueNR,
    CellIdentity,
    CSI-RS-Index,
    GapConfig,
    maxBandComb,
    maxNrofSCells,
    maxNrofServingCells-1,
    maxNrofIndexesToReport,
    MeasQuantityResults,
    MeasResultList2NR,
    MeasResultSCG-Failure,
    MeasResultCellListSFTD,
    P-Max,
    PhysCellId,
    RadioBearerConfig,
    RRCReconfiguration,
    ServCellIndex,
    SetupRelease,
    SSB-Index,
    SSB-MTC,
    ShortMAC-I,
    UE-CapabilityRAT-ContainerList
FROM NR-RRC-Definitions;

-- TAG_NR-INTER-NODE-DEFINITIONS-STOP
```

```
-- ASN1STOP
```

11.2.2 Message definitions

– *HandoverCommand*

Editor's Note: Targeted for completion in Sept 2018.

This message is used to transfer the handover command as generated by the target gNB.

Direction: target gNB to source gNB/source RAN.

HandoverCommand message

```
-- ASN1START
-- TAG-HANDOVER-COMMAND-START

HandoverCommand ::=                 SEQUENCE {
    criticalExtensions                  CHOICE {
        c1                                  CHOICE{
            handoverCommand                 HandoverCommand-IEs,
            spare3 NULL, spare2 NULL, spare1 NULL
        },
        criticalExtensionsFuture            SEQUENCE {}
    }
}

HandoverCommand-IEs ::=             SEQUENCE {
    handoverCommandMessage              OCTET STRING (CONTAINING RRCReconfiguration),
    nonCriticalExtension                SEQUENCE {}                         OPTIONAL
}

-- TAG-HANDOVER-COMMAND-STOP
-- ASN1STOP
```

***HandoverCommand* field descriptions**
handoverCommandMessage Contains the *RRCReconfiguration* message used to perform handover within NR or handover to NR, as generated (entirely) by the target gNB.

– *HandoverPreparationInformation*

Editor's Note: Targeted for completion in Sept 2018.

This message is used to transfer the NR RRC information used by the target gNB during handover preparation, including UE capability information.

Direction: source gNB/source RAN to target gNB.

HandoverPreparationInformation message

```
-- ASN1START
-- TAG-HANDOVER-PREPARATION-INFORMATION-START

HandoverPreparationInformation ::=  SEQUENCE {
    criticalExtensions                  CHOICE {
        c1                                  CHOICE{
            handoverPreparationInformation      HandoverPreparationInformation-IEs,
            spare3 NULL, spare2 NULL, spare1 NULL
        },
        criticalExtensionsFuture            SEQUENCE {}
    }
}

HandoverPreparationInformation-IEs ::= SEQUENCE {
    ue-CapabilityRAT-List               UE-CapabilityRAT-ContainerList,
    sourceConfig                        OCTET STRING (CONTAINING RRCReconfiguration),
    rrm-Config                          RRM-Config              OPTIONAL,
    as-Context                          AS-Context              OPTIONAL,
    nonCriticalExtension                SEQUENCE {}             OPTIONAL
}

AS-Context ::=                          SEQUENCE {
    reestablishmentInfo                     SEQUENCE {
        sourcePhysCellId                        PhysCellId,
        targetCellShortMAC-I                    ShortMAC-I,
        additionalReestabInfoList               ReestabNCellInfoList                    OPTIONAL
    }                                                                                   OPTIONAL,
    -- FFS Whether to change e.g. move all re-establishment info to Xx
    configRestrictInfo                  ConfigRestrictInfoSCG                       OPTIONAL,
    ...
}

ReestabNCellInfoList ::=        SEQUENCE ( SIZE (1..maxCellPrep) ) OF ReestabNCellInfo

ReestabNCellInfo::= SEQUENCE{
    cellIdentity                            CellIdentity,
    key-gNodeB-Star                         BIT STRING (SIZE (256)),
    shortMAC-I                              ShortMAC-I
}

RRM-Config ::=              SEQUENCE {
    ue-InactiveTime             ENUMERATED {
                                    s1, s2, s3, s5, s7, s10, s15, s20,
                                    s25, s30, s40, s50, min1, min1s20c, min1s40,
                                    min2, min2s30, min3, min3s30, min4, min5, min6,
                                    min7, min8, min9, min10, min12, min14, min17, min20,
                                    min24, min28, min33, min38, min44, min50, hr1,
                                    hr1min30, hr2, hr2min30, hr3, hr3min30, hr4, hr5, hr6,
                                    hr8, hr10, hr13, hr16, hr20, day1, day1hr12, day2,
                                    day2hr12, day3, day4, day5, day7, day10, day14, day19,
                                    day24, day30, dayMoreThan30}        OPTIONAL ,
    candidateCellInfoList       MeasResultList2NR       OPTIONAL,
```

```
    ...
}

-- TAG-HANDOVER-PREPARATION-INFORMATION-STOP
-- ASN1STOP
```

***HandoverPreparationInformation* field descriptions**
as-Context Local RAN context required by the target gNB.
sourceConfig The radio resource configuration as used in the source cell.
rrm-Config Local RAN context used mainly for RRM purposes.
ue-CapabilityRAT-List The UE radio access related capabilities concerning RATs supported by the UE. FFS whether certain capabilities are mandatory to provide by source e.g. of target and/or source RAT.

– *CG-Config*

This message is used to transfer the SCG radio configuration as generated by the SgNB.

Direction: Secondary gNB to master gNB or eNB.

***CG-Config* message**

```
-- ASN1START
-- TAG-CG-CONFIG-START

CG-Config ::=                   SEQUENCE {
    criticalExtensions                  CHOICE {
        c1                                  CHOICE{
            cg-Config                   CG-Config-IEs,
            spare3 NULL, spare2 NULL, spare1 NULL
        },
        criticalExtensionsFuture            SEQUENCE {}
    }
}

CG-Config-IEs ::=           SEQUENCE {
    scg-CellGroupConfig                 OCTET STRING (CONTAINING RRCReconfiguration)    OPTIONAL,
    scg-RB-Config                       OCTET STRING (CONTAINING RadioBearerConfig)     OPTIONAL,
    configRestrictModReq                ConfigRestrictModReqSCG                         OPTIONAL,
    drx-InfoSCG                         DRX-Info                                        OPTIONAL,
    candidateCellInfoListSN             OCTET STRING (CONTAINING MeasResultList2NR) OPTIONAL,
    measConfigSN                        MeasConfigSN                                    OPTIONAL,
    selectedBandCombinationNR           BandCombinationIndex                            OPTIONAL,
    fr-InfoListSCG                      FR-InfoList                                     OPTIONAL,
    nonCriticalExtension                SEQUENCE {}                                     OPTIONAL
}
```

```
MeasConfigSN ::= SEQUENCE {
    measuredFrequenciesSN               SEQUENCE (SIZE (1.. maxMeasFreqsSN))    OF NR-FreqInfo  OPTIONAL,
    ...
}

NR-FreqInfo ::= SEQUENCE {
    measuredFrequency                   ARFCN-ValueNR                                   OPTIONAL,
    ...
}

ConfigRestrictModReqSCG ::=         SEQUENCE {
    requestedBC-MRDC                    BandCombinationIndex                            OPTIONAL,
    requestedP-MaxFR1                   P-Max                                           OPTIONAL,
    ...
}

BandCombinationIndex ::= INTEGER (1..maxBandComb)

FR-InfoList ::= SEQUENCE (SIZE (1..maxNrofServingCells-1)) OF FR-Info

FR-Info ::= SEQUENCE {
    servCellIndex       ServCellIndex,
    fr-Type             ENUMERATED {fr1, fr2}
}

-- TAG-CG-CONFIG-STOP
-- ASN1STOP
```

***CG-Config* field descriptions**
candidateCellInfoListSN Contains information regarding cells that the source secondary node suggests the target secondary gNB to consider configuring.
fr-InfoListSCG Contains information of FR information of serving cells.
measuredFrequenciesSN Used by SN to indicate a list of frequencies measured by the UE.
requestedP-MaxFR1 IRequested value for the maximum power for FR1 (see TS 38.104 [12]) the UE can use in NR SCG.
requestedBC-MRDC Used to request configuring an NR band combination which is forbidden to use by MN. Each entry refers to a band combination numbered according to supportedBandCombination in the UE-MRDC-Capability.
scg-CellGroupConfig Contains the RRCReconfiguration message, used to (re-)configure the SCG configuration upon SCG establishment or modification, as generated (entirely) by the (target) SgNB
scg-RB-Config Contains the IE RadioBearerConfig, used to establish or reconfigure the SCG configuration, used to (re-)configure the SCG RB configuration upon SCG establishment or modification, as generated (entirely) by the (target) SgNB
selectedBandCombinationNR Indicates the band combination selected by SN for the EN-DC.
configRestrictModReq Used by SN to request changes to SCG configuration restrictions previously set by MN to ensure UE capabilities are respected. E.g. can used to request configuring an NR band combination whose use MN has previously forbidden.

– *CG-ConfigInfo*

This message is used by master eNB or gNB to request the SgNB to perform certain actions e.g. to establish, modify or release an SCG. The message may include additional information e.g. to assist the SgNB to set the SCG configuration.It can also be used by a CU to request a DU to perform certain actions, e.g. to establish, modify or release an MCG or SCG.

Direction: Master eNB or gNB to secondary gNB, alternatively CU to DU.

***CG-ConfigInfo* message**

```
-- ASN1START
-- TAG-CG-CONFIG-INFO-START

CG-ConfigInfo ::=               SEQUENCE {
    criticalExtensions              CHOICE {
        c1                              CHOICE{
            cg-ConfigInfo               CG-ConfigInfo-IEs,
            spare3 NULL, spare2 NULL, spare1 NULL
        },
        criticalExtensionsFuture        SEQUENCE {}
    }
}
```

```
CG-ConfigInfo-IEs ::=       SEQUENCE {
    ue-CapabilityInfo           OCTET STRING (CONTAINING UE-CapabilityRAT-ContainerList)        OPTIONAL,-- Cond SN-Addition
    candidateCellInfoListMN         MeasResultList2NR                                       OPTIONAL,
    candidateCellInfoListSN         OCTET STRING (CONTAINING MeasResultList2NR)             OPTIONAL,
    measResultCellListSFTD          MeasResultCellListSFTD                                      OPTIONAL,
    scgFailureInfo                  SEQUENCE {
        failureType                     ENUMERATED { t310-Expiry, randomAccessProblem,
                                                     rlc-MaxNumRetx, scg-ChangeFailure,
                                                     scg-reconfigFailure,
                                                     srb3-IntegrityFailure},
        measResultSCG                   OCTET STRING (CONTAINING MeasResultSCG-Failure)
    }                                                                                           OPTIONAL,
    configRestrictInfo          ConfigRestrictInfoSCG                                           OPTIONAL,
    drx-InfoMCG                 DRX-Info                                                        OPTIONAL,
    measConfigMN                MeasConfigMN                                                    OPTIONAL,
    sourceConfigSCG             OCTET STRING (CONTAINING RRCReconfiguration)                    OPTIONAL,
    scg-RB-Config               OCTET STRING (CONTAINING RadioBearerConfig)                     OPTIONAL,
    mcg-RB-Config               OCTET STRING (CONTAINING RadioBearerConfig)                     OPTIONAL,
    nonCriticalExtension        SEQUENCE {}                                                     OPTIONAL
}

ConfigRestrictInfoSCG ::=       SEQUENCE {
    allowedBC-ListMRDC              BandCombinationIndexList                                    OPTIONAL,
    powerCoordination-FR1               SEQUENCE {
        p-maxNR                         P-Max                                                   OPTIONAL,
        p-maxEUTRA                      P-Max                                                   OPTIONAL
    }                                                                                           OPTIONAL,
    servCellIndexRangeSCG           SEQUENCE {
        lowBound                        ServCellIndex,
        upBound                         ServCellIndex
    }                                                                                           OPTIONAL,   -- Cond SN-Addition
    maxMeasFreqsSCG-NR                  INTEGER(1..maxMeasFreqsMN)                              OPTIONAL,
    maxMeasIdentitiesSCG-NR             INTEGER(1..maxMeasIdentitiesMN)                         OPTIONAL,
    ...
}

BandCombinationIndexList ::= SEQUENCE (SIZE (1..maxBandComb)) OF BandCombinationIndex

DRX-Info ::=                    SEQUENCE {
    drx-LongCycleStartOffset        CHOICE {
        ms10                            INTEGER(0..9),
        ms20                            INTEGER(0..19),
        ms32                            INTEGER(0..31),
        ms40                            INTEGER(0..39),
        ms60                            INTEGER(0..59),
        ms64                            INTEGER(0..63),
        ms70                            INTEGER(0..69),
        ms80                            INTEGER(0..79),
        ms128                           INTEGER(0..127),
        ms160                           INTEGER(0..159),
        ms256                           INTEGER(0..255),
        ms320                           INTEGER(0..319),
        ms512                           INTEGER(0..511),
```

```
        ms640                           INTEGER(0..639),
        ms1024                          INTEGER(0..1023),
        ms1280                          INTEGER(0..1279),
        ms2048                          INTEGER(0..2047),
        ms2560                          INTEGER(0..2559),
        ms5120                          INTEGER(0..5119),
        ms10240                         INTEGER(0..10239)
    },
    shortDRX                            SEQUENCE {
        drx-ShortCycle                      ENUMERATED  {
                                                ms2, ms3, ms4, ms5, ms6, ms7, ms8, ms10, ms14, ms16, ms20, ms30, ms32,
                                                ms35, ms40, ms64, ms80, ms128, ms160, ms256, ms320, ms512, ms640, spare9,
                                                spare8, spare7, spare6, spare5, spare4, spare3, spare2, spare1 },
        drx-ShortCycleTimer                 INTEGER (1..16)
    }                                                                   OPTIONAL
}

MeasConfigMN ::= SEQUENCE {
    measuredFrequenciesMN               SEQUENCE (SIZE (1..maxMeasFreqsMN)) OF NR-FreqInfo  OPTIONAL,
    measGapConfig                   SetupRelease { GapConfig }          OPTIONAL,
    gapPurpose                          ENUMERATED {perUE, perFR1}          OPTIONAL,
    ...
}


-- TAG-CG-CONFIG-INFO-STOP
-- ASN1STOP
```

***CG-ConfigInfo* field descriptions**
allowedBandCombinationListMRDC A list of indices referring to band combinations in MR-DC capabilities from which SN is allowed to select an NR band combination. Each entry refers to a band combination numbered according to supportedBandCombination in the UE-MRDC-Capability. All MR-DC band combinations indicated by this field comprise the same LTE band combination.
candidateCellInfoListMN, ***candidateCellInfoListSN*** Contains information regarding cells that the master node or the source node suggests the target gNB to consider configuring. Including CSI-RS measurement results in candidateCellInfoListMN is not supported in this version of the specification.
maxMeasFreqsSCG-NR Indicates the maximum number of NR inter-frequency carriers the SN is allowed to configure with PSCell for measurements.
maxMeasIdentitiesSCG-NR Indicates the maximum number of allowed measurement identities that the SCG is allowed to configure.
measuredFrequenciesMN Used by MN to indicate a list of frequencies measured by the UE.
measGapConfig Indicates the measurement gap configuration configured by MN.
mcg-RB-Config Contains the IE RadioBearerConfig of the MN, used to support delta configuration for bearer type change between MN terminated to SN terminated bearer and SN change.
p-maxEUTRA Indicates the maximum power for EUTRA (see TS 36.104 [XX]) the UE can use in LTE MCG.
p-maxNR Indicates the maximum power for NR (see TS 38.104 [12]) the UE can use in NR SCG.
powerCoordination-FR1 Indicates the maximum power that the UE can use in FR1.
scg-RB-Config Contains the IE RadioBearerConfig of the SN, used to support delta configuration e.g. during SN change. This field is absent when master eNB uses full configuration option.
sourceConfigSCG Includes the current dedicated SCG configuration in the same format as the *RRCReconfiguration* message, i.e. not only CellGroupConfig but also e.g. measConfig. This field is absent when master eNB uses full configuration option.
ConfigRestrictInfo Includes fields for which SgNB is explictly indicated to observe a configuration restriction.
servCellIndexRangeSCG Range of serving cell indices that SN is allowed to configure for SCG serving cells.

Conditional Presence	Explanation
SN-Addition	The field is mandatory present upon SN addition.

– *MeasurementTimingConfiguration*

Editor's Note: Targeted for completion in Sept 2018. Usage and Direction need further RAN2 discussions.

The *MeasurementTimingConfiguration* message is used to convey assistance information for measurement timing betwen master eNB and secondary gNB.

Direction: Secondary gNB to Master eNB, alternatively gNB DU to gNB CU, and gNB CU to gNB DU.

***MeasurementTimingConfiguration* message**

```
-- ASN1START
-- TAG-MEASUREMENT-TIMING-CONFIGURATION-START

MeasurementTimingConfiguration ::=              SEQUENCE {
    criticalExtensions              CHOICE {
        c1                              CHOICE{
            measTimingConf                  MeasurementTimingConfiguration-IEs,
            spare3 NULL, spare2 NULL, spare1 NULL
        },
        criticalExtensionsFuture        SEQUENCE {}
    }
}

MeasurementTimingConfiguration-IEs ::=  SEQUENCE {
    measTiming                          MeasTimingList                          OPTIONAL,
    nonCriticalExtension                SEQUENCE {}                             OPTIONAL
}

MeasTimingList ::= SEQUENCE (SIZE (1..maxMeasFreqsMN)) OF MeasTiming

MeasTiming ::= SEQUENCE {
    frequencyAndTiming                  SEQUENCE {
        carrierFreq                         ARFCN-ValueNR,
        ssb-MeasurementTimingConfiguration  SSB-MTC
    }                                                                           OPTIONAL,
    ...
}

-- TAG-MEASUREMENT-TIMING-CONFIGURATION-STOP
-- ASN1STOP
```

***MeasurementTimingConfiguration* field descriptions**
measTiming A list of SMTC information and associated NR frequency that SN informs MN via EN-DC X2 Setup and EN-DC Configuration Update procedures, or F1 messages from gNB DU to gNB CU.

11.3 Inter-node RRC information element definitions

11.4 Inter-node RRC multiplicity and type constraint values

– Multiplicity and type constraints definitions

```
-- ASN1START
-- TAG_NR-MULTIPLICITY-AND-CONSTRAINTS-START

maxMeasFreqsMN              INTEGER ::= 32  -- Maximum number of MN-configured measurement frequencies
maxMeasFreqsSN              INTEGER ::= 32  -- Maximum number of SN-configured measurement frequencies
maxMeasIdentitiesMN         INTEGER ::= 62  -- Maximum number of measurement identities that a UE can be configured with
maxCellPrep                 INTEGER ::= 32  -- Maximum number of cells prepared for handover

-- TAG_NR-MULTIPLICITY-AND-CONSTRAINTS-STOP
-- ASN1STOP
```

– *End of NR-InterNodeDefinitions*

```
-- ASN1START
-- TAG_NR-INTER-NODE-DEFINITIONS-END-START

END

-- TAG_NR-INTER-NODE-DEFINITIONS-END-STOP
-- ASN1STOP
```

12 Processing delay requirements for RRC procedures

The UE performance requirements for RRC procedures are specified in the following tables. The performance requirement is expressed as the time in [ms] from the end of reception of the network -> UE message on the UE physical layer up to when the UE shall be ready for the reception of uplink grant for the UE -> network response message with no access delay other than the TTI-alignment (e.g. excluding delays caused by scheduling, the random access procedure or physical layer synchronisation).

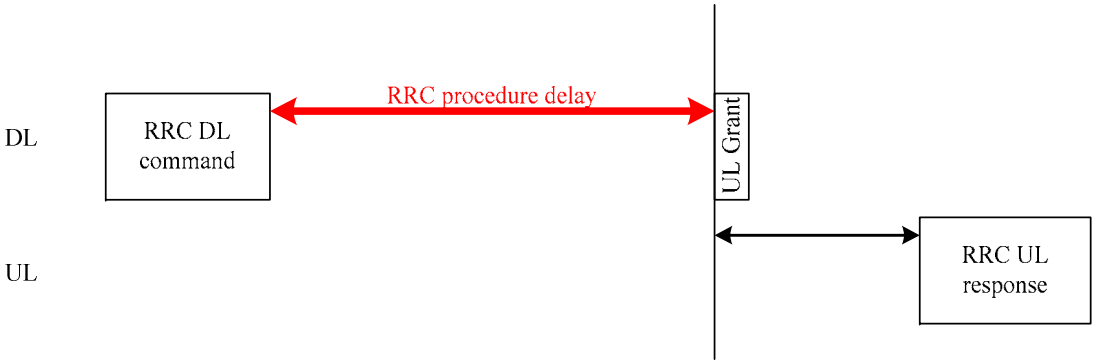


Figure 11.2-1: Illustration of RRC procedure delay

Table 11.2-1: UE performance requirements for RRC procedures for UEs

Procedure title:	Network -> UE	UE -> Network	Value [ms]	Notes
RRC Connection Control Procedures				
RRC reconfiguration	*RRCReconfiguration*	*RRCReconfigurationComplete*	X	

Annex A (informative): Guidelines, mainly on use of ASN.1

A.1 Introduction

The following clauses contain guidelines for the specification of RRC protocol data units (PDUs) with ASN.1.

A.2 Procedural specification

A.2.1 General principles

The procedural specification provides an overall high level description regarding the UE behaviour in a particular scenario.

It should be noted that most of the UE behaviour associated with the reception of a particular field is covered by the applicable parts of the PDU specification. The procedural specification may also include specific details of the UE behaviour upon reception of a field, but typically this should be done only for cases that are not easy to capture in the PDU section e.g. general actions, more complicated actions depending on the value of multiple fields.

Likewise, the procedural specification need not specify the UE requirements regarding the setting of fields within the messages that are sent to the network i.e. this may also be covered by the PDU specification.

A.2.2 More detailed aspects

The following more detailed conventions should be used:

- Bullets:
  - Capitals should be used in the same manner as in other parts of the procedural text i.e. in most cases no capital applies since the bullets are part of the sentence starting with 'The UE shall:'
  - All bullets, including the last one in a sub-clause, should end with a semi-colon i.e. an ';.
- Conditions:
  - Whenever multiple conditions apply, a semi-colon should be used at the end of each conditions with the exception of the last one, i.e. as in 'if cond1, or cond2.

A.3 PDU specification

A.3.1 General principles

A.3.1.1 ASN.1 sections

The RRC PDU contents are formally and completely described using abstract syntax notation (ASN.1), see X.680 [13], X.681 (02/2002) [14].

The complete ASN.1 code is divided into a number of ASN.1 sections in the specifications. In order to facilitate the extraction of the complete ASN.1 code from the specification, each ASN.1 section begins with the following:

- a first text paragraph consisting entirely of an *ASN.1 start tag*, which consists of a double hyphen followed by a single space and the text string "ASN1START" (in all upper case letters);

- a second text paragraph consisting entirely of a *block start tag* is included, which consists of a double hyphen followed by a single space and the text string "TAG-NAME-START" (in all upper case letters), where the "NAME" refers to the main name of the paragraph (in all upper-case letters).

Similarly, each ASN.1 section ends with the following:

- a first text paragraph consisting entirely of a *block stop tag*, which consists of a double hyphen followed by a single space and the text string "TAG-NAME-STOP" (in all upper-case letters), where the "NAME" refers to the main name of the paragraph (in all upper-case letters);

- a second text paragraph consisting entirely of an *ASN.1 stop tag*, which consists of a double hyphen followed by a singlespace and the text "ASN1STOP" (in all upper case letters).

This results in the following tags:

```
-- ASN1START
-- TAG-NAME-START

-- TAG-NAME-STOP
-- ASN1STOP
```

The text paragraphs containing either of thestart and stop tags should not contain any ASN.1 code significant for the complete description of the RRC PDU contents. The complete ASN.1 code may be extracted by copying all the text paragraphs between an ASN.1 start tag and the following ASN.1 stop tag in the order they appear, throughout the specification.

NOTE: A typical procedure for extraction of the complete ASN.1 code consists of a first step where the entire RRC PDU contents description (ultimately the entire specification) is saved into a plain text (ASCII) file format, followed by a second step where the actual extraction takes place, based on the occurrence of the ASN.1 start and stop tags.

A.3.1.2 ASN.1 identifier naming conventions

The naming of identifiers (i.e., the ASN.1 field and type identifiers) should be based on the following guidelines:

- Message (PDU) identifiers should be ordinary mixed case without hyphenation. These identifiers, *e.g.*, the *RRCConnectionModificationCommand*, should be used for reference in the procedure text. Abbreviations should be avoided in these identifiers and abbreviated forms of these identifiers should not be used.

- Type identifiers other than PDU identifiers should be ordinary mixed case, with hyphenation used to set off acronyms only where an adjacent letter is a capital, *e.g.*, *EstablishmentCause*, *SelectedPLMN* (not *Selected-PLMN*, since the "d" in "Selected" is lowercase), *InitialUE-Identity* and *MeasSFN-SFN-TimeDifference*.

- Field identifiers shall start with a lowercase letter and use mixed case thereafter, *e.g.*, *establishmentCause*. If a field identifier begins with an acronym (which would normally be in upper case), the entire acronym is lowercase (*plmn-Identity*, not *pLMN-Identity*). The acronym is set off with a hyphen (*ue-Identity*, not *ueIdentity*), in order to facilitate a consistent search pattern with corresponding type identifiers.

- Identifiers should convey the meaning of the identifier and should avoid adding unnecessary postfixes (e.g. abstractions like 'Info') for the name.

- Identifiers that are likely to be keywords of some language, especially widely used languages, such as C++ or Java, should be avoided to the extent possible.

- Identifiers, other than PDU identifiers, longer than 25 characters should be avoided where possible. It is recommended to use abbreviations, which should be done in a consistent manner i.e. use 'Meas' instead of 'Measurement' for all occurrences. Examples of typical abbreviations are given in table A.3.1.2.1-1 below.

- *For future extension:* When an extension is introduced a suffix is added to the identifier of the concerned ASN.1 field and/or type. A suffix of the form "-rX" is used, with X indicating the release, for ASN.1 fields or types introduced in a later release (i.e. a release later than the original/first release of the protocol) as well as for ASN.1 fields or types for which a revision is introduced in a later release replacing a previous version, *e.g.*, *Foo-r9* for the Rel-9 version of the ASN.1 type *Foo*. A suffix of the form "-rXb" is used for the first revision of a field that it appears in the same release (X) as the original version of the field, "-rXc" for a second intra-release revision and so on. A suffix of the form "-vXYZ" is used for ASN.1 fields or types that only are an extension of a corresponding earlier field or type (see sub-clause A.4), e.g., *AnElement-v10b0* for the extension of the ASN.1 type *AnElement* introduced in version 10.11.0 of the specification. A number *0...9, 10, 11, etc.* is used to represent the first part of the version number, indicating the release of the protocol. Lower case letters *a, b, c, etc.* are used to represent the second (and third) part of the version number if they are greater than 9. In the procedural specification, in field descriptions as well as in headings suffices are not used, unless there is a clear need to distinguish the extension from the original field.

- More generally, in case there is a need to distinguish different variants of an ASN.1 field or IE, a suffix should be added at the end of the identifiers e.g. *MeasObjectUTRA*, *ConfigCommon*. When there is no particular need to distinguish the fields (e.g. because the field is included in different IEs), a common field identifier name may be used. This may be attractive e.g. in case the procedural specification is the same for the different variants.

- It should be avoided to use field identifiers with the same name within the elements of a CHOICE, including using a CHOICE inside a SEQUENCE (to avoid certain compiler errors).

Table A.3.1.2-1: Examples of typical abbreviations used in ASN.1 identifiers

Abbreviation	Abbreviated word
Config	Configuration
DL	Downlink
Ext	Extension
Freq	Frequency
Id	Identity
Ind	Indication
Meas	Measurement
MIB	MasterInformationBlock
Neigh	Neighbour(ing)
Param(s)	Parameter(s)
Phys	Physical
PCI	Physical Cell Id
Proc	Process
Reconfig	Reconfiguration
Reest	Re-establishment
Req	Request
Rx	Reception
Sched	Scheduling
SIB	SystemInformationBlock
Sync	Synchronisation
Thr	Threshold
Tx	Transmission
UL	Uplink

NOTE: The table A.3.1.2.1-1 is not exhaustive. Additional abbreviations may be used in ASN.1 identifiers when needed.

A.3.1.3 Text references using ASN.1 identifiers

A text reference into the RRC PDU contents description from other parts of the specification is made using the ASN.1 field identifier of the referenced type. The ASN.1 field and type identifiers used in text references should be in the *italic font style*. The "do not check spelling and grammar" attribute in Word should be set. Quotation marks (i.e., " ") should not be used around the ASN.1 field or type identifier.

A reference to an RRC PDU should be made using the corresponding ASN.1 field identifier followed by the word "message", e.g., a reference to the *RRCRelease* message.

A reference to a specific part of an RRC PDU, or to a specific part of any other ASN.1 type, should be made using the corresponding ASN.1 field identifier followed by the word "field", e.g., a reference to the *prioritisedBitRate* field in the example below.

```
-- /example/ ASN1START

LogicalChannelConfig ::=            SEQUENCE {
    ul-SpecificParameters               SEQUENCE {
        priority                            Priority,
```

```
        prioritisedBitRate                  PrioritisedBitRate,
        bucketSizeDuration                  BucketSizeDuration,
        logicalChannelGroup                 INTEGER (0..3)
    }       OPTIONAL
}

-- ASN1STOP
```

NOTE: All the ASN.1 start tags in the ASN.1 sections, used as examples in this annex to the specification, are deliberately distorted, in order not to include them when the ASN.1 description of the RRC PDU contents is extracted from the specification.

A reference to a specific type of information element should be made using the corresponding ASN.1 type identifier preceded by the acronym "IE", e.g., a reference to the IE *LogicalChannelConfig* in the example above.

References to a specific type of information element should only be used when those are generic, i.e., without regard to the particular context wherein the specific type of information element is used. If the reference is related to a particular context, e.g., an RRC PDU type (message) wherein the information element is used, the corresponding field identifier in that context should be used in the text reference.

A reference to a specific value of an ASN.1 field should be made using the corresponding ASN.1 value without using quotation marks around the ASN.1 value, e.g., 'if the *status* field is set to value *true*'.

A.3.2 High-level message structure

Within each logical channel type, the associated RRC PDU (message) types are alternatives within a CHOICE, as shown in the example below.

```
-- /example/ ASN1START

DL-DCCH-Message ::= SEQUENCE {
    message                 DL-DCCH-MessageType
}

DL-DCCH-MessageType ::= CHOICE {
    c1                      CHOICE {
        dlInformationTransfer                   DLInformationTransfer,
        handoverFromEUTRAPreparationRequest     HandoverFromEUTRAPreparationRequest,
        mobilityFromEUTRACommand                MobilityFromEUTRACommand,
        rrcConnectionReconfiguration            RRCConnectionReconfiguration,
        rrcConnectionRelease                    RRCConnectionRelease,
        securityModeCommand                     SecurityModeCommand,
        ueCapabilityEnquiry                     UECapabilityEnquiry,
        spare1 NULL
    },
    messageClassExtension   SEQUENCE {}
}

-- ASN1STOP
```

A nested two-level CHOICE structure is used, where the alternative PDU types are alternatives within the inner level *c1* CHOICE.

Spare alternatives (i.e., *spare1* in this case) may be included within the *c1* CHOICE to facilitate future extension. The number of such spare alternatives should not extend the total number of alternatives beyond an integer-power-of-two number of alternatives (i.e., eight in this case).

Further extension of the number of alternative PDU types is facilitated using the *messageClassExtension* alternative in the outer level CHOICE.

A.3.3 Message definition

Each PDU (message) type is specified in an ASN.1 section similar to the one shown in the example below.

```
-- /example/ ASN1START

RRCConnectionReconfiguration ::=    SEQUENCE {
    rrc-TransactionIdentifier           RRC-TransactionIdentifier,
    criticalExtensions                  CHOICE {
        c1                                  CHOICE{
            rrcConnectionReconfiguration-r8     RRCConnectionReconfiguration-r8-IEs,
            spare3 NULL, spare2 NULL, spare1 NULL
        },
        criticalExtensionsFuture            SEQUENCE {}
    }
}

RRCConnectionReconfiguration-r8-IEs ::= SEQUENCE {
    -- Enter the IEs here.
    ...
}

-- ASN1STOP
```

Hooks for *critical* and *non-critical* extension should normally be included in the PDU type specification. How these hooks are used is further described in sub-clause A.4.

Critical extensions are characterised by a redefinition of the PDU contents and need to be governed by a mechanism for protocol version agreement between the encoder and the decoder of the PDU, such that the encoder is prevented from sending a critically extended version of the PDU type, which is not comprehended by the decoder.

Critical extension of a PDU type is facilitated by a two-level CHOICE structure, where the alternative PDU contents are alternatives within the inner level *c1* CHOICE. Spare alternatives (i.e., *spare3* down to *spare1* in this case) may be included within the *c1* CHOICE. The number of spare alternatives to be included in the original PDU specification should be decided case by case, based on the expected rate of critical extension in the future releases of the protocol.

Further critical extension, when the spare alternatives from the original specifications are used up, is facilitated using the *criticalExtensionsFuture* in the outer level CHOICE.

In PDU types where critical extension is not expected in the future releases of the protocol, the inner level *c1* CHOICE and the spare alternatives may be excluded, as shown in the example below.

```
-- /example/ ASN1START

RRCConnectionReconfigurationComplete ::= SEQUENCE {
    rrc-TransactionIdentifier           RRC-TransactionIdentifier,
    criticalExtensions                  CHOICE {
        rrcConnectionReconfigurationComplete-r8
```

```
                                        RRCConnectionReconfigurationComplete-r8-IEs,
        criticalExtensionsFuture        SEQUENCE {}
    }
}

RRCConnectionReconfigurationComplete-r8-IEs ::= SEQUENCE {
    -- Enter the fields here.
    ...
}

-- ASN1STOP
```

Non-critical extensions are characterised by the addition of new information to the original specification of the PDU type. If not comprehended, a non-critical extension may be skipped by the decoder, whilst the decoder is still able to complete the decoding of the comprehended parts of the PDU contents.

Non-critical extensions at locations other than the end of the message or other than at the end of a field contained in a BIT or OCTET STRING are facilitated by use of the ASN.1 extension marker "...". The original specification of a PDU type should normally include the extension marker at the end of the sequence of information elements contained.

Non-critical extensions at the end of the message or at the end of a field that is contained in a BIT or OCTET STRING may be facilitated by use of an empty sequence that is marked OPTIONAL e.g. as shown in the following example:

```
-- /example/ ASN1START

RRCMessage-r8-IEs ::=                   SEQUENCE {
    field1                                  InformationElement1,
    field2                                  InformationElement2,

    nonCriticalExtension                    SEQUENCE {}                     OPTIONAL
}

-- ASN1STOP
```

The ASN.1 section specifying the contents of a PDU type may be followed by a *field description* table where a further description of, e.g., the semantic properties of the fields may be included. The general format of this table is shown in the example below. The field description table is absent in case there are no fields for which further description needs to be provided e.g. because the PDU does not include any fields, or because an IE is defined for each field while there is nothing specific regarding the use of this IE that needs to be specified.

***%PDU-TypeIdentifier%* field descriptions**
%field identifier% Field description.
%field identifier% Field description.

The field description table has one column. The header row shall contain the ASN.1 type identifier of the PDU type.

The following rows are used to provide field descriptions. Each row shall include a first paragraph with a *field identifier* (in ***bold and italic*** font style) referring to the part of the PDU to which it applies. The following paragraphs at the same row may include (in regular font style), e.g., semantic description, references to other specifications and/or specification of value units, which are relevant for the particular part of the PDU.

The parts of the PDU contents that do not require a field description shall be omitted from the field description table.

A.3.4 Information elements

Each IE (information element) type is specified in an ASN.1 section similar to the one shown in the example below.

```
-- /example/ ASN1START

PRACH-ConfigSIB ::=                 SEQUENCE {
    rootSequenceIndex                   INTEGER (0..1023),
    prach-ConfigInfo                    PRACH-ConfigInfo
}

PRACH-Config ::=                    SEQUENCE {
    rootSequenceIndex                   INTEGER (0..1023),
    prach-ConfigInfo                    PRACH-ConfigInfo                    OPTIONAL    -- Need N
}

PRACH-ConfigInfo ::=                SEQUENCE {
    prach-ConfigIndex                   ENUMERATED {ffs},
    highSpeedFlag                       ENUMERATED {ffs},
    zeroCorrelationZoneConfig           ENUMERATED {ffs}
}

-- ASN1STOP
```

IEs should be introduced whenever there are multiple fields for which the same set of values apply. IEs may also be defined for other reasons e.g. to break down a ASN.1 definition in to smaller pieces.

A group of closely related IE type definitions, like the IEs *PRACH-ConfigSIB* and *PRACH-Config* in this example, are preferably placed together in a common ASN.1 section. The IE type identifiers should in this case have a common base, defined as the *generic type identifier*. It may be complemented by a suffix to distinguish the different variants. The "*PRACH-Config*" is the generic type identifier in this example, and the "*SIB*" suffix is added to distinguish the variant. The sub-clause heading and generic references to a group of closely related IEs defined in this way should use the generic type identifier.

The same principle should apply if a new version, or an extension version, of an existing IE is created for *critical* or *non-critical* extension of the protocol (see sub-clause A.4). The new version, or the extension version, of the IE is included in the same ASN.1 section defining the original. A suffix is added to the type identifier, using the naming conventions defined in sub-clause A.3.1.2, indicating the release or version of the where the new version, or extension version, was introduced.

Local IE type definitions, like the IE *PRACH-ConfigInfo* in the example above, may be included in the ASN.1 section and be referenced in the other IE types defined in the same ASN.1 section. The use of locally defined IE types should be encouraged, as a tool to break up large and complex IE type definitions. It can improve the readability of the code. There may also be a benefit for the software implementation of the protocol end-points, as these IE types are typically provided by the ASN.1 compiler as independent data elements, to be used in the software implementation.

An IE type defined in a local context, like the IE *PRACH-ConfigInfo*, should not be referenced directly from other ASN.1 sections in the RRC specification. An IE type which is referenced in more than one ASN.1 section should be defined in a separate sub-clause, with a separate heading and a separate ASN.1 section (possibly as one in a set of closely related IE types, like the IEs *PRACH-ConfigSIB* and *PRACH-Config* in the example above). Such IE types are also referred to as 'global IEs'.

NOTE: Referring to an IE type, that is defined as a local IE type in the context of another ASN.1 section, does not generate an ASN.1 compilation error. Nevertheless, using a locally defined IE type in that way makes the IE type definition difficult to find, as it would not be visible at an outline level of the specification. It should be avoided.

The ASN.1 section specifying the contents of one or more IE types, like in the example above, may be followed by a *field description* table, where a further description of, e.g., the semantic properties of the fields of the information elements may be included. This table may be absent, similar as indicated in sub-clause A.3.3 for the specification of the PDU type. The general format of the *field description* table is the same as shown in sub-clause A.3.3 for the specification of the PDU type.

A.3.5 Fields with optional presence

A field with optional presence may be declared with the keyword DEFAULT. It identifies a default value to be assumed, if the sender does not include a value for that field in the encoding:

```
-- /example/ ASN1START

PreambleInfo ::=                    SEQUENCE {
    numberOfRA-Preambles                INTEGER (1..64)                     DEFAULT 1,
    ...
}

-- ASN1STOP
```

Alternatively, a field with optional presence may be declared with the keyword OPTIONAL. It identifies a field for which a value can be omitted. The omission carries semantics, which is different from any normal value of the field:

```
-- /example/ ASN1START

PRACH-Config ::=                SEQUENCE {
    rootSequenceIndex                   INTEGER (0..1023),
    prach-ConfigInfo                    PRACH-ConfigInfo                    OPTIONAL    -- Need N
}

-- ASN1STOP
```

The semantics of an optionally present field, in the case it is omitted, should be indicated at the end of the paragraph including the keyword OPTIONAL, using a short comment text with a need code. The need code includes the keyword "Need", followed by one of the predefined semantics tags (S, M, N or R) defined in sub-clause 6.1. If the semantics tag S is used, the semantics of the absent field are further specified either in the field description table following the ASN.1 section, or in procedure text.

The addition of OPTIONAL keywords for capability groups is based on the following guideline. If there is more than one field in the lower level IE, then OPTIONAL keyword is added at the group level. If there is only one field in the lower level IE, OPTIONAL keyword is not added at the group level.

A.3.6 Fields with conditional presence

A field with conditional presence is declared with the keyword OPTIONAL. In addition, a short comment text shall be included at the end of the paragraph including the keyword OPTIONAL. The comment text includes the keyword "Cond", followed by a condition tag associated with the field ("UL" in this example):

```
-- /example/ ASN1START

LogicalChannelConfig ::=            SEQUENCE {
    ul-SpecificParameters               SEQUENCE {
        priority                            INTEGER (0),
        ...
    }       OPTIONAL                                                    -- Cond UL
}

-- ASN1STOP
```

When conditionally present fields are included in an ASN.1 section, the field description table after the ASN.1 section shall be followed by a *conditional presence* table. The conditional presence table specifies the conditions for including the fields with conditional presence in the particular ASN.1 section.

Conditional presence	Explanation
UL	Specification of the conditions for including the field associated with the condition tag = "UL". Semantics in case of optional presence under certain conditions may also be specified.

The conditional presence table has two columns. The first column (heading: "Conditional presence") contains the condition tag (in *italic* font style), which links the fields with a condition tag in the ASN.1 section to an entry in the table. The second column (heading: "Explanation") contains a text specification of the conditions and requirements for the presence of the field. The second column may also include semantics, in case of an optional presence of the field, under certain conditions i.e. using the same predefined tags as defined for optional fields in A.3.5.

Conditional presence should primarily be used when presence of a field depends on the presence and/or value of other fields within the same message. If the presence of a field depends on whether another feature/function has been configured, while this function can be configured independently e.g. by another message and/or at another point in time, the relation is best reflected by means of a statement in the field description table.

If the ASN.1 section does not include any fields with conditional presence, the conditional presence table shall not be included.

Whenever a field is only applicable in specific cases e.g. TDD, use of conditional presence should be considered.

A.3.7 Guidelines on use of lists with elements of SEQUENCE type

Where an information element has the form of a list (the SEQUENCE OF construct in ASN.1) with the type of the list elements being a SEQUENCE data type, an information element shall be defined for the list elements even if it would not otherwise be needed.

For example, a list of PLMN identities with reservation flags is defined as in the following example:

```
-- /example/ ASN1START
```

```
PLMN-IdentityInfoList ::=               SEQUENCE (SIZE (1..6)) OF PLMN-IdentityInfo

PLMN-IdentityInfo ::=               SEQUENCE {
    plmn-Identity                       PLMN-Identity,
    cellReservedForOperatorUse          ENUMERATED {reserved, notReserved}
}

-- ASN1STOP
```

rather than as in the following (bad) example, which may cause generated code to contain types with unpredictable names:

```
-- /bad example/ ASN1START

PLMN-IdentityList ::=                   SEQUENCE (SIZE (1..6)) OF SEQUENCE {
    plmn-Identity                           PLMN-Identity,
    cellReservedForOperatorUse              ENUMERATED {reserved, notReserved}
}

-- ASN1STOP
```

A.3.8 Guidelines on use of parameterised SetupRelease type

The usage of the parameterised *SetupRelease* type is like a function call in programming languages where the element type parameter is passed as a parameter. The parameterised type only implies a textual change in abstract syntax where all references to the parameterised type are replaced by the compiler with the release/setup choice. Two examples of the usage are shown below:

```
-- /example/ ASN1START

RRCMessage-r15-IEs ::= SEQUENCE {
    field-r15               SetupRelease { IE-r15 }                 OPTIONAL,   --  Need M
    ...
}


RRCMessage-r15-IEs ::= SEQUENCE {
    field-r15       SetupRelease { Element-r15 }
}                                                                   OPTIONAL,   -- Need M

Element-r15 ::= SEQUENCE {
    field1-r15                  IE1-r15,
    field2-r15                  IE2-r15                             OPTIONAL    -- Need N
}                                                                   OPTIONAL,   -- Need M

-- /example/ ASN1STOP
```

The *SetupRelease* is always be used with only named IEs, i.e. the example below is not allowed:

```
-- /example/ ASN1START
```

```
RRCMessage-r15-IEs ::= SEQUENCE {
    field-r15       SetupRelease { SEQUENCE {   -- Unnamed SEQUENCEs are not allowed!
            field1-r15                  IE1-r15,
            field2-r15                  IE2-r15                         OPTIONAL    -- Need N
        }
    }                                                                   OPTIONAL,   -- Need M
}

-- /example/ ASN1STOP
```

If a field defined using the parameterized SetupRelease type requires procedural text, the field is referred to using the values defined for the type itself, namely, "setup" and "release". For example, procedural text for field-r15 above could be as follows:

1> if *field-r15* is set to "setup":

2> do something;

1> else (*field-r15* is set to "release"):

2> release *field-r15* (if appropriate).

A.3.9 Guidelines on use of ToAddModList and ToReleaseList

In order to benefit from delta signalling when modifying lists with many and/or large elements, so-called add/mod- and release- lists should be used. Instead of a single list containing all elements of the list, the ASN.1 provides two lists. One list is used to convey the actual elements that are to be added to the list or modified in the list. The second list conveys only the identities (IDs) of the list elements that are to be released from the list. In other words, the ASN.1 defines only means to signal modifications to a list maintained in the receiver (typically the UE). An example is provided below:

```
-- /example/ ASN1START

AnExampleIE ::=         SEQUENCE {
    elementsToAddModList    SEQUENCE (SIZE (1..maxNrofElements)) OF Element                         OPTIONAL,   -- Need N
    elementsToReleaseList   SEQUENCE (SIZE (1..maxNrofElements)) OF ElementId                       OPTIONAL,   -- Need N
    ...
}

Element ::=         SEQUENCE {
    elementId               ElementId,
    aField                  INTEGER (0..16777215),
    anotherField            OCTET STRING,
    ...
}

ElementId ::=           INTEGER (0..maxNrofElements-1)

maxNrofElements         INTEGER ::= 50
maxNrofElements-1       INTEGER ::= 49
```

```
-- /example/ ASN1STOP
```

As can be seen, the elements of the list must contain an identity (INTEGER) that identifies the elements unambiguously upon addition, modification and removal. It is recommended to define an IE for that identifier (here ElementId) so that it can be used both for a field inside the element as well as in the *elementsToReleaseList*.

Both lists should be made OPTIONAL and flagged as ”Need N”. The need code reflects that the UE does not maintain the received lists as such but rather updates its configuration using the information therein. In other words, it is not possible to provide via delta signalling an update to a previously signalled *elementsToAddModList* or elementsToReleaseList (which Need M would imply). The update is always in relation to the UE's internal configuration.

If no procedural text is provided for a set of ToAddModList and ToReleaseList, the following generic procedure applies:

The UE shall:

1> for each *ElementId* in the *elementsToReleaseList*,:

2> if the current UE configuration includes an *Element* with the given *ElementId*:

3> release the *Element* from the current UE configuration;

1> for each *Element* in the *elementsToAddModList*:

2> if the current UE configuration includes an *Element* with the given *ElementId*:

3> modify the configured *Element* in accordance with the received *Element*;

2> else:

3> add received *Element* to the UE configuration.

A.4 Extension of the PDU specifications

A.4.1 General principles to ensure compatibility

It is essential that extension of the protocol does not affect interoperability i.e. it is essential that implementations based on different versions of the RRC protocol are able to interoperate. In particular, this requirement applies for the following kind of protocol extensions:

- Introduction of new PDU types (i.e. these should not cause unexpected behaviour or damage).
- Introduction of additional fields in an extensible PDUs (i.e. it should be possible to ignore uncomprehended extensions without affecting the handling of the other parts of the message).
- Introduction of additional values of an extensible field of PDUs. If used, the behaviour upon reception of an uncomprehended value should be defined.

It should be noted that the PDU extension mechanism may depend on the logical channel used to transfer the message e.g. for some PDUs an implementation may be aware of the protocol version of the peer in which case selective ignoring of extensions may not be required.

The non-critical extension mechanism is the primary mechanism for introducing protocol extensions i.e. the critical extension mechanism is used merely when there is a need to introduce a 'clean' message version. Such a need appears when the last message version includes a large number of non-critical extensions, which results in issues like readability, overhead associated with the extension markers. The critical extension mechanism may also be considered when it is complicated to accommodate the extensions by means of non-critical extension mechanisms.

A.4.2 Critical extension of messages and fields

The mechanisms to critically extend a message are defined in A.3.3. There are both "outer branch" and "inner branch" mechanisms available. The "outer branch" consists of a CHOICE having the name *criticalExtensions*, with two values, *c1* and *criticalExtensionsFuture*. The *criticalExtensionsFuture* branch consists of an empty SEQUENCE, while the c1 branch contains the "inner branch" mechanism.

The "inner branch" structure is a CHOICE with values of the form "*MessageName-rX-IEs*" (e.g., "*RRCConnectionReconfiguration-r8-IEs*") or "*spareX*", with the spare values having type NULL. The "-rX-IEs" structures contain the *complete* structure of the message IEs for the appropriate release; i.e., the critical extension branch for the Rel-10 version of a message includes all Rel-8 and Rel-9 fields (that are not obviated in the later version), rather than containing only the additional Rel-10 fields.

The following guidelines may be used when deciding which mechanism to introduce for a particular message, i.e. only an 'outer branch', or an 'outer branch' in combination with an 'inner branch' including a certain number of spares:

- For certain messages, e.g. initial uplink messages, messages transmitted on a broadcast channel, critical extension may not be applicable.
- An outer branch may be sufficient for messages not including any fields.
- The number of spares within inner branch should reflect the likelihood that the message will be critically extended in future releases (since each release with a critical extension for the message consumes one of the spare values). The estimation of the critical extension likelyhood may be based on the number, size and changeability of the fields included in the message.
- In messages where an inner branch extension mechanism is available, all spare values of the inner branch should be used before any critical extensions are added using the outer branch.

The following example illustrates the use of the critical extension mechanism by showing the ASN.1 of the original and of a later release

```
-- /example/ ASN1START                  -- Original release

RRCMessage ::=                          SEQUENCE {
    rrc-TransactionIdentifier               RRC-TransactionIdentifier,
    criticalExtensions                  CHOICE {
        c1                                  CHOICE{
            rrcMessage-r8                       RRCMessage-r8-IEs,
            spare3 NULL, spare2 NULL, spare1 NULL
        },
        criticalExtensionsFuture            SEQUENCE {}
    }
}
```

```
-- ASN1STOP


-- /example/ ASN1START                  -- Later release

RRCMessage ::=                          SEQUENCE {
    rrc-TransactionIdentifier               RRC-TransactionIdentifier,
    criticalExtensions                  CHOICE {
        c1                                  CHOICE{
            rrcMessage-r8                       RRCMessage-r8-IEs,
            rrcMessage-r10                      RRCMessage-r10-IEs,
            rrcMessage-r11                      RRCMessage-r11-IEs,
            rrcMessage-r14                      RRCMessage-r14-IEs
        },
        later                           CHOICE {
            c2                                  CHOICE{
                rrcMessage-r16                      RRCMessage-r16-IEs,
                spare7 NULL, spare6 NULL, spare5 NULL, spare4 NULL,
                spare3 NULL, spare2 NULL, spare1 NULL
            },
            criticalExtensionsFuture                SEQUENCE {}
        }
    }
}

-- ASN1STOP
```

It is important to note that critical extensions may also be used at the level of individual fields i.e. a field may be replaced by a critically extended version. When sending the extended version, the original version may also be included (e.g. original field is mandatory, EUTRAN is unaware if UE supports the extended version). In such cases, a UE supporting both versions may be required to ignore the original field. The following example illustrates the use of the critical extension mechanism by showing the ASN.1 of the original and of a later release.

```
-- /example/ ASN1START                  -- Original release

RRCMessage ::=                          SEQUENCE {
    rrc-TransactionIdentifier               RRC-TransactionIdentifier,
    criticalExtensions                  CHOICE {
        c1                                  CHOICE{
            rrcMessage-r8                       RRCMessage-r8-IEs,
            spare3 NULL, spare2 NULL, spare1 NULL
        },
        criticalExtensionsFuture            SEQUENCE {}
    }
}

RRCMessage-rN-IEs ::= SEQUENCE {
    field1-rN                           ENUMERATED {
                                            value1, value2, value3, value4} OPTIONAL,   -- Need N
    field2-rN                           InformationElement2-rN              OPTIONAL,   -- Need N
    nonCriticalExtension                RRCConnectionReconfiguration-vMxy-IEs   OPTIONAL
}
```

```
RRCConnectionReconfiguration-vMxy-IEs ::= SEQUENCE {
    field2-rM                           InformationElement2-rM          OPTIONAL, -- Cond NoField2rN
    nonCriticalExtension                SEQUENCE {}                     OPTIONAL
}

-- ASN1STOP
```

Conditional presence	Explanation
NoField2rN	The field is optionally present, need N, if field2-rN is absent. Otherwise the field is not present

Finally, it is noted that a critical extension may be introduced in the same release as the one in which the original field was introduced e.g. to correct an essential ASN.1 error. In such cases a UE capability may be introduced, to assist the network in deciding whether or not to use the critically extension.

A.4.3 Non-critical extension of messages

A.4.3.1 General principles

The mechanisms to extend a message in a non-critical manner are defined in A.3.3. W.r.t. the use of extension markers, the following additional guidelines apply:

- When further non-critical extensions are added to a message that has been critically extended, the inclusion of these non-critical extensions in earlier critical branches of the message should be avoided when possible.
- The extension marker ("...") is the primary non-critical extension mechanism that is used but empty sequences may be used if length determinant is not required. Examples of cases where a length determinant is not required:
  - at the end of a message;
  - at the end of a structure contained in a BIT STRING or OCTET STRING.
- When an extension marker is available, non-critical extensions are preferably placed at the location (e.g. the IE) where the concerned parameter belongs from a logical/ functional perspective (referred to as the '*default extension location*').
- It is desirable to aggregate extensions of the same release or version of the specification into a group, which should be placed at the lowest possible level.
- In specific cases it may be preferrable to place extensions elsewhere (referred to as the '*actual extension location*') e.g. when it is possible to aggregate several extensions in a group. In such a case, the group should be placed at the lowest suitable level in the message. <TBD: ref to seperate example>
- In case placement at the default extension location affects earlier critical branches of the message, locating the extension at a following higher level in the message should be considered.
- In case an extension is not placed at the default extension location, an IE should be defined. The IE's ASN.1 definition should be placed in the same ASN.1 section as the default extension location. In case there are intermediate levels in-between the actual and the default extension location, an IE may be defined for each level. Intermediate levels are primarily introduced for readability and overview. Hence intermediate levels need not allways be introduced e.g. they may not be needed when the default and the actual extension location are within the same ASN.1 section. <TBD: ref to seperate example>

A.4.3.2 Further guidelines

Further to the general principles defined in the previous section, the following additional guidelines apply regarding the use of extension markers:

- Extension markers within SEQUENCE:
  - Extension markers are primarily, but not exclusively, introduced at the higher nesting levels.
  - Extension markers are introduced for a SEQUENCE comprising several fields as well as for information elements whose extension would result in complex structures without it (e.g. re-introducing another list).
  - Extension markers are introduced to make it possible to maintain important information structures e.g. parameters relevant for one particular RAT.
  - Extension markers are also used for size critical messages (i.e. messages on BCCH, BR-BCCH, PCCH and CCCH), although introduced somewhat more carefully.
  - The extension fields introduced (or frozen) in a specific version of the specification are grouped together using double brackets.
- Extension markers within ENUMERATED:
  - Spare values may be used until the number of values reaches the next power of 2, while the extension marker caters for extension beyond that limit, given that the use of spare values in a later Release is possible without any error cases.
  - A suffix of the form "vXYZ" is used for the identifier of each new value, e.g. "value-vXYZ".
- Extension markers within CHOICE:
  - Extension markers are introduced when extension is foreseen and when comprehension is not required by the receiver i.e. behaviour is defined for the case where the receiver cannot comprehend the extended value (e.g. ignoring an optional CHOICE field). It should be noted that defining the behaviour of a receiver upon receiving a not comprehended choice value is not required if the sender is aware whether or not the receiver supports the extended value.
  - A suffix of the form "vXYZ" is used for the identifier of each new choice value, e.g. "choice-vXYZ".

Non-critical extensions at the end of a message/ of a field contained in an OCTET or BIT STRING:

- When a nonCriticalExtension is actually used, a "Need" code should not be provided for the field, which always is a group including at least one extension and a field facilitating further possible extensions. For simplicity, it is recommended not to provide a "Need" code when the field is not actually used either.

Further, more general, guidelines:

- In case a need code is not provided for a group, a "Need" code is provided for all individual extension fields within the group i.e. including for fields that are not marked as OPTIONAL. The latter is to clarify the action upon absence of the whole group.

A.4.3.3 Typical example of evolution of IE with local extensions

The following example illustrates the use of the extension marker for a number of elementary cases (sequence, enumerated, choice). The example also illustrates how the IE may be revised in case the critical extension mechanism is used.

NOTE In case there is a need to support further extensions of release n while the ASN.1 of release (n+1) has been frozen, without requiring the release n receiver to support decoding of release (n+1) extensions, more advanced mechanisms are needed e.g. including multiple extension markers.

```
-- /example/ ASN1START

InformationElement1 ::=             SEQUENCE {
    field1                              ENUMERATED {
                                            value1, value2, value3, value4-v880,
                                            ..., value5-v960 },
    field2                              CHOICE {
        field2a                             BOOLEAN,
        field2b                             InformationElement2b,
        ...,
        field2c-v960                        InformationElement2c-r9
    },
    ...,
    [[  field3-r9                           InformationElement3-r9      OPTIONAL        -- Need R
    ]],
    [[  field3-v9a0                         InformationElement3-v9a0    OPTIONAL,       -- Need R
        field4-r9                           InformationElement4         OPTIONAL        -- Need R
    ]]
}

InformationElement1-r10 ::=         SEQUENCE {
    field1                              ENUMERATED {
                                            value1, value2, value3, value4-v880,
                                            value5-v960, value6-v1170, spare2, spare1, ... },
    field2                              CHOICE {
        field2a                             BOOLEAN,
        field2b                             InformationElement2b,
        field2c-v960                        InformationElement2c-r9,
        ...,
        field2d-v12b0                       INTEGER (0..63)
    },
    field3-r9                           InformationElement3-r10         OPTIONAL,   -- Need R
    field4-r9                           InformationElement4             OPTIONAL,   -- Need R
    field5-r10                          BOOLEAN,
    field6-r10                          InformationElement6-r10         OPTIONAL,   -- Need R
    ...,
    [[  field3-v1170                    InformationElement3-v1170       OPTIONAL    -- Need R
    ]]
}

-- ASN1STOP
```

Some remarks regarding the extensions of *InformationElement1* as shown in the above example:

– The *InformationElement1* is initially extended with a number of non-critical extensions. In release 10 however, a critical extension is introduced for the message using this IE. Consequently, a new version of the IE *InformationElement1* (i.e. *InformationElement1-r10*) is defined in which the earlier non-critical extensions are incorporated by means of a revision of the original field.

– The *value4-v880* is replacing a spare value defined in the original protocol version for *field1*. Likewise *value6-v1170* replaces *spare3* that was originally defined in the r10 version of *field1*.

– Within the critically extended release 10 version of *InformationElement1*, the names of the original fields/IEs are not changed, unless there is a real need to distinguish them from other fields/IEs. E.g. the *field1* and *InformationElement4* were defined in the original protocol version (release 8) and hence not tagged. Moreover, the *field3-r9* is introduced in release 9 and not re-tagged; although, the *InformationElement3* is also critically extended and therefore tagged *InformationElement3-r10* in the release 10 version of InformationElement1.

A.4.3.4 Typical examples of non critical extension at the end of a message

The following example illustrates the use of non-critical extensions at the end of the message or at the end of a field that is contained in a BIT or OCTET STRING i.e. when an empty sequence is used.

```
-- /example/ ASN1START

RRCMessage-r8-IEs ::=           SEQUENCE {
    field1                          InformationElement1,
    field2                          InformationElement2,
    field3                          InformationElement3                 OPTIONAL,   -- Need N
    nonCriticalExtension            RRCMessage-v860-IEs                 OPTIONAL
}

RRCMessage-v860-IEs ::=         SEQUENCE {
    field4-v860                     InformationElement4                 OPTIONAL,   -- Need S
    field5-v860                     BOOLEAN                             OPTIONAL,   -- Cond C54
    nonCriticalExtension            RRCMessage-v940-IEs                 OPTIONAL
}

RRCMessage-v940-IEs ::=         SEQUENCE {
    field6-v940                     InformationElement6-r9              OPTIONAL,   -- Need R
    nonCriticalExtensions           SEQUENCE {}                         OPTIONAL
}

-- ASN1STOP
```

Some remarks regarding the extensions shown in the above example:

– The *InformationElement4* is introduced in the original version of the protocol (release 8) and hence no suffix is used.

A.4.3.5 Examples of non-critical extensions not placed at the default extension location

The following example illustrates the use of non-critical extensions in case an extension is not placed at the default extension location.

– *ParentIE-WithEM*

The IE *ParentIE-WithEM* is an example of a high level IE including the extension marker (EM). The root encoding of this IE includes two lower level IEs *ChildIE1-WithoutEM* and *ChildIE2-WithoutEM* which not include the extension marker. Consequently, non-critical extensions of the Child-IEs have to be included at the level of the Parent-IE.

The example illustrates how the two extension IEs *ChildIE1-WithoutEM-vNx0* and *ChildIE2-WithoutEM-vNx0* (both in release N) are used to connect non-critical extensions with a default extension location in the lower level IEs to the actual extension location in this IE.

ParentIE-WithEM information element

```
-- /example/ ASN1START

ParentIE-WithEM ::=                 SEQUENCE {
    -- Root encoding, including:
    childIE1-WithoutEM                  ChildIE1-WithoutEM              OPTIONAL,       -- Need N
    childIE2-WithoutEM                  ChildIE2-WithoutEM              OPTIONAL,       -- Need N
    ...,
    [[  childIE1-WithoutEM-vNx0             ChildIE1-WithoutEM-vNx0     OPTIONAL,       -- Need N
        childIE2-WithoutEM-vNx0             ChildIE2-WithoutEM-vNx0     OPTIONAL        -- Need N
    ]]
}

-- ASN1STOP
```

Some remarks regarding the extensions shown in the above example:

- The fields *childIEx-WithoutEM-vNx0* may not really need to be optional (depends on what is defined at the next lower level).
- In general, especially when there are several nesting levels, fields should be marked as optional only when there is a clear reason.

– *ChildIE1-WithoutEM*

The IE *ChildIE1-WithoutEM* is an example of a lower level IE, used to control certain radio configurations including a configurable feature which can be setup or released using the local IE *ChIE1-ConfigurableFeature*. The example illustrates how the new field *chIE1-NewField* is added in release N to the configuration of the configurable feature. The example is based on the following assumptions:

- When initially configuring as well as when modifying the new field, the original fields of the configurable feature have to be provided also i.e. as if the extended ones were present within the setup branch of this feature.
- When the configurable feature is released, the new field should be released also.
- When omitting the original fields of the configurable feature the UE continues using the existing values (which is used to optimise the signalling for features that typically continue unchanged upon handover).
- When omitting the new field of the configurable feature the UE releases the existing values and discontinues the associated functionality (which may be used to support release of unsupported functionality upon handover to an eNB supporting an earlier protocol version).

The above assumptions, which affect the use of conditions and need codes, may not always apply. Hence, the example should not be re-used blindly.

ChildIE1-WithoutEM information elements

```
-- /example/ ASN1START
```

```
ChildIE1-WithoutEM ::=              SEQUENCE {
    -- Root encoding, including:
    chIE1-ConfigurableFeature           ChIE1-ConfigurableFeature       OPTIONAL         -- Need N
}

ChildIE1-WithoutEM-vNx0 ::=     SEQUENCE {
    chIE1-ConfigurableFeature-vNx0      ChIE1-ConfigurableFeature-vNx0  OPTIONAL    -- Cond ConfigF
}

ChIE1-ConfigurableFeature ::=       CHOICE {
    release                             NULL,
    setup                               SEQUENCE {
        -- Root encoding
    }
}

ChIE1-ConfigurableFeature-vNx0 ::=  SEQUENCE {
    chIE1-NewField-rN                   INTEGER (0..31)
}

-- ASN1STOP
```

Conditional presence	Explanation
ConfigF	The field is optional present, need R, in case of chIE1-ConfigurableFeature is included and set to "setup"; otherwise the field is not present and the UE shall delete any existing value for this field.

– *ChildIE2-WithoutEM*

The IE *ChildIE2-WithoutEM* is an example of a lower level IE, typically used to control certain radio configurations. The example illustrates how the new field *chIE1-NewField* is added in release N to the configuration of the configurable feature.

ChildIE2-WithoutEM information element

```
-- /example/ ASN1START

ChildIE2-WithoutEM ::=              CHOICE {
    release                             NULL,
    setup                               SEQUENCE {
        -- Root encoding
    }
}

ChildIE2-WithoutEM-vNx0 ::=         SEQUENCE {
    chIE2-NewField-rN                   INTEGER (0..31)                 OPTIONAL    -- Cond ConfigF
}

-- ASN1STOP
```

Conditional presence	Explanation
ConfigF	The field is optional present, need R, in case of chIE2-ConfigurableFeature is included and set to "setup"; otherwise the field is not present and the UE shall delete any existing value for this field.

A.5 Guidelines regarding inclusion of transaction identifiers in RRC messages

The following rules provide guidance on which messages should include a Transaction identifier

1: DL messages on CCCH that move UE to RRC-Idle should not include the RRC transaction identifier.

2: All network initiated DL messages by default should include the RRC transaction identifier.

3: All UL messages that are direct response to a DL message with an RRC Transaction identifier should include the RRC Transaction identifier.

4: All UL messages that require a direct DL response message should include an RRC transaction identifier.

5: All UL messages that are not in response to a DL message nor require a corresponding response from the network should not include the RRC Transaction identifier.

A.6 Guidelines regarding use of need codes

The following rule provides guidance for determining need codes for optional downlink fields:

- if the field needs to be stored by the UE (i.e. maintained) when absent:
  - use Need M (=Maintain);
- else, if the field needs to be released by the UE when absent:
  - use Need R (=Release);
- else, if UE shall take no action when the field is absent (i.e. UE does not even need to maintain any existing value of the field):
  - use Need N (=None);
- else (UE behaviour upon absence does not fit any of the above conditions):
  - use Need S (=Specified);
  - specify the UE behaviour upon absence of the field in the procedural text or in the field description table.

A.7 Guidelines regarding use of conditions

Conditions are primarily used to specify network restrictions, for which the following types can be distinguished:

- CondM: Message Contents related constraints e.g. that a field B is mandatory present if the same message includes field A and when it is set value X.
- CondC: Configuration Constraints e.g. that a field D can only be signalled if field C is configured and set to value Y. (i.e. regardless of whether field C is present in the same message or previously configured).

The use of these conditions is illustrated by an example.

```
-- /example/ ASN1START

RRCMessage-IEs ::= SEQUENCE {
    fieldA                          FieldA                  OPTIONAL,   -- Need M
    fieldB                          FieldB                  OPTIONAL,   -- CondM-FieldAsetToX
    fieldC                          FieldC                  OPTIONAL,   -- Need M
    fieldD                          FieldD                  OPTIONAL,   -- CondC-FieldCsetToY
    nonCriticalExtension            SEQUENCE {}             OPTIONAL
}

-- /example/ ASN1STOP
```

Conditional presence	Explanation
Message (content) constraints	
CondM-FieldAsetToX	The field is mandatory present if fieldA is included and set to valueX. Otherwise the field is optional present, need R.
Configuration constraints	
CondC- FieldCsetToY	The field is optional present, need M, if fieldC is configured and set to valueY. Otherwise the field is not present and the UE does not maintain the value

Annex B (informative): Change history

Change history							
Date	Meeting	TDoc	CR	Rev	Cat	Subject/Comment	New version
04/2017	RAN2#97bis	R2-1703395					0.0.1
04/2017	RAN2#97bis	R2-1703922					0.0.2
05/2017	RAN2#98	R2-1705815					0.0.3
06/2017	RAN2#NR2	R2-1707187					0.0.4
08/2017	RAN2#99	R2-1708468					0.0.5
09/2017	RAN2#99bis	R2-1710557					0.1.0
11/2017	RAN2#100	R2-1713629					0.2.0
11/2017	RAN2#100	R2-1714126					0.3.0
12/2017	RAN2#100	R2-1714259					0.4.0
12/2017	RP-78	RP-172570				Submitted for Approval in RAN#78	1.0.0
12/2017	RP-78					Upgraded to Rel-15 (MCC)	15.0.0
03/2018	RP-79	RP-180479	0008	1	F	Corrections for EN-DC (Note: the clause numbering between 15.0.0 and 15.1.0 has changed in some cases).	15.1.0
06/2018	RP-80	RP-181326	0042	7	F	Miscellaneous EN-DC corrections	15.2.0
	RP-80					Correction: Duplicate Foreword section removed & ASN.1 sections touched up	15.2.1

History

Document history		
V15.2.1	June 2018	Publication

EXHIBIT K

ETSI TS 138 306 V15.2.0 (2018-09)

5G;
NR;
User Equipment (UE) radio access capabilities
(3GPP TS 38.306 version 15.2.0 Release 15)

Reference
RTS/TSGR-0238306vf20

Keywords
5G

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Important notice

The present document can be downloaded from:
http://www.etsi.org/standards-search

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the only prevailing document is the print of the Portable Document Format (PDF) version kept on a specific network drive within ETSI Secretariat.

Users of the present document should be aware that the document may be subject to revision or change of status.
Information on the current status of this and other ETSI documents is available at
https://portal.etsi.org/TB/ETSIDeliverableStatus.aspx

If you find errors in the present document, please send your comment to one of the following services:
https://portal.etsi.org/People/CommiteeSupportStaff.aspx

Copyright Notification

No part may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm except as authorized by written permission of ETSI.
The content of the PDF version shall not be modified without the written authorization of ETSI.
The copyright and the foregoing restriction extend to reproduction in all media.

© ETSI 2018.
All rights reserved.

DECT™, **PLUGTESTS**™, **UMTS**™ and the ETSI logo are trademarks of ETSI registered for the benefit of its Members.
3GPP™ and **LTE**™ are trademarks of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners.
oneM2M logo is protected for the benefit of its Members.
GSM® and the GSM logo are trademarks registered and owned by the GSM Association.

Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (https://ipr.etsi.org/).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

Foreword

This Technical Specification (TS) has been produced by ETSI 3rd Generation Partnership Project (3GPP).

The present document may refer to technical specifications or reports using their 3GPP identities, UMTS identities or GSM identities. These should be interpreted as being references to the corresponding ETSI deliverables.

The cross reference between GSM, UMTS, 3GPP and ETSI identities can be found under http://webapp.etsi.org/key/queryform.asp.

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

Contents

Intellectual Property Rights 2
Foreword 2
Modal verbs terminology 2
Foreword 4
1 Scope 5
2 References 5
3 Definitions, symbols and abbreviations 5
3.1 Definitions 5
3.2 Symbols 6
3.3 Abbreviations 6
4 UE radio access capability parameters 6
4.1 Supported max data rate 6
4.1.1 General 6
4.1.2 Max data rate without *ue-CategoryDL* and *ue-CategoryUL* 6
4.1.3 Max data rate with *ue-CategoryDL* and *ue-CategoryUL* 7
4.1.4 Total layer 2 buffer size 7
4.2 UE Capability Parameters 8
4.2.1 Introduction 8
4.2.2 General parameters 8
4.2.3 SDAP Parameters 8
4.2.4 PDCP Parameters 9
4.2.5 RLC parameters 9
4.2.6 MAC parameters 10
4.2.7 Physical layer parameters 11
4.2.8 RF parameters 21
4.2.9 Measurement parameters 27
4.2.10 Inter-RAT parameters 27
4.2.10.1 *eutraFDD* 27
4.2.10.2 *eutraTDD* 27
4.2.11 Neighbour cell SI acquisition parameters 28
4.2.11.1 *eutra-CGI-Reporting* 28
4.2.11.2 *nr-CGI-Reporting* 28
4.2.12 MMTEL parameters 28
- *delayBudgetReporting* 28
- *recommendedBitRate* 28
- *recommendedBitRateQuery* 28
5 Optional features without UE radio access capability parameters 28
6 Conditionally mandatory features 28
7 Capability coordination in MR-DC operation 28
Annex A (informative): Change history 29
History 30

Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

- x the first digit:
  - 1 presented to TSG for information;
  - 2 presented to TSG for approval;
  - 3 or greater indicates TSG approved document under change control.
- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The present document defines the NR UE Radio Access Capability Parameters.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 38.101-1: "NR; User Equipment (UE) radio transmission and reception Part 1: Range 1 Standalone".

[3] 3GPP TS 38.101-2: "NR; User Equipment (UE) radio transmission and reception Part 2: Range 2 Standalone".

[4] 3GPP TS 38.101-3: "NR; User Equipment (UE) radio transmission and reception Part 3: Range 1 and Range 2 Interworking operation with other radios".

[5] 3GPP TS 38.133: "NR; Requirements for support of radio resource management".

[6] 3GPP TS 38.211: "NR; Physical channels and modulation".

[7] 3GPP TS 37.340: "Evolved Universal Terrestrial Radio Access (E-UTRA) and NR Multi-connectivity".

[8] 3GPP TS 38.321: "NR; Medium Access Control (MAC) protocol specification".

[9] 3GPP TS 38.331: "NR; Radio Resource Control (RRC) protocol specification".

[10] 3GPP TS 38.212: "NR; Multiplexing and channel coding".

[11] 3GPP TS 38.213: "NR; Physical layer procedures for control".

[12] 3GPP TS 38.214: "NR; Physical layer procedures for data".

[13] 3GPP TS 38.215: "NR; Physical layer measurements".

[14] 3GPP TS 36.101: "Evolved Universal Terrestrial Radio Access (E-UTRA) radio transmission and reception".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

Fallback band combination: A band combination that would result from another band combination by releasing at least one SCell or uplink configuration of SCell.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

MaxDLDataRate: Maximum DL data rate
MaxDLDataRate_MN: Maximum DL data rate in the MN
MaxDLDataRate_SN: Maximum DL data rate in the SN
MaxULDataRate: Maximum UL data rate

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

DL Downlink
MAC Medium Access Control
MCG Master Cell Group
MN Master Node
MR-DC Multi-RAT Dual Connectivity
PDCP Packet Data Convergence Protocol
RLC Radio Link Control
RTT Round Trip Time
SCG Secondary Cell Group
SDAP Service Data Adaptation Protocol
SN Secondary Node
UL Uplink

4 UE radio access capability parameters

4.1 Supported max data rate

4.1.1 General

The DL and UL max data rate supported by the UE is calculated by band or band combinations supported by the UE. A UE supporting MR-DC shall support the calculated DL and UL max data rate defined in 4.1.2. A non MR-DC capable UE supporting a max data rate lower than the calculated max data rate indicates the DL and UL max data rate by the UE category as defined in 4.1.3.

4.1.2 Max data rate without *ue-CategoryDL* and *ue-CategoryUL*

For NR, the approximate data rate for a given number of aggregated carriers in a band or band combination is computed as follows.

$$\text{data rate (in Mbps)} = 10^{-6} \cdot \sum_{j=1}^{J} \left(v_{Layers}^{(j)} \cdot Q_m^{(j)} \cdot f^{(j)} \cdot R_{\max} \cdot \frac{N_{PRB}^{BW(j),\mu} \cdot 12}{T_s^{\mu}} \cdot \left(1 - OH^{(j)}\right) \right)$$

wherein

J is the number of aggregated component carriers in a band or band combination
R_{max} = 948/1024
For the j-th CC,

$v_{Layers}^{(j)}$ is the maximum number of layers

$Q_m^{(j)}$ is the maximum modulation order

$f^{(j)}$ is the scaling factor

The scaling factor can take the values 1, 0.8, 0.75, and 0.4.

$f^{(j)}$ is signalled per band and per band per band combination

μ is the numerology (as defined in TS 38.211 [6])

T_s^μ is the average OFDM symbol duration in a subframe for numerology μ, i.e. $T_s^\mu = \frac{10^{-3}}{14 \cdot 2^\mu}$. Note that normal cyclic prefix is assumed.

$N_{PRB}^{BW(j),\mu}$ is the maximum RB allocation in bandwidth $BW^{(j)}$ with numerology μ, as defined in 5.3 TS 38.101-1 [2] and 5.3 TS 38.101-2 [3], where $BW^{(j)}$ is the UE supported maximum bandwidth in the given band or band combination.

$OH^{(j)}$ is the overhead and takes the following values
[0.14], for frequency range FR1 for DL
[0.18], for frequency range FR2 for DL
[0.08], for frequency range FR1 for UL
[0.10], for frequency range FR2 for UL

NOTE: Only one of the UL or SUL carriers (the one with the higher data rate) is counted for a cell operating SUL.

The approximate maximum data rate can be computed as the maximum of the approximate data rates computed using the above formula for each of the supported band or band combinations.

For EUTRA in case of MR-DC, the approximate data rate for a given number of aggregated carriers in a band or band combination is computed as follows.

Data rate (in Mbps) = $10^{-3} * \sum_{j=1}^{J} TBS_j$

wherein

J is the number of aggregated EUTRA component carriers in MR-DC band combination

TBS_j is the total maximum number of DL-SCH transport block bits received within a 1ms TTI for j-th CC, as derived from TS36.213 [22] based on the UE supported maximum MIMO layers for the j-th carrier, and based on the modulation order and number of PRBs based on the bandwidth of the j-th carrier.

The approximate maximum data rate can be computed as the maximum of the approximate data rates computed using the above formula for each of the supported band or band combinations.

For MR-DC, the approximate maximum data rate is computed as the sum of the approximate maximum data rates from NR and EUTRA.

4.1.3 Max data rate with *ue-CategoryDL* and *ue-CategoryUL*

4.1.4 Total layer 2 buffer size

The total layer 2 buffer size is defined as the sum of the number of bytes that the UE is capable of storing in the RLC transmission windows and RLC reception and reordering windows for all radio bearers, and for UEs capable of split bearers, also in PDCP reordering windows for all split radio bearers.

The required total layer 2 buffer size for split bearer operation in MR-DC is calculated by *MaxULDataRate * RLC RTT + MaxDLDataRate_SN * RLC RTT + MaxDLDataRate_MN * (RLC RTT + Xn delay + Queuing in SN)*. Otherwise it is calculated by *MaxDLDataRate * RLC RTT + MaxULDataRate * RLC RTT*. The required total layer 2 buffer size is determined as the maximum total layer 2 buffer size of all the calculated ones for each band combination in the supported MR-DC or NR band combinations.

wherein

Xn delay + Queuing in SN = 25ms

RLC RTT for EUTRA cell group = 75ms

RLC RTT for NR cell group is defined in Table 4.1.4-1

Table 4.1.4-1: RLC RTT per SCS

SCS (KHz)	RLC RTT (ms)
15KHz	TBD
30KHz	TBD
60KHz	TBD
120KHz	TBD

Editor's Note: Both MN terminated split bearer and SN terminated split bearers are considered for L2 buffer size calculation for MR-DC and discussion/decision on the detailed equation is needed.

4.2 UE Capability Parameters

4.2.1 Introduction

If the UE supports both FDD and TDD, set all fields in UE-MRDC-Capability and/or UE-NR-Capability, except fdd-UE-MRDC-Capability, tdd-UE-MRDC-Capability, fdd-UE-NR-Capability, and tdd-UE-NR-Capability, to include the values applicable for both FDD and TDD (i.e. functionality supported by both modes). If (some of) the UE capability fields have a different value for FDD and TDD, the UE includes supported FDD/TDD dedicated additional functionality by the field in fdd-UE-MRDC-Capability/tdd-UE-MRDC-Capability and/or fdd-UE-NR-Capability/tdd-UE-NR-Capability. If the UE supports either FDD or TDD only, set all fields in UE-MRDC-Capability and/or UE-NR-Capability, except fdd-UE-MRDC-Capability, tdd-UE-MRDC-Capability, fdd-UE-NR-Capability and tdd-UE-NR-Capability, to include the values applicable for the FDD/TDD supported by the UE.

4.2.2 General parameters

Definitions for parameters	Per	M	FDD-TDD diff
splitSRB-WithOneUL-Path Indicates whether the UE supports UL transmission via either MCG path or SCG path for the split SRB as specified in TS 37.340 [7].	UE	TBD	Yes
splitDRB-withUL-Both-MCG-SCG Indicates whether the UE supports UL transmission via both MCG path and SCG path for the split DRB as specified in TS 37.340 [7].	UE	TBD	Yes
srb3 Indicates whether the UE supports direct SRB between the SN and the UE as specified in TS 37.340 [7].	UE	TBD	Yes

4.2.3 SDAP Parameters

Editor's Note: Targeted for completion in June 2018.

4.2.4 PDCP Parameters

Definitions for parameters	Per	M	FDD-TDD diff
continueROHC-Context Defines whether the UE supports ROHC context continuation operation where the UE does not reset the current ROHC context upon handover.	UE	No	No
dataRateDRB-IP Defines the upper bound of the aggregated data rate of user plane integrity protected data in either UL or DL DRBs. Value 64kbps corresponds to the aggregated data rate of user plane integrity protected data in either UL or DL cannot exceed 64kbps and so on. It is not supported in this version and is targeted for completion in June 2018. NOTE: It may be moved to NAS as part of the rest of the UE security capability (CT1/SA3 confirmation is needed).	UE	N/A	No
maxNumberROHC-ContextSessions Defines the maximum number of header compression context sessions supported by the UE, excluding context sessions that leave all headers uncompressed.	UE	No	No
outOfOrderDelivery Indicates whether UE supports Out of order delivery of data to upper layers by PDCP.	UE	TBD	No
shortSN Indicates whether the UE supports 12 bit length of PDCP sequence number.	UE	Yes	No
supportedROHC-Profiles Defines which ROHC profiles from the list below are supported by the UE: - 0x0000 ROHC No compression (RFC 5795) - 0x0001 ROHC RTP/UDP/IP (RFC 3095, RFC 4815) - 0x0002 ROHC UDP/IP (RFC 3095, RFC 4815) - 0x0003 ROHC ESP/IP (RFC 3095, RFC 4815) - 0x0004 ROHC IP (RFC 3843, RFC 4815) - 0x0006 ROHC TCP/IP (RFC 6846) - 0x0101 ROHC RTP/UDP/IP (RFC 5225) - 0x0102 ROHC UDP/IP (RFC 5225) - 0x0103 ROHC ESP/IP (RFC 5225) - 0x0104 ROHC IP (RFC 5225) A UE that supports one or more of the listed ROHC profiles shall support ROHC profile 0x0000 ROHC uncompressed (RFC 5795).	UE	No	No
uplinkOnlyROHC-Profiles Indicates which ROHC profile(s) from the list below are supported in uplink-only ROHC operation by the UE. - 0x0006 ROHC TCP (RFC [6846]) A UE that supports uplink-only ROHC profile(s) shall support ROHC profile 0x0000 ROHC uncompressed (RFC 5795).	UE	No	No

4.2.5 RLC parameters

Definitions for parameters	Per	M	FDD-TDD diff
am-WithShortSN Indicates whether the UE supports RLC AM with 12 bit length of RLC sequence number.	UE	Yes	No
um-WIthLongSN Indicates whether the UE supports RLC UM with 12 bit length of RLC sequence number.	UE	Yes	No
um-WithShortSN Indicates whether the UE supports RLC UM with 6 bit length of RLC sequence number.	UE	Yes	No

4.2.6 MAC parameters

Definitions for parameters	Per	M	FDD-TDD diff
lcp-Restriction Indicates whether UE supports the selection of logical channels for each UL grant based on RRC configured restriction.	UE	No	No
logicalChannelSR-DelayTimer Indicates whether the UE supports the logicalChannelSR-DelayTimer as specified in TS 38.321 [8]	UE	TBD	Yes
longDRX-Cycle Indicates whether UE supports long DRX cycle as specified in TS 38.321 [8].	UE	Yes	Yes
multipleConfiguredGrant Indicates whether UE supports [16] configured grant configurations per cell group.	UE	No	Yes
multipleSR-Configurations Indicates whether the UE supports [8] SR configurations per cell group.	UE	No	Yes
pucch-SpatialRelInfoMAC-CE Indicates whether the UE supports indication of PUCCH-spatialrelationinfo by a MAC CE per PUCCH resource.	UE	No	No
shortDRX-Cycle Indicates whether UE supports short DRX cycle as specified in TS 38.321 [8].	UE	Yes	Yes
skipUplinkTxDynamic Indicates whether the UE supports skipping of UL transmission for an uplink grant indicated on PDCCH if no data is available for transmission as specified in TS 38.321 [8].	UE	TBD	Yes

4.2.7 Physical layer parameters

Definitions for parameters	Per	M	FDD TDD DIFF	FR1 FR2 DIFF
absoluteTPC-Command Indicates whether the UE supports absolute TPC command mode.	UE	Tbd	No	Yes
almostContiguousCP-OFDM-UL Indicates whether the UE supports almost contiguous UL CP-OFDM transmissions.	UE	Tbd	No	Yes
bwp-SwitchingDelay Defines whether the UE supports BWP switching delay within type1 or type2 specified in TS38.xxx	UE	Yes	No	No
calibrationGapPA Indicates whether the UE needs PA calibration gap to meet the UE Tx requirements.	UE	Tbd	No	No FR2
cbg-FlushIndication-DL Indicates whether the UE supports CBG-based (re)transmission for DL using CBG flushing out information (CBGFI) as specified in TS 38.214 [12].	UE	Tbd	No	No
cbg-TransIndication-DL Indicates whether the UE supports CBG-based (re)transmission for DL using CBG transmission information (CBGTI) as specified in TS 38.214 [12].	UE	Tbd	No	No
cbg-TransIndication-UL Indicates whether the UE supports CBG-based (re)transmission for UL using CBG transmission information (CBGTI) as specified in TS 38.214 [12].	UE	Tbd	No	No
channelBW-90mhz Indicates whether the UE supports the channel bandwidth of 90 MHz.	CC per band and BC	No	No	No
configuredUL-GrantType1 Indicates whether the UE supports Type 1 PUSCH transmissions with configured grant as specified in TS 38.214 [12] with UL-TWG-repK value of one.	UE	Tbd	No	No
configuredUL-GrantType2 Indicates whether the UE supports Type 2 PUSCH transmissions with configured grant as specified in TS 38.214 [12] with UL-TWG-repK value of one.	UE	Tbd	No	No
crossCarrierSameNumerology Indicates whether the UE supports cross carrier scheduling for the same numerology in carrier aggregation with carrier indicator field (CIF).	UE	Tbd	Yes	No
crossCarrierDiffNumerology Indicates whether the UE supports cross carrier scheduling for the different numerologies in carrier aggregation with carrier indicator field (CIF).	UE	Tbd	Yes	No
csi-ReportWithoutCQI Indicates whether UE supports CSI reporting with report quantity set to 'CRI/RI/i1' as defined in Section 5.2.1.4 of TS 38.214 [12].	UE	Tbd	No	Yes
csi-ReportWithoutPMI Indicates whether UE supports CSI reporting with report quantity set to 'CRI/RI/CQI' as defined in Section 5.2.1.4 of TS 38.214 [12].	UE	Tbd	No	Yes
csi-RS-CFRA-ForHO Indicates whether the UE can perform handover using a contention free random access on PRACH resources that are associated with CSI-RS resources of the target cell.	UE	No	No	No
csi-RS-IM-ReceptionForFeedback Indicates support of CSI-RS and CSI-IM reception for CSI feedback. This capability signalling comprises the following parameters: - *maxNumberNZP-CSI-RS-PerCC* indicates the maximum number of configured NZP-CSI-RS resources per CC; - *maxNumberPortsAcrossNZP-CSI-RS-PerCC* indicates the maximum number of ports across all configured NZP-CSI-RS resources per CC; - *maxNumberCS-IM-PerCC* indicates the maximum number of configured CSI-IM resources per CC; - *maxNumberSimultaneousCSI-RS-ActBWP-AllCC* indicates the maximum number of simultaneous CSI-RS resources in active BWPs across all CCs; - *totalNumberPortsSimultaneousCSI-RS-ActBWP-AllCC* indicates the total number of CSI-RS ports in simultaneous CSI-RS resources in active BWPs across all CCs.	CC per band per BC	Tbd	No	No

csi-RS-MeasSCellWithoutSSB Defines whether the UE can perform CSI-RSRP and CSI-RSRQ measurement as specified in TS38.215 [13], where CSI-RS resource is configured for a cell that does not transmit SS/PBCH block. A UE that supports this feature shall also support scellWithoutSSB.	CC per band per BC	No	No	No
diffNumerologyAcrossPUCCH-Group Indicates whether different numerology across PUCCH groups in CA is supported by the UE.	CC per band per BC	Tbd	No	No
diffNumerologyWithinPUCCH-Group Indicates whether UE supports different numerology across carriers within a PUCCH group and a same numerology between DL and UL per carrier for data/control channel at a given time.	CC per band per BC	Tbd	No	No
downlinkSPS Indicates whether the UE supports PDSCH reception based on semi-persistent scheduling.	UE	Tbd	No	No
dynamicBetaOffsetInd-HARQ-ACK-CSI Indicates whether the UE supports indicating beta-offset (UCI repetition factor onto PUSCH) for HARQ-ACK and/or SR via DCI among the RRC configured beta-offsets.	UE	Tbd	No	No
dynamicHARQ-ACK-CodeB-CBG-Retx-DL Indicates whether the UE supports HARQ-ACK codebook size for CBG-based (re)transmission based on the DAI-based solution as specified in TS 38.213 [11].	UE	Tbd	No	No
dynamicHARQ-ACK-Codebook Indicates whether the UE supports HARQ-ACK codebook dynamically constructed by DCI(s).	UE	Yes	No	No
dynamicPowerSharing Indicates whether the UE supports dynamic EN-DC power sharing or not. If the UE supports this capability it will dynamically share the power between NR and LTE if P_LTE + P_NR > Pcmax.	UE	Tbd	No	Tbd
dynamicPRB-BundlingDL Indicates whether UE supports DCI-based indication of the PRG size for PDSCH reception.	UE	No	No	No
dynamicSFI Indicates whether the UE supports monitoring for DCI format 2_0 and determination of slot formats via DCI format 2_0.	UE	No	Yes	Yes
dynamicSwitchRA-Type0-1-PDSCH Indicates whether the UE supports dynamic switching between resource allocation Types 0 and 1 for PDSCH as specified in TS 38.212 [10].	UE	Tbd	No	No
dynamicSwitchRA-Type0-1-PUSCH Indicates whether the UE supports dynamic switching between resource allocation Types 0 and 1 for PUSCH as specified in TS 38.212 [10].	UE	Tbd	No	No
dynamicSwitchSUL Indicates whether the UE supports supplemental uplink with dynamic switch (DCI based selection of PUSCH carrier)	CC per band per BC	Tbd	No	No
freqHoppingPUCCH-F0-2 Indicates whether the UE supports transmission of a PUCCH format 0 or 2 without frequency hopping.	UE	No	No	Yes
freqHoppingPUCCH-F1-3-4 Indicates whether the UE supports transmission of a PUCCH format 1, 3 or 4 without frequency hopping.	UE	No	No	Yes
interleavingVRB-ToPRB-PDSCH Indicates whether the UE supports receiving PDSCH with interleaved VRB-to-PRB mapping as specified in TS 38.211 [6].	UE	Tbd	No	No
interSlotFreqHopping-PUSCH Indicates whether the UE supports inter-slot frequency hopping for PUSCH transmissions.	UE	Tbd	No	No
intraSlotFreqHopping-PUSCH Indicates whether the UE supports intra-slot frequency hopping for PUSCH transmission, except for PUSCH scheduled by PDCCH in the Type1-PDCCH common search space before RRC connection establishment.	UE	Yes	No	Yes

maxNumberMIMO-LayersPDSCH Defines the maximum number of spatial multiplexing layer(s) supported by the UE for DL reception.	CC per band per BC	Tbd	No	No
maxNumberMIMO-LayersCB-PUSCH Defines supported maximum number of MIMO layers at the UE for PUSCH transmission with codebook precoding. UE indicating support of this feature shall also indicate support of PUSCH codebook coherency subset.	CC per band per BC	Tbd	No	No
maxNumberMIMO-LayersNonCB-PUSCH Defines supported maximum number of MIMO layers at the UE for PUSCH transmission using non-codebook precoding.	CC per band per BC	Tbd	No	No
maxNumberSRS-ResourcePerSet Defines the maximum number of SRS resources per SRS resource set configured for codebook based transmission to the UE.	CC per band per BC	Tbd	No	No
multipleCORESET Indicates whether the UE supports configuration of more than one PDCCH CORESET per BWP in addition to the CORESET with CORESET-ID 0 in the BWP. It is mandatory with capability signaling for FR2.	UE	Yes /No	No	No
mux-SR-HARQ-ACK-CSI-PUCCH Indicates whether the UE supports multiplexing SR, HARQ-ACK and CSI on a PUCCH or piggybacking on a PUSCH once per slot.	UE	No	No	Yes
nzp-CSI-RS-IntefMgmt Indicates whether the UE supports interference measurements using NZP CSI-RS.	UE	[No]	No	No
oneFL-DMRS-ThreeAdditionalDMRS Defines whether the UE supports DM-RS pattern for DL reception and/or UL transmission with 1 symbol front-loaded DM-RS with three additional DM-RS symbols.	UE	Tbd	No	Yes
oneFL-DMRS-TwoAdditionalDMRS Defines support of DM-RS pattern for DL reception and/or UL transmission with 1 symbol front-loaded DM-RS with 2 additional DM-RS symbols and more than 1 antenna ports.	UE	Yes	No	Yes
onePortsPTRS Defines whether UE supports PT-RS with 1 antenna port in DL reception and/or UL transmission for FR1. For FR2, it is mandatory with UE capability signalling.	UE	Yes /No	No	Yes
onePUCCH-LongAndShortFormat Indicates whether the UE supports transmission of one long PUCCH format and one short PUCCH format in TDM in the same slot.	UE	Tbd	No	Yes
pdcch-BlindDetectionCA Indicates PDCCH blind decoding capabilities supported by the UE for CA with more than 4 CCs as specified in TS 38.213 [11]. The field value is from 4 to 16.	UE	Tbd	No	Yes
pdcchMonitoringAnyOccasions Defines the supported PDCCH search space monitoring occasions. withoutDCI-gap indicates whether the UE supports PDCCH search space monitoring occasions in any symbol of the slot for Type 1-PDCCH common search space configured by dedicated RRC signaling, for a Type 3-PDCCH common search space, or for a UE-specific search space with the capability of supporting at least 44, 36, 22, and 20 blind decodes in a slot for 15 kHz, 30 kHz, 60kHz, and 120 kHz subcarrier spacing values respectively. withDCI-gap indicates whether the UE supports PDCCH search space monitoring occasions in any symbol of the slot with minimum time separation between two consecutive transmissions of PDCCH scrambled with C-RNTI or CS-RNTI for Type 1-PDCCH common search space configured by dedicated RRC signaling, for a Type 3-PDCCH common search space, or for a UE-specific search space, with the capability of supporting at least 44, 36, 22, and 20 blind decodes in a slot for 15 kHz, 30 kHz, 60kHz, and 120 kHz subcarrier spacing values respectively.	CC per band per BC	No	No	No
pdcchMonitoringAnyOccasionsWithSpanGap Indicates whether the UE supports PDCCH search space monitoring occasions in any symbol of the slot with minimum time separation between two consecutive transmissions of PDCCH scrambled with C-RNTI or CS-RNTI for Type 1-PDCCH common search space configured by dedicated RRC signaling, for a Type 3-PDCCH common search space, or for a UE-specific search space with span up to two OFDM symbols for two OFDM symbols or span up to three OFDM symbols for four and seven OFDM symbols.	CC per band per BC	Tbd	No	No

pdcchMonitoringSingleOccasion Indicates whether the UE supports receiving PDCCH scrambled with C-RNTI or CS-RNTI in a search space configured to be monitored within a single span of any three contiguous OFDM symbols in a slot with the capability of supporting at least 44 blind decodes in a slot for 15 kHz subcarrier spacing.	UE	No	No	No FR1
pdsch-256QAM-FR1 Indicates whether the UE supports 256QAM for PDSCH for FR1.	UE	Yes	No	Yes
pdsch-DifferentTB-PerSlot Defines whether the UE supports reception of up to two, four or seven PDSCHs for different transport blocks with PDSCH scrambled using C-RNTI, TC-RNTI, or CS-RNTI within the same slot.	CC per band per BC	Tbd	No	No
pdsch-MappingTypeA Indicates whether the UE supports receiving PDSCH using PDSCH mapping type A with less than seven symbols.	UE	Yes	No	No
pdsch-MappingTypeB Indicates whether the UE supports receiving PDSCH using PDSCH mapping type B.	UE	Yes	No	No
pdsch-RE-MappingFR1/FR2 Indicates the maximum number of PDSCH Resource Element (RE) mapping supported for FR1 and FR2, respectively. Value n6 means 6 RE mapping patterns and n10 means 10 RE mapping patterns, and so on.	UE	Tbd	No	Yes
pdsch-RepetitionMultiSlots Indicates whether the UE supports receiving PDSCH scheduled by DCI format 1_0 or 1_1 when configured with higher layer parameter aggregationFactorDL > 1.	UE	Tbd	No	Tbd
pre-EmptIndication-DL Indicates whether the UE supports interrupted transmission indication for PDSCH reception based on reception of DCI format 2_1 as defined in TS 38.213 [11].	UE	Tbd	No	No
precoderGranularityCORESET Indicates whether the UE supports receiving PDCCH in CORESETs configured with CORESET-precoder-granularity equal to the size of the CORESET in the frequency domain as specified in TS 38.211 [6].	UE	No	No	No
pucch-F2-WithFH Indicates whether the UE supports transmission of a PUCCH format 2 (2 OFDM symbols in total) with frequency hopping in a slot.	UE	Yes	No	Yes
pucch-F3-4-HalfPi-BPSK Indicates whether the UE supports pi/2-BPSK for PUCCH format 3/4. For FR1, it is optional.	UE	No	No	Yes
pucch-F3-WithFH Indicates whether the UE supports transmission of a PUCCH format 3 (4~14 OFDM symbols in total) with frequency hopping in a slot.	UE	Yes	No	Yes
pucch-F4-WithFH Indicates whether the UE supports transmission of a PUCCH format 4 (4~14 OFDM symbols in total) with frequency hopping in a slot.	UE	Yes	No	Yes
pusch-LBRM Indicates whether the UE supports limited buffer rate matching in UL as specified in TS 38.212 [10].	UE	Tbd	No	Yes
pucch-Repetition-F1-3-4 Indicates whether the UE supports transmission of a PUCCH format 1 or 3 or 4 over multiple slots with the repetition factor 2, 4 or 8.	UE	[Yes]	No	No
pusch-DifferentTB-PerSlot Indicates whether the UE supports transmission of up to two, four or seven PUSCHs for different transport blocks within the same slot.	CC per band per BC	Tbd	No	No
pusch-HalfPi-BPSK Indicates whether the UE supports pi/2-BPSK for PUSCH. For FR1, it is optional.	UE	No	No	Yes
pusch-RepetitionMultiSlots Indicates whether the UE supports transmitting PUSCH scheduled by DCI format 0_0 or 0_1 when configured with higher layer parameter aggregationFactorIUL > 1.	UE	Tbd	No	No
ra-Type0-PUSCH Indicates whether the UE supports resource allocation Type 0 for PUSCH as specified in TS 38.214 [12].	UE	Tbd	No	No
rateMatchingLTE-CRS Indicates whether the UE supports receiving PDSCH with resource mapping that excludes the REs determined by the higher layer configuration LTE-carrier configuring common RS, as specified in TS 38.214 [12].	UE	Tbd	No	No

rateMatchingResrcSetDynamic Indicates whether the UE supports receiving PDSCH with resource mapping that excludes the REs corresponding to resource sets configured with RB-symbol level granularity based on dynamic indication in the scheduling DCI as specified in TS 38.214 [12].	UE	Tbd	No	No
rateMatchingResrcSetSemi-Static Indicates whether the UE supports receiving PDSCH with resource mapping that excludes the REs corresponding to resource sets configured with RB-symbol level granularity following the semi-static configuration as specified in TS 38.214 [12].	UE	Yes	No	No
scalingFactor Indicates the scaling factor to be applied to the band in the max data rate calculation as defined in 4.1.2. Value f0p4 indicates the scaling factor 0.4, f0p75 indicates 0.75, and so on. If absent, the scaling factor 1 is applied to the band in the max data rate calculation.	CC per band per BC	Tbd	Tbd	Tbd
scellWithoutSSB Defines whether the UE supports configuration of SCell that does not transmit SS/PBCH block. This is conditionally mandatory for intra-band CA but not supported for inter-band CA.	CC per band per BC	Yes /No	No	No
scs-60kHz Indicates whether the UE supports 60kHz subcarrier spacing for data channel in FR1.	UE	Tbd	No	No FR1
searchSpaceSharingCA-DL Defines whether the UE supports DL PDCCH search space sharing for carrier aggregation operation.	CC per band per BC	Tbd	No	No
searchSpaceSharingCA-UL Defines whether the UE supports UL PDCCH search space sharing for carrier aggregation operation.	CC per band per BC	Tbd	No	No
semiOpenLoopCSI Indicates whether UE supports CSI reporting with report quantity set to 'CRI/RI/i1' as defined in Section 5.2.1.4 of TS 38.214 [12].	UE	Tbd	No	Yes
semiStaticHARQ-ACK-Codebook Indicates whether the UE supports HARQ-ACK codebook constructed by semi-static configuration	UE	Yes	No	No
simultaneousRxTxSUL Indicates whether the UE supports simultaneous reception and transmission for a NR CA band combination including SUL.	BC	Tbd	No	No
simultaneousTxSUL-NonSUL Indicates whether the UE supports simultaneous transmission of SRS on an SUL/non-SUL carrier and PUSCH/PUCCH/SRS/PRACH on the other UL carrier in the same cell.	CC per band per BC	Tbd	No	No
spatialBundlingHARQ-ACK Indicates whether the UE supports spatial bundling of HARQ-ACK bits carried on PUCCH or PUSCH per PUCCH group. With spatial bundling, two HARQ-ACK bits for a DL MIMO data is bundled into a single bit by logical "AND" operation.	UE	Yes	No	No
Sp-CSI-RS Indicates whether the UE supports semi-persistent CSI-RS.	UE	Tbd	No	Yes
Sp-CSI-IM Indicates whether the UE supports semi-persistent CSI-IM.	UE	Tbd	No	Yes
sp-CSI-ReportPUCCH Indicates whether UE supports semi-persistent CSI reporting using PUCCH formats 2, 3 and 4.	UE	No	No	No
sp-CSI-ReportPUSCH Indicates whether UE supports semi-persistent CSI reporting using PUSCH.	UE	No	No	No
srs-AssocCSI-RS Indicates whether UE supports calculation of the precoder for SRS transmission based on channel measurements using associated NZP CSI-RS resource as described in Section 6.1.1.2 of TS 38.214 [12]. UE supporting this feature shall also indicate support of non-codebook based PUSCH transmission	CC per band per BC	No	No	No
srs-TxSwitch Defines whether UE supports SRS antenna port switching as defined in Section 6.2.1.2 of TS 38.214 [12].	CC per band per BC	Tbd	No	No

supportedBandwidthDL Indicates maximum DL channel bandwidth supported for a given SCS that UE supports within a single CC, which is defined in Table 5.3.5-1 in TS38.101-1 [2] for FR1 and Table 5.3.5-1 in TS38.101-2 [3] for FR2.	CC per band per BC	Tbd	No	Tbd
supportedBandwidthUL Indicates maximum UL channel bandwidth supported for a given SCS that UE supports within a single CC, which is defined in Table 5.3.5-1 in TS38.101-1 [2] for FR1 and Table 5.3.5-1 in TS38.101-2 [3] for FR2.	CC per band per BC	Tbd	No	Tbd
supportedDMRS-TypeDL Defines supported DM-RS configuration types at the UE for DL reception.	UE	Tbd	No	Yes
supportedDMRS-TypeUL Defines supported DM-RS configuration types at the UE for UL transmission. At least support of type1 is mandatory.	UE	Yes /No ?	No	Yes
supportedModulationOrderDL Defines the supported modulation scheme for DL by the UE.	CC per band per BC	Tbd	No	Tbd
supportedModulationOrderUL Defines the supported modulation scheme for UL by the UE.	CC per band per BC	Tbd	No	Tbd
supportedNumberTAG Defines the number of timing advance groups are supported by the UE	CC per band per BC	Tbd	No	No
supportedSRS-Resources Defines support of SRS resources. The capability signalling comprising indication of: - Supported maximum number of aperiodic SRS resources that can be configured for the UE per each BWP - Supported maximum number of aperiodic SRS resources per slot in the BWP - Supported maximum number of periodic SRS resources per BWP - Supported maximum number of periodic SRS resources per slot in the BWP - Supported maximum number of semi-persistent SRS resources that can be configured for the UE per each BWP - Supported maximum number of semi-persistent SRS resources per slot in the BWP - Supported maximum number of SRS antenna port per each SRS resource	CC per band per BC	Tbd	No	No
supportedSubCarrierSpacingDL Defines the supported sub-carrier spacing for DL by the UE indicating the UE supports simultaneous reception with same or different numerologies in CA. Note the UE shall support all mandated sub-carrier spacing for FR1/FR2.	CC per band per BC	No	No	No
supportedSubCarrierSpacingUL Defines the supported sub-carrier spacing for UL by the UE, indicating the UE supports simultaneous transmission with same or different numerogies in CA, or indicating the UE supports different numerologies on NR UL and SUL within one cell. Note the UE shall support all mandated sub-carrier spacing for FR1/FR2.	CC per band per BC	No	No	No
tdd-MultiDL-UL-SwitchPerSlot Indicates whether the UE supports more than one switch points in a slot for actual DL/UL transmission(s).	UE	Tbd	TDD only	Yes
tdm-Pattern Indicates whether the UE supports the *tdm-Pattern for single UL transmission* associated functionality. Support is conditionally mandatory for UEs that do not support dynamic power sharing and for UEs that indicate single UL for any BC, and optional otherwise.	UE	Yes /No	Yes	Tbd
timeDurationForQCL Defines minimum number of OFDM symbols required by the UE to perform PDCCH reception and applying spatial QCL information received in DCI for PDSCH processing as described in TS 38.214 [12] Section 5.1.5. UE shall indicate one value of the minimum number of OFDM symbols per each subcarrier spacing of 60kHz and 120kHz.	CC per band per BC	Tbd	No	No FR2

tpc-PUCCH-RNTI Indicates whether the UE supports group DCI message based on TPC-PUCCH-RNTI for TPC commands for PUCCH.	UE	Tbd	No	Yes
tpc-PUSCH-RNTI Indicates whether the UE supports group DCI message based on TPC-PUSCH-RNTI for TPC commands for PUSCH.	UE	Tbd	No	Yes
tpc-SRS-RNTI Indicates whether the UE supports group DCI message based on TPC-SRS-RNTI for TPC commands for SRS.	UE	Tbd	No	Yes
twoDifferentTPC-Loop-PUCCH Indicates whether the UE supports two different TPC loops for PUCCH closed loop power control.	UE	Yes	Yes	Yes
twoDifferentTPC-Loop-PUSCH Indicates whether the UE supports two different TPC loops for PUSCH closed loop power control.	UE	Yes	Yes	Yes
twoFL-DMRS Defines whether the UE supports DM-RS pattern for DL reception and/or UL transmission with 2 symbols front-loaded DM-RS without additional DM-RS symbols.	UE	Tbd	No	Yes
twoFL-DMRS-TwoAdditionalDMRS Defines whether the UE supports DM-RS pattern for DL reception and/or UL transmission with 2 symbols front-loaded DM-RS with one additional 2 symbols DM-RS.	UE	Tbd	No	Yes
twoPUCCH-AnyOthersInSlot Indicates whether the UE supports transmission of two PUCCH formats in TDM in the same slot, which are not covered by 4-22 and 4-2.	UE	Tbd	No	Yes
twoPUCCH-F0-2-ConsecSymbols Indicates whether the UE supports transmission of two PUCCHs of format 0 or 2 in consecutive symbols in a slot.	UE	Tbd	Yes	Yes
twoPUCCH-Group Indicates whether two PUCCH group in CA with a same numerology across CCs for data and control channel [at a given time] is supported by the UE.	CC per band per BC	Tbd	No	No
type1-3-CSS Defines whether the UE is able to receive PDCCH in a Type1-PDCCH common search space configured by dedicated RRC signaling, or in a Type3-PDCCH common search space or in a UE-specific search space, with an associated CORESET duration of 3 symbols in FR2.	CC per band per BC	Yes	No	No
type1-PUSCH-RepetitionMultiSlots Indicates whether the UE supports Type 1 PUSCH transmissions with configured grant as specified in TS 38.214 [12] with UL-TWG-repK value equal to 2, 4, or 8 with a single repetition of the transport block within each slot, and redundancy version pattern as indicated by UL-TWG-RV-rep. A UE supporting this feature shall also support Type 1 PUSCH transmissions with configured grant as specified in TS 38.214 [12] with UL-TWG-repK value of one.	UE	Tbd	No	No
type2-PUSCH-RepetitionMultiSlots Indicates whether the UE supports Type 1 PUSCH transmissions with configured grant as specified in TS 38.214 [12] with UL-TWG-repK value equal to 2, 4, or 8 with a single repetition of the transport block within each slot, and redundancy version pattern as indicated by UL-TWG-RV-rep. A UE supporting this feature shall also support Type 2 PUSCH transmissions with configured grant as specified in TS 38.214 [12] with UL-TWG-repK value of one.	UE	Tbd	No	No

typeI-SinglePanelCodebookList List of type I single panel codebooks supported by the UE. Each entry includes the following parameters: - *maxNumberTxPortsPerResource* indicates the maximum number of Tx ports in a resource across all CCs simultaneously; - *maxNumberResources* indicates the maximum number of resources across all CCs simultaneously; - *totalNumberTxPorts* indicates the total number of Tx ports across all CCs simultaneously; - *supportedCodebookMode* indicates suppoted codebook modes (mode 1 or both of mode 1 and mode 2); - *maxNumberCSI-RS-PerResourceSet* indicates the maximum number of CSI-RS resource in a resource set.	CC per band per BC	Tbd	No	No
typeI-MultiPanelCodebookList List of type I multi-panel codebooks supported by the UE. Each entry includes the following parameters: - *maxNumberTxPortsPerResource* indicates the maximum number of Tx ports in a resource across all CCs simultaneously; - *maxNumberResources* indicates the maximum number of resources across all CCs simultaneously; - *totalNumberTxPorts* indicates the total number of Tx ports across all CCs simultaneously; - *supportedCodebookMode* indicates supported codebook modes (mode 1, mode2 or both of mode 1 and mode 2); - *supportedNumberPanels* indicates supported number of panels; - *maxNumberCSI-RS-PerResourceSet* indicates the maximum number of CSI-RS resource in a resource set.	CC per band per BC	Tbd	No	No
typeII-CodebookList List of type II codebooks supported by the UE. Each entry includes the following parameters: - *maxNumberTxPortsPerResource* indicates the maximum number of Tx ports in a resource across all CCs simultaneously; - *maxNumberResources* indicates the maximum number of resources across all CCs simultaneously; - *totalNumberTxPorts* indicates the total number of Tx ports across all CCs simultaneously; - *parameterLx* indicates the parameter "Lx" in codebook generation where x is an index of Tx ports indicated by *maxNumberTxPortsPerResource*; - *amplitudeScalingType* inciates the amplitude scaling type supported by the UE (wideband or both of wideband and sub-band; - *amplitudeSubsetRestriction* indicates whether amplitude subset restriction is supported for the UE; - *maxNumberCSI-RS-PerResourceSet* indicates the maximum number of CSI-RS resource in a resource set.	CC per band per BC	Tbd	No	No

typeII-CodebookPortSelectionList List of type II codebooks with port selection supported by the UE. Each entry includes the following parameters: - *maxNumberTxPortsPerResource* indicates the maximum number of Tx ports in a resource across all CCs simultaneously; - *maxNumberResources* indicates the maximum number of resources across all CCs simultaneously; - *totalNumberTxPorts* indicates the total number of Tx ports across all CCs simultaneously; - *parameterLx* indicates the parameter "Lx" in codebook generation where x is an index of Tx ports indicated by *maxNumberTxPortsPerResource*; - *amplitudeScalingType* inciates the amplitude scaling type supported by the UE (wideband or both of wideband and sub-band; - *maxNumberCSI-RS-PerResourceSet* indicates the maximum number of CSI-RS resource in a resource set.	CC per band per BC	Tbd	No	No
type2-SP-CSI-Feedback-LongPUCCH Indicates whether UE supports Type II CSI semi-persistent CSI reporting over PUCCH Formats 3 and 4 as defined in Section 5.2.4 of TS 38.214 [12].	UE	[No]	No	No
uci-CodeBlockSegmentation Indicates whether the UE supports segmenting UCI into multiple code blocks depending on the payload size.	UE	Yes	No	Yes
ue-SpecificUL-DL-Assignment Indicates whether the UE supports dynamic determination of UL and DL link direction and slot format based on Layer 1 scheduling DCI and higher layer configured parameter UL-DL-configuration-dedicated as specified in TS 38.213 [11].	CC per band per BC	Tbd	No	No

4.2.8 RF parameters

Definitions for parameters	Per	M	FDD TDD DIFF
additionalActiveTCI-StatePDCCH Indicates whether the UE supports one additional active TCI-State for control in addition to the supported number of active TCI-States for PDSCH. The UE can include this field only if *maxNumberConfiguredTCIstatesPerCC* in *tci-StatePDSCH* is set to 1. Otherwise, the UE does not include this field.	Band	Yes	No
aperiodicBeamReport Indicates whether the UE supports aperiodic 'CRI/RSRP' or 'SSBRI/RSRP' reporting on PUSCH. For FR2, it is mandatory.	Band	Yes /No	No
aperiodicTRS Indicates whether the UE supports DCI triggering aperiodic TRS associated with periodic TRS.	Band	No	No
asyncIntraBandENDC Indicates whether the UE supports asynchronous FDD-FDD intra-band EUTRA-NR EN-DC with MRTD and MTTD as specified in [x]. If it is not supported for FDD-FDD intra-band EUTRA-NR EN-DC, the UE supports only synchronous FDD-FDD intra-band EUTRA-NR EN-DC.	BC	Tbd	Tbd
beamCorrespondence Indicates whether UE supports beam correspondence as defined in <TBD RAN4 >. For FR2, it is mandatory.	Band	[Yes/No]	No
beamManagementSSB-CSI-RS Defines support of SS/PBCH and CSI-RS based RSRP measurements. The capability comprises signalling of - Maximum total number of one port NZP CSI-RS resources and SS/PBCH blocks that are supported by the UE for 'CRI/RSRP' and 'SSBRI/RSRP' reporting within a slot and across all serving cells. Support of n8 is mandatory for at least for >6Ghz bands. - Maximum total number of two ports NZP CSI-RS resources that are supported by the UE for 'CRI/RSRP' or 'SSBRI/RSRP' reporting within a slot and across all serving cells. - Supported density of one RE per PRB for one port NZP CSI-RS resource for RSRP reporting. At least density of CSI-RS =3 is mandatory at least for FR2.	Band	No	No
beamReportTiming Indicates the number of OFDM symbols between the last symbol of SSB/CSI-RS and the first symbol of the transmission channel containing beam report. The UE includes this filed for each supported sub-carrier spacing.	Band	Tbd	No
bwp-DiffNumerology Indicates whether the UE supports BWP adaptation up to 4 BWPs with the different numerologies. For the UE capable of this feature, the bandwidth of a UE-specific RRC configured BWP includes the bandwidth of the initial DL BWP and SSB for PCell and PSCell. For SCell(s), the bandwidth of the UE-specific RRC configured BWP includes SSB, if there is SSB on SCell(s).	Band	No	No
bwp-SameNumerology Defines type A/B BWP adaptation (up to 2/4 BWPs) with the same numerology. For the UE capable of this feature, the bandwidth of a UE-specific RRC configured BWP includes the bandwidth of the initial DL BWP and SSB for PCell and PSCell. For SCell(s), the bandwidth of the UE-specific RRC configured BWP includes SSB, if there is SSB on SCell(s).	Band	Tbd	No
bwp-WithoutRestriction Indicates support of BWP operation without bandwidth restriction. The Bandwidth restriction in terms of BWP for PCell and PSCell means that the bandwidth of a UE-specific RRC configured BWP may not include the bandwidth of initial DL BWP and SSB. For SCell(s), it means that the bandwidth of BWP may not include SSB.	Band	Tbd	No
ca-ParametersEUTRA Contains the EUTRA part of band combination parameters for a given EN-DC band combination.	BC	No	No

csi-ReportFramework Indicates whether the UE supports CSI report framework. This capability signalling comprises the following parameters: - *maxNumberPeriodicCSI-ReportPerBWP* indicates the maximum number of periodic CSI report per BWP; - *maxNumberAperiodicCSI-ReportPerBWP* indicates the maximum number of aperiodic CSI report setting per BWP; - *maxNumberSemiPersistentCSI-ReportPerBWP* indicates the maximum number of semi-persistent CSI report setting per BWP; - *simultaneousCSI-ReportsAllCC* indicates the number of CSI report(s) which the UE can simultaneously process across all CCs. The CSI report comprises periodic, semi-persistent and aperiodic CSI and any latency classes and codebook types.	Band	Tbd	No
csi-RS-ForTracking Indicates support of CSI-RS for tracking (i.e. TRS). This capability signalling comprises the following parameters: - *butstLength* indicates the TRS burst length; - *maxSimultaneousResourceSetsPerCC* indicates the maximum number of TRS resource sets per CC which the UE can track simultaneously; - *maxConfiguredResourceSetsPerCC* indicates the maximum number of TRS resource sets configured to UE per CC; - *maxConfiguredResourceSetsAllCC* indicates the maximum number of TRS resource sets configured to UE across CCs.	Band	Tbd	No
downlinkSetNR Indicates the features that the UE supports on the DL carriers corresponding to one band entry in a band combination by FeatureSetDownlinkId. The FeatureSetDownlinkId=0 is not used by an actual FeatureSetDownlink but means that the UE does not support a DL carrier in this band of a band combination.	Band per BC	Tbd	No
extendedCP Indicates whether the UE supports 60 kHz subcarrier spacing with extended CP length for reception of PDCCH, and PDSCH, and transmission of PUCCH, PUSCH, and SRS.	Band	No	No
featureSets Pools of downlink and uplink features sets as well as a pool of FeatureSetCombination elements. A FeatureSetCombination refers to the IDs of the feature set(s) that the UE supports in that FeatureSetCombination. The BandCombination entries in the BandCombinationList then indicate the ID of the FeatureSetCombination that the UE supports fot that band combination.	UE	Tbd	No
featureSetCombination Indicates the feature set that the UE supports on the NR CA or MR-DC band combination by FeatureSetCombinationId.	BC	Tbd	No
featureSetCombinations Pools of feature sets that the UE supports on the NR CA or MR-DC band combinations.	UE	Tbd	No
featureSetListPerDownlinkCC Indicates which features the UE supports on the individual DL carriers of the feature set (and hence of a band entry that refer to the feature set) by FeatureSetDownlinkPerCC-Id. The UE shall hence include as many FeatureSetDownlinkPerCC-Id in this list as the number of carriers it supports according to the ca-bandwidthClassDL. The order of the elements in this list is not relevant, i.e., the network may configure any of the carriers in accordance with any of the FeatureSetDownlinkPerCC-Id in this list.	CC per band per BC	Tbd	No
featureSetListPerUplinkCC Indicates which features the UE supports on the individual UL carriers of the feature set (and hence of a band entry that refer to the feature set) by FeatureSetUplinkPerCC-Id. The UE shall hence include as many FeatureSetUplinkPerCC-Id in this list as the number of carriers it supports according to the ca-bandwidthClassUL. The order of the elements in this list is not relevant, i.e., the network may configure any of the carriers in accordance with any of the FeatureSetUplinkPerCC-Id in this list.	CC per band per BC	Tbd	No

groupBeamReporting Indicates whether UE supports RSRP reporting for the group of two reference signals.	Band	No	No
intraBandFreqSeparationDL Indicates DL frequency separation class the UE supports, which indicates frequency separation between lower edge of lowest CC and upper edge of highest CC in a frequency band, for intra-band non-contiguous CA.	Band per BC	Tbd	No
intraBandFreqSeparationUL Indicates UL frequency separation class the UE supports, which indicates frequency separation between lower edge of lowest CC and upper edge of highest CC in a frequency band, for intra-band non-contiguous CA.	Band per BC	Tbd	No
maxNumberActiveTCI-PerCC Defines maximum number of TCI states that can be configured for the UE using RRC signalling. This value shall not be lower than the maximum number of TCI states supported by the UE for MAC Control Element activation.	Band	Tbd	No
maxNumberConfiguredTCIstates Defines maximum number of Transmission Configuration Indication (TCI) states for PDSCH reception that can be activated for the UE using MAC Control Element from the set of RRC configured TCI states as defined in TS 38.214 [12] Section 5.1.5.	Band	Tbd	No
maxNumberSimultaneousSRS-PerCC Defines the number of SRS resources that can be transmitted by the UE in one OFDM symbol per each CC.	Band	Tbd	No
maxNumberCSI-RS-BFR Indicates maximal number of CSI-RS resources across all CCs for UE to monitor PDCCH quality	Band	Tbd	No
maxNumberCSI-RS-SSB-BFR Defines maximal number of different CSI-RS [and/or SSB] resources across all CCs for new beam identifications.	Band	Tbd	No
maxNumberNonGroupBeamReporting Defines support of non-group based RSRP reporting using N_max RSRP values reported.	Band	Tbd	No
maxNumberRxBeam Defines whether UE supports receive beamforming switching using NZP CSI-RS resource. UE shall indicate a single value for the preferred number of NZP CSI-RS resource repetitions per CSI-RS resource set.	Band	Tbd	No
maxNumberRxTxBeamSwitchDL Defines the number of Tx and Rx beam changes UE can perform within a slot across all configured serving cells. UE shall report one value per each subcarrier spacing supported by the UE.	Band	Tbd	No
maxNumberSSB-BFR Defines maximal number of different SSBs across all CCs for UE to monitor PDCCH quality	Band	Tbd	No
modifiedMPR-Behaviour Indicates whether the UE supports modified A-MPR due to some reasons e.g. regulatory requirements change, RB restriction is replaced to A-MPR for better frequency usage efficiency.	Band	Tbd	Tbd
multipleTCI Indicates whether the UE supports more than one configuration of *TCI-StatesPDCCH* for a PDCCH CORESET configured by dedicated RRC signaling.	Band	No	No
multipleTimingAdvances Indicates whether multiple timing advances are supported by the UE. For NR CA band combination, if the band combination comprised of more than one band entry (i.e., inter-band or intra-band non-contiguous band combination), the field indicates that different timing advances on different band entries are supported. For EN-DC band combination, this field is not presented and it is mandatory for the UE supporting EN-DC band combination. In this release, up to two timing advances are supported for EN-DC band combination or NR CA band combination. Note: For NR CA, it is mandatory with IOT bit for inter-band NR CA, otherwise optional. For EN-DC, it is mandatory without IOT bit.	BC	Yes /No	No
parallelTxSRS-PUCCH-PUSCH Indicates whether the UE supports parallel transmission of SRS, PUCCH and PUSCH across CCs in an inter-band CA band combination.	BC	Tbd	No
parallelTxPRACH-SRS-PUCCH-PUSCH Indicates whether the UE supports parallel transmission of PRACH, SRS, PUCCH and PUSCH across CCs in an inter-band CA band combination.	BC	Tbd	No
periodicBeamReport Indicates whether UE supports periodic 'CRI/RSRP' or 'SSBRI/RSRP' reporting using PUCCH formats 2, 3 and 4 in one slot. For FR2, it is mandatory.	Band	Yes /No	No

pdsch-256QAM-FR2 Indicates whether the UE supports 256QAM for PDSCH for FR2.	Band	No	No
ptrs-DensityRecommendationSetDL For each supported sub-carrier spacing, indicates preferred threshold sets for determining DL PTRS density. For each supported sub-carrier spacing, this field comprises: - two values of *frequencyDensity*; - three values of *timeDensity*.	Band	Yes for FR 2	No
ptrs-DensityRecommendationSetUL For each supported sub-carrier spacing, indicates preferred threshold sets for determining UL PTRS density. For each supported sub-carrier spacing, this field comprises: - two values of *frequencyDensity*; - three values of *timeDensity*; - five values of *sampleDensity*.	Band	No	No
pusch-256QAM Indicates whether the UE supports 256QAM for PUSCH.	Band	No	No
pusch-TransCoherence Defines support of the uplink codebook subset by the UE for UL precoding for PUSCH transmission as described in Section 6.1.1.1 of TS 38.214 [12]. UE indicated support of partial coherent codebook subset shall also support non-coherent codebook subset. UE indicated support of full coherent codebook subset shall also support partial and non-coherent codebook subset.	Band	Tbd	No
simultaneousRxTxInterBandCA Indicates whether the UE supports simultaneous transmission and reception in TDD-TDD and TDD-FDD inter-band NR CA. It is mandatory for certain TDD-FDD and TDD-TDD band combinations defined in TS 38.101-1 [2], 38.101-2 [3] and 38.101-3 [4].	BC	Yes /No	No
simultaneousRxTxInterBandENDC Indicates whether the UE supports simultaneous transmission and reception in TDD-TDD and TDD-FDD inter-band EN-DC. It is mandatory for certain TDD-FDD and TDD-TDD band combinations defined in TS 38.101-3 [4].	BC	Yes /No	No
singleUL-Transmission Indicates that the UE does not support simultaneous UL transmissions as defined in TS 38.101-3 [4]. The UE may only set this bit for certain band combinations defined in TS 38.101-3 [4]. If set for a particular band combination, the bit applies to all fallback band combinations of this band combination that are defined in TS 38.101-3 [4] as being allowed to set the bit and does not apply to any other fallback band combinations defined in TS 38.101-3 [4].	BC	Tbd	No
sp-BeamReportPUCCH Indicates support of semi-persistent 'CRI/RSRP' or 'SSBRI/RSRP' reporting using PUCCH formats 2, 3 and 4 in one slot.	Band	No	No
sp-BeamReportPUSCH Indicates support of semi-persistent 'CRI/RSRP' or 'SSBRI/RSRP' reporting on PUSCH.	Band	No	No
supportedBandCombination Defines the supported CA and/or MR-DC band combinations by the UE. For each band combination the UE identifies the associated feature set combination by featureSetCombinations index referring to featureSetCombination.	UE	Yes	No
supportedBandListNR Includes the supported NR bands as defined in TS 38.101-1 [2] and TS 38.101-2 [3].	UE	Yes	No
supportedBandwidthCombinationSet Defines the supported bandwidth combination for the band combination set as defined in the 38.101-1 [2], 38.101-2 [3] and 38.101-3 [4]. Field encoded as a bit map, where bit N is set to "1" if UE support Bandwidth Combination Set N for this band combination as defined in the 38.101-1 [2], 38.101-2 [3] and 38.101-3 [4]. The leading / leftmost bit (bit 0) corresponds to the Bandwidth Combination Set 0, the next bit corresponds to the Bandwidth Combination Set 1 and so on.	BC	Tbd	No

tci-StatePDSCH Defines support of TCI-States for PDSCH. The capability signalling comprises the following parameters: - *maxNumberConfiguredTCIstatesPerCC* indicates the supported number of active TCI-states per BWP per CC, including control and data; - *maxNumberActiveTCI-PerBWP* indicates the maximum number of configured TCI-states per CC for PDSCH.	Band	Tbd	No
twoPortsPTRS-DL Defines whether UE supports PT-RS with 2 antenna ports for DL reception.	Band	No	No
twoPortsPTRS-UL Defines whether UE supports PT-RS with 2 antenna ports for UL transmission.	Band	No	No
ue-PowerClass If the UE supports the different power class than the default power class (see TS 36.101 [14]), the UE shall report the supported power class in this field.	Band	Yes	No
ul-SharingEUTRA-NR Indicates whether the UE supports EN-DC with EUTRA-NR coexistence in UL sharing from UE perspective.	BC	No	No
ul-SwitchingTimeEUTRA-NR Indicates support of switching type between LTE UL and NR UL for EN-DC with LTE-NR coexistence in UL sharing from UE perspective. Type1 indicates UE supports switching within less than 0 us and type2 indicates UE supports switching within less than 20us.	BC	Tbd	No
uplinkBeamManagement Defines support of beam management for UL. The capability include indication of the - Maximum number of SRS resources per SRS resource set supported by the UE. - Maximum number of SRS resource sets supported by the UE.	Band	Tbd	No
uplinkSetNR Indicates the features that the UE supports on the UL carriers corresponding to one band entry in a band combination by FeatureSetUplinkId. The FeatureSetUplinkId=0 is not used by an actual FeatureSetUplink but means that the UE does not support a UL carrier in this band of a band combination.	Band per BC	Tbd	No

4.2.9 Measurement parameters

Definitions for parameters	Per	M	FDD-TDD diff	FR1 FR2 diff
csi-RS-RLM Indicates whether the UE can perform radio link monitoring procedure based on measurement of CSI-RS as specified in TS38.213 [11] and 38.133 [5]. This parameter needs FR1 and FR2 differentiation.	UE	Yes	No	Yes
csi-RSRP-AndRSRQ-MeasWithSSB Indicates whether the UE can perform CSI-RSRP and CSI-RSRQ measurement as specified in TS38.215 [13], where CSI-RS resource is configured with an associated SS/PBCH. This parameter needs FR1 and FR2 differentiation.	UE	No	No	Yes
csi-RSRP-AndRSRQ-MeasWithoutSSB Indicates whether the UE can perform CSI-RSRP and CSI-RSRQ measurement as specified in TS38.215 [13], where CSI-RS resource is configured for a cell that transmits SS/PBCH block and without an associated SS/PBCH block. This parameter needs FR1 and FR2 differentiation.	UE	No	No	Yes
csi-SINR-Meas Indicates whether the UE can perform CSI-SINR measurements based on configured CSI-RS resources as specified in TS38.215 [13]. This parameter needs FR1 and FR2 differentiation.	UE	No	No	Yes
eventA-MeasAndReport Indicates whether the UE supports NR measurements and events A triggered reporting as specified in TS 38.331 [9]	UE	Yes	Yes	No
independentGapConfig This field indicates whether the UE supports two independent measurement gap configurations for FR1 and FR2 specified in TS 38.133 [5].	UE	No	Yes	No
intraAndInterF-MeasAndReport Indicates whether the UE supports NR intra-frequency and inter-frequency measurements and at least periodical reporting.	UE	Yes	Yes	No
simultaneousRxDataSSB-DiffNumerology Indicates whether the UE supports concurrent intra-frequency measurement on serving cell or neighbouring cell and PDCCH or PDSCH reception from the serving cell with a different numerology.	UE	Tbd	Yes	Yes
sftd-MeasPSCell Indicates whether the UE supports SFTD measurements between the Pcell and a configured PSCell.	UE	No	Yes	No
sftd-MeasNR-Cell Indicates whether the SFTD measurement between the Pcell and the NR cells is supported by the UE which is capable of EN-DC when EN-DC is not configured.	UE	No	Yes	No
ss-SINR-Meas Indicates whether the UE can perform SS-SINR measurement as specified in TS38.215 [13]. This parameter needs FR1 and FR2 differentiation.	UE	No	No	Yes
supportedGapPattern Indicates measurement gap pattern(s) optionally supported by the UE. The leading / leftmost bit (bit 0) corresponds to the gap pattern 2, the next bit corresponds to the gap pattern 3, as specified in TS 38.311 [9] and so on.	UE	No	No	No

4.2.10 Inter-RAT parameters

4.2.10.1 *eutraFDD*

This parameter defines whether the UE supports EUTRA FDD.

4.2.10.2 *eutraTDD*

This parameter defines whether the UE supports EUTRA TDD.

4.2.11 Neighbour cell SI acquisition parameters

4.2.11.1 *eutra-CGI-Reporting*

This parameter defines whether the UE supports acquisition of relevant information from a neighbouring E-UTRA cell by reading the SI of the neighbouring cell and reporting the acquired information to the network as specified in TS 38.331 [9].

4.2.11.2 *nr-CGI-Reporting*

This parameter defines whether the UE supports acquisition of relevant information from a neighbouring intra-frequency or inter-frequency NR cell by reading the SI of the neighbouring cell and reporting the acquired information to the network as specified in TS 38.331 [9].

4.2.12 MMTEL parameters

- *delayBudgetReporting*

This field indicates whether the UE supports delay budget reporting as specified in TS 38.331[9].

- *recommendedBitRate*

This field indicates whether the UE supports the bit rate recommendation message from the gNB to the UE as specified in TS 38.321 [8].

- *recommendedBitRateQuery*

This field indicates whether the UE supports the bit rate recommendation query message from the UE to the gNB as specified in TS 38.321[8]. This field is only applicable if the UE supports *recommendedBitRate*.

5 Optional features without UE radio access capability parameters

Editor's Note: Features will be added once feature lists as optional w/o capability are decided.

6 Conditionally mandatory features

Features	Condition
Skipping UL configured grant if no data to transmit.	Configured grant type ½ is supported.
multipleTimingAdvances	EN-DC is supported.
tdm-pattern	*dynamicPowerSharing* is not supported or single UL for any band combination is indicated.

7 Capability coordination in MR-DC operation

In MR-DC operation, only two nodes (one EUTRA eNB and one NR gNB) need to be considered in the EUTRA/NR capability coordination. For capabilities for which coordination is needed, it is up to the MN to make the decision on how to resolve the dependency between MN and SN configurations. The MN provides the resulting UE capabilities usable for SCG configuration to the SN. The SN is allowed to initiate the re-negotiation of capability. For capabilities for which no coordination is needed, the SN specific capabilities are just forwarded by the MN to the SN. For feature set combination, MN determines its own feature set combination to be used in MN side based on *supportedBandCombination* in MRDC container then determines the allowed feature set combination list in SN side and indicates them to SN via *SCG-ConfigInfo*. SN may request to MN different feature set combination to be used in SN side via *SCG-Config*.

Annex A (informative): Change history

Change history							
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
06/2017	RAN2#98	R2-1704810				First version	0.0.1
06/2017	RAN2#NR 2	R2-1707386					0.0.2
08/2017	RAN2#99	R2-1708750					0.0.3
12/2017	RAN2#100	R2-1712587					0.0.4
12/2017	RAN2#100	R2-1714141					0.0.5
12/2017	RAN2#100	R2-1714271					0.1.0
12/2017	RP-78	RP-172521				Submitted to RAN#78 for approval	1.0.0
12/2017	RP-78					Upgraded to Rel-15	15.0.0
03/2018	RP-79	RP-180440	0003	3	F	Updates on UE capabilities	15.1.0
06/2018	RP-80	RP-181216	0009	2	B	Introduce ANR in NR	15.2.0
	RP-80	RP-181216	0012	1	F	Miscellaneous corrections	15.2.0
	RP-80	RP-181216	0013	-	B	Delay budget report and MAC CE adaptation for NR for TS 38.306	15.2.0

History

Document history		
V15.2.0	September 2018	Publication

EXHIBIT L

ETSI TS 136 423 V15.2.0 (2018-07)

LTE;
Evolved Universal Terrestrial Radio Access Network (E-UTRAN);
X2 Application Protocol (X2AP)
(3GPP TS 36.423 version 15.2.0 Release 15)

Reference
RTS/TSGR-0336423vf20

Keywords
LTE

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Important notice

The present document can be downloaded from:
http://www.etsi.org/standards-search

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the only prevailing document is the print of the Portable Document Format (PDF) version kept on a specific network drive within ETSI Secretariat.

Users of the present document should be aware that the document may be subject to revision or change of status.
Information on the current status of this and other ETSI documents is available at
https://portal.etsi.org/TB/ETSIDeliverableStatus.aspx

If you find errors in the present document, please send your comment to one of the following services:
https://portal.etsi.org/People/CommiteeSupportStaff.aspx

Copyright Notification

No part may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm except as authorized by written permission of ETSI.
The content of the PDF version shall not be modified without the written authorization of ETSI.
The copyright and the foregoing restriction extend to reproduction in all media.

© ETSI 2018.
All rights reserved.

DECT™, **PLUGTESTS**™, **UMTS**™ and the ETSI logo are trademarks of ETSI registered for the benefit of its Members.
3GPP™ and **LTE**™ are trademarks of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners.
oneM2M logo is protected for the benefit of its Members.
GSM® and the GSM logo are trademarks registered and owned by the GSM Association.

Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (https://ipr.etsi.org/).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

Foreword

This Technical Specification (TS) has been produced by ETSI 3rd Generation Partnership Project (3GPP).

The present document may refer to technical specifications or reports using their 3GPP identities, UMTS identities or GSM identities. These should be interpreted as being references to the corresponding ETSI deliverables.

The cross reference between GSM, UMTS, 3GPP and ETSI identities can be found under http://webapp.etsi.org/key/queryform.asp.

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

Contents

Intellectual Property Rights 2
Foreword 2
Modal verbs terminology 2
Foreword 11
1 Scope 12
2 References 12
3 Definitions, symbols and abbreviations 13
3.1 Definitions 13
3.2 Symbols 14
3.3 Abbreviations 14
4 General 15
4.1 Procedure specification principles 15
4.2 Forwards and backwards compatibility 15
4.3 Specification notations 16
5 X2AP services 16
5.1 X2AP procedure modules 16
5.2 Parallel transactions 16
6 Services expected from signalling transport 16
7 Functions of X2AP 16
8 X2AP procedures 18
8.1 Elementary procedures 18
8.2 Basic mobility procedures 21
8.2.1 Handover Preparation 21
8.2.1.1 General 21
8.2.1.2 Successful Operation 21
8.2.1.3 Unsuccessful Operation 24
8.2.1.4 Abnormal Conditions 24
8.2.2 SN Status Transfer 25
8.2.2.1 General 25
8.2.2.2 Successful Operation 25
8.2.2.3 Abnormal Conditions 27
8.2.3 UE Context Release 27
8.2.3.1 General 27
8.2.3.2 Successful Operation 27
8.2.3.3 Unsuccessful Operation 29
8.2.3.4 Abnormal Conditions 29
8.2.4 Handover Cancel 29
8.2.4.1 General 29
8.2.4.2 Successful Operation 29
8.2.4.3 Unsuccessful Operation 29
8.2.4.4 Abnormal Conditions 29
8.3 Global Procedures 30
8.3.1 Load Indication 30
8.3.1.1 General 30
8.3.1.2 Successful Operation 30
8.3.1.3 Unsuccessful Operation 31
8.3.1.4 Abnormal Conditions 31
8.3.2 Error Indication 31
8.3.2.1 General 31
8.3.2.2 Successful Operation 32
8.3.2.3 Unsuccessful Operation 33
8.3.2.4 Abnormal Conditions 33

8.3.3 X2 Setup 33
8.3.3.1 General 33
8.3.3.2 Successful Operation 33
8.3.3.3 Unsuccessful Operation 34
8.3.3.4 Abnormal Conditions 34
8.3.4 Reset 35
8.3.4.1 General 35
8.3.4.2 Successful Operation 35
8.3.4.3 Unsuccessful Operation 35
8.3.4.4 Abnormal Conditions 35
8.3.5 eNB Configuration Update 36
8.3.5.1 General 36
8.3.5.2 Successful Operation 36
8.3.5.3 Unsuccessful Operation 38
8.3.5.4 Abnormal Conditions 38
8.3.6 Resource Status Reporting Initiation 38
8.3.6.1 General 38
8.3.6.2 Successful Operation 38
8.3.6.3 Unsuccessful Operation 40
8.3.6.4 Abnormal Conditions 40
8.3.7 Resource Status Reporting 41
8.3.7.1 General 41
8.3.7.2 Successful Operation 41
8.3.7.3 Unsuccessful Operation 41
8.3.7.4 Abnormal Conditions 41
8.3.8 Mobility Settings Change 41
8.3.8.1 General 41
8.3.8.2 Successful Operation 42
8.3.8.3 Unsuccessful Operation 42
8.3.8.4 Abnormal Conditions 42
8.3.9 Radio Link Failure Indication 42
8.3.9.1 General 42
8.3.9.2 Successful Operation 43
8.3.9.3 Unsuccessful Operation 43
8.3.9.4 Abnormal Conditions 43
8.3.10 Handover Report 43
8.3.10.1 General 43
8.3.10.2 Successful Operation 44
8.3.10.3 Unsuccessful Operation 44
8.3.10.4 Abnormal Conditions 44
8.3.11 Cell Activation 44
8.3.11.1 General 44
8.3.11.2 Successful Operation 45
8.3.11.3 Unsuccessful Operation 45
8.3.11.4 Abnormal Conditions 45
8.3.12 X2 Removal 45
8.3.12.1 General 45
8.3.12.2 Successful Operation 45
8.3.12.3 Unsuccessful Operation 46
8.3.12.4 Abnormal Conditions 46
8.3.13 Retrieve UE Context 46
8.3.13.1 General 46
8.3.13.2 Successful Operation 47
8.3.13.3 Unsuccessful Operation 48
8.3.13.4 Abnormal Conditions 48
8.3.14 EN-DC X2 Removal 48
8.3.14.1 General 48
8.3.14.2 Successful Operation 48
8.3.14.3 Unsuccessful Operation 49
8.3.14.4 Abnormal Conditions 50
8.4 X2 Release 50
8.4.1 General 50

8.4.2 Successful Operation 50
8.4.3 Unsuccessful Operation 50
8.4.4 Abnormal Condition 50
8.5 X2AP Message Transfer 50
8.5.1 General 50
8.5.2 Successful Operation 51
8.5.3 Unsuccessful Operation 51
8.5.4 Abnormal Condition 51
8.6 Procedures for Dual Connectivity 51
8.6.1 SeNB Addition Preparation 51
8.6.1.1 General 51
8.6.1.2 Successful Operation 52
8.6.1.3 Unsuccessful Operation 53
8.6.1.4 Abnormal Conditions 53
8.6.2 SeNB Reconfiguration Completion 54
8.6.2.1 General 54
8.6.2.2 Successful Operation 54
8.6.2.3 Abnormal Conditions 54
8.6.3 MeNB initiated SeNB Modification Preparation 54
8.6.3.1 General 54
8.6.3.2 Successful Operation 55
8.6.3.3 Unsuccessful Operation 57
8.6.3.4 Abnormal Conditions 57
8.6.4 SeNB initiated SeNB Modification 58
8.6.4.1 General 58
8.6.4.2 Successful Operation 58
8.6.4.3 Unsuccessful Operation 59
8.6.4.4 Abnormal Conditions 59
8.6.5 MeNB initiated SeNB Release 59
8.6.5.1 General 59
8.6.5.2 Successful Operation 60
8.6.5.3 Unsuccessful Operation 60
8.6.5.4 Abnormal Conditions 60
8.6.6 SeNB initiated SeNB Release 60
8.6.6.1 General 60
8.6.6.2 Successful Operation 61
8.6.6.3 Unsuccessful Operation 61
8.6.6.4 Abnormal Conditions 61
8.6.7 SeNB Counter Check 61
8.6.7.1 General 61
8.6.7.2 Successful Operation 61
8.6.7.3 Unsuccessful Operation 62
8.6.7.4 Abnormal Conditions 62
8.7 Procedures for E-UTRAN-NR Dual Connectivity 62
8.7.1 EN-DC X2 Setup 62
8.7.1.1 General 62
8.7.1.2 Successful Operation 62
8.7.1.3 Unsuccessful Operation 63
8.7.1.4 Abnormal Conditions 63
8.7.2 EN-DC Configuration Update 64
8.7.2.1 General 64
8.7.2.2 Successful Operation 64
8.7.2.3 Unsuccessful Operation 65
8.7.2.4 Abnormal Conditions 66
8.7.3 EN-DC Cell Activation 66
8.7.3.1 General 66
8.7.3.2 Successful Operation 66
8.7.3.3 Unsuccessful Operation 67
8.7.3.4 Abnormal Conditions 67
8.7.4 SgNB Addition Preparation 67
8.7.4.1 General 67
8.7.4.2 Successful Operation 67

8.7.4.3 Unsuccessful Operation 69
8.7.4.4 Abnormal Conditions 69
8.7.5 SgNB Reconfiguration Completion 70
8.7.5.1 General 70
8.7.5.2 Successful Operation 70
8.7.5.3 Abnormal Conditions 71
8.7.6 MeNB initiated SgNB Modification Preparation 71
8.7.6.1 General 71
8.7.6.2 Successful Operation 71
8.7.6.3 Unsuccessful Operation 74
8.7.6.4 Abnormal Conditions 74
8.7.7 SgNB initiated SgNB Modification 75
8.7.7.1 General 75
8.7.7.2 Successful Operation 75
8.7.7.3 Unsuccessful Operation 77
8.7.7.4 Abnormal Conditions 77
8.7.8 SgNB Change 77
8.7.8.1 General 77
8.7.8.2 Successful Operation 78
8.7.8.3 Unsuccessful Operation 78
8.7.8.4 Abnormal Conditions 78
8.7.9 MeNB initiated SgNB Release 79
8.7.9.1 General 79
8.7.9.2 Successful Operation 79
8.7.9.3 Unsuccessful Operation 79
8.7.9.4 Abnormal Conditions 79
8.7.10 SgNB initiated SgNB Release 80
8.7.10.1 General 80
8.7.10.2 Successful Operation 80
8.7.10.3 Unsuccessful Operation 80
8.7.10.4 Abnormal Conditions 80
8.7.11 SgNB Counter Check 80
8.7.11.1 General 80
8.7.11.2 Successful Operation 81
8.7.11.3 Unsuccessful Operation 81
8.7.11.4 Abnormal Conditions 81
8.7.12 RRC Transfer 81
8.7.12.1 General 81
8.7.12.2 Successful Operation 81
8.7.12.3 Abnormal Conditions 82
8.7.13 Secondary RAT Data Usage Report 82
8.7.13.1 General 82
8.7.13.2 Successful Operation 82
8.7.13.3 Unsuccessful Operation 82
8.7.13.4 Abnormal Conditions 82
8.7.14 Partial reset of EN-DC 82
8.7.14.1 General 82
8.7.14.2 Successful Operation 83
8.7.14.3 Unsuccessful Operation 84
8.7.14.4 Abnormal Conditions 84
8.7.15 E-UTRA – NR Cell Resource Coordination 84
8.7.15.1 General 84
8.7.15.2 Successful Operation 84
8.7.16 SgNB Activity Notification 85
8.7.16.1 General 85
8.7.16.2 Successful Operation 85
8.7.16.3 Abnormal Conditions 85

9 Elements for X2AP Communication 85
9.0 General 85
9.1 Message Functional Definition and Content 86
9.1.1 Messages for Basic Mobility Procedures 86

9.1.1.1 HANDOVER REQUEST 86
9.1.1.2 HANDOVER REQUEST ACKNOWLEDGE....88
9.1.1.3 HANDOVER PREPARATION FAILURE 90
9.1.1.4 SN STATUS TRANSFER 90
9.1.1.5 UE CONTEXT RELEASE 93
9.1.1.6 HANDOVER CANCEL 93
9.1.2 Messages for global procedures....94
9.1.2.1 LOAD INFORMATION....94
9.1.2.2 ERROR INDICATION....94
9.1.2.3 X2 SETUP REQUEST....95
9.1.2.4 X2 SETUP RESPONSE....96
9.1.2.5 X2 SETUP FAILURE....97
9.1.2.6 RESET REQUEST 97
9.1.2.7 RESET RESPONSE....98
9.1.2.8 ENB CONFIGURATION UPDATE 98
9.1.2.9 ENB CONFIGURATION UPDATE ACKNOWLEDGE 101
9.1.2.10 ENB CONFIGURATION UPDATE FAILURE....101
9.1.2.11 RESOURCE STATUS REQUEST....101
9.1.2.12 RESOURCE STATUS RESPONSE....103
9.1.2.13 RESOURCE STATUS FAILURE....105
9.1.2.14 RESOURCE STATUS UPDATE....106
9.1.2.15 MOBILITY CHANGE REQUEST....106
9.1.2.16 MOBILITY CHANGE ACKNOWLEDGE....107
9.1.2.17 MOBILITY CHANGE FAILURE....107
9.1.2.18 RLF INDICATION....107
9.1.2.19 HANDOVER REPORT....108
9.1.2.20 CELL ACTIVATION REQUEST....109
9.1.2.21 CELL ACTIVATION RESPONSE....110
9.1.2.22 CELL ACTIVATION FAILURE....110
9.1.2.23 X2 RELEASE....110
9.1.2.24 X2AP MESSAGE TRANSFER....110
9.1.2.25 X2 REMOVAL REQUEST....111
9.1.2.26 X2 REMOVAL RESPONSE....111
9.1.2.27 X2 REMOVAL FAILURE....111
9.1.2.28 RETRIEVE UE CONTEXT REQUEST....111
9.1.2.29 RETRIEVE UE CONTEXT RESPONSE....112
9.1.2.30 RETRIEVE UE CONTEXT FAILURE....114
9.1.2.31 EN-DC X2 SETUP REQUEST....114
9.1.2.32 EN-DC X2 SETUP RESPONSE....115
9.1.2.33 EN-DC X2 SETUP FAILURE....116
9.1.2.34 EN-DC CONFIGURATION UPDATE....116
9.1.2.35 EN-DC CONFIGURATION UPDATE ACKNOWLEDGE....118
9.1.2.36 EN-DC CONFIGURATION UPDATE FAILURE....118
9.1.2.37 EN-DC CELL ACTIVATION REQUEST....118
9.1.2.38 EN-DC CELL ACTIVATION RESPONSE....119
9.1.2.39 EN-DC CELL ACTIVATION FAILURE....119
9.1.2.40 EN-DC X2 REMOVAL REQUEST....119
9.1.2.41 EN-DC X2 REMOVAL RESPONSE....120
9.1.2.42 EN-DC X2 REMOVAL FAILURE....120
9.1.3 Messages for Dual Connectivity Procedures....120
9.1.3.1 SENB ADDITION REQUEST....120
9.1.3.2 SENB ADDITION REQUEST ACKNOWLEDGE....122
9.1.3.3 SENB ADDITION REQUEST REJECT....124
9.1.3.4 SENB RECONFIGURATION COMPLETE....124
9.1.3.5 SENB MODIFICATION REQUEST....125
9.1.3.6 SENB MODIFICATION REQUEST ACKNOWLEDGE....127
9.1.3.7 SENB MODIFICATION REQUEST REJECT....129
9.1.3.8 SENB MODIFICATION REQUIRED....130
9.1.3.9 SENB MODIFICATION CONFIRM....130
9.1.3.10 SENB MODIFICATION REFUSE....131
9.1.3.11 SENB RELEASE REQUEST....132
9.1.3.12 SENB RELEASE REQUIRED....132

9.1.3.13 SENB RELEASE CONFIRM 133
9.1.3.14 SENB COUNTER CHECK REQUEST 134
9.1.4 Messages for E-UTRAN-NR Dual Connectivity Procedures 135
9.1.4.1 SGNB ADDITION REQUEST 135
9.1.4.2 SGNB ADDITION REQUEST ACKNOWLEDGE 138
9.1.4.3 SGNB ADDITION REQUEST REJECT 140
9.1.4.4 SGNB RECONFIGURATION COMPLETE 141
9.1.4.5 SGNB MODIFICATION REQUEST 141
9.1.4.6 SGNB MODIFICATION REQUEST ACKNOWLEDGE 145
9.1.4.7 SGNB MODIFICATION REQUEST REJECT 148
9.1.4.8 SGNB MODIFICATION REQUIRED 149
9.1.4.9 SGNB MODIFICATION CONFIRM 151
9.1.4.10 SGNB MODIFICATION REFUSE 152
9.1.4.11 SGNB RELEASE REQUEST 153
9.1.4.12 SGNB RELEASE REQUEST ACKNOWLEDGE 155
9.1.4.13 SGNB RELEASE REQUEST REJECT 155
9.1.4.14 SGNB RELEASE REQUIRED 155
9.1.4.15 SGNB RELEASE CONFIRM 156
9.1.4.16 SGNB COUNTER CHECK REQUEST 158
9.1.4.17 SGNB CHANGE REQUIRED 158
9.1.4.18 SGNB CHANGE CONFIRM 159
9.1.4.19 SGNB CHANGE REFUSE 161
9.1.4.20 SECONDARY RAT DATA USAGE REPORT 161
9.1.4.21 RRC TRANSFER 161
9.1.4.22 PARTIAL RESET REQUIRED 162
9.1.4.23 PARTIAL RESET CONFIRM 163
9.1.4.24 E-UTRA – NR CELL RESOURCE COORDINATION REQUEST 163
9.1.4.25 E-UTRA – NR CELL RESOURCE COORDINATION RESPONSE 164
9.1.4.26 SGNB ACTIVITY NOTIFICATION 165
9.2 Information Element definitions 166
9.2.0 General 166
9.2.1 GTP Tunnel Endpoint 166
9.2.2 Trace Activation 167
9.2.3 Handover Restriction List 167
9.2.4 PLMN Identity 169
9.2.5 DL Forwarding 169
9.2.6 Cause 169
9.2.7 Criticality Diagnostics 174
9.2.8 Served Cell Information 175
9.2.9 E-RAB Level QoS Parameters 179
9.2.10 GBR QoS Information 179
9.2.11 Bit Rate 182
9.2.12 UE Aggregate Maximum Bit Rate 182
9.2.13 Message Type 183
9.2.14 ECGI 183
9.2.15 COUNT Value 183
9.2.16 GUMMEI 184
9.2.17 UL Interference Overload Indication 184
9.2.18 UL High Interference Indication 184
9.2.19 Relative Narrowband Tx Power (RNTP) 184
9.2.20 GU Group Id 187
9.2.21 Location Reporting Information 187
9.2.22 Global eNB ID 187
9.2.23 E-RAB ID 187
9.2.24 eNB UE X2AP ID 188
9.2.25 Subscriber Profile ID for RAT/Frequency priority 188
9.2.26 EARFCN 188
9.2.27 Transmission Bandwidth 188
9.2.28 E-RAB List 188
9.2.29 UE Security Capabilities 189
9.2.30 AS Security Information 189
9.2.31 Allocation and Retention Priority 189

9.2.32 Time To Wait 190
9.2.33 SRVCC Operation Possible 190
9.2.34 Hardware Load Indicator 190
9.2.35 S1 TNL Load Indicator 191
9.2.36 Load Indicator 191
9.2.37 Radio Resource Status 191
9.2.38 UE History Information 191
9.2.39 Last Visited Cell Information 192
9.2.40 Last Visited E-UTRAN Cell Information 192
9.2.41 Last Visited GERAN Cell Information 192
9.2.42 Cell Type 192
9.2.43 Number of Antenna Ports 193
9.2.44 Composite Available Capacity Group 193
9.2.45 Composite Available Capacity 193
9.2.46 Cell Capacity Class Value 193
9.2.47 Capacity Value 194
9.2.48 Mobility Parameters Information 194
9.2.49 Mobility Parameters Modification Range 194
9.2.50 PRACH Configuration 194
9.2.51 Subframe Allocation 195
9.2.52 CSG Membership Status 195
9.2.53 CSG ID 195
9.2.54 ABS Information 195
9.2.55 Invoke Indication 197
9.2.56 MDT Configuration 197
9.2.57 Void 200
9.2.58 ABS Status 200
9.2.59 Management Based MDT Allowed 200
9.2.60 MultibandInfoList 201
9.2.61 M3 Configuration 201
9.2.62 M4 Configuration 201
9.2.63 M5 Configuration 201
9.2.64 MDT PLMN List 202
9.2.65 EARFCN Extension 202
9.2.66 COUNT Value Extended 202
9.2.67 Extended UL Interference Overload Info 202
9.2.68 RNL Header 203
9.2.69 Masked IMEISV 203
9.2.70 Expected UE Behaviour 204
9.2.71 Expected UE Activity Behaviour 204
9.2.72 SeNB Security Key 204
9.2.73 SCG Change Indication 204
9.2.74 CoMP Information 205
9.2.75 CoMP Hypothesis Set 205
9.2.76 RSRP Measurement Report List 206
9.2.77 Dynamic DL transmission information 207
9.2.78 ProSe Authorized 207
9.2.79 CSI Report 207
9.2.80 Wideband CQI 208
9.2.81 Subband CQI 208
9.2.82 COUNT Value for PDCP SN Length 18 209
9.2.83 LHN ID 209
9.2.84 Correlation ID 209
9.2.85 UE Context Kept Indicator 209
9.2.86 eNB UE X2AP ID Extension 209
9.2.87 M6 Configuration 210
9.2.88 M7 Configuration 210
9.2.89 Tunnel Information 210
9.2.90 X2 Benefit Value 211
9.2.91 Resume ID 211
9.2.92 Bearer Type 211
9.2.93 V2X Services Authorized 211

9.2.94 Offset of NB-IoT Channel Number to EARFCN 212
9.2.95 WT ID 212
9.2.96 WT UE XwAP ID 212
9.2.97 UE Sidelink Aggregate Maximum Bit Rate 212
9.2.99 Extended Bit Rate 213
9.2.100 en-gNB UE X2AP ID 214
9.2.101 SgNB Security Key 214
9.2.102 Target SgNB ID Information 214
9.2.103 SCG Configuration Query 214
9.2.104 Delivery Status 214
9.2.105 Void 214
9.2.106 NR Frequency Info 215
9.2.107 NR UE Security Capabilities 215
9.2.108 EN-DC Resource Configuration 216
9.2.109 PDCP Change Indication 216
9.2.110 Served NR Cell Information 217
9.2.111 NR CGI 217
9.2.112 Global en-gNB ID 218
9.2.113 NR Carrier Information 218
9.2.114 NR Transmission Bandwidth 218
9.2.115 Cell Assistance Information 219
9.2.116 MeNB Resource Coordination Information 219
9.2.117 SgNB Resource Coordination Information 221
9.2.118 UL Configuration 223
9.2.119 RLC Mode 223
9.2.120 Secondary RAT Usage Report List 223
9.2.121 UE Application layer measurement configuration 224
9.2.122 DRB ID 225
9.2.123 SUL Information 225
9.2.124 Packet Loss Rate 226
9.2.125 Protected E-UTRA Resource Indication 226
9.2.126 Data Traffic Resource Indication 230
9.2.127 Data Traffic Resources 231
9.2.128 Reserved Subframe Pattern 232
9.2.129 Aerial UE subscription information 233
9.2.130 User plane traffic activity report 233
9.3 Message and Information Element Abstract Syntax (with ASN.1) 234
9.3.1 General 234
9.3.2 Usage of Private Message Mechanism for Non-standard Use 234
9.3.3 Elementary Procedure Definitions 234
9.3.4 PDU Definitions 246
9.3.5 Information Element definitions 322
9.3.6 Common definitions 369
9.3.7 Constant definitions 370
9.3.8 Container definitions 378
9.4 Message transfer syntax 382
9.5 Timers 382
10 Handling of unknown, unforeseen and erroneous protocol data 382
Annex A (informative): Change history 383
History 389

Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

- x the first digit:
  - 1 presented to TSG for information;
  - 2 presented to TSG for approval;
  - 3 or greater indicates TSG approved document under change control.
- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The present document specifies the radio network layer signalling procedures of the control plane between eNBs in E-UTRAN. X2AP supports the functions of X2 interface by signalling procedures defined in this document. X2AP is developed in accordance to the general principles stated in TS 36.401 [2] and TS 36.420 [3].

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 36.401: "Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Architecture Description".

[3] 3GPP TS 36.420: "Evolved Universal Terrestrial Radio Access Network (E-UTRAN); X2 General Aspects and Principles".

[4] 3GPP TS 36.413: "Evolved Universal Terrestrial Radio Access Network (E-UTRAN); S1 Application Protocol (S1AP)".

[5] ITU-T Recommendation X.691 (2002-07): "Information technology - ASN.1 encoding rules - Specification of Packed Encoding Rules (PER) ".

[6] 3GPP TS 32.422: "Telecommunication Management; Subscriber and Equipment Trace; Trace Control and Configuration Management".

[7] 3GPP TS 32.421: "Telecommunication Management; Subscriber and Equipment Trace; Trace concepts and requirements".

[8] 3GPP TS 36.424: "Evolved Universal Terrestrial Radio Access Network (E-UTRAN); X2 data transport".

[9] 3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRAN); Radio Resource Control (RRC) Protocol Specification".

[10] 3GPP TS 36.211: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Channels and Modulation".

[11] 3GPP TS 36.213: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures ".

[12] 3GPP TS 23.401: "General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access".

[13] 3GPP TS 23.203: "Policy and charging control architecture".

[14] 3GPP TS 24.301: "Non-Access-Stratum (NAS) protocol for Evolved Packet System; Stage 3".

[15] 3GPP TS 36.300: "Evolved Universal Terrestrial Radio Access (E-UTRA), Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; stage 2".

[16] 3GPP TS 36.104: "Base Station (BS) radio transmission and reception ".

[17] Void.

[18] 3GPP TS 33.401: "Security architecture".

[19] 3GPP TS 36.414: "Evolved Universal Terrestrial Radio Access Network (E-UTRAN); S1 data transport".

[20] 3GPP TS 23.216: "Single Radio Voice Call Continuity (SRVCC)".

[21] 3GPP TS 36.422: "Evolved Universal Terrestrial Radio Access Network (E-UTRAN); X2 signaling transport".

[22] 3GPP TS 36.314: "Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Layer 2 - Measurements".

[23] Void.

[24] 3GPP TS 25.413: "UTRAN Iu interface RANAP signalling"

[25] 3GPP TS 37.320: "Universal Terrestrial Radio Access (UTRA) and Evolved Universal Terrestrial Radio Access (E-UTRA); Radio measurement collection for Minimization of Drive Tests (MDT);Overall description; Stage 2".

[26] 3GPP TS 29.281: "General Packet Radio Service (GPRS); Tunnelling Protocol User Plane (GTPv1-U)".

[27] ITU-T Recommendation X.680 (2002-07): "Information technology – Abstract Syntax Notation One (ASN.1): Specification of basic notation".

[28] ITU-T Recommendation X.681 (2002-07): "Information technology – Abstract Syntax Notation One (ASN.1): Information object specification".

[29] 3GPP TS 23.003: "Technical Specification Group Core Network and Terminals; Numbering, addressing and identification".

[30] 3GPP TR 25.921 (version.7.0.0): "Guidelines and principles for protocol description and error handling".

[31] 3GPP TS 38.331: "NR; Radio Resource Control (RRC); Protocol Specification".

[32] 3GPP TS 37.340: "Evolved Universal Terrestrial Radio Access (E-UTRA) and NR; Multi-connectivity; Stage 2".

[33] 3GPP TS 38.323: "NR; Packet Data Convergence Protocol (PDCP) specification".

[34] 3GPP TS 38.401: "NG-RAN; Architecture description".

[35] IETF RFC 5905: "Network Time Protocol Version 4: Protocol and Algorithms Specification".

[36] 3GPP TS 26.247: "Transparent end-to-end Packet-switched Streaming Service (PSS); Progressive Download and Dynamic Adaptive Streaming over HTTP (3GP-DASH)".

[37] 3GPP TS 38.104: "NR; Base Station (BS) radio transmission and reception".

[38] 3GPP TS 23.501: "System Architecture for the 5G System"

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

Elementary Procedure: X2AP protocol consists of Elementary Procedures (EPs). An X2AP Elementary Procedure is a unit of interaction between two eNBs. An EP consists of an initiating message and possibly a response message. Two kinds of EPs are used:

- **Class 1:** Elementary Procedures with response (success or failure),
- **Class 2:** Elementary Procedures without response.

E-RAB: Defined in TS 36.401 [2].

CSG Cell: as defined in TS 36.300 [15].

Dual Connectivity: as defined in TS 36.300 [15].

E-UTRA-NR Dual Connectivity: as defined in TS 37.340 [32].

Hybrid cell: as defined in TS 36.300 [15].

Master eNB: as defined in TS 36.300 [15].

Secondary Cell Group: as defined in TS 36.300 [15].

Secondary eNB: as defined in TS 36.300 [15].

en-gNB: as defined in TS 37.340 [32].

3.2 Symbols

For the purposes of the present document, the following symbols apply:

<symbol> <Explanation>

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

ABS	Almost Blank Subframe
BBF	Broadband Forum
BL	Bandwidth reduced Low complexity
CCO	Cell Change Order
CE	Coverage Enhancement
CoMP	Coordinated Multi Point
DC	Dual Connectivity
DL	Downlink
EARFCN	E-UTRA Absolute Radio Frequency Channel Number
E-CID	Enhanced Cell-ID (positioning method)
eNB	E-UTRAN NodeB
EN-DC	E-UTRA-NR Dual Connectivity
EP	Elementary Procedure
EPC	Evolved Packet Core
E-RAB	E-UTRAN Radio Access Bearer
E-UTRAN	Evolved UTRAN
GNSS	Global Navigation Satellite System
GUMMEI	Globally Unique MME Identifier
HFN	Hyper Frame Number
IE	Information Element
L-GW	Local GateWay
LWA	LTE-WLAN Aggregation
MCG	Master Cell Group

MDT	Minimization of Drive Tests
MeNB	Master eNB
MME	Mobility Management Entity
MTSI	Multimedia Telephony Service for IMS
NAICS	Network-Assisted Interference Cancellation and Suppression
NR	New Radio
PDCP	Packet Data Convergence Protocol
PLMN	Public Land Mobile Network
ProSe	Proximity Service
QMC	QoE Measurement Collection
QoE	Quality of Experience
SCG	Secondary Cell Group
S-GW	Serving Gateway
SeNB	Secondary eNB
SgNB	Secondary gNB
SIPTO	Selected IP Traffic Offload
SIPTO@LN	Selected IP Traffic Offload at the Local Network
SN	Sequence Number
TAC	Tracking Area Code
UE	User Equipment
UL	Uplink
V2X	Vehicle-to-Everything
WLAN	Wireless Local Area Network
WT	WLAN Termination

4 General

4.1 Procedure specification principles

The principle for specifying the procedure logic is to specify the functional behaviour of the terminating eNB exactly and completely. Any rule that specifies the behaviour of the originating eNB shall be possible to be verified with information that is visible within the system.

The following specification principles have been applied for the procedure text in clause 8:

- The procedure text discriminates between:

  1) Functionality which "shall" be executed

     The procedure text indicates that the receiving node "shall" perform a certain function Y under a certain condition. If the receiving node supports procedure X but cannot perform functionality Y requested in the initiating message of a Class 1 EP, the receiving node shall respond with the message used to report unsuccessful outcome for this procedure, containing an appropriate cause value.

  2) Functionality which "shall, if supported" be executed

     The procedure text indicates that the receiving node "shall, if supported," perform a certain function Y under a certain condition. If the receiving node supports procedure X, but does not support functionality Y, the receiving node shall proceed with the execution of the EP, possibly informing the requesting node about the not supported functionality.

- Any required inclusion of an optional IE in a response message is explicitly indicated in the procedure text. If the procedure text does not explicitly indicate that an optional IE shall be included in a response message, the optional IE shall not be included. For requirements on including *Criticality Diagnostics* IE, see section 10.

4.2 Forwards and backwards compatibility

The forwards and backwards compatibility of the protocol is assured by a mechanism where all current and future messages, and IEs or groups of related IEs, include ID and criticality fields that are coded in a standard format that will not be changed in the future. These parts can always be decoded regardless of the standard version.

4.3 Specification notations

For the purposes of the present document, the following notations apply:

Procedure	When referring to an elementary procedure in the specification the Procedure Name is written with the first letters in each word in upper case characters followed by the word "procedure", e.g. Handover Preparation procedure.
Message	When referring to a message in the specification the MESSAGE NAME is written with all letters in upper case characters followed by the word "message", e.g. HANDOVER REQUEST message.
IE	When referring to an information element (IE) in the specification the *Information Element Name* is written with the first letters in each word in upper case characters and all letters in Italic font followed by the abbreviation "IE", e.g. *E-RAB ID* IE.
Value of an IE	When referring to the value of an information element (IE) in the specification the "Value" is written as it is specified in sub clause 9.2 enclosed by quotation marks, e.g. "Value".

5 X2AP services

The present clause describes the services an eNB offers to its neighbours.

5.1 X2AP procedure modules

The X2 interface X2AP procedures are divided into two modules as follows:

1. X2AP Basic Mobility Procedures;
2. X2AP Global Procedures;

The X2AP Basic Mobility Procedures module contains procedures used to handle the UE mobility within E-UTRAN.

The Global Procedures module contains procedures that are not related to a specific UE. The procedures in this module are in contrast to the above module involving two peer eNBs.

5.2 Parallel transactions

Unless explicitly indicated in the procedure specification, at any instance in time one protocol peer shall have a maximum of one ongoing X2AP procedure related to a certain UE.

6 Services expected from signalling transport

The signalling connection shall provide in sequence delivery of X2AP messages. X2AP shall be notified if the signalling connection breaks.

X2 signalling transport is described in TS 36.422 [21].

7 Functions of X2AP

The X2AP protocol provides the following functions:

- Mobility Management. This function allows the eNB to move the responsibility of a certain UE to another eNB. Forwarding of user plane data, Status Transfer and UE Context Release function are parts of the mobility management.
- Dual Connectivity. This function allows the eNB to request another eNB to provide radio resources for a certain UE while keeping responsibility for that UE.
- E-UTRA-NR Dual Connectivity. This function allows the eNB to request another en-gNB to provide radio resources for a certain UE while keeping responsibility for that UE.

- Load Management. This function is used by eNBs to indicate resource status, overload and traffic load to each other.
- Reporting of General Error Situations. This function allows reporting of general error situations, for which function specific error messages have not been defined.
- Resetting the X2. This function is used to reset the X2 interface.
- Setting up the X2. This function is used to exchange necessary data for the eNB or en-gNB for setup the X2 interface and implicitly perform an X2 Reset.
- eNB Configuration Update. This function allows updating of application level data needed for two eNBs to interoperate correctly over the X2 interface.
- Mobility Parameters Management. This function allows the eNB to coordinate adaptation of mobility parameter settings with a peer eNB.
- Mobility Robustness Optimisation. This function allows reporting of information related to mobility failure events.
- Energy Saving. This function allows decreasing energy consumption by enabling indication of cell activation/deactivation over the X2 interface.
- X2 Release. This function allows an eNB to be aware that the signalling connection to a peer eNB is unavailable.
- Message Transfer. This function allows indirect transport of X2AP messages to a peer eNB.
- Registration. This function allows registration of eNB in case indirect transport of X2AP messages is supported.
- Removing the X2. This function allows removing the signalling connection between two eNBs or between eNB and en-gNB in a controlled manner.
- Inter-eNB UE Context Resume. This function allows retrieval of a suspended UE context.
- Secondary RAT Data Usage Report. This function allows eNB to get the uplink and downlink data volumes for the Secondary RAT on a per E-RAB basis.
- E-UTRA - NR Spectrum Sharing. This function allows uplink and downlink spectrum sharing between a number of E - UTRA and a number of NR cells with overlapping coverage.

The mapping between the above functions and X2 EPs is shown in the table below.

Table 7-1: Mapping between X2AP functions and X2AP EPs

Function	Elementary Procedure(s)
Mobility Management	a) Handover Preparation b) SN Status Transfer c) UE Context Release d) Handover Cancel
Dual Connectivity	a) SeNB Addition Preparation b) SeNB Reconfiguration Completion c) MeNB initiated SeNB Modification Preparation d) SeNB initiated SeNB Modification e) MeNB initiated SeNB Release f) SeNB initiated SeNB Release g) SeNB Counter Check
E-UTRA-NR Dual Connectivity	a) SgNB Addition Preparation b) SgNB Reconfiguration Completion c) MeNB initiated SgNB Modification Preparation d) SgNB initiated SgNB Modification e) SgNB change f) MeNB initiated SgNB Release g) SgNB initiated SgNB Release h) SgNB Counter Check i) RRC transfer j) EN-DC X2 Setup k) EN-DC Configuration Update l) EN-DC Cell Activation m) SgNB Activity Notification n) EN-DC X2 Removal
Load Management	a) Load Indication b) Resource Status Reporting Initiation c) Resource Status Reporting
Reporting of General Error Situations	Error Indication
Resetting the X2	Reset
Setting up the X2	X2 Setup
eNB Configuration Update	a) eNB Configuration Update b) Cell Activation
Mobility Parameters Management	Mobility Settings Change
Mobility Robustness Optimisation	a) Radio Link Failure Indication b) Handover Report
Energy Saving	a) eNB Configuration Update b) Cell Activation
X2 Release	X2 Release
Message Transfer Registration	X2AP Message Transfer
Removing the X2	X2 Removal
Inter-eNB UE Context Resume	Retrieve UE Context
Secondary RAT Data Usage Report	Secondary RAT Data Usage Report
E-UTRA – NR Spectrum Sharing	E-UTRA - NR Cell Resource Coordination

8 X2AP procedures

8.1 Elementary procedures

In the following tables, all EPs are divided into Class 1 and Class 2 EPs.

Table 8.1-1: Class 1 Elementary Procedures

Elementary Procedure	Initiating Message	Successful Outcome	Unsuccessful Outcome
		Response message	Response message
Handover Preparation	HANDOVER REQUEST	HANDOVER REQUEST ACKNOWLEDGE	HANDOVER PREPARATION FAILURE
Reset	RESET REQUEST	RESET RESPONSE	
X2 Setup	X2 SETUP REQUEST	X2 SETUP RESPONSE	X2 SETUP FAILURE
eNB Configuration Update	ENB CONFIGURATION UPDATE	ENB CONFIGURATION UPDATE ACKNOWLEDGE	ENB CONFIGURATION UPDATE FAILURE
Resource Status Reporting Initiation	RESOURCE STATUS REQUEST	RESOURCE STATUS RESPONSE	RESOURCE STATUS FAILURE
Mobility Settings Change	MOBILITY CHANGE REQUEST	MOBILITY CHANGE ACKNOWLEDGE	MOBILITY CHANGE FAILURE
Cell Activation	CELL ACTIVATION REQUEST	CELL ACTIVATION RESPONSE	CELL ACTIVATION FAILURE
SeNB Addition Preparation	SENB ADDITION REQUEST	SENB ADDITION REQUEST ACKNOWLEDGE	SENB ADDITION REQUEST REJECT
MeNB initiated SeNB Modification Preparation	SENB MODIFICATION REQUEST	SENB MODIFICATION REQUEST ACKNOWLEDGE	SENB MODIFICATION REQUEST REJECT
SeNB initiated SeNB Modification	SENB MODIFICATION REQUIRED	SENB MODIFICATION CONFIRM	SENB MODIFICATION REFUSE
SeNB initiated SeNB Release	SENB RELEASE REQUIRED	SENB RELEASE CONFIRM	
X2 Removal	X2 REMOVAL REQUEST	X2 REMOVAL RESPONSE	X2 REMOVAL FAILURE
Retrieve UE Context	RETRIEVE UE CONTEXT REQUEST	RETRIEVE UE CONTEXT RESPONSE	RETRIEVE UE CONTEXT FAILURE
SgNB Addition Preparation	SGNB ADDITION REQUEST	SGNB ADDITION REQUEST ACKNOWLEDGE	SGNB ADDITION REQUEST REJECT
MeNB initiated SgNB Modification Preparation	SGNB MODIFICATION REQUEST	SGNB MODIFICATION REQUEST ACKNOWLEDGE	SGNB MODIFICATION REQUEST REJECT
SgNB initiated SgNB Modification	SGNB MODIFICATION REQUIRED	SGNB MODIFICATION CONFIRM	SGNB MODIFICATION REFUSE
SgNB change	SGNB CHANGE REQUIRED	SGNB CHANGE CONFIRM	SGNB CHANGE REFUSE
MeNB initiated SgNB Release	SGNB RELEASE REQUEST	SGNB RELEASE REQUEST ACKNOWLEDGE	SGNB RELEASE REQUEST REJECT
SgNB initiated SgNB Release	SGNB RELEASE REQUIRED	SGNB RELEASE CONFIRM	
EN-DC X2 Setup	EN-DC X2 SETUP REQUEST	EN-DC X2 SETUP RESPONSE	EN-DC X2 SETUP FAILURE
EN-DC Configuration Update	EN-DC CONFIGURATION UPDATE	EN-DC CONFIGURATION UPDATE ACKNOWLEDGE	EN-DC CONFIGURATION UPDATE FAILURE
EN-DC Cell Activation	EN-DC CELL ACTIVATION REQUEST	EN-DC CELL ACTIVATION RESPONSE	EN-DC CELL ACTIVATION FAILURE
E-UTRA - NR Cell Resource Coordination	E-UTRA - NR CELL RESOURCE COORDINATION REQUEST	E-UTRA - NR CELL RESOURCE COORDINATION RESPONSE	

Elementary Procedure	Initiating Message	Successful Outcome	Unsuccessful Outcome
		Response message	Response message
EN-DC X2 Removal	EN-DC X2 REMOVAL REQUEST	EN-DC X2 REMOVAL RESPONSE	EN-DC X2 REMOVAL FAILURE

Table 8.1-2: Class 2 Elementary Procedures

Elementary Procedure	Initiating Message
Load Indication	LOAD INFORMATION
Handover Cancel	HANDOVER CANCEL
SN Status Transfer	SN STATUS TRANSFER
UE Context Release	UE CONTEXT RELEASE
Resource Status Reporting	RESOURCE STATUS UPDATE
Error Indication	ERROR INDICATION
Radio Link Failure Indication	RLF INDICATION
Handover Report	HANDOVER REPORT
X2 Release	X2 RELEASE
X2AP Message Transfer	X2AP MESSAGE TRANSFER
SeNB Reconfiguration Completion	SENB RECONFIGURATION COMPLETE
MeNB initiated SeNB Release	SENB RELEASE REQUEST
SeNB Counter Check	SENB COUNTER CHECK REQUEST
SgNB Reconfiguration Completion	SGNB RECONFIGURATION COMPLETE
SgNB Counter Check	SGNB COUNTER CHECK REQUEST
RRC Transfer	RRC TRANSFER
Secondary RAT Data Usage Report	SECONDARY RAT DATA USAGE REPORT
SgNB Activity Notification	SGNB ACTIVITY NOTIFICATION

8.2 Basic mobility procedures

8.2.1 Handover Preparation

8.2.1.1 General

This procedure is used to establish necessary resources in an eNB for an incoming handover.

The procedure uses UE-associated signalling.

8.2.1.2 Successful Operation

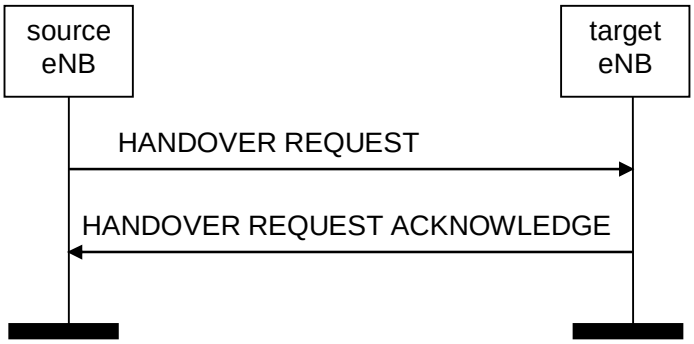


Figure 8.2.1.2-1: Handover Preparation, successful operation

The source eNB initiates the procedure by sending the HANDOVER REQUEST message to the target eNB. When the source eNB sends the HANDOVER REQUEST message, it shall start the timer $T_{RELOCprep}$.

The allocation of resources according to the values of the *Allocation and Retention Priority* IE included in the *E-RAB Level QoS Parameters* IE shall follow the principles described for the E-RAB Setup procedure in TS 36.413 [4].

The source eNB may include in the *GUMMEI* IE any GUMMEI corresponding to the source MME node.

If at least one of the requested non-GBR E-RABs is admitted to the cell indicated by the *Target Cell ID* IE, the target eNB shall reserve necessary resources, and send the HANDOVER REQUEST ACKNOWLEDGE message back to the source eNB. The target eNB shall include the E-RABs for which resources have been prepared at the target cell in the *E-RABs Admitted List* IE. The target eNB shall include the E-RABs that have not been admitted in the *E-RABs Not Admitted List* IE with an appropriate cause value.

At reception of the HANDOVER REQUEST message the target eNB shall:

- prepare the configuration of the AS security relation between the UE and the target eNB by using the information in the *UE Security Capabilities* IE and the *AS Security Information* IE in the *UE Context Information* IE**.**

For each E-RAB for which the source eNB proposes to do forwarding of downlink data, the source eNB shall include the *DL Forwarding* IE within the *E-RABs To be Setup Item* IE of the HANDOVER REQUEST message. For each E-RAB that it has decided to admit, the target eNB may include the *DL GTP Tunnel Endpoint* IE within the *E-RABs Admitted Item* IE of the HANDOVER REQUEST ACKNOWLEDGE message to indicate that it accepts the proposed forwarding of downlink data for this bearer. This GTP tunnel endpoint may be different from the corresponding *GTP TEID* IE in the *E-RAB To Be Switched in Downlink List* IE of the PATH SWITCH REQUEST message (see TS 36.413 [4]) depending on implementation choice.

For each bearer in the *E-RABs Admitted List* IE, the target eNB may include the *UL GTP Tunnel Endpoint* IE to indicate that it requests data forwarding of uplink packets to be performed for that bearer.

Upon reception of the HANDOVER REQUEST ACKNOWLEDGE message the source eNB shall stop the timer $T_{RELOCprep}$, start the timer $TX2_{RELOCoverall}$ and terminate the Handover Preparation procedure. The source eNB is then defined to have a Prepared Handover for that X2 UE-associated signalling.

If the *Trace Activation* IE is included in the HANDOVER REQUEST message then the target eNB shall, if supported, initiate the requested trace function as described in TS 32.422 [6]. In particular, the target eNB shall, if supported:

- if the *Trace Activation* IE does not include the *MDT Configuration* IE, initiate the requested trace session as described in TS 32.422 [6];

- if the *Trace Activation* IE includes the *MDT Activation* IE, within the *MDT Configuration* IE, set to “Immediate MDT and Trace” initiate the requested trace session and MDT session as described in TS 32.422 [6];

- if the *Trace Activation* IE includes the *MDT Activation* IE, within the *MDT Configuration* IE, set to “Immediate MDT Only” initiate the requested MDT session as described in TS 32.422 [6] and the target eNB shall ignore *Interfaces To Trace* IE, and *Trace Depth* IE;

- if the *Trace Activation* IE includes the *MDT Location Information* IE, within the *MDT Configuration* IE, store this information and take it into account in the requested MDT session;

- if the *Trace Activation* IE includes the *Signalling based MDT PLMN List* IE, within the *MDT Configuration* IE, the eNB may use it to propagate the MDT Configuration as described in TS 37.320 [31];

- if the *Trace Activation* IE includes the *UE Application layer measurement configuration* IE, initiate the requested trace session and QoE Measurement Collection function as described in TS 36.300 [15].

If the *Management Based MDT Allowed* IE only or the *Management Based MDT Allowed* IE and the *Management Based MDT PLMN List* IE is contained in the HANDOVER REQUEST message, the target eNB shall, if supported, store the received information in the UE context, and use this information to allow subsequent selection of the UE for management based MDT defined in TS 32.422 [6].

If the *Masked IMEISV* IE is contained in the HANDOVER REQUEST message the target eNB shall, if supported, use it to determine the characteristics of the UE for subsequent handling.

The source eNB shall, if supported and available in the UE context, include the *Management Based MDT Allowed* IE and the *Management Based MDT PLMN List* IE in the HANDOVER REQUEST message, except if the source eNB selects a serving PLMN in the target eNB which is not included in the Management Based MDT PLMN List. If the *Management Based MDT PLMN List* IE is not present, the source eNB shall, if supported, include the *Management Based MDT Allowed* IE, if this information is available in the UE context, in the HANDOVER REQUEST message, except if the source eNB selects a serving PLMN in the target eNB different from the serving PLMN in the source eNB.

If the *Handover Restriction List* IE is

- contained in the HANDOVER REQUEST message, the target eNB shall
  - store the information received in the *Handover Restriction List* IE in the UE context;
  - use this information to determine a target for the UE during subsequent mobility action for which the eNB provides information about the target of the mobility action towards the UE, except when one of the E-RABs has a particular ARP value (TS 23.401 [12]) in which case the information shall not apply;
  - use this information to select a proper SCG during dual connectivity operation.
- not contained in the HANDOVER REQUEST message, the target eNB shall consider that no roaming and no access restriction apply to the UE.

If the *Location Reporting Information* IE is included in the HANDOVER REQUEST message then the target eNB should initiate the requested location reporting functionality as defined in TS 36.413 [4].

If the *SRVCC Operation Possible* IE is included in the HANDOVER REQUEST message, the target eNB shall store the content of such IE in the UE context and use it as defined in TS 23.216 [20].

If the *UE Security Capabilities* IE included in the HANDOVER REQUEST message only contains the EIA0 algorithm as defined in TS 33.401 [18] and if this EIA0 algorithm is defined in the configured list of allowed integrity protection algorithms in the eNB (TS 33.401 [18]), the eNB shall take it into use and ignore the keys received in the *AS Security Information* IE.

The HANDOVER REQUEST message shall contain the *Subscriber Profile ID for RAT/Frequency priority* IE, if available.

If the *Subscriber Profile ID for RAT/Frequency priority* IE is contained in the HANDOVER REQUEST message, the target eNB shall store this information and the target eNB should use the information as defined in TS 36.300 [15].

Upon reception of *UE History Information* IE in the HANDOVER REQUEST message, the target eNB shall collect the information defined as mandatory in the *UE History Information* IE and shall, if supported, collect the information defined as optional in the *UE History Information* IE, for as long as the UE stays in one of its cells, and store the collected information to be used for future handover preparations.

Upon reception of the *UE History Information from the UE* IE in the HANDOVER REQUEST message, the target eNB shall, if supported, store the collected information to be used for future handover preparations.

If the *Mobility Information* IE is provided in the HANDOVER REQUEST message, the target eNB shall, if supported, store this information and use it as defined in TS 36.300 [15]. The target eNB shall, if supported, store the C-RNTI of the source cell received in the HANDOVER REQUEST message.

If the *Expected UE Behaviour* IE is provided in the HANDOVER REQUEST message, the target eNB shall, if supported, store this information and may use it to determine the RRC connection time.

If the *ProSe Authorized* IE is contained in the HANDOVER REQUEST message and it contains one or more IEs set to "authorized", the eNB shall, if supported, consider that the UE is authorized for the relevant ProSe service(s).

If the *V2X Services Authorized* IE is contained in the HANDOVER REQUEST message and it contains one or more IEs set to "authorized", the eNB shall, if supported, consider that the UE is authorized for the relevant service(s).

If the *UE Context Reference at the SeNB* IE is contained in the HANDOVER REQUEST message the target eNB may use it as specified in TS 36.300 [15]. In this case, the source eNB may expect the target eNB to include the *UE Context Kept Indicator* IE set to "True" in the HANDOVER REQUEST ACKNOWLEDGE message, which shall use this information as specified in TS 36.300 [15]. If the *UE Context Reference at the WT* IE is contained in the HANDOVER REQUEST message, the target eNB may use it as specified in TS 36.300 [15]. In this case, the source eNB may expect the target eNB to include the *WT UE Context Kept Indicator* IE set to "True" in the HANDOVER REQUEST ACKNOWLEDGE message; the source eNB shall use this information as specified in TS 36.300 [15].

If the *UE Context Reference at the SgNB* IE is contained in the HANDOVER REQUEST message the target eNB may use it as specified in TS 37.340 [32]. In this case, the source eNB may expect the target eNB to include the *UE Context Kept Indicator* IE set to "True" in the HANDOVER REQUEST ACKNOWLEDGE message, which shall use this information as specified in TS 37.340 [32].

If the *Bearer Type* IE is included in the HANDOVER REQUEST message and is set to “non IP”, then the target eNB shall not perform header compression for the concerned E-RAB.If the *UE Sidelink Aggregate Maximum Bit Rate* IE is contained in the HANDOVER REQUEST message, the target eNB shall, if supported, use it for the concerned UE's sidelink communication in network scheduled mode for V2X services.

If the *NR UE Security Capabilities* IE is included in the HANDOVER REQUEST message, the target eNB shall, if supported, store this information in the UE context and send it to the respective peer node during subsequent handover preparations and/or EN-DC operations for the UE as defined in TS 33.401 [15].

If the *Aerial UE subscription information* IE is included in the HANDOVER REQUEST message, the target eNB shall, if supported, store this information in the UE context and use it as defined in TS 36.300 [15].

8.2.1.3 Unsuccessful Operation

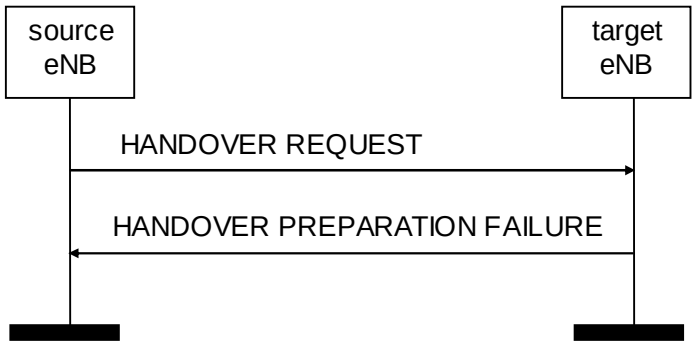


Figure 8.2.1.3-1: Handover Preparation, unsuccessful operation

If the target eNB does not admit at least one non-GBR E-RAB, or a failure occurs during the Handover Preparation, the target eNB shall send the HANDOVER PREPARATION FAILURE message to the source eNB. The message shall contain the *Cause* IE with an appropriate value.

If the target eNB receives a HANDOVER REQUEST message containing *RRC Context* IE that does not include required information as specified in TS 36.331 [9], the target eNB shall send the HANDOVER PREPARATION FAILURE message to the source eNB.

Interactions with Handover Cancel procedure:

If there is no response from the target eNB to the HANDOVER REQUEST message before timer $T_{RELOCprep}$ expires in the source eNB, the source eNB should cancel the Handover Preparation procedure towards the target eNB by initiating the Handover Cancel procedure with the appropriate value for the *Cause* IE. The source eNB shall ignore any HANDOVER REQUEST ACKNOWLEDGE or HANDOVER PREPARATION FAILURE message received after the initiation of the Handover Cancel procedure and remove any reference and release any resources related to the concerned X2 UE-associated signalling.

8.2.1.4 Abnormal Conditions

If the target eNB receives a HANDOVER REQUEST message containing multiple *E-RAB ID* IEs (in the *E-RABs To Be Setup List* IE) set to the same value, the target eNB shall not admit the corresponding E-RABs.

If the target eNB receives a HANDOVER REQUEST message containing a *E-RAB Level QoS Parameters* IE which contains a *QCI* IE indicating a GBR bearer (as defined in TS 23.203 [13]), and which does not contain the *GBR QoS Information* IE, the target eNB shall not admit the corresponding E-RAB.

If the supported algorithms for encryption defined in the *Encryption Algorithms* IE in the *UE Security Capabilities* IE in the *UE Context Information* IE, plus the mandated support of EEA0 in all UEs (TS 33.401 [18]), do not match any algorithms defined in the configured list of allowed encryption algorithms in the target eNB (TS 33.401 [18]), the target eNB shall reject the procedure using the HANDOVER PREPARATION FAILURE message.

If the supported algorithms for integrity defined in the *Integrity Protection Algorithms* IE in the *UE Security Capabilities* IE in the *UE Context Information* IE, plus the mandated support of the EIA0 algorithm in all UEs (TS 33.401 [18]), do not match any algorithms defined in the configured list of allowed integrity protection algorithms in the eNB (TS 33.401 [18]), the eNB shall reject the procedure using the HANDOVER PREPARATION FAILURE message.

If the target eNB receives a HANDOVER REQUEST message which does not contain the *Handover Restriction List* IE, and the PLMN to be used cannot be determined otherwise, the target eNB shall reject the procedure using the HANDOVER PREPARATION FAILURE message.

If the target eNB receives a HANDOVER REQUEST message containing the *Handover Restriction List* IE, and the serving PLMN is not supported by the target cell, the target eNB shall reject the procedure using the HANDOVER PREPARATION FAILURE message.

If the target eNB receives a HANDOVER REQUEST message which does not contain the *CSG Membership Status* IE, and the target cell is a hybrid cell, the target eNB shall reject the procedure using the HANDOVER PREPARATION FAILURE message.

If the target cell is a CSG cell and the target eNB has not received any CSG ID of the source cell, the target eNB shall reject the procedure using the HANDOVER PREPARATION FAILURE message.

If the target cell is a CSG cell with a different CSG from the source cell, the target eNB shall reject the procedure using the HANDOVER PREPARATION FAILURE message.

8.2.2 SN Status Transfer

8.2.2.1 General

The purpose of the SN Status Transfer procedure is to transfer the uplink PDCP SN and HFN receiver status and the downlink PDCP SN and HFN transmitter status either, from the source to the target eNB during an X2 handover, between the eNBs involved in dual connectivity and/or LWA, or between eNB and en-gNB involved in EN-DC, for each respective E-RAB for which PDCP SN and HFN status preservation applies.

If the SN Status Transfer procedure is applied in the course of dual connectivity, LWA, or EN-DC, in the subsequent specification text

- the behaviour of the eNB from which the E-RAB context is transferred, i.e., the eNB involved in dual connectivity, LWA, or EN-DC from which data forwarding, is specified by the behaviour of the "source eNB",
- the behaviour of the eNB to which the E-RAB context is transferred, i.e., the eNB involved in dual connectivity, LWA, or EN-DC to which data is forwarded, is specified by the behaviour of the "target eNB".
- the behaviour of the en-gNB from which the E-RAB context is transferred, i.e., the en-gNB involved in EN-DC from which data forwarding, is specified by the behaviour of the "source en-gNB",
- the behaviour of the en-gNB to which the E-RAB context is transferred, i.e., the en-gNB involved in EN-DC to which data is forwarded, is specified by the behaviour of the "target en-gNB".

The procedure uses UE-associated signalling.

8.2.2.2 Successful Operation

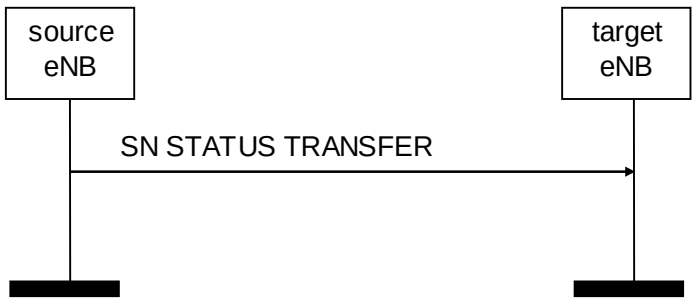


Figure 8.2.2.2-1: SN Status Transfer, successful operation

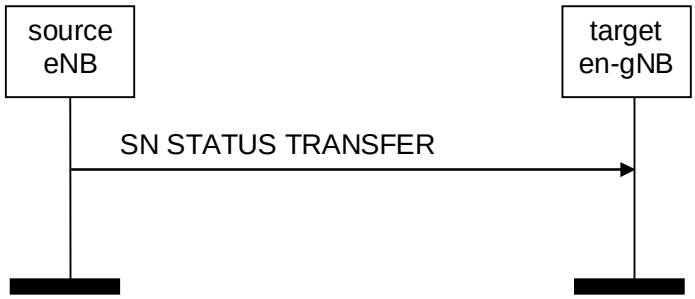


Figure 8.2.2.2-2: eNB initiated SN Status Transfer for EN-DC, successful operation

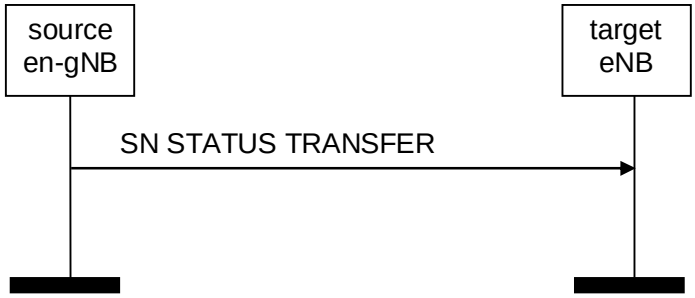


Figure 8.2.2.2-3: en-gNB initiated SN Status Transfer for EN-DC, successful operation

The source eNB initiates the procedure by stop assigning PDCP SNs to downlink SDUs and stop delivering UL SDUs towards the EPC and sending the SN STATUS TRANSFER message to the target eNB at the time point when it considers the transmitter/receiver status to be frozen. The target eNB using Full Configuration for this handover as per TS 36.300 [15] shall ignore the information received in this message.

The *E-RABs Subject To Status Transfer List* IE included in the SN STATUS TRANSFER message contains the E-RAB ID(s) corresponding to the E-RAB(s) for which PDCP SN and HFN status preservation shall be applied.

If the source eNB includes in the SN STATUS TRANSFER message, the information on the missing and received uplink SDUs in the *Receive Status Of UL PDCP SDUs* IE or *Receive Status Of UL PDCP SDUs Extended* IE or *Receive Status Of UL PDCP SDUs for PDCP SN Length 18* IE for each E-RAB for which the source eNB has accepted the request from the target eNB for uplink forwarding, then the target eNB may use it in a Status Report message sent to the UE over the radio.

For each E-RAB for which the *DL COUNT Value* IE is received in the SN STATUS TRANSFER message, the target eNB shall use it to mark with the value contained in the *PDCP-SN* IE of this IE the first downlink packet for which there is no PDCP SN yet assigned. If the *DL COUNT Value Extended* IE or *DL COUNT Value for PDCP SN Length 18* IE is included in the *E-RABs Subject To Status Transfer Item* IE, the target eNB shall, if supported, use the value contained in the *PDCP-SN Extended* IE of the *DL COUNT Value Extended* IE or *PDCP-SN Length 18 IE of the DL COUNT Value for PDCP SN Length 18* IE instead of the value contained in the *PDCP-SN* IE of the *DL COUNT Value* IE.

For each E-RAB for which the *UL COUNT Value* IE is received in the SN STATUS TRANSFER message, the target eNB shall not deliver any uplink packet which has a PDCP SN lower than the value contained in the *PDCP-SN* IE of this IE. If the *UL COUNT Value Extended* IE or *UL COUNT Value for PDCP SN Length 18* IE is included in the *E-RABs Subject To Status Transfer Item* IE, the target eNB shall, if supported, use the value contained in the *PDCP-SN Extended* IE of the *UL COUNT Value Extended* IE or *PDCP-SN Length 18 IE of the UL COUNT Value for PDCP SN Length 18* IE instead of the value contained in the *PDCP-SN* IE of the *UL COUNT Value* IE.

EN-DC

If the en-gNB sends the message to the MeNB, then the *SgNB UE X2AP ID* IE shall be included in the SN STATUS TRANSFER message, while the *Old eNB UE X2AP ID* IE is ignored. The *SgNB UE X2AP ID* IE is used as the old UE ID.

If the MeNB sends the message to the en-gNB, then the *SgNB UE X2AP ID* IE shall be included in the SN STATUS TRANSFER message, while the *New eNB UE X2AP ID* IE is ignored. The *SgNB UE X2AP ID* IE is used as the new UE ID.

8.2.2.3 Abnormal Conditions

If the target eNB receives this message for a UE for which no prepared handover exists at the target eNB, the target eNB shall ignore the message.

8.2.3 UE Context Release

8.2.3.1 General

For handover, the UE Context Release procedure is initiated by the target eNB to indicate to the source eNB that radio and control plane resources for the associated UE context are allowed to be released.

For dual connectivity, UE Context Release procedure is initiated by the MeNB to finally release the UE context at the SeNB. For dual connectivity specific mobility scenarios specified in TS 36.300 [15] only resources related to the UE-associated signalling connection between the MeNB and the SeNB are released. For EN-DC, the UE Context Release procedure is initiated by the MeNB to finally release the UE context at the en-gNB. For EN-DC specific mobility scenarios specified in TS 37.340 [32] where SCG radio resources in the en-gNB are kept, only resources related to the UE-associated signalling connection between the MeNB and the en-gNB are released.

The procedure uses UE-associated signalling.

8.2.3.2 Successful Operation

Figure 8.2.3.2-1: UE Context Release, successful operation for handover

Figure 8.2.3.2-2: UE Context Release, successful operation for dual connectivity

Figure 8.2.3.2-3: UE Context Release, successful operation for EN-DC

Handover

The UE Context Release procedure is initiated by the target eNB. By sending the UE CONTEXT RELEASE message the target eNB informs the source eNB of Handover success and triggers the release of resources.

Upon reception of the UE CONTEXT RELEASE message, the source eNB may release radio and control plane related resources associated to the UE context. For E-RABs for which data forwarding has been performed, the source eNB should continue forwarding of U-plane data as long as packets are received at the source eNB from the EPC or the source eNB buffer has not been emptied (an implementation dependent mechanism decides that data forwarding can be stopped). When the eNB supporting L-GW function for SIPTO@LN operation releases radio and control plane related resources associated to the UE context, it shall also request using intra-node signalling the collocated L-GW to release the SIPTO@LN PDN connection as defined in TS 23.401 [12].

Dual Connectivity

The UE Context Release procedure is initiated by the MeNB. By sending the UE CONTEXT RELEASE message the MeNB informs the SeNB that the UE Context can be removed.

Upon reception of the UE CONTEXT RELEASE message, the SeNB may release radio and control plane related resources associated to the UE context. For E-RABs for which data forwarding has been performed, the SeNB should continue forwarding of U-plane data as long as packets are received at the SeNB from the EPC or the SeNB buffer has not been emptied (an implementation dependent mechanism decides that data forwarding can be stopped). The SeNB supporting L-GW function for LIPA operation shall also request using intra-node signalling the collocated L-GW to release the LIPA PDN connection as defined in TS 23.401 [12]. If the *SIPTO Bearer Deactivation Indication* IE is received in the UE CONTEXT RELEASE message, the SeNB supporting L-GW function for SIPTO@LN operation shall also request using intra-node signalling the collocated L-GW to release the SIPTO@LN PDN connection as defined in TS 23.401 [12].

EN-DC

The UE Context Release procedure is initiated by the MeNB. By sending the UE CONTEXT RELEASE message the MeNB informs the en-gNB that the UE Context can be removed.

Upon reception of the UE CONTEXT RELEASE message, the en-gNB may release radio and control plane related resources associated to the UE context. For E-RABs for which data forwarding has been performed, the en-gNB should continue forwarding of U-plane data as long as packets are received at the en-gNB from the EPC or the en-gNB buffer has not been emptied (an implementation dependent mechanism decides that data forwarding can be stopped).

In the course of signalling for EN-DC, the *SgNB UE X2AP ID* IE shall be included in the UE CONTEXT RELEASE message, while the *Old eNB UE X2AP ID* IE is ignored. The *SgNB UE X2AP ID* IE is used as the new UE ID.

Interaction with the MeNB initiated SeNB Release procedure:

The SeNB may receive the SENB RELEASE REQUEST message including the *UE Context Kept Indicator* IE set to “True”, upon which the SeNB shall, if supported, only release the resources related to the UE-associated signalling connection between the MeNB and the SeNB, as specified in TS 36.300 [15].

Interaction with the MeNB initiated SgNB Release procedure:

The en-gNB may receive the SGNB RELEASE REQUEST message including the *UE Context Kept Indicator* IE set to "True", upon which the en-gNB shall, if supported, only release the resources related to the UE-associated signalling connection between the MeNB and the en-gNB, as specified in TS 37.340 [32].

8.2.3.3 Unsuccessful Operation

Not applicable.

8.2.3.4 Abnormal Conditions

If the UE Context Release procedure is not initiated towards the source eNB from any prepared eNB before the expiry of the timer $TX2_{RELOCoverall}$, the source eNB shall request the MME to release the UE context.

If the UE returns to source eNB before the reception of the UE CONTEXT RELEASE message or the expiry of the timer $TX2_{RELOCoverall}$, the source eNB shall stop the $TX2_{RELOCoverall}$ and continue to serve the UE.

8.2.4 Handover Cancel

8.2.4.1 General

The Handover Cancel procedure is used to enable a source eNB to cancel an ongoing handover preparation or an already prepared handover.

The procedure uses UE-associated signalling.

8.2.4.2 Successful Operation

Figure 8.2.4.2-1: Handover Cancel, successful operation

The source eNB initiates the procedure by sending the HANDOVER CANCEL message to the target eNB. The source eNB shall indicate the reason for cancelling the handover by means of an appropriate cause value.

At the reception of the HANDOVER CANCEL message, the target eNB shall remove any reference to, and release any resources previously reserved to the concerned UE context.

The *New eNB UE X2AP ID* IE and, if available, the *New eNB UE X2AP ID Extension* IE shall be included if it has been obtained from the target eNB.

8.2.4.3 Unsuccessful Operation

Not applicable.

8.2.4.4 Abnormal Conditions

Should the HANDOVER CANCEL message refer to a context that does not exist, the target eNB shall ignore the message.

8.3 Global Procedures

8.3.1 Load Indication

8.3.1.1 General

The purpose of the Load Indication procedure is to transfer load and interference co-ordination information between eNBs controlling intra-frequency neighboring cells, and additionally between eNBs controlling inter-frequency neighboring cells for TDD.

The procedure uses non UE-associated signalling.

8.3.1.2 Successful Operation

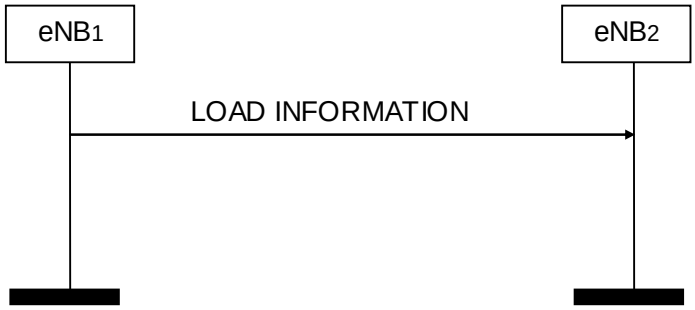


Figure 8.3.1.2-1: Load Indication, successful operation

An eNB_1 initiates the procedure by sending LOAD INFORMATION message to a peer eNB_2.

If the *UL Interference Overload Indication* IE is received in the LOAD INFORMATION message, it indicates the interference level experienced by the indicated cell on all resource blocks, per PRB. If the *Extended UL Interference Overload Info* IE is received in the LOAD INFORMATION message, the *UL Interference Overload Indication* IE indicates the interference level experienced by the indicated cell ignoring the UL subframe(s) represented as value "1" in the *Associated Subframes* IE. The receiving eNB may take such information into account when setting its scheduling policy and shall consider the received *UL Interference Overload Indication* IE value valid until reception of a new LOAD INFORMATION message carrying an update of the same IE.

If the *UL High Interference Indication* IE is received in the LOAD INFORMATION message, it indicates, per PRB, the occurrence of high interference sensitivity, as seen from the sending eNB. The receiving eNB should try to avoid scheduling cell edge UEs in its cells for the concerned PRBs. The *Target Cell ID* IE received within the *UL High Interference Information* IE group in the LOAD INFORMATION message indicates the cell for which the corresponding UL High Interference Indication is meant. The receiving eNB shall consider the value of the *UL High Interference Information* IE group valid until reception of a new LOAD INFORMATION message carrying an update.

If the *Relative Narrowband Tx Power (RNTP)* IE is received in the LOAD INFORMATION message, it indicates, per PRB or per subframe per PRB (Enhanced RNTP), whether downlink transmission power is lower than the value indicated by the *RNTP Threshold* IE. If the *Enhanced RNTP* IE is included in the *Relative Narrowband Tx Power (RNTP)* IE, it additionally indicates whether the downlink transmission power is lower than the value specified by the *RNTP High Power Threshold* IE. The receiving eNB may take such information into account when setting its scheduling policy and shall consider the received *Relative Narrowband Tx Power (RNTP)* IE value valid until reception of a new LOAD INFORMATION message carrying an update. If the *Enhanced RNTP* IE included in the *Relative Narrowband Tx Power (RNTP)* IE is present, the receiving eNB shall consider the received *Enhanced RNTP* IE value valid starting from the subframe indicated by the *Start SFN* IE and *Start Subframe Number* IE, if present.

If the *ABS Information* IE is included in the LOAD INFORMATION message, the *ABS Pattern Info* IE indicates the subframes designated as almost blank subframes by the sending eNB for the purpose of interference coordination. The receiving eNB may take such information into consideration when scheduling UEs.

The receiving eNB may use the *Measurement Subset* IE received in the LOAD INFORMATION message, for the configuration of specific measurements towards the UE.

The receiving eNB shall consider the received information as immediately applicable. The receiving eNB shall consider the value of the *ABS Information* IE valid until reception of a new LOAD INFORMATION message carrying an update.

If an ABS indicated in the *ABS pattern info* IE coincides with a MBSFN subframe, the receiving eNB shall consider that the subframe is designated as almost blank subframe by the sending eNB.

If the *Invoke Indication* IE is included in the LOAD INFORMATION message, it indicates which type of information the sending eNB would like the receiving eNB to send back. The receiving eNB may take such request into account.

If the *Invoke Indication* IE is set to "ABS Information", it indicates the sending eNB would like the receiving eNB to initiate the Load Indication procedure, with the LOAD INFORMATION message containing the *ABS Information* IE indicating non-zero ABS patterns in the relevant cells. If the *Invoke Indication* IE is set to "Start NAICS Information", it indicates the sending eNB would like the receiving eNB to initiate the Load Indication procedure with the LOAD INFORMATION message containing the *Dynamic DL transmission information* IE. The first time the *Dynamic DL transmission information* IE is signalled after receiving the *Invoke Indication* IE set to "Start NAICS Information", all the NAICS parameters in the *NAICS Information* IE shall be included. If the *Invoke Indication* IE is set to "Stop NAICS Information", it indicates the sending eNB does not need NAICS information and therefore the receiving eNB should stop signalling NAICS parameters for the concerned cell.

If the *NAICS Information* IE is set to "NAICS Active", the receiving eNB may use it for the configuration of DL interference mitigation assistance information towards the UE. Information included in the *NAICS Information* IE shall replace corresponding NAICS information existing at the receiver. If the *NAICS Information* IE is set to "NAICS Inactive", the receiving eNB shall consider the existing NAICS information as invalid.

If the *Intended UL-DL Configuration* IE is included in the LOAD INFORMATION message, it indicates the UL-DL configuration intended to be used by the indicated cell. The receiving eNB may take such information into account when setting its scheduling policy and shall consider the received *Intended UL-DL Configuration* IE value valid until reception of a new LOAD INFORMATION message carrying an update of the same IE.

If the *Extended UL Interference Overload Info* IE is received in the LOAD INFORMATION message, the *Extended UL Interference Overload Indication* IE indicates the interference level experienced by the indicated cell on all resource blocks, per PRB, in the UL subframe(s) which is represented as value “1” in the *Associated Subframes* IE. The receiving eNB may take such information into account when setting its scheduling policy and shall consider the received *Extended UL Interference Overload Info* IE value valid until reception of a new LOAD INFORMATION message carrying an update of the same IE.

If the *CoMP Information* IE is received in the LOAD INFORMATION message, the receiving eNB may take the IE into account for RRM. The receiving eNB shall consider the *CoMP Information* IE valid starting in the subframe indicated by the *Start SFN* IE and *Start Subframe Number* IE, if present. If the *Start SFN* IE and *Start Subframe Number* IE are not present, then the receiving eNB shall consider the *CoMP Information* IE as immediately valid. The receiving eNB shall consider the *CoMP Information* IE valid until an update of the same IE, received in a new LOAD INFORMATION message, is considered valid.

8.3.1.3 Unsuccessful Operation

Not applicable.

8.3.1.4 Abnormal Conditions

Void.

8.3.2 Error Indication

8.3.2.1 General

The Error Indication procedure is initiated by an eNB to report detected errors in one incoming message, provided they cannot be reported by an appropriate failure message.

If the error situation arises due to reception of a message utilising UE associated signalling, then the Error Indication procedure uses UE-associated signalling. Otherwise the procedure uses non UE-associated signalling.

8.3.2.2 Successful Operation

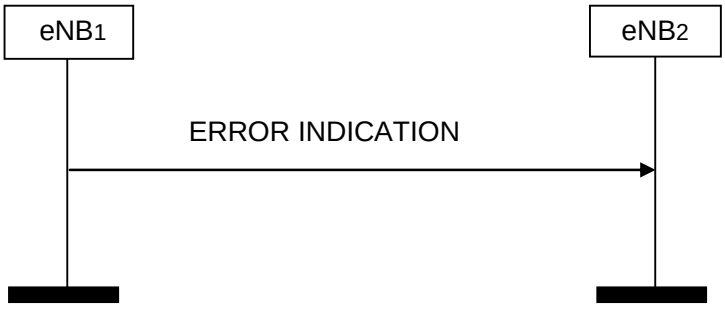


Figure 8.3.2.2-1: Error Indication, successful operation.

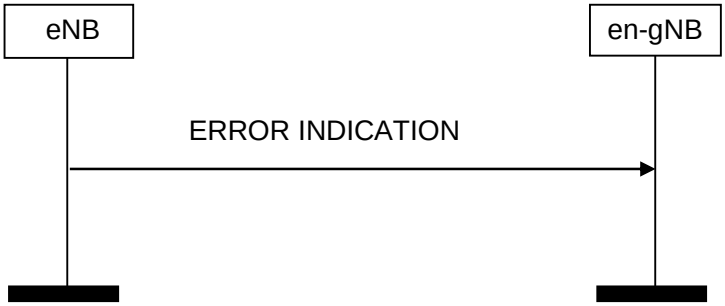


Figure 8.3.2.2-2: eNB initiated Error Indication for EN-DC, successful operation.

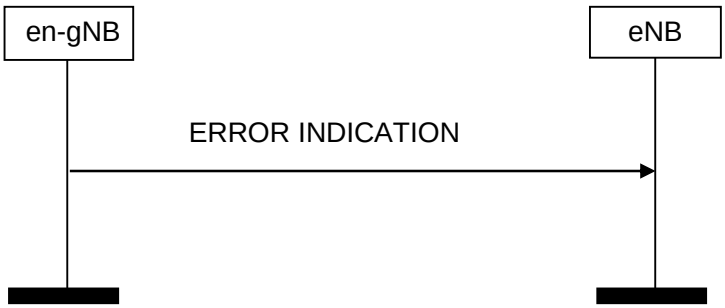


Figure 8.3.2.2-3: en-gNB initiated Error Indication for EN-DC, successful operation.

When the conditions defined in clause 10 are fulfilled, the Error Indication procedure is initiated by an ERROR INDICATION message sent from the node detecting the error situation.

The ERROR INDICATION message shall contain at least either the *Cause* IE or the *Criticality Diagnostics* IE.

In case the Error Indication procedure is triggered by UE associated signalling, in the course of handover signalling and signalling for dual connectivity, the *Old eNB UE X2AP ID* IE and the *New eNB UE X2AP ID* IE shall be included in the ERROR INDICATION message. In case the Error Indication procedure is triggered by UE associated signalling, in the course of signalling for EN-DC, the *Old en-gNB UE X2AP ID* IE and the *New eNB UE X2AP ID* IE shall be included in the ERROR INDICATION message. If any of *Old eNB UE X2AP ID* IE, *Old en-gNB UE X2AP ID* IE and *New eNB UE X2AP ID* IE is not correct, the cause shall be set to appropriate value e.g. "unknown Old eNB UE X2AP ID", "unknown Old en-gNB UE X2AP ID", "unknown New eNB UE X2AP ID" or "unknown pair of UE X2AP ID".

If the UE-associated signalling connection is identified by extended eNB UE X2AP IDs the specification text above is applicable for the UE X2AP ID Extension accordingly.

8.3.2.3 Unsuccessful Operation

Not applicable.

8.3.2.4 Abnormal Conditions

Not applicable.

8.3.3 X2 Setup

8.3.3.1 General

The purpose of the X2 Setup procedure is to exchange application level configuration data needed for two eNBs to interoperate correctly over the X2 interface. This procedure erases any existing application level configuration data in the two nodes and replaces it by the one received. This procedure also resets the X2 interface like a Reset procedure would do.

The procedure uses non UE-associated signalling.

8.3.3.2 Successful Operation

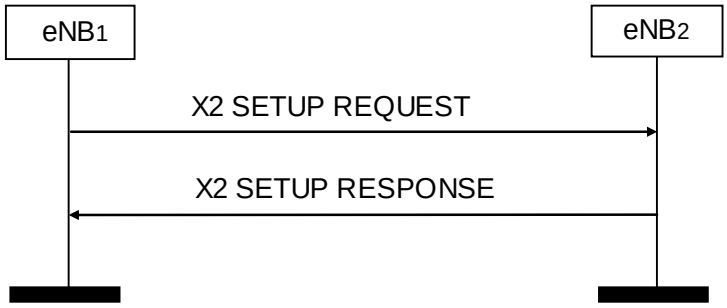


Figure 8.3.3.2-1: X2 Setup, successful operation

An eNB_1 initiates the procedure by sending the X2 SETUP REQUEST message to a candidate eNB_2. The candidate eNB_2 replies with the X2 SETUP RESPONSE message. The initiating eNB_1 shall transfer the complete list of its served cells and, if available, a list of supported GU Group Ids to the candidate eNB_2. The candidate eNB_2 shall reply with the complete list of its served cells and shall include, if available, a list of supported GU Group Ids in the reply.

If a cell is switched off for energy savings reasons, it should be activated before initiating or responding to the X2 Setup procedure and shall still be included in the list of served cells.

The initiating eNB_1 may include the *Neighbour Information* IE in the X2 SETUP REQUEST message. The candidate eNB_2 may also include the *Neighbour Information* IE in the X2 SETUP RESPONSE message. The *Neighbour Information* IE shall only include E-UTRAN cells that are direct neighbours of cells in the reporting eNB. A direct neighbour of one cell of a given eNB may be any cell belonging to an eNB that is a neighbour of that given eNB cell e.g. even if the cell has not been reported by a UE. The initiating eNB_1 may include the *TAC* IE with the *Neighbour Information* IE in the X2 SETUP REQUEST message. The candidate eNB_2 may also include the *TAC* IE with the *Neighbour Information* IE in the X2 SETUP RESPONSE message. The eNB receiving the IE may use it according to TS 36.300 [15].

The initiating eNB_1 may include the *Number of Antenna Ports* IE in the X2 SETUP REQUEST message. The candidate eNB_2 may also include the *Number of Antenna Ports* IE in the X2 SETUP RESPONSE message. The eNB receiving the IE may use it according to TS 36.331 [9].

The initiating eNB_1 may include the *PRACH Configuration* IE in the X2 SETUP REQUEST message. The candidate eNB_2 may also include the *PRACH Configuration* IE in the X2 SETUP RESPONSE message. The eNB receiving the IE may use this information for RACH optimisation.

The initiating eNB_1 may include the *MBSFN Subframe Info* IE in the X2 SETUP REQUEST message. The candidate eNB_2 may also include the *MBSFN Subframe Info* IE in the X2 SETUP RESPONSE message. The eNB receiving the IE may use it according to TS 36.331 [9].

For each CSG cell or hybrid cell served by the initiating eNB_1 the X2 SETUP REQUEST message shall contain the *CSG ID* IE. For each CSG cell or hybrid cell served by the candidate eNB_2 the X2 SETUP RESPONSE message shall contain the *CSG ID* IE. The eNB receiving the IE shall take this information into account when further deciding whether X2 handover between the source cell and the target cell may be performed.

The initiating eNB_1 may include the *MBMS Service Area Identity List* IE in the X2 SETUP REQUEST message. The candidate eNB_2 may also include the *MBMS Service Area Identity List* IE in the X2 SETUP RESPONSE message. The eNB receiving the IE may use it according to TS 36.300 [15].

For each cell served by the initiating eNB_1 the X2 SETUP REQUEST message may contain the *MultibandInfoList* IE and may also contain the *FreqBandIndicatorPriority* IE. For each cell served by the candidate eNB_2 the X2 SETUP RESPONSE message may contain the *MultibandInfoList* IE and may also contain the *FreqBandIndicatorPriority* IE. The eNB receiving the *MultibandInfoList* IE shall, if supported, take this information into account when further deciding whether subsequent mobility actions between the source cell and the target cell may be performed, and use this IE and the *FreqBandIndicatorPriority* IE, if received, as specified in TS 36.331 [9].

The initiating eNB_1 may include the *LHN ID* IE in the X2 SETUP REQUEST message. The candidate eNB_2 may also include *LHN ID* IE in the X2 SETUP RESPONSE message. The eNB receiving the IE may use it according to TS 36.300 [15].

The initiating eNB_1 may include the *BandwidthReducedSI* IE in the X2 SETUP REQUEST message. The candidate eNB_2 may also include *BandwidthReducedSI* IE in the X2 SETUP RESPONSE message. The eNB receiving the IE may use it to determine a suitable target in case of subsequent outgoing mobility involving BL UEs or UEs requiring CE.

8.3.3.3 Unsuccessful Operation

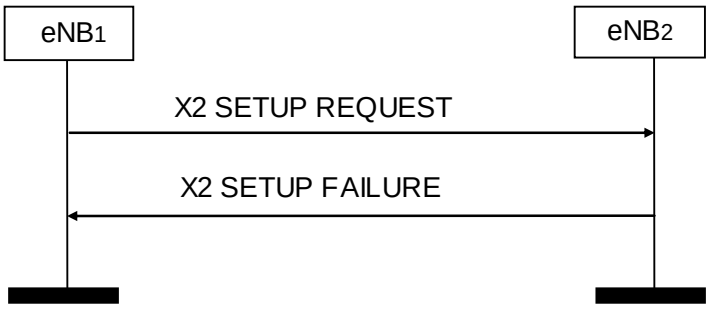


Figure 8.3.3.3-1: X2 Setup, unsuccessful operation

If the candidate eNB_2 cannot accept the setup it shall respond with an X2 SETUP FAILURE message with appropriate cause value.

If the X2 SETUP FAILURE message includes the *Time To Wait* IE the initiating eNB_1 shall wait at least for the indicated time before reinitiating the X2 Setup procedure towards the same eNB_2.

8.3.3.4 Abnormal Conditions

If the first message received for a specific TNL association is not an X2 SETUP REQUEST, X2 SETUP RESPONSE, or X2 SETUP FAILURE message then this shall be treated as a logical error.

If the initiating eNB_1 does not receive either X2 SETUP RESPONSE message or X2 SETUP FAILURE message, the eNB_1 may reinitiate the X2 Setup procedure towards the same eNB, provided that the content of the new X2 SETUP REQUEST message is identical to the content of the previously unacknowledged X2 SETUP REQUEST message.

If the initiating eNB_1 receives an X2 SETUP REQUEST message from the peer entity on the same X2 interface:

- In case the eNB_1 answers with an X2 SETUP RESPONSE message and receives a subsequent X2 SETUP FAILURE message, the eNB_1 shall consider the X2 interface as non operational and the procedure as unsuccessfully terminated according to sub clause 8.3.3.3.

- In case the eNB_1 answers with an X2 SETUP FAILURE message and receives a subsequent X2 SETUP RESPONSE message, the eNB_1 shall ignore the X2 SETUP RESPONSE message and consider the X2 interface as non operational.

8.3.4 Reset

8.3.4.1 General

The purpose of the Reset procedure is to align the resources in eNB_1 and eNB_2, or the resources in eNB and en-gNB involved in the EN-DC in the event of an abnormal failure. The procedure resets the X2 interface. This procedure doesn't affect the application level configuration data exchanged during, e.g., the X2 Setup procedure, EN-DC X2 Setup procedure.

The procedure uses non UE-associated signalling.

8.3.4.2 Successful Operation

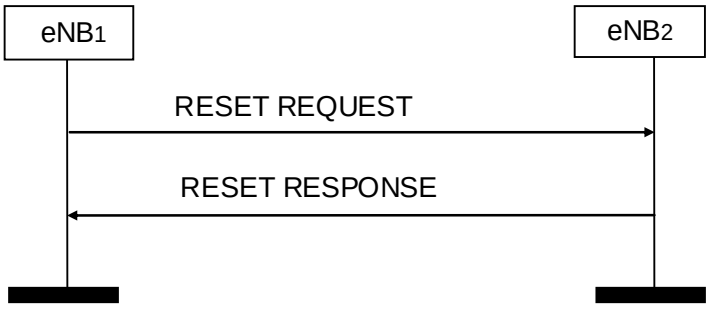


Figure 8.3.4.2-1: Reset, successful operation

The procedure is initiated with a RESET REQUEST message sent from the eNB_1 to the eNB_2. Upon receipt of this message, eNB_2 shall abort any other ongoing procedures over X2 between eNB_1 and eNB_2. The eNB_2 shall delete all the context information related to the eNB_1, except the application level configuration data exchanged during the X2 Setup or eNB Configuration Update procedures, and release the corresponding resources. After completion of release of the resources, the eNB_2 shall respond with a RESET RESPONSE message.

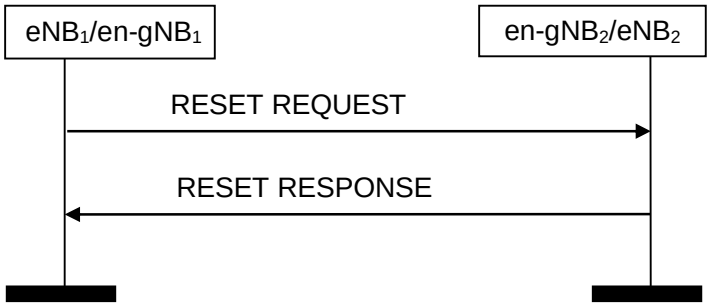


Figure 8.3.4.2-2: Reset, successful operation for EN-DC.

The procedure is initiated with a RESET REQUEST message sent from the eNB_1/en-gNB_1 to en-gNB_2/eNB_2. Upon receipt of this message, eNB_2/en-gNB_2 shall abort any other ongoing procedures over X2 between both nodes. eNB_2/en-gNB_2 shall delete all the context information related to eNB_1/en-gNB_1, except the application level configuration data exchanged during the EN-DC X2 Setup or EN-DC Configuration Update procedures, and release the corresponding resources. After completion of release of the resources, eNB_2/en-gNB_2 shall respond with a RESET RESPONSE message.

8.3.4.3 Unsuccessful Operation

Void.

8.3.4.4 Abnormal Conditions

If the RESET REQUEST message is received, any other ongoing procedure (except another Reset procedure) on the same X2 interface shall be aborted.

If Reset procedure is ongoing and the responding node receives the RESET REQUEST message from the peer entity on the same X2 interface, it shall respond with the RESET RESPONSE message as described in 8.3.4.2.

If the initiating node does not receive RESET RESPONSE message, the initiating node may reinitiate the Reset procedure towards the same eNB/en-gNB, provided that the content of the new RESET REQUEST message is identical to the content of the previously unacknowledged RESET REQUEST message.

8.3.5 eNB Configuration Update

8.3.5.1 General

The purpose of the eNB Configuration Update procedure is to update application level configuration data needed for two eNBs to interoperate correctly over the X2 interface.

The procedure uses non UE-associated signalling.

8.3.5.2 Successful Operation

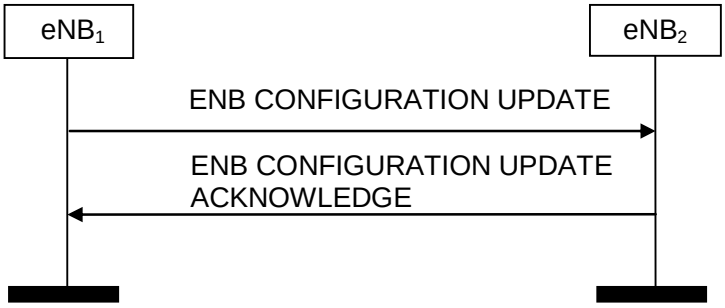


Figure 8.3.5.2-1: eNB Configuration Update, successful operation

An eNB_1 initiates the procedure by sending an ENB CONFIGURATION UPDATE message to a peer eNB_2. Such message shall include an appropriate set of up-to-date configuration data, including, but not limited to, the complete lists of added, modified and deleted served cells, that eNB_1 has just taken into operational use.

Upon reception of an ENB CONFIGURATION UPDATE message, eNB_2 shall update the information for eNB_1 as follows:

Update of Served Cell Information:

- If *Served Cells To Add* IE is contained in the ENB CONFIGURATION UPDATE message, eNB_2 shall add cell information according to the information in the *Served Cell Information* IE.
- If *Number of Antenna Ports* IE is contained in the *Served Cell Information* IE in the ENB CONFIGURATION UPDATE message, eNB_2 may use this information according to TS 36.331 [9].
- If the *PRACH Configuration* IE is contained in the *Served Cell Information* IE in the ENB CONFIGURATION UPDATE message, the eNB receiving the IE may use this information for RACH optimisation.
- If *Served Cells To Modify* IE is contained in the ENB CONFIGURATION UPDATE message, eNB_2 shall modify information of cell indicated by *Old ECGI* IE according to the information in the *Served Cell Information* IE.
- If *MBSFN Subframe Info* IE is contained in the *Served Cell Information* IE in the ENB CONFIGURATION UPDATE message, eNB_2 may use this information according to TS 36.331 [9]. If a MBSFN subframe indicated in the *MBSFN Subframe Info* IE coincides with an ABS, the eNB_2 shall consider that the subframe is designated as ABS by the sending eNB.
- If *BandwidthReducedSI* IE is contained in the *Served Cell Information* IE in the ENB CONFIGURATION UPDATE message, eNB_2 may use this information to determine a suitable target in case of subsequent outgoing mobility involving BL UEs or UEs requiring CE.

  When either served cell information or neighbour information of an existing served cell in eNB_1 need to be updated, the whole list of neighbouring cells, if any, shall be contained in the *Neighbour Information* IE.

If the *Deactivation Indication* IE is contained in *Served Cells To Modify* IE, it indicates that the concerned cell was switched off to lower energy consumption.

The eNB_2 shall overwrite the served cell information and the whole list of neighbour cell information for the affected served cell.

- If *Served Cells To Delete* IE is contained in the ENB CONFIGURATION UPDATE message, eNB_2 shall delete information of cell indicated by *Old ECGI* IE.
- If *MBMS Service Area Identity List* IE is contained in the *Served Cell Information* IE in the ENB CONFIGURATION UPDATE message, the eNB receiving the IE may use it according to TS 36.300 [15].

  When the MBMS Service Area Identities of a cell in eNB_1 need to be updated, the whole list of MBMS Service Area Identities of the affected cell shall be contained in the *Served Cell Information* IE.

Update of GU Group Id List:

- If *GU Group Id To Add List* IE is contained in the ENB CONFIGURATION UPDATE message, eNB_2 shall add the GU Group Id to its GU Group Id List.
- If *GU Group Id To Delete List* IE is contained in the ENB CONFIGURATION UPDATE message, eNB_2 shall remove the GU Group Id from its GU Group Id List.

If *Neighbour Information* IE is contained in the ENB CONFIGURATION UPDATE message, eNB_2 may use this information to update its neighbour cell relations, or use it for other functions, like PCI selection. The *Neighbour Information* IE shall only include E-UTRAN cells that are direct neighbours of cells in the reporting eNB. A direct neighbour of one cell of a given eNB may be any cell belonging to an eNB that is a neighbour of that given eNB cell e.g. even if that cell has not been reported by a UE. The *Neighbour Information* IE may contain the *TAC* IE of the included cells. The receiving eNB may use *TAC* IE, as described in TS 36.300 [15].

After successful update of requested information, eNB_2 shall reply with the ENB CONFIGURATION UPDATE ACKNOWLEDGE message to inform the initiating eNB_1 that the requested update of application data was performed successfully. In case the peer eNB_2 receives an ENB CONFIGURATION UPDATE without any IE except for *Message Type* IE it shall reply with ENB CONFIGURATION UPDATE ACKNOWLEDGE message without performing any updates to the existing configuration.

The eNB_1 may initiate a further eNB Configuration Update procedure only after a previous eNB Configuration Update procedure has been completed.

For each cell served by the initiating eNB_1 the ENB CONFIGURATION UPDATE message may contain the *MultibandInfoList* IE and may also contain the *FreqBandIndicatorPriority* IE. The eNB receiving the *MultibandInfoList* IE shall, if supported, take this information into account when further deciding whether subsequent mobility actions between the source cell and the target cell may be performed, and use this IE and the *FreqBandIndicatorPriority* IE, if received, as specified in TS 36.331 [9].

If the *Coverage Modification List* IE is present, eNB_2 may use the information in the *Cell Coverage State* IE to identify the cell deployment configuration enabled by eNB_1 and for configuring the mobility towards the cell(s) indicated by the *ECGI* IE, as described in TS 36.300 [15]. If the *Cell Deployment Status Indicator* IE is present in the *Coverage Modification List* IE, the eNB_2 shall consider the cell deployment configuration of the cell to be modified as the next planned configuration and shall remove any planned configuration stored for this cell. If the *Cell Deployment Status Indicator* IE is present and the *Cell Replacing Info* IE contains non-empty cell list, the eNB_2 may use this list to avoid connection or re-establishment failures during the reconfiguration, e.g. consider the cells in the list as possible alternative handover targets. If the *Cell Deployment Status Indicator* IE is not present, the eNB_2 shall consider the cell deployment configuration of cell to be modified as activated and replace any previous configuration for the cells indicated in the *Coverage Modification List* IE.

Interaction with the eNB Configuration Update procedure:

If an eNB_2 which has not stored a *FreqBandIndicatorPriority* IE received from eNB_1, but has signaled a *FreqBandIndicatorPriority* IE to eNB_1 after the TNL association has become available, receives an ENB CONFIGURATION UPDATE message from eNB_1 containing the *FreqBandIndicatorPriority* IE, the eNB_2 shall initiate the eNB Configuration Update procedure towards eNB_1 including the *FreqBandIndicatorPriority* IE.

8.3.5.3 Unsuccessful Operation

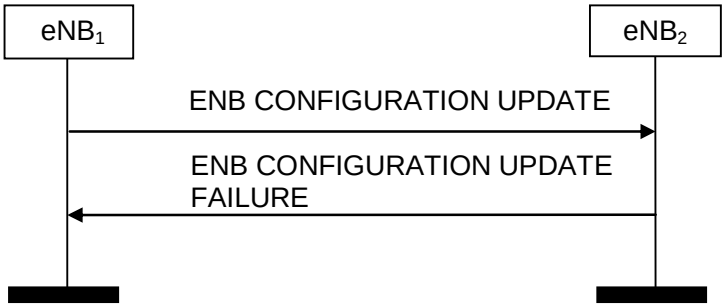


Figure 8.3.5.3-1: eNB Configuration Update, unsuccessful operation

If the eNB_2 can not accept the update it shall respond with an ENB CONFIGURATION UPDATE FAILURE message and appropriate cause value.

If the ENB CONFIGURATION UPDATE FAILURE message includes the *Time To Wait* IE the eNB_1 shall wait at least for the indicated time before reinitiating the eNB Configuration Update procedure towards the same eNB_2. Both nodes shall continue to operate the X2 with their existing configuration data.

8.3.5.4 Abnormal Conditions

If the eNB_1 after initiating eNB Configuration Update procedure receives neither ENB CONFIGURATION UPDATE ACKNOWLEDGE message nor ENB CONFIGURATION UPDATE FAILURE message, the eNB_1 may reinitiate the eNB Configuration Update procedure towards the same eNB_2, provided that the content of the new ENB CONFIGURATION UPDATE message is identical to the content of the previously unacknowledged ENB CONFIGURATION UPDATE message.

8.3.6 Resource Status Reporting Initiation

8.3.6.1 General

This procedure is used by an eNB to request the reporting of load measurements to another eNB.

The procedure uses non UE-associated signalling.

8.3.6.2 Successful Operation

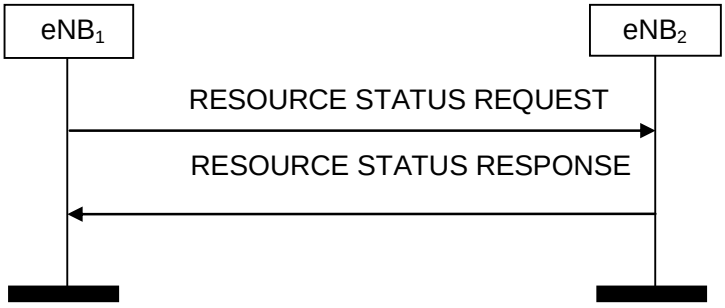


Figure 8.3.6.2-1: Resource Status Reporting Initiation, successful operation

The procedure is initiated with a RESOURCE STATUS REQUEST message sent from eNB_1 to eNB_2. Upon receipt, eNB_2:

- shall initiate the requested measurement according to the parameters given in the request in case the *Registration Request* IE set to "start"; or
- shall stop all cells measurements and terminate the reporting in case the *Registration Request* IE is set to “stop"; or
- if supported, stop cell measurements and terminate the reporting for cells indicated in the *Cell To Report* IE list, in case the *Registration Request* IE is set to "partial stop"; or

- if supported, add cells indicated in the *Cell To Report* IE list to the measurements initiated before for the given measurement IDs, in case the *Registration Request* IE is set to "add".

If the eNB_2 received a RESOURCE STATUS REQUEST message, which includes the *Registration Request* IE set to "stop", the *Cell To Report* IE list shall be ignored.

If the *Registration Request* IE is set to "start" then the *Report Characteristics* IE shall be included in RESOURCE STATUS REQUEST message. The eNB_2 shall ignore the *Report Characteristics* IE, if the *Registration Request* IE is not set to "start".

The *Report Characteristics* IE indicates the type of objects eNB_2 shall perform measurements on. For each cell, the eNB_2 shall include in the RESOURCE STATUS UPDATE message:

- the *Radio Resource Status* IE, if the first bit, “PRB Periodic” of the *Report Characteristics* IE included in the RESOURCE STATUS REQUEST message is set to 1;
- the *S1 TNL Load Indicator* IE, if the second bit, “TNL Load Ind Periodic” of the *Report Characteristics* IE included in the RESOURCE STATUS REQUEST message is set to 1;
- the *Hardware Load Indicator* IE, if the third bit, “HW Load Ind Periodic” of the *Report Characteristics* IE included in the RESOURCE STATUS REQUEST message is set to 1;
- the *Composite Available Capacity Group* IE, if the fourth bit, “Composite Available Capacity Periodic” of the *Report Characteristics* IE included in the RESOURCE STATUS REQUEST message is set to 1. If *Cell Capacity Class Value* IE is included within the *Composite Available Capacity Group* IE, this IE is used to assign weights to the available capacity indicated in the *Capacity Value* IE;
- the *ABS Status* IE, if the fifth bit, “ABS Status Periodic” of the *Report Characteristics* IE included in the RESOURCE STATUS REQUEST message is set to 1 and eNB_1 had indicated the ABS pattern to eNB_2;
- the *RSRP Measurement Report List* IE, if the sixth bit, “RSRP Measurement Report Periodic” of the *Report Characteristics* IE included in the RESOURCE STATUS REQUEST message is set to 1;
- the *CSI Report* IE, if the seventh bit, “CSI Report Periodic” of the *Report Characteristics* IE included in the RESOURCE STATUS REQUEST message is set to 1.

If the *Reporting Periodicity* IE is included in the RESOURCE STATUS REQUEST message, eNB_2 shall use its value as the time interval between two subsequent RESOURCE STATUS UPDATE messages that include the *Radio Resource Status* IE, *S1 TNL Load Indicator* IE, *Hardware Load Indicator* IE, *Composite Available Capacity Group* IE, or *ABS Status* IE.

If the *Reporting Periodicity of RSRP Measurement Report* IE is included in the RESOURCE STATUS REQUEST message, eNB_2 shall use its value as the minimum time interval between two subsequent RESOURCE STATUS UPDATE messages that include the *RSRP Measurement Report List* IE.

If the *Reporting Periodicity of CSI Report* IE is included in the RESOURCE STATUS REQUEST message, eNB_2 shall use its value as the minimum time interval between two subsequent RESOURCE STATUS UPDATE messages that include the *CSI Report* IE.

If eNB_2 is capable to provide all requested resource status information, it shall initiate the measurement as requested by eNB_1, and respond with the RESOURCE STATUS RESPONSE message.

If eNB_2 is capable to provide some but not all of the requested resource status information and the *Partial Success Indicator* IE is present in the RESOURCE STATUS REQUEST message, it shall initiate the measurement for the admitted measurement objects and include the *Measurement Initiation Result* IE in the RESOURCE STATUS RESPONSE message.

8.3.6.3 Unsuccessful Operation

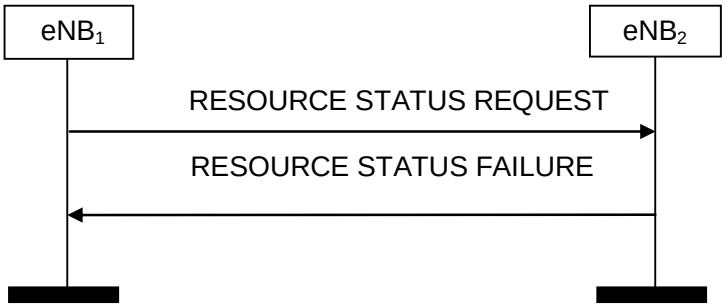


Figure 8.3.6.3-1: Resource Status Reporting Initiation, unsuccessful operation

If none of the requested measurements can be initiated, eNB_2 shall send a RESOURCE STATUS FAILURE message. The *Cause* IE shall be set to an appropriate value e.g. "Measurement Temporarily not Available" or "Measurement not Supported For The Object" for each requested measurement object. The eNB may use the *Complete Failure Cause Information* IE to enhance the failure cause information per measurement in the RESOURCE STATUS FAILURE message.

8.3.6.4 Abnormal Conditions

If the initiating eNB_1 does not receive either RESOURCE STATUS RESPONSE message or RESOURCE STATUS FAILURE message, the eNB_1 may reinitiate the Resource Status Reporting Initiation procedure towards the same eNB, provided that the content of the new RESOURCE STATUS REQUEST message is identical to the content of the previously unacknowledged RESOURCE STATUS REQUEST message.

If the initiating eNB_1 receives the RESOURCE STATUS RESPONSE message including the *Measurement Initiation Result* IE containing no admitted measurements, the eNB_1 shall consider the procedure as failed.

If the *Report Characteristics* IE bitmap is set to "0" (all bits are set to "0") in the RESOURCE STATUS REQUEST message then eNB_2 shall initiate a RESOURCE STATUS FAILURE message, the cause shall be set to appropriate value e.g. "ReportCharacteristicsEmpty".

If the *Reporting Periodicity* IE value is not specified when at least one of the bits of the *Report Characteristics* IE, for which semantics is specified, other than the sixth or seventh bit, is set to 1 then eNB_2 shall initiate a RESOURCE STATUS FAILURE message, the cause shall be set to appropriate value e.g. "NoReportPeriodicity".

If the *Reporting Periodicity of RSRP Measurement Report* IE value is not specified when the sixth bit of the *Report Characteristics* IE is set to 1, then eNB_2 shall initiate the RESOURCE STATUS FAILURE message and the cause shall be set to appropriate value e.g. "NoReportPeriodicity".

If the *Reporting Periodicity of CSI Report* IE value is not specified when the seventh bit of the *Report Characteristics* IE is set to 1, then eNB_2 shall initiate the RESOURCE STATUS FAILURE message and the cause shall be set to appropriate value e.g. "NoReportPeriodicity".

If the eNB_2 received a RESOURCE STATUS REQUEST message which includes the *Registration Request* IE set to "start" and the *eNB1Measurement ID* IE corresponding to an existing on-going load measurement reporting, then eNB_2 shall initiate a RESOURCE STATUS FAILURE message, the cause shall be set to appropriate value e.g. "ExistingMeasurementID".

If the *Registration Request* IE is set to "stop", "partial stop" or "add" and the RESOURCE STATUS REQUEST message does not contain *eNB2 Measurement ID* IE, eNB_2 shall consider the procedure as failed and respond with the RESOURCE STATUS FAILURE message, the cause shall be set to appropriate value e.g. "Unknown eNB Measurement ID".

If the *Registration Request* IE is set to "partial stop" and the *Cell To Report* IE contains cells that have not been initiated for the reporting before, eNB_2 shall consider the procedure as failed and respond with the RESOURCE STATUS FAILURE message, the cause shall be set to appropriate value e.g. "Cell not Available". If the *Registration Request* IE is set to "add" and the *Cell To Report* IE contains cells that have been initiated for the reporting before, eNB_2 shall consider the procedure as failed and respond with the RESOURCE STATUS FAILURE message, the cause shall be set to appropriate value e.g. "Cell not Available".

8.3.7 Resource Status Reporting

8.3.7.1 General

This procedure is initiated by eNB_2 to report the result of measurements admitted by eNB_2 following a successful Resource Status Reporting Initiation procedure.

The procedure uses non UE-associated signalling.

8.3.7.2 Successful Operation

Figure 8.3.7.2-1: Resource Status Reporting, successful operation

The eNB_2 shall report the results of the admitted measurements in RESOURCE STATUS UPDATE message. The admitted measurements are the measurements that were successfully initiated during the preceding Resource Status Reporting Initiation procedure, and thus not reported in the *Measurement Failed Report Characteristics* IE for the concerned cell in the RESOURCE STATUS RESPONSE message.

If the eNB_1 receives the RESOURCE STATUS UPDATE message which includes the *UE ID* IE in the *RSRP Measurement Report List* IE, the eNB_1 may use the *UE ID* IE to link the associated RSRP measurement report with other measurement results (e.g. CSI reports, RSRP measurement reports) of the same UE.

If the *CSI Report* IE including the *CSI Process Configuration Index* IE is received, eNB_1 shall interpret this IE as an index identifying one of the CSI process configurations that can be configured for all UEs within the cell where the CSI measurements were collected. For all UEs within the cell, the maximum number of CSI process configurations is given by the maximum value of the *CSI Process Configuration Index* IE.

If the eNB_1 receives the RESOURCE STATUS UPDATE message, which includes the *Cell Reporting Indicator* IE set to "stop request" in one or more items of the *Cell Measurement Result* IE, the eNB_1 should initialise the Resource Status Reporting Initiation procedure to remove all or some of the corresponding cells from the measurement.

8.3.7.3 Unsuccessful Operation

Not applicable.

8.3.7.4 Abnormal Conditions

If the eNB_1 receives a RESOURCE STATUS UPDATE message which includes the *ABS Status* IE, and all bits in the *Usable ABS Pattern Info* IE are set to '0', the eNB1 shall ignore the *DL ABS Status* IE.

8.3.8 Mobility Settings Change

8.3.8.1 General

This procedure enables an eNB to negotiate the handover trigger settings with a peer eNB controlling neighbouring cells.

The procedure uses non UE-associated signalling.

8.3.8.2 Successful Operation

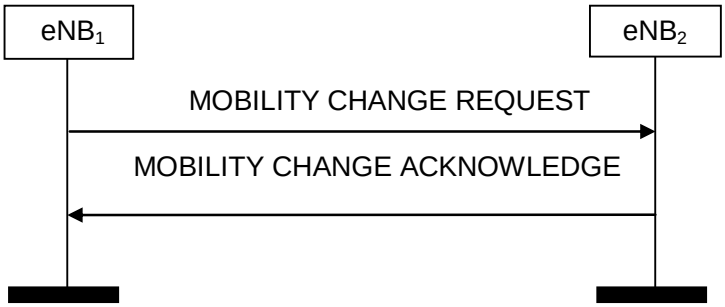


Figure 8.3.8.2-1: Mobility Settings Change, successful operation

The procedure is initiated with a MOBILITY CHANGE REQUEST message sent from eNB_1 to eNB_2.

Upon receipt, eNB_2 shall evaluate if the proposed eNB_2 handover trigger modification may be accepted. If eNB_2 is able to successfully complete the request it shall reply with MOBILITY CHANGE ACKNOWLEDGE.

8.3.8.3 Unsuccessful Operation

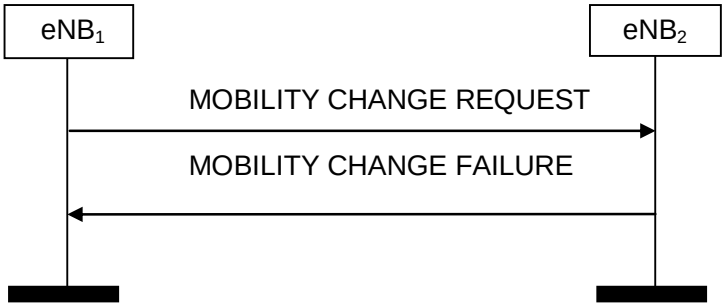


Figure 8.3.8.3-1: Mobility Settings Change, unsuccessful operation

If the requested parameter modification is refused by the eNB_2, or if the eNB_2 is not able to complete the procedure, the eNB_2 shall send a MOBILITY CHANGE FAILURE message with the *Cause* IE set to an appropriate value. The eNB_2 may include *eNB2 Mobility Parameters Modification Range* IE in MOBILITY CHANGE FAILURE message, for example in cases when the proposed change is out of permitted range.

8.3.8.4 Abnormal Conditions

Void.

8.3.9 Radio Link Failure Indication

8.3.9.1 General

The purpose of the Radio Link Failure Indication procedure is to transfer information regarding RRC re-establishment attempts, or received RLF Reports, between eNBs. The signalling takes place from the eNB at which a re-establishment attempt is made, or an RLF Report is received, to an eNB to which the UE concerned may have previously been attached prior to the connection failure. This may aid the detection of radio link failure and handover failure cases (TS 36.300 [15]).

The procedure uses non UE-associated signalling.

8.3.9.2 Successful Operation

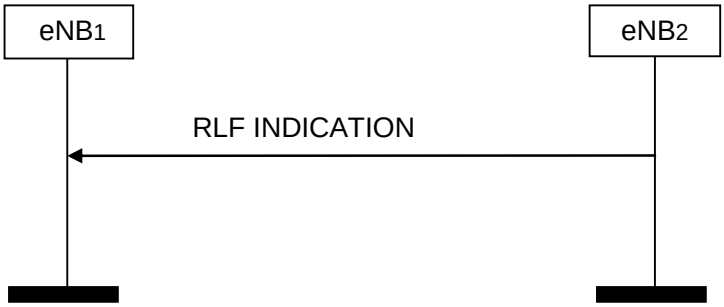


Figure 8.3.9.2-1: Radio Link Failure Indication, successful operation

eNB_2 initiates the procedure by sending the RLF INDICATION message to eNB_1 following a re-establishment attempt or an RLF Report reception from a UE at eNB_2, when eNB_2 considers that the UE may have previously suffered a connection failure at a cell controlled by eNB_1.

eNB_2 may include the *ShortMAC-I* IE in the RLF INDICATION message, e.g., in order to aid the eNB_1 to resolve a potential PCI confusion situation or to aid the eNB_1 to identify the UE.

eNB_2 may include the *UE RLF Report Container* IE and optionally also the *UE RLF Report Container for extended bands* IE in the RLF INDICATION message, which may be used by the eNB_1 to determine the nature of the failure. If the *UE RLF Report Container* IE is included in the RLF INDICATION message sent after successful re-establishment, the eNB_2 shall use the *Re-establishment Cell ECGI* IE in the RLF INDICATION message to indicate the ECGI of the cell where the re-establishment was successful.

eNB_2 may include the *RRC Conn Setup Indicator* IE in the RLF INDICATION message, which indicates that the RLF Report is retrieved after an RRC connection setup or an incoming successful handover.

If the *RRC Conn Setup Indicator* IE is present in the RLF INDICATION message, the eNB_1 shall ignore the values in the *Failure cell PCI* IE, *Re-establishment cell ECGI* IE, *C-RNTI* IE and *ShortMAC-I* IE.

eNB_2 may include the *RRC Conn Reestab Indicator* IE in the RLF INDICATION message, which may be used by the eNB_1 to determine where the failure occurred.

8.3.9.3 Unsuccessful Operation

Not applicable.

8.3.9.4 Abnormal Conditions

Void.

8.3.10 Handover Report

8.3.10.1 General

The purpose of the Handover Report procedure is to transfer mobility related information between eNBs.

The procedure uses non UE-associated signalling.

8.3.10.2 Successful Operation

Figure 8.3.10.2-1: Handover Report, successful operation

An eNB initiates the procedure by sending an HANDOVER REPORT message to another eNB. By sending the message eNB_1 indicates to eNB_2 that a mobility-related problem was detected.

If the *Handover Report Type* IE is set to "HO too early" or "HO to wrong cell", then the eNB_1 indicates to eNB_2 that, following a successful handover from a cell of eNB_2 to a cell of eNB_1, a radio link failure occurred and the UE attempted RRC Re-establishment either at the original cell of eNB_2 (Handover Too Early), or at another cell (Handover to Wrong Cell). The detection of Handover Too Early and Handover to Wrong Cell events is made according to TS 36.300 [15].

If the UE-related information is available in eNB_1, the eNB_1 should include in HANDOVER REPORT message:

- the *Mobility Information* IE, if the *Mobility Information* IE was sent for this handover from eNB_2;
- the *Source cell C-RNTI* IE.

If received, the eNB_2 uses the above information according to TS 36.300 [15].

If the UE RLF Report received from the eNB sending the RLF INDICATION message, as described in TS 36.300 [15], is available, the eNB_1 may also include it in the HANDOVER REPORT as *UE RLF Report Container* IE and optionally also *UE RLF Report Container for extended bands* IE.

If the *Handover Report Type* IE is set to "InterRAT ping-pong", then the eNB_1 indicates to eNB_2 that a completed handover from a cell of eNB_2 to a cell in other RAT might have resulted in an inter-RAT ping-pong and the UE was successfully handed over to a cell of eNB_1 (indicated with *Failure cell ECGI* IE).

The report contains the source and target cells, and cause of the handover. If the *Handover Report Type* IE is set to "HO to wrong cell", then the *Re-establishment cell ECGI* IE shall be included in the HANDOVER REPORT message. If the *Handover Report Type* IE is set to "InterRAT ping-pong", then the *Target cell in UTRAN* IE shall be included in the HANDOVER REPORT message.

8.3.10.3 Unsuccessful Operation

Not applicable.

8.3.10.4 Abnormal Conditions

Void.

8.3.11 Cell Activation

8.3.11.1 General

The purpose of the Cell Activation procedure is to request to a neighbouring eNB to switch on one or more cells, previously reported as inactive due to energy saving reasons.

The procedure uses non UE-associated signalling.

8.3.11.2 Successful Operation

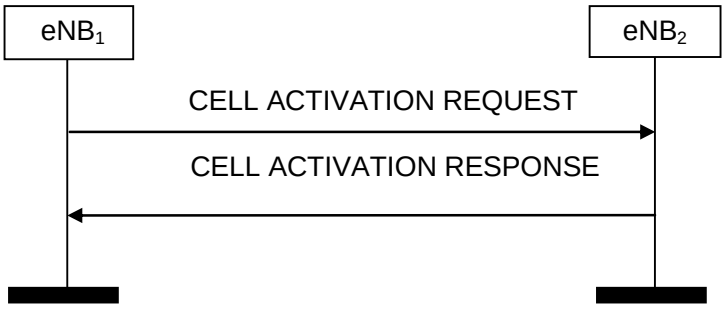


Figure 8.3.11.2-1: Cell Activation, successful operation

An eNB_1 initiates the procedure by sending a CELL ACTIVATION REQUEST message to a peer eNB_2.

Upon receipt of this message, eNB_2 should activate the cell(s) indicated in the CELL ACTIVATION REQUEST message and shall indicate in the CELL ACTIVATION RESPONSE message for which cells the request was fulfilled.

Interactions with eNB Configuration Update procedure:

eNB_2 shall not send an ENB CONFIGURATION UPDATE message to eNB_1 just for the reason of the cell(s) indicated in the CELL ACTIVATION REQUEST message changing state, as the receipt of the CELL ACTIVATION RESPONSE message by eNB_1 is used to update the information about cell activation state of eNB_2 cells in eNB_1.

8.3.11.3 Unsuccessful Operation

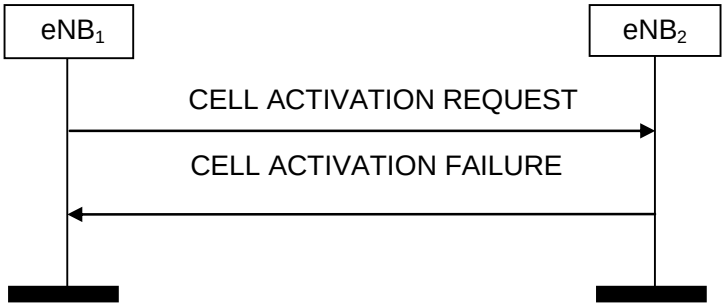


Figure 8.3.11.3-1: Cell Activation, unsuccessful operation

If the eNB_2 cannot activate any of the cells indicated in the CELL ACTIVATION REQUEST message, it shall respond with a CELL ACTIVATION FAILURE message with an appropriate cause value.

8.3.11.4 Abnormal Conditions

Not applicable.

8.3.12 X2 Removal

8.3.12.1 General

The purpose of the X2 Removal procedure is to remove the signaling connection between two eNBs in a controlled manner. If successful, this procedure erases any existing application level configuration data in the two nodes.

The procedure uses non UE-associated signaling.

8.3.12.2 Successful Operation

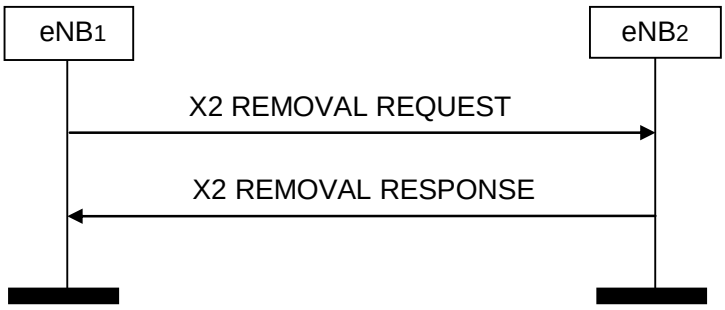


Figure 8.3.12.2-1: X2 Removal, successful operation

An eNB_1 initiates the procedure by sending the X2 REMOVAL REQUEST message to a candidate eNB_2. Upon reception of the X2 REMOVAL REQUEST message the candidate eNB_2 shall reply with the X2 REMOVAL RESPONSE message. After receiving the X2 REMOVAL RESPONSE message, the initiating eNB_1 shall initiate removal of the TNL association towards eNB_2 and may remove all resources associated with that signaling connection. The candidate eNB_2 may then remove all resources associated with that signaling connection.

If the *X2 Removal Threshold* IE is included in the X2 REMOVAL REQUEST message, the candidate eNB_2 shall, if supported, accept to remove the signalling connection with eNB_1 if the X2 Benefit Value of the signalling connection determined at the candidate eNB_2 is lower than the value of the *X2 Removal Threshold* IE.

8.3.12.3 Unsuccessful Operation

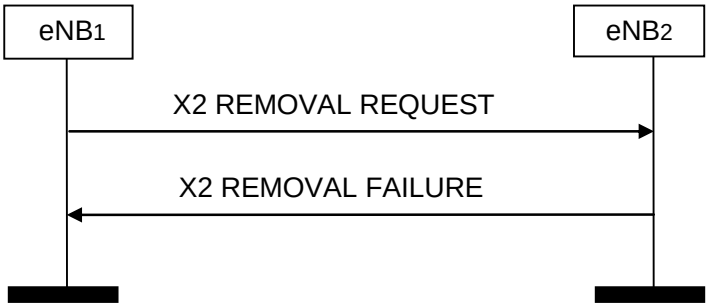


Figure 8.3.12.3-1: X2 Removal, unsuccessful operation

If the candidate eNB_2 cannot accept to remove the signaling connection with eNB_1 it shall respond with an X2 REMOVAL FAILURE message with an appropriate cause value.

8.3.12.4 Abnormal Conditions

Void.

8.3.13 Retrieve UE Context

8.3.13.1 General

The purpose of the Retrieve UE Context procedure is to retrieve the UE context from the eNB where the RRC connection has been suspended (old eNB) and transfer it to the eNB where the RRC Connection has been requested to be resumed (new eNB) or to retrieve the UE context for a UE which attempts to re-establish its RRC connection in an eNB (the new eNB) different from the eNB (the old eNB) where the RRC connection failed, e.g. due to RLF.

The procedure uses UE-associated signalling.

8.3.13.2 Successful Operation

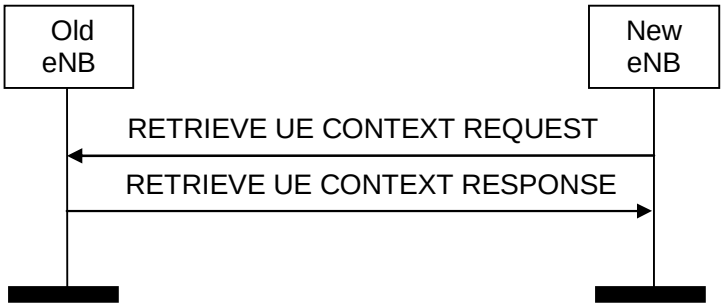


Figure 8.3.13.2-1: Retrieve UE Context, successful operation

The new eNB initiates the procedure by sending the RETRIEVE UE CONTEXT REQUEST message to the old eNB.

If the old eNB is able to identify the UE context and to successfully verify the UE by means of the Resume ID, the ShortMAC-I, optionally the C-RNTI, the failure cell PCI and the E-UTRAN Cell Identifier of the new cell contained in the RETRIEVE UE CONTEXT REQUEST message, it shall respond with the RETRIEVE UE CONTEXT RESPONSE message. The allocation of resources according to the values of the *Allocation and Retention Priority* IE included in the *E-RAB Level QoS Parameters* IE shall follow the principles described for the E-RAB Setup procedure in TS 36.413 [4].

If the *C-RNTI* IE is present in the RETRIEVE UE CONTEXT REQUEST, the old eNB shall ignore the *Resume ID* IE.

The old eNB may include in the *GUMMEI* IE any GUMMEI corresponding to the source MME node.

If the PLMN of the new cell is not the Serving PLMN stored in the UE Context the old eNB shall replace the Serving PLMN with the PLMN of the new cell and move the Serving PLMN to the equivalent PLMN list, before propagating the roaming and access restriction information to the new eNB.The new eNB shall act upon reception of the

- *UE Security Capabilities* IE,
- *AS Security Information* IE,
- *Subscriber Profile ID for RAT/Frequency priority* IE,
- *Handover Restriction List* IE,
- *Location Reporting Information* IE,
- *Management Based MDT Allowed* IE
- *Management Based MDT PLMN List* IE
- *Trace Activation* IE,
- *SRVCC Operation Possible* IE,
- *Masked IMEISV* IE
- *Expected UE Behaviour* IE,
- *ProSe Authorized* IE,
- *V2X Services Authorized* IE,
- *Aerial UE subscription information* IE,

within the RETRIEVE UE CONTEXT RESPONSE message as specified for the target eNB upon reception of the HANDOVER REQUEST message for the Handover Preparation procedure.

If the *UE Sidelink Aggregate Maximum Bit Rate* IE is contained in the RETRIEVE UE CONTEXT RESPONSE message, the new eNB shall, if supported, use it for the concerned UE's sidelink communication in network scheduled mode for V2X services.

If the *Aerial UE subscription information* IE is included in the RETRIEVE UE CONTEXT RESPONSE message, the target eNB shall, if supported, store this information in the UE context and use it as defined in TS 36.300 [15].

8.3.13.3 Unsuccessful Operation

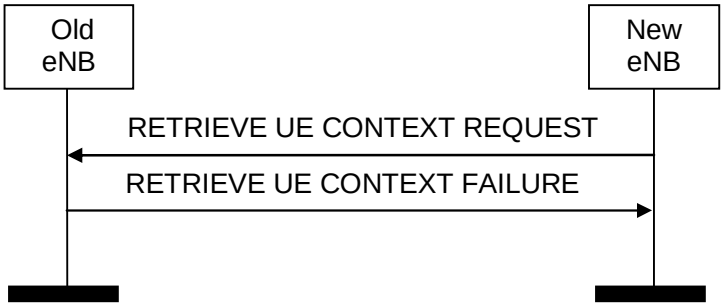


Figure 8.3.13.3-1: Retrieve UE Context, unsuccessful operation

If the old eNB is not able to identify the UE context by means of the Resume ID, or with the ShortMAC-I, C-RNTI, failed cell PCI and new E-UTRAN Cell Identifier contained in the RETRIEVE UE CONTEXT REQUEST message, it shall respond to the new eNB with the RETRIEVE UE CONTEXT FAILURE message.

8.3.13.4 Abnormal Conditions

Void.

8.3.14 EN-DC X2 Removal

8.3.14.1 General

The purpose of the EN-DC X2 Removal procedure is to remove the signaling connection between eNB and en-gNB in a controlled manner. If successful, this procedure erases any existing application level configuration data in the two nodes.

The procedure uses non UE-associated signaling.

8.3.14.2 Successful Operation

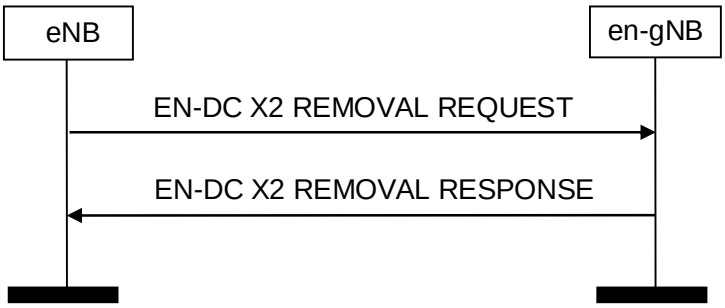


Figure 8.3.14.2-1: eNB Initiated EN-DC X2 Removal, successful operation

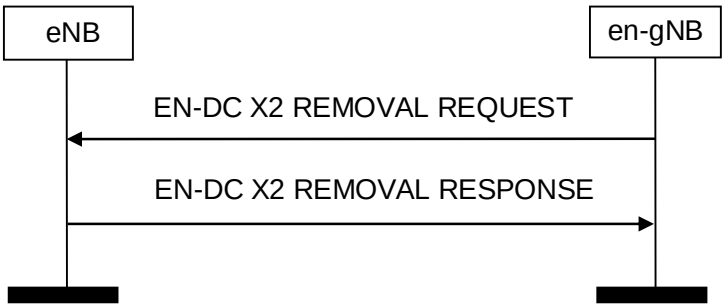


Figure 8.3.14.2-2: en-gNB Initiated EN-DC X2 Removal, successful operation

eNB initiated EN-DC X2 Removal:

An eNB initiates the procedure by sending the EN-DC X2 REMOVAL REQUEST message to a candidate en-gNB. Upon reception of the EN-DC X2 REMOVAL REQUEST message the candidate en-gNB shall reply with the EN-DC X2 REMOVAL RESPONSE message. After receiving the EN-DC X2 REMOVAL RESPONSE message, the initiating eNB shall initiate removal of the TNL association towards en-gNB and may remove all resources associated with that signaling connection. The candidate eNB may then remove all resources associated with that signaling connection.

If the *X2 Removal Threshold* IE is included in the EN-DC X2 REMOVAL REQUEST message, the candidate en-gNB shall, if supported, accept to remove the signalling connection with eNB if the X2 Benefit Value of the signalling connection determined at the candidate en-gNB is lower than the value of the *X2 Removal Threshold* IE.

en-gNB initiated EN-DC X2 Removal:

An en-gNB initiates the procedure by sending the EN-DC X2 REMOVAL REQUEST message to a candidate eNB. Upon reception of the EN-DC X2 REMOVAL REQUEST message the candidate eNB shall reply with the EN-DC X2 REMOVAL RESPONSE message. After receiving the EN-DC X2 REMOVAL RESPONSE message, the initiating en-gNB shall initiate removal of the TNL association towards eNB and may remove all resources associated with that signaling connection. The candidate eNB may then remove all resources associated with that signaling connection.

If the *X2 Removal Threshold* IE is included in the EN-DC X2 REMOVAL REQUEST message, the candidate eNB shall, if supported, accept to remove the signalling connection with en-gNB if the X2 Benefit Value of the signalling connection determined at the candidate eNB is lower than the value of the *X2 Removal Threshold* IE.

8.3.14.3 Unsuccessful Operation

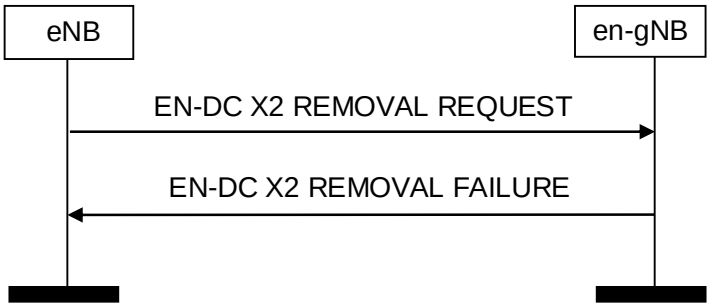


Figure 8.3.14.3-1: eNB Initiated EN-DC X2 Removal, unsuccessful operation

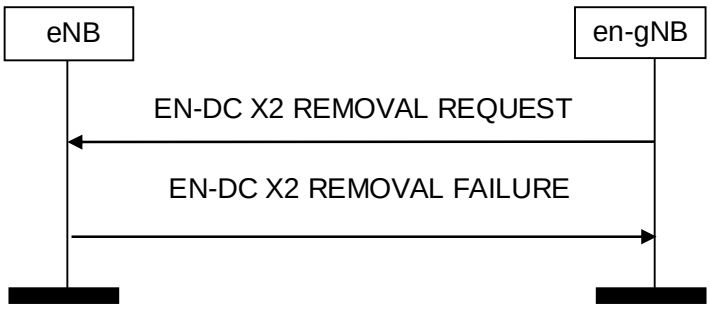


Figure 8.3.14.3-2: en-gNB Initiated EN-DC X2 Removal, unsuccessful operation

If the candidate receiving node cannot accept to remove the signaling connection with initiating node it shall respond with an EN-DC X2 REMOVAL FAILURE message with an appropriate cause value.

8.3.14.4 Abnormal Conditions

Void.

8.4 X2 Release

8.4.1 General

The purpose of the X2 Release procedure is to inform an eNB that the signalling (i.e. SCTP) connection to a peer eNB is unavailable.

8.4.2 Successful Operation

Figure 8.4.2-1: X2AP Release, successful operation

eNB_1 initiates the procedure by sending the X2 RELEASE message to eNB_2. Upon the reception of X2 RELEASE message, eNB_2 shall consider that the signalling connection to an eNB indicated by the *eNB ID* IE is unavailable. eNB_2 may delete all the context information related to the indicated eNB.

8.4.3 Unsuccessful Operation

Not Applicable

8.4.4 Abnormal Condition

Not Applicable.

8.5 X2AP Message Transfer

8.5.1 General

The purpose of the X2AP Message Transfer procedure is to allow indirect transport of an X2AP message (except the X2AP MESSAGE TRANSFER message) between two eNBs and to allow an eNB to perform registration.

8.5.2 Successful Operation

Figure 8.5.2-1: X2AP Message Transfer, successful operation

eNB_1 initiates the procedure by sending the X2AP MESSAGE TRANSFER message to eNB_2.

Upon the reception of X2 MESSAGE TRANSFER message the target eNB may:

- Retrieve the X2AP message included in the *X2AP Message* IE;
- Consider the target eNB ID contained in the *Target eNB ID* IE, included in the *RNL Header* IE, as the destination for the X2AP message signaled in the *X2AP Message* IE;
- Consider the source eNB ID contained in the *Source eNB ID* IE, included in the *RNL Header* IE, as the source of the X2AP message signaled in the *X2AP Message* IE.

In case the included *RNL Header* IE does not contain the *Target eNB ID* IE, the receiving eNB shall consider the eNB ID included in the *Source eNB ID* IE as the eNB ID corresponding to the TNL address(es) of the sender and update its internal information.

8.5.3 Unsuccessful Operation

Not Applicable.

8.5.4 Abnormal Condition

Not Applicable.

8.6 Procedures for Dual Connectivity

8.6.1 SeNB Addition Preparation

8.6.1.1 General

The purpose of the SeNB Addition Preparation procedure is to request the SeNB to allocate resources for dual connectivity operation for a specific UE.

The procedure uses UE-associated signalling.

8.6.1.2 Successful Operation

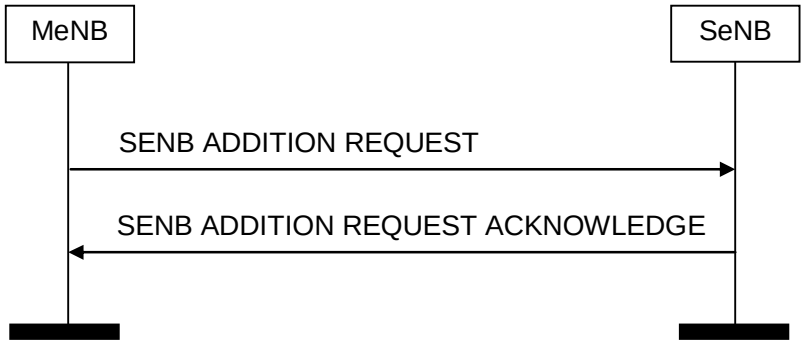


Figure 8.6.1.2-1: SeNB Addition Preparation, successful operation

The MeNB initiates the procedure by sending the SENB ADDITION REQUEST message to the SeNB. When the MeNB sends the SENB ADDITION REQUEST message, it shall start the timer T_{DCprep}.

The allocation of resources according to the values of the *Allocation and Retention Priority* IE included in the *E-RAB Level QoS Parameters* IE shall follow the principles described for the E-RAB Setup procedure in TS 36.413 [4].

If the SENB ADDITION REQUEST message contains the *Serving PLMN* IE, the SeNB may use it for RRM purposes.

If the SENB ADDITION REQUEST message contains the *Expected UE Behaviour* IE, the SeNB shall, if supported, store this information and may use it to optimize resource allocation.

The SeNB shall report to the MeNB, in the SENB ADDITION REQUEST ACKNOWLEDGE message, the result for all the requested E-RABs in the following way:

- A list of E-RABs which are successfully established shall be included in the *E-RABs Admitted To Be Added List* IE.
- A list of E-RABs which failed to be established shall be included in the *E-RABs Not Admitted List* IE.

NOTE: The MeNB may trigger the SeNB Addition Preparation procedure in the course of the Inter-MeNB handover without SeNB change procedure as described in 36.300 [15]. The deleted E-RABs are not included in the *E-RABs To Be Added List* IE in the SENB ADDITION REQUEST message, from MeNB point of view. If the SeNB reports a certain E-RAB to be successfully established, respective SCG resources, from an SeNB point of view, may be actually successfully established or modified or kept; if a certain E-RAB is reported to be failed to be established, respective SCG resources, from an SeNB point of view, may be actually failed to be established or modified or kept.

For each E-RAB configured with the SCG bearer option

- the SeNB shall choose the ciphering algorithm based on the information in the *UE Security Capabilities* IE and locally configured priority list of AS encryption algorithms and apply the key indicated in the *SeNB Security Key* IE as specified in the TS 33.401 [18].
- the MeNB may propose to apply forwarding of downlink data by including the *DL Forwarding* IE within the *E-RABs To be Added Item* IE of the SENB ADDITION REQUEST message. For each E-RAB that it has decided to admit, the SeNB may include the *DL Forwarding GTP Tunnel Endpoint* IE within the *E-RABs Admitted To Be Added Item* IE of the SENB ADDITION REQUEST ACKNOWLEDGE message to indicate that it accepts the proposed forwarding of downlink data for this bearer. This GTP tunnel endpoint may be different from the corresponding *DL GTP TEID* IE in the *E-RAB To Be Modified List* IE of the E-RAB MODIFICATION INDICATION message (see TS 36.413 [4]) depending on implementation choice.
- the SeNB may include for each bearer in the *E-RABs Admitted To Be Added List* IE the *UL Forwarding GTP Tunnel Endpoint* IE to indicate that it requests data forwarding of uplink packets to be performed for that bearer.
- If the *Correlation ID* IE for the concerned E-RAB is received by the SeNB, the SeNB shall use this information for LIPA operation for the concerned E-RAB.
- If the *SIPTO Correlation ID* IE for the concerned E-RAB is received by the SeNB, the SeNB shall use this information for SIPTO@LN operation for the concerned E-RAB.

If the *CSG Membership Status* IE is included in the SENB ADDITION REQUEST message, the SeNB shall act as specified in TS 36.300 [15].

Upon reception of the SENB ADDITION REQUEST ACKNOWLEDGE message the MeNB shall stop the timer T_{DCprep}.

If the *GW Transport Layer Address* IE is received in the SENB ADDITION REQUEST ACKNOWLEDGE message, the MeNB stores this information and use it according to TS 36.300 [15].

If the *SIPTO L-GW Transport Layer Address* IE is received in the SENB ADDITION REQUEST ACKNOWLEDGE message, the MeNB stores this information and use it according to TS 36.300 [15].

If the *SeNB UE X2AP ID* IE and/or *SeNB UE X2AP ID Extension* IE are contained in the SENB ADDITION REQUEST message, the SeNB shall, if supported, store this information and use it as defined in TS 36.300 [15].

If the *Tunnel Information for BBF* IE is received in the SENB ADDITION REQUEST ACKNOWLEDGE message, the MeNB shall, if supported, transfer the tunnel information for BBF to the core network.

Interactions with the SeNB Reconfiguration Completion procedure:

If the SeNB admits at least one E-RAB, the SeNB shall start the timer $T_{DCoverall}$ when sending the SENB ADDITION REQUEST ACKNOWLEDGE message to the MeNB. The reception of the SENB RECONFIGURATION COMPLETE message shall stop the timer $T_{DCoverall}$.

8.6.1.3 Unsuccessful Operation

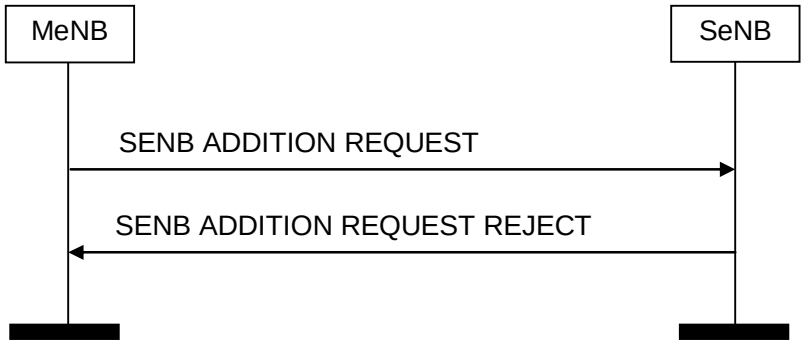


Figure 8.6.1.3-1: SeNB Addition Preparation, unsuccessful operation

If the SeNB is not able to accept any of the bearers or a failure occurs during the SeNB Addition Preparation, the SeNB sends the SENB ADDITION REQUEST REJECT message with an appropriate cause value to the MeNB.

8.6.1.4 Abnormal Conditions

If the SeNB receives a SENB ADDITION REQUEST message containing multiple *E-RAB ID* IEs (in the *E-RABs To Be Added List* IE) set to the same value, the SeNB shall consider the establishment of the corresponding E-RAB as failed.

If the SeNB receives a SENB ADDITION REQUEST message containing a *E-RAB Level QoS Parameters* IE which contains a *QCI* IE indicating a GBR bearer (as defined in TS 23.203 [13]), and which does not contain the *GBR QoS Information* IE, the SeNB shall consider the establishment of the corresponding E-RAB as failed.

If the supported algorithms for encryption defined in the *Encryption Algorithms* IE in the *UE Security Capabilities* IE, plus the mandated support of EEA0 in all UEs (TS 33.401 [18]), do not match any algorithms defined in the configured list of allowed encryption algorithms in the SeNB (TS 33.401 [18]), the SeNB shall reject the procedure using the SENB ADDITION REQUEST REJECT message.

If the SeNB receives a SENB ADDITION REQUEST message which does not contain the *CSG Membership Status* IE, and the SCell served by the SeNB is a hybrid cell, the SeNB shall reject the procedure using the SENB ADDITION REQUEST REJECT message.

If the SeNB receives a SENB ADDITION REQUEST message containing a *SeNB UE X2AP ID* IE that does not match any existing UE Context that has such ID, the SeNB shall reject the procedure using the SENB ADDITION REQUEST REJECT message.

If the SeNB receives a SENB ADDITION REQUEST message containing both the *Correlation ID* and the *SIPTO Correlation ID* IEs for the same E-RAB, the SeNB shall consider the establishment of the corresponding E-RAB as failed.

Interactions with the SeNB Reconfiguration Completion and SeNB initiated SeNB Release procedure:

If the timer $T_{DCoverall}$ expires before the SeNB has received the SENB RECONFIGURATION COMPLETE or the SENB RELEASE REQUEST message, the SeNB shall regard the requested RRC connection reconfiguration as being not applied by the UE and shall trigger the SeNB initiated SeNB Release procedure.

Interactions with the MeNB initiated SeNB Release procedure:

If the timer T_{DCprep} expires before the MeNB has received the SENB ADDITION REQUEST ACKNOWLEDGE message, the MeNB shall regard the SeNB Addition Preparation procedure as being failed and shall trigger the MeNB initiated SeNB Release procedure.

8.6.2 SeNB Reconfiguration Completion

8.6.2.1 General

The purpose of the SeNB Reconfiguration Completion procedure is to provide information to the SeNB whether the requested configuration was successfully applied by the UE.

The procedure uses UE-associated signalling.

8.6.2.2 Successful Operation

Figure 8.6.2.2-1: SeNB Reconfiguration Complete procedure, successful operation.

The MeNB initiates the procedure by sending the SENB RECONFIGURATION COMPLETE message to the SeNB.

The SENB RECONFIGURATION COMPLETE message may contain information that

- either the UE has successfully applied the configuration requested by the SeNB. The MeNB may also provide configuration information in the *MeNB to SeNB Container* IE.
- or the MeNB has not triggered configuration requested by the SeNB. The MeNB shall provide information with sufficient precision in the included *Cause* IE to enable the SeNB to know the reason for an unsuccessful reconfiguration. The MeNB may also provide configuration information in the *MeNB to SeNB Container* IE.

Upon reception of the SENB RECONFIGURATION COMPLETE message the SeNB shall stop the timer $T_{DCoverall}$.

8.6.2.3 Abnormal Conditions

Void.

8.6.3 MeNB initiated SeNB Modification Preparation

8.6.3.1 General

This procedure is used to enable an MeNB to request an SeNB to modify the UE context at the SeNB.

The procedure uses UE-associated signalling.

8.6.3.2 Successful Operation

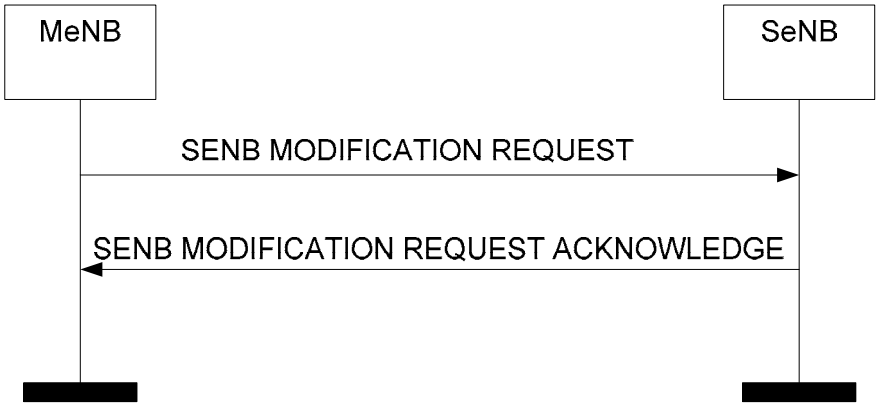


Figure 8.6.3.2-1: MeNB initiated SeNB Modification Preparation, successful operation

The MeNB initiates the procedure by sending the SENB MODIFICATION REQUEST message to the SeNB. When the MeNB sends the SENB MODIFICATION REQUEST message, it shall start the timer T_{DCprep}.

The SENB MODIFICATION REQUEST message may contain

- within the *UE Context Information* IE;
  - E-RABs to be added within the *E-RABs To Be Added Item* IE;
  - E-RABs to be modified within the *E-RABs To Be Modified Item* IE;
  - E-RABs to be released within the *E-RABs To Be Released Item* IE;
  - the *SeNB UE Aggregate Maximum Bit Rate* IE;
- the *MeNB to SeNB Container* IE;
- the *SCG Change Indication* IE;
- the *CSG Membership Status* IE.

If the SENB MODIFICATION REQUEST message contains the *Serving PLMN* IE, the SeNB may use it for RRM purposes.

If the *SeNB UE Aggregate Maximum Bit Rate* IE is included in the SENB MODIFICATION REQUEST message, the SeNB shall:

- replace the previously provided SeNB UE Aggregate Maximum Bit Rate by the received SeNB UE Aggregate Maximum Bit Rate in the UE context;
- use the received SeNB UE Aggregate Maximum Bit Rate for non-GBR Bearers for the concerned UE as defined in TS 36.300 [15].

The allocation of resources according to the values of the *Allocation and Retention Priority* IE included in the *E-RAB Level QoS Parameters* IE shall follow the principles described for the E-RAB Setup procedure in TS 36.413 [4].

If at least one of the requested modifications is admitted by the SeNB, the SeNB shall modify the related part of the UE context accordingly and send the SENB MODIFICATION REQUEST ACKNOWLEDGE message back to the MeNB.

The SeNB shall include the E-RABs for which resources have been either added or modified or released at the SeNB either in the *E-RABs Admitted To Be Added List* IE or the *E-RABs Admitted To Be Modified List* IE or the *E-RABs Admitted To Be Released List* IE. The SeNB shall include the E-RABs that have not been admitted in the *E-RABs Not Admitted List* IE with an appropriate cause value.

For each E-RAB configured with the SCG bearer option

- the SeNB shall, if included, choose the ciphering algorithm based on the information in the *UE Security Capabilities* IE and locally configured priority list of AS encryption algorithms and apply the key indicated in the *SeNB Security Key* IE as specified in the TS 33.401 [18].

- if applicable, the MeNB may propose to apply forwarding of downlink data by including the *DL Forwarding* IE within the *E-RABs To Be Added Item* IE of the SENB MODIFICATION REQUEST message. For each E-RAB that it has decided to admit, the SeNB may include the *DL Forwarding GTP Tunnel Endpoint* IE within the *E-RABs Admitted To Be Added Item* IE of the SENB MODIFICATION REQUEST ACKNOWLEDGE message to indicate that it accepts the proposed forwarding of downlink data for this bearer. The MeNB may also provide for an applicable E-RAB to be released the *DL Forwarding GTP Tunnel Endpoint* IE and the *UL Forwarding GTP Tunnel Endpoint* IE within the *E-RABs To Be Released Item* IE of the SENB MODIFICATION REQUEST message.

- if applicable, the SeNB may include for each bearer in the *E-RABs Admitted To Be Added List* IE in the SENB MODIFICATION REQUEST ACKNOWLEDGE message the *UL Forwarding GTP Tunnel Endpoint* IE to indicate that it requests data forwarding of uplink packets to be performed for that bearer.

- If the *Correlation ID* IE for the concerned E-RAB is received by the SeNB, the SeNB shall use this information for LIPA operation for the concerned E-RAB.

- If the *SIPTO Correlation ID* IE for the concerned E-RAB is received by the SeNB, the SeNB shall use this information for SIPTO@LN operation for the concerned E-RAB.

For each E-RAB configured with the split bearer option to be modified, if the SENB MODIFICATION REQUEST message includes the *SCG Change Indication* IE and the *MeNB GTP Tunnel Endpoint* IE in the *E-RABs To Be Modified Item* IE, the SeNB shall act as specified in TS 36.300 [15].

For each E-RAB configured with the split bearer option to be modified (released)

- if applicable, the MeNB may provide for an applicable E-RAB to be released the *DL Forwarding GTP Tunnel Endpoint* IE within the *E-RABs To Be Released Item* IE of the SENB MODIFICATION REQUEST message.

If the *E-RAB level QoS parameter* IE is included in the SENB MODIFICATION REQUEST message for an E-RAB to be modified the SeNB shall allocate respective resources and provide corresponding radio configuration information within the *SeNB to MeNB Container* IE as described in TS 36.300 [15].

If the SENB MODIFICATION REQUEST message contains for an E-RAB to be modified which is configured with the SCG bearer option the *S1 UL GTP Tunnel Endpoint* IE the SeNB shall use it as the new UL S1-U address.

If the SENB MODIFICATION REQUEST message contains for an E-RAB to be modified which is configured with the split bearer option the *MeNB GTP Tunnel Endpoint* IE the SeNB shall use it as the new UL X2-U address.

For an E-RAB to be modified which is configured with the SCG bearer option the SeNB may include in the SENB MODIFICATION REQUEST ACKNOWLEDGE message the *S1 DL GTP Tunnel Endpoint* IE.

For an E-RAB to be modified which is configured with the split bearer option the SeNB may include in the SENB MODIFICATION REQUEST ACKNOWLEDGE message the *SeNB GTP Tunnel Endpoint* IE.

If the *SCG Change Indication* IE is included in the SENB MODIFICATION REQUEST message, the SeNB shall act as specified in TS 36.300 [15].

If the *CSG Membership Status* IE is included in the SENB MODIFICAITON REQUEST message, the SeNB shall act as specified in TS 36.300 [15].

Upon reception of the SENB MODIFICATION REQUEST ACKNOWLEDGE message the MeNB shall stop the timer T_{DCprep}. If the SENB MODIFICATION REQUEST ACKNOWLEDGE message has included the *SeNB to MeNB Container* IE the MeNB is then defined to have a Prepared SeNB Modification for that X2 UE-associated signalling.

When the SeNB supporting L-GW function for LIPA operation releases radio and control plane related resources associated to the LIPA bearer, it shall also request using intra-node signalling the collocated L-GW to release the LIPA PDN connection as defined in TS 23.401 [12].

Interactions with the SeNB Reconfiguration Completion procedure:

If the SeNB admits a modification of the UE context requiring the MeNB to report about the success of the RRC connection reconfiguration procedure, the SeNB shall start the timer $T_{DCoverall}$ when sending the SENB

MODIFICATION REQUEST ACKNOWLEDGE message to the MeNB. The reception of the SeNB RECONFIGURATION COMPLETE message shall stop the timer $T_{DCoverall}$.

8.6.3.3 Unsuccessful Operation

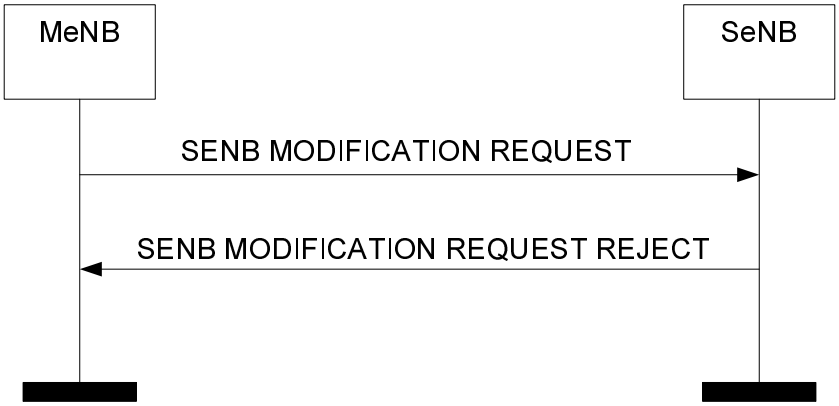


Figure 8.6.3.3-1: MeNB initiated SeNB Modification Preparation, unsuccessful operation

If the SeNB does not admit any modification requested by the MeNB, or a failure occurs during the MeNB initiated SeNB Modfication Preparation, the SeNB shall send the SENB MODIFICATION REQUEST REJECT message to the MeNB. The message shall contain the *Cause* IE with an appropriate value.

If the SeNB receives a SENB MODIFICATION REQUEST message containing the *MeNB to SeNB Container* IE that does not include required information as specified in TS 36.331 [9], the SeNB shall send the SENB MODIFICATION REQUEST REJECT message to the MeNB.

8.6.3.4 Abnormal Conditions

If the SeNB receives a SENB MODIFICATION REQUEST message containing multiple *E-RAB ID* IEs (in the *E-RABs To Be Added List* IE and/or the *E-RABs To Be Modified List* IE) set to the same value, the SeNB shall not admit the action requested for the corresponding E-RABs.

If the SeNB receives an SENB MODIFICATION REQUEST message containing multiple *E-RAB ID* IEs (in the *E-RAB To Be Released List* IE) set to the same value, the SeNB shall initiate the release of one corresponding E-RAB and ignore the duplication of the instances of the selected corresponding E-RABs.

If the SeNB receives a SENB MODIFICATION REQUEST message containing a *E-RAB Level QoS Parameters* IE which contains a *QCI* IE indicating a GBR bearer (as defined in TS 23.203 [13]), and which does not contain the *GBR QoS Information* IE, the SeNB shall not admit the corresponding E-RAB.

If the supported algorithms for encryption defined in the *Encryption Algorithms* IE in the *UE Security Capabilities* IE in the *UE Context Information* IE, plus the mandated support of EEA0 in all UEs (TS 33.401 [18]), do not match any algorithms defined in the configured list of allowed encryption algorithms in the SeNB (TS 33.401 [18]), the SeNB shall reject the procedure using the SENB MODIFICATION REQUEST REJECT message.

If the timer T_{DCprep} expires before the MeNB has received the SENB MODIFICATION REQUEST ACKNOWLEDGE message, the MeNB shall regard the MeNB initiated SeNB Modification Preparation procedure as being failed and shall release the UE Context at the SeNB.

If the SeNB receives a SENB MODIFICATION REQUEST message containing both the *Correlation ID* and the *SIPTO Correlation ID* IEs for the same E-RAB, the SeNB shall consider the establishment of the corresponding E-RAB as failed.

Interactions with the SeNB Reconfiguration Completion and SeNB initiated SeNB Release procedure:

If the timer $T_{DCoverall}$ expires before the SeNB has received the SENB RECONFIGURATION COMPLETE or the SENB RELEASE REQUEST message, the SeNB shall regard the requested modification RRC connection reconfiguration as being not applied by the UE and shall trigger the SeNB initiated SeNB Release procedure.

Interaction with the SeNB initiated SeNB Modification Preparation procedure:

If the MeNB, after having initiated the MeNB initiated SeNB Modification procedure, receives the SENB MODIFICATION REQUIRED message, the MeNB shall refuse the SeNB initiated SeNB Modification procedure with an appropriate cause value in the *Cause* IE.

If the MeNB has a Prepared SeNB Modification and receives the SENB MODIFICATION REQUIRED message, the MeNB shall respond with the SENB MODIFICATION REFUSE message to the SeNB with an appropriate cause value in the *Cause* IE.

8.6.4 SeNB initiated SeNB Modification

8.6.4.1 General

This procedure is used by the SeNB to modify the UE context in the SeNB.

The procedure uses UE-associated signalling.

8.6.4.2 Successful Operation

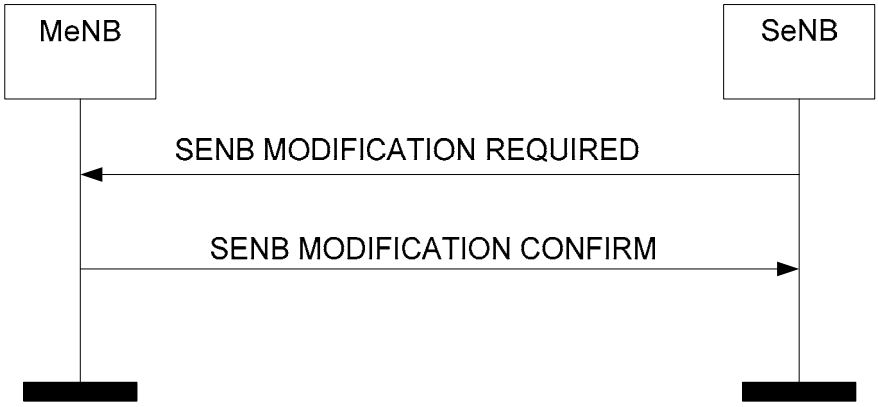


Figure 8.6.4.2-1: SeNB initiated SeNB Modification, successful operation.

The SeNB initiates the procedure by sending the SENB MODIFICATION REQUIRED message to the MeNB. When the SeNB sends the SENB MODIFICATION REQUIRED message, it shall start the timer $T_{DCoverall.}$

The SENB MODIFICATION REQUIRED message may contain

- the *SeNB to MeNB Container* IE.
- E-RABs to be released within the *E-RABs To Be Released Item* IE;
- the *SCG Change Indication* IE.

If the MeNB receives a SENB MODIFICATION REQUIRED message containing the *SCG Change Indication* IE, the MeNB shall act as specified in TS 36.300 [15].

If the MeNB is able to perform the modifications requested by the SeNB, the MeNB shall send the SENB MODIFICATION CONFIRM message to the SeNB. The SENB MODIFICATION CONFIRM message may contain the *MeNB to SeNB Container* IE.

Upon reception of the SENB MODIFICATION CONFIRM message the SeNB shall stop the timer $T_{DCoverall}$.

Interaction with the MeNB initiated SeNB Modification Preparation procedure:

If applicable, as specified in TS 36.300 [15], the SeNB may receive, after having initiated the SeNB initiated SeNB Modification procedure, the SENB MODIFICATION REQUEST message including the *DL Forwarding GTP Tunnel Endpoint* IE and the *UL Forwarding GTP Tunnel Endpoint* IE within the *E-RABs To Be Released List* IE.

If applicable, as specified in TS 36.300 [15], the SeNB may receive, after having initiated the SeNB initiated SeNB Modification procedure, the SENB MODIFICATION REQUEST message including the *SeNB Security Key* IE within the *UE Context Information* IE.

If the SeNB has initiated the SeNB initiated SeNB Modification procedure with the SENB MODIFICATION REQUIRED message including the *E-RABs To Be Released Item* IE, it may receive the SENB MODIFICATION REQUEST message including the *SCG Change Indication* IE, upon which the SeNB shall provide respective information in the *SeNB to MeNB Container* IE within the SENB MODIFICATION REQUEST ACKNOWLEDGMENT message, as specified in TS 36.300 [15].

8.6.4.3 Unsuccessful Operation

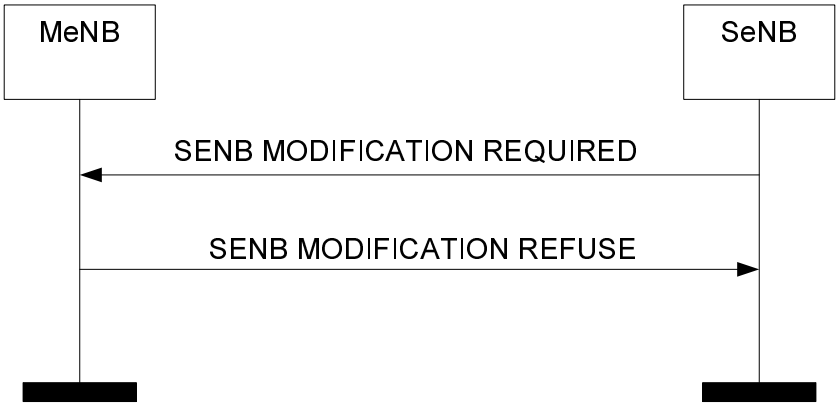


Figure 8.6.4.3-1: SeNB initiated SeNB Modification, unsuccessful operation.

In case the request modification cannot be performed successfully the MeNB shall respond with the SENB MODIFICATION REFUSE message to the SeNB with an appropriate cause value in the *Cause* IE.

The MeNB may also provide configuration information in the *MeNB to SeNB Container* IE.

8.6.4.4 Abnormal Conditions

If the timer $T_{DCoverall}$ expires before the SeNB has received the SENB MODIFICATION CONFIRM or the SENB MODIFICATION REFUSE message, the SeNB shall regard the requested modification as failed and may take further actions like triggering the SeNB initiated SeNB Release procedure to release all SeNB resources allocated for the UE.

If the MeNB is aware that the SeNB didn't receive the latest configuration information concerning the MCG, the MeNB may respond with the SENB MODIFICATION REFUSE message to the SeNB with an appropriate cause value in the *Cause* IE.

If the value received in the *E-RAB ID* IE of any of the *E-RABs To Be Released Items* IE is not known at the MeNB, the MeNB shall regard the procedure as failed and may take appropriate actions like triggering the MeNB initiated SeNB Release procedure.

Interaction with the MeNB initiated SeNB Modification Preparation procedure:

If the SeNB, after having initiated the SeNB initiated SeNB Modification procedure, receives the SENB MODIFICATION REQUEST message including other IEs than an applicable *SeNB Security Key* IE and/or applicable forwarding addresses and/or the *SCG Change Indication* IE the SeNB shall

- regard the SeNB initiated SeNB Modification Procedure as being failed,
- stop the $T_{DCoverall}$, which was started to supervise the SeNB initiated SeNB Modification procedure,
- be prepared to receive the SENB MODIFICATION REFUSE message from the MeNB and
- continue with the MeNB initiated SeNB Modification Preparation procedure as specified in section 8.6.3.

8.6.5 MeNB initiated SeNB Release

8.6.5.1 General

The MeNB initiated SeNB Release procedure is triggered by the MeNB to initiate the release of the resources for a specific UE.

The procedure uses UE-associated signalling.

8.6.5.2 Successful Operation

Figure 8.6.5.2-1: MeNB initiated SeNB Release, successful operation

The MeNB initiates the procedure by sending the SENB RELEASE REQUEST message. Upon reception of the SENB RELEASE REQUEST message the SeNB shall stop providing user data to the UE. The *SeNB UE X2AP ID* IE and, if available, the *SeNB UE X2AP ID Extension* IE shall be included if it has been obtained from the SeNB. The MeNB may provide appropriate information within the *Cause* IE.

If the bearer context in the SeNB was configured with the SCG bearer option, for each SCG bearer for which the MeNB requests forwarding of uplink/downlink data, the MeNB includes the *UL Forwarding GTP Tunnel Endpoint*/ *DL Forwarding GTP Tunnel Endpoint* IE within the *E-RABs To Be Released Item* IE of the SENB RELEASE REQUEST message to indicate that the SeNB should perform data forwarding of uplink/downlink packets for that SCG bearer.

If the bearer context in the SeNB was configured with the split bearer option, for each Split bearer for which the MeNB requests forwarding of downlink data, the MeNB includes the *DL Forwarding GTP Tunnel Endpoint* IE within the *E-RABs To Be Released Item* IE of the SENB RELEASE REQUEST message to indicate that the SeNB should perform data forwarding of downlink packets for that split bearer.

Upon reception of the SENB RELEASE REQUEST message containing *UE Context Kept Indicator* IE set to “True”, the SeNB shall, if supported, only initiate the release of the resources related to the UE-associated signalling connection between the MeNB and the SeNB.

Upon reception of the SENB RELEASE REQUEST message containing *MakeBeforeBreak Indicator* IE set to “True”, the SeNB shall, if supported, perform Make-Before-Break SeNB change as specified in TS 36.300 [15].

8.6.5.3 Unsuccessful Operation

Not applicable.

8.6.5.4 Abnormal Conditions

Should the SENB RELEASE REQUEST message refer to a context that does not exist, the SeNB shall ignore the message.

When the MeNB has initiated the procedure and did not include the *SeNB UE X2AP ID* IE the MeNB shall regard the resources for the UE at the SeNB as being fully released.

8.6.6 SeNB initiated SeNB Release

8.6.6.1 General

This procedure is triggered by the SeNB to initiate the release of the resources for a specific UE.

The procedure uses UE-associated signalling.

8.6.6.2 Successful Operation

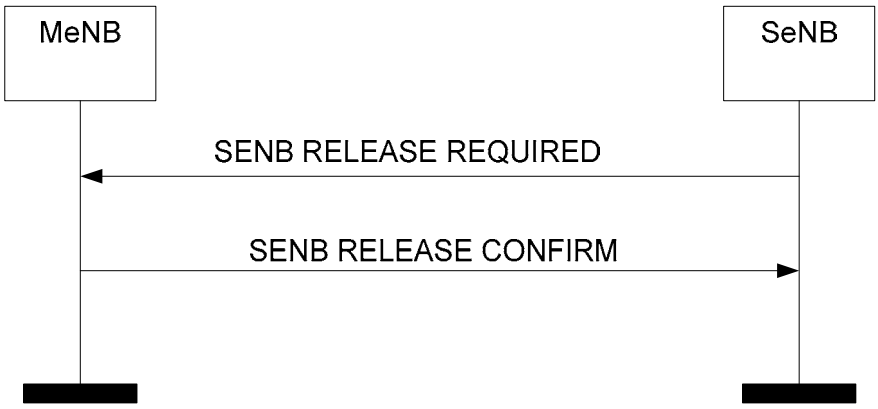


Figure 8.6.6.2-1: SeNB initiated SeNB Release, successful operation.

The SeNB initiates the procedure by sending the SENB RELEASE REQUIRED message to the MeNB.

Upon reception of the SENB RELEASE REQUIRED message, the MeNB replies with the SENB RELEASE CONFIRM message. For each E-RAB configured with the SCG bearer option, the MeNB may include the *DL Forwarding GTP Tunnel Endpoint* IE and the *UL Forwarding GTP Tunnel Endpoint* IE within the *E-RABs To Be Released Item* IE to indicate that it requests data forwarding of uplink and downlink packets to be performed for that bearer. For each E-RAB configured with the split bearer option, the MeNB may include the *DL Forwarding GTP Tunnel Endpoint* IE within the *E-RABs To Be Released Item* IE to indicate that it requests data forwarding of downlink packets to be performed for that bearer.

The SeNB may start data forwarding and stop providing user data to the UE upon reception of the SENB RELEASE CONFIRM message,

8.6.6.3 Unsuccessful Operation

Not applicable.

8.6.6.4 Abnormal Conditions

Void.

8.6.7 SeNB Counter Check

8.6.7.1 General

This procedure is initiated by the SeNB to request the MeNB to execute a counter check procedure to verify the value of the PDCP COUNTs associated with SCG bearers established in the SeNB.

The procedure uses UE-associated signalling.

8.6.7.2 Successful Operation

Figure 8.6.7.2-1: SeNB Counter Check procedure, successful operation.

The SeNB initiates the procedure by sending the SENB COUNTER CHECK REQUEST message to the MeNB.

Upon reception of the SENB COUNTER CHECK REQUEST message, the MeNB may perform the RRC counter check procedure as defined in TS 33.401 [18].

8.6.7.3 Unsuccessful Operation

Not applicable.

8.6.7.4 Abnormal Conditions

Not applicable.

8.7 Procedures for E-UTRAN-NR Dual Connectivity

8.7.1 EN-DC X2 Setup

8.7.1.1 General

The purpose of the EN-DC X2 Setup procedure is to exchange application level configuration data needed for eNB and en-gNB to interoperate correctly over the X2 interface. This procedure erases any existing application level configuration data in the two nodes and replaces it by the one received. This procedure also resets the X2 interface like a Reset procedure would do.

The procedure uses non UE-associated signalling.

8.7.1.2 Successful Operation

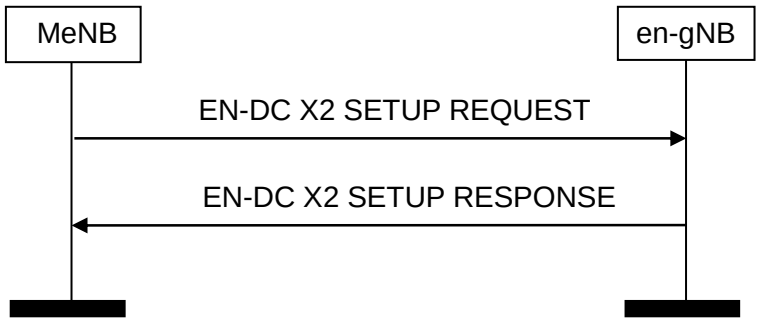


Figure 8.7.1.2-1: eNB Initiated EN-DC X2 Setup, successful operation

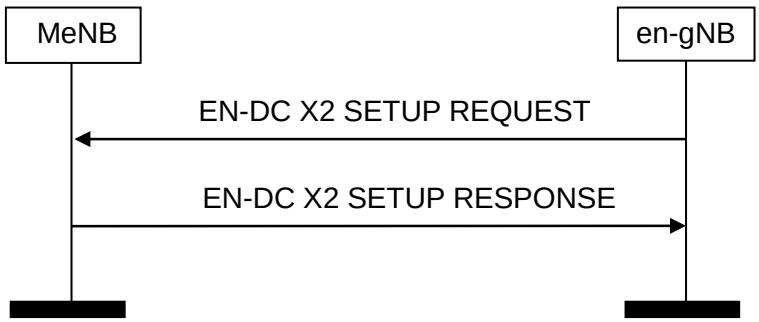


Figure 8.7.1.2-2: en-gNB Initiated EN-DC X2 Setup, successful operation

eNB initiated EN-DC X2 Setup:

An eNB initiates the procedure by sending the EN-DC X2 SETUP REQUEST message to a candidate en-gNB. The candidate en-gNB replies with the EN-DC X2 SETUP RESPONSE message. The initiating eNB shall transfer the complete list of its served cells to the candidate en-gNB. The candidate en-gNB shall reply with the complete list of its served cells. If Supplementary Uplink is configured at the candidate en-gNB, the candidate en-gNB shall include in the

EN-DC X2 SETUP RESPONSE message the *SUL Information* IE and the *Supported SUL band List* IE for each served cell where supplementary uplink is configured.

If the EN-DC X2 SETUP REQUEST message contains the *Protected E-UTRA Resource Indication* IE, the receiving en-gNB should forward it to lower layers and use it for cell-level resource coordination with the eNB. The en-gNB shall consider the received *Protected E-UTRA Resource Indication* IE when expressing its desired resource allocation to the eNB during E-UTRA – NR Cell Resource Coordination procedure. The en-gNB shall consider the received *Protected E-UTRA Resource Indication* IE content valid until reception of a new update of the IE for the same eNB.

The protected resource pattern indicated in the *Protected E-UTRA Resource Indication* IE is not valid in subframes indicated by the *Reserved Subframes* IE, as well as in the non-control region of the MBSFN subframes i.e. it is valid only in the control region therein. The size of the control region of MBSFN subframes is indicated in the *Protected E-UTRA Resource Indication* IE.

en-gNB initiated EN-DC X2 Setup:

An en-gNB initiates the procedure by sending the EN-DC X2 SETUP REQUEST message to a candidate eNB. The candidate eNB replies with the EN-DC X2 SETUP RESPONSE message. The initiating en-gNB shall transfer the complete list of its served cells to the candidate eNB. The candidate eNB shall reply with the complete list of its served cells.

If Supplementary Uplink is configured at the en-gNB, the en-gNB shall include in the EN-DC X2 SETUP REQUEST message the *SUL Information* IE and the *Supported SUL band List* IE for each served cell where supplementary uplink is configured.

8.7.1.3 Unsuccessful Operation

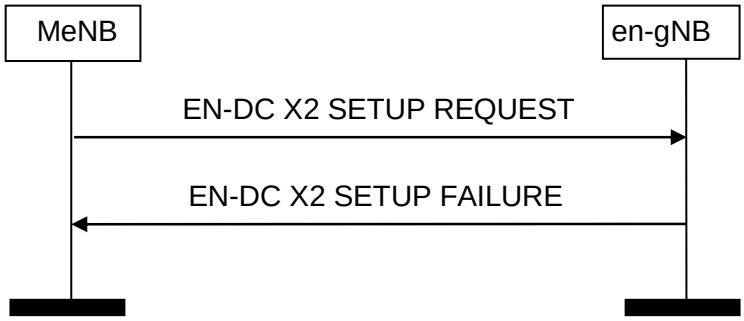


Figure 8.7.1.3-1: eNB Initiated EN-DC X2 Setup, unsuccessful operation

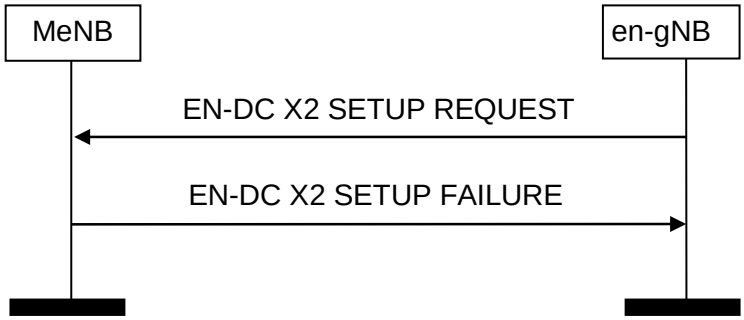


Figure 8.7.1.3-2: en-gNB Initiated EN-DC X2 Setup, unsuccessful operation

If the candidate receving node cannot accept the setup it shall respond with an EN-DC X2 SETUP FAILURE message with appropriate cause value.

8.7.1.4 Abnormal Conditions

If the first message received for a specific TNL association is not an EN-DC X2 SETUP REQUEST, EN-DC X2 SETUP RESPONSE, or EN-DC X2 SETUP FAILURE message then this shall be treated as a logical error.

If the initiating node does not receive either EN-DC X2 SETUP RESPONSE message or EN-DC X2 SETUP FAILURE message, the initiating node may reinitiate the EN-DC X2 Setup procedure towards the same candidate node, provided

that the content of the EN-DC X2 SETUP REQUEST message is identical to the content of the previously unacknowledged EN-DC X2 SETUP REQUEST message.

8.7.2 EN-DC Configuration Update

8.7.2.1 General

The purpose of the EN-DC Configuration Update procedure is to update application level configuration data needed for eNB and en-gNB to interoperate correctly over the X2 interface.

The procedure uses non UE-associated signalling.

8.7.2.2 Successful Operation

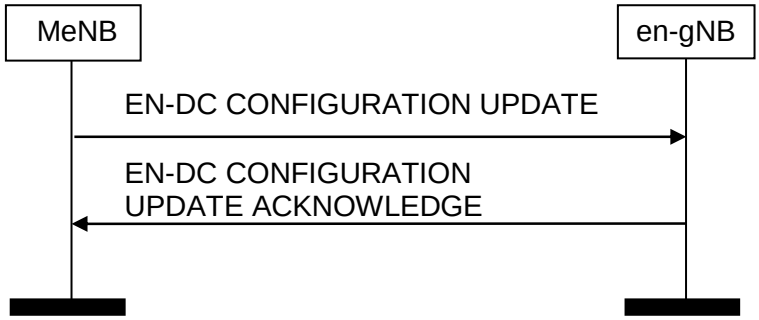


Figure 8.7.2.2-1: eNB Initiated EN-DC Configuration Update, successful operation

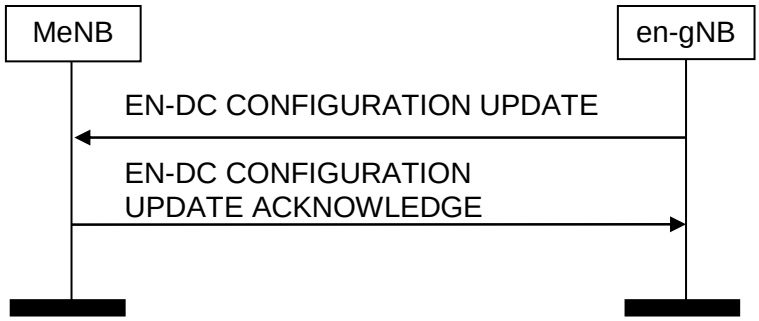


Figure 8.7.2.2-2: en-gNB Initiated EN-DC Configuration Update, successful operation

eNB initiated EN-DC Configuration Update:

An eNB initiates the procedure by sending an EN-DC CONFIGURATION UPDATE message to a peer en-gNB.

After successful update of requested information, en-gNB shall reply with the EN-DC CONFIGURATION UPDATE ACKNOWLEDGE message to inform the initiating eNB that the requested update of application data was performed successfully.

If the *Cell Assistance Information* IE is present, the en-gNB may use it to generate the *List of Served NR Cells* IE and include the list in the EN-DC CONFIGURATION UPDATE ACKNOWLEDGE message.

If the EN-DC CONFIGURATION UPDATE REQUEST message contains the Protected E-UTRA Resource Indication IE, the receiving en-gNB should forward it to lower layers and use it for cell-level resource coordination with the eNB. The en-gNB shall consider the received Protected E-UTRA Resource Indication IE when expressing its desired resource allocation to the eNB during E-UTRA – NR Cell Resource Coordination procedure. The en-gNB shall consider the received Protected E-UTRA Resource Indication IE content valid until reception of a new update of the IE for the same eNB.

The protected resource pattern indicated in the Protected E-UTRA Resource Indication IE is not valid in subframes indicated by the Reserved Subframes IE, as well as in the non-control region of the MBSFN subframes i.e. it is valid

only in the control region therein. The size of the control region of MBSFN subframes is indicated in the Protected E-UTRA Resource Indication IE.

The eNB may initiate a further EN-DC Configuration Update procedure only after a previous EN-DC Configuration Update procedure has been completed.

If Supplementary Uplink is configured at the en-gNB, the en-gNB shall include in the EN-DC X2 CONFIGURATION UPDATE ACKNOWLEDGE message the *SUL Information* IE and the *Supported SUL band List* IE for each cell added in the Served NR Cells To Add IE and in the Served NR Cells To Modify IE.

en-gNB initiated EN-DC Configuration Update:

An en-gNB initiates the procedure by sending an EN-DC CONFIGURATION UPDATE message to an eNB.

If Supplementary Uplink is configured at the en-gNB, the en-gNB shall include in the EN-DC X2 CONFIGURATION UPDATE message the *SUL Information* IE and the *Supported SUL band List* IE for each served cell added in the Served NR Cells To Add IE and in the Served NR Cells To Modify IE.

If the Deactivation Indication IE is contained in the *Served NR Cells To Modify* IE, it indicates that the concerned NR cell was switched off to lower energy consumption, and is available for activation on request from the eNB, as described in TS 36.300 [15].

After successful update of requested information, eNB shall reply with the EN-DC CONFIGURATION UPDATE ACKNOWLEDGE message to inform the initiating en-gNB that the requested update of application data was performed successfully. In case the eNB receives an EN-DC CONFIGURATION UPDATE without any IE except for *Message Type* IE it shall reply with EN-DC CONFIGURATION UPDATE ACKNOWLEDGE message without performing any updates to the existing configuration.

Upon reception of an EN-DC CONFIGURATION UPDATE message, eNB shall update the information for en-gNB as follows:

Update of Served NR Cell Information:

- If *Served NR Cells To Add* IE is contained in the EN-DC CONFIGURATION UPDATE message, eNB shall add cell information according to the information in the *Served NR Cell Information* IE.
- If *Served NR Cells To Modify* IE is contained in the EN-DC CONFIGURATION UPDATE message, eNB shall modify information of cell indicated by *Old NR-CGI* IE according to the information in the *Served NR Cell Information* IE.
- If *Served NR Cells To Delete* IE is contained in the EN-DC CONFIGURATION UPDATE message, eNB shall delete information of cell indicated by *Old NR-CGI* IE.

The en-gNB may initiate a further EN-DC Configuration Update procedure only after a previous EN-DC Configuration Update procedure has been completed.

8.7.2.3 Unsuccessful Operation

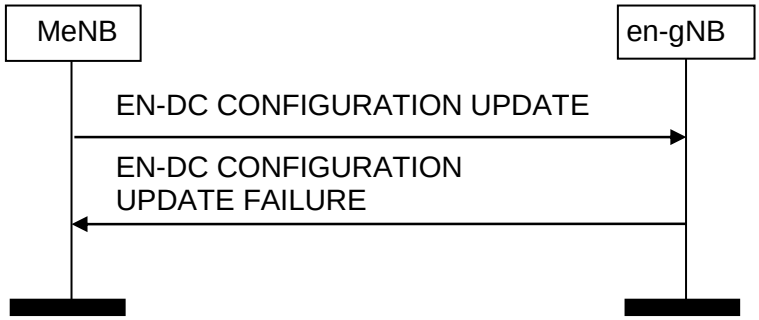


Figure 8.7.2.3-1: eNB Initiated EN-DC Configuration Update, unsuccessful operation

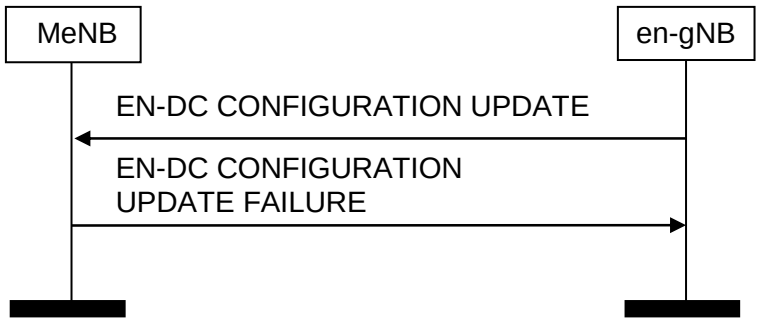


Figure 8.7.2.3-2: en-gNB Initiated EN-DC Configuration Update, unsuccessful operation

If the candidate receving node can not accept the update it shall respond with an EN-DC CONFIGURATION UPDATE FAILURE message and appropriate cause value.

8.7.2.4 Abnormal Conditions

If the initiating node after initiating EN-DC Configuration Update procedure receives neither EN-DC CONFIGURATION UPDATE ACKNOWLEDGE message nor EN-DC CONFIGURATION UPDATE FAILURE message, the initiating node may reinitiate the EN-DC Configuration Update procedure towards the same candidate receving node, provided that the content of the EN-DC CONFIGURATION UPDATE message is identical to the content of the previously unacknowledged EN-DC CONFIGURATION UPDATE message.

8.7.3 EN-DC Cell Activation

8.7.3.1 General

The purpose of the EN-DC Cell Activation procedure is to enable an eNB to request a neighbouring en-gNB to switch on one or more cells, previously reported as inactive due to energy saving reasons.

The procedure uses non UE-associated signalling.

8.7.3.2 Successful Operation

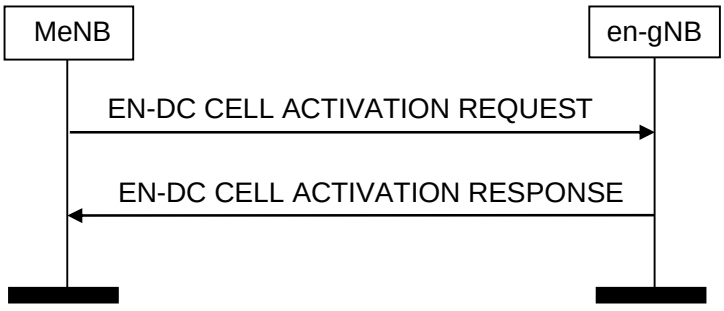


Figure 8.7.3.2-1: EN-DC Cell Activation, successful operation

An eNB initiates the procedure by sending a EN-DC CELL ACTIVATION REQUEST message to a peer en-gNB.

Upon receipt of this message, the en-gNB should activate the cell(s) indicated in the EN-DC CELL ACTIVATION REQUEST message and shall indicate in the EN-DC CELL ACTIVATION RESPONSE message for which cells the request was fulfilled.

Interactions with EN-DC Configuration Update procedure:

The en-gNB shall not send an EN-DC CONFIGURATION UPDATE message to the eNB just for the reason of the cell(s) indicated in the EN-DC CELL ACTIVATION REQUEST message changing cell activation state, as the receipt of the EN-DC CELL ACTIVATION RESPONSE message by the eNB is used to update the information about the activation state of en-gNB cells in the eNB.

8.7.3.3 Unsuccessful Operation

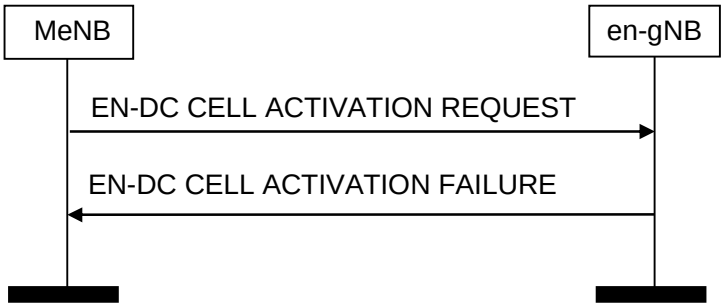


Figure 8.7.3.3-1: EN-DC Cell Activation, unsuccessful operation

If the en-gNB cannot activate any of the cells indicated in the EN-DC CELL ACTIVATION REQUEST message, it shall respond with a EN-DC CELL ACTIVATION FAILURE message with an appropriate cause value.

8.7.3.4 Abnormal Conditions

Not applicable.

8.7.4 SgNB Addition Preparation

8.7.4.1 General

The purpose of the SgNB Addition Preparation procedure is to request the en-gNB to allocate resources for EN-DC connectivity operation for a specific UE.

The procedure uses UE-associated signalling.

8.7.4.2 Successful Operation

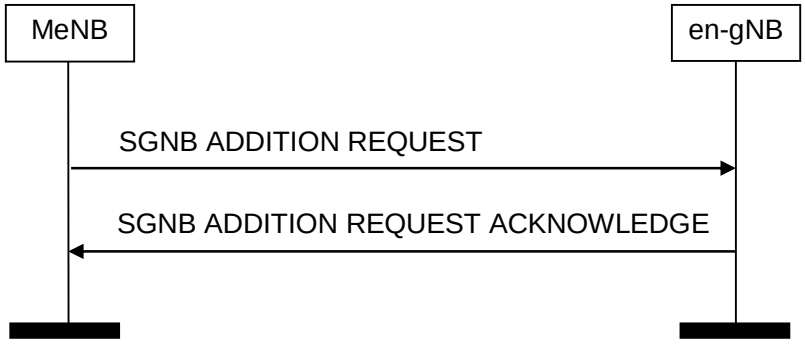


Figure 8.7.4.2-1: SgNB Addition Preparation, successful operation

The MeNB initiates the procedure by sending the SGNB ADDITION REQUEST message to the en-gNB. When the MeNB sends the SGNB ADDITION REQUEST message, it shall start the timer T_{DCprep}.

The allocation of resources according to the values of the *Allocation and Retention Priority* IE included in the *Full E-RAB Level QoS Parameters* IE or in the *Maximum MCG admittable E-RAB Level QoS Parameters* IE or in the *Requested MCG E-RAB Level QoS Parameters IE* or in the *Requested SCG E-RAB Level QoS Parameters* IE shall follow the principles described for the E-RAB Setup procedure in TS 36.413 [4].

If the SGNB ADDITION REQUEST message contains the *Serving PLMN* IE, the en-gNB may use it for RRM purposes.

If the SGNB ADDITION REQUEST message contains the *Expected UE Behaviour* IE, the en-gNB shall, if supported, store this information and may use it to optimize resource allocation.

If the SGNB ADDITION REQUEST message contains the *Handover Restriction List* IE, the en-gNB node, if supported, shall store this information and use it to select an appropriate NR cell.

If the SGNB ADDITION REQUEST message contains the *MeNB Resource Coordination Information* IE, the en-gNB should forward it to lower layers and it may use it for the purpose of resource coordination with the MeNB. The en-gNB shall consider the received *UL Coordination Information* IE value valid until reception of a new update of the IE for the same UE. The en-gNB shall consider the received *DL Coordination Information* IE value valid until reception of a new update of the IE for the same UE.

The en-gNB shall choose the ciphering algorithm based on the information in the *NR UE Security Capabilities* IE and locally configured priority list of AS encryption algorithms and apply the key indicated in the *SgNB Security Key* IE as specified in the TS 33.401 [18].

If the SGNB ADDITION REQUEST message contains the *Subscriber Profile ID for RAT/Frequency Priority* IE, the en-gNB may use it for RRM purposes.

The en-gNB shall search for the target NR cell among the NR neighbour cells of the E-UTRAN cell indicated in *MeNB Cell ID* IE, as specified in the TS 37.340 [32].

The en-gNB shall report to the MeNB, in the SGNB ADDITION REQUEST ACKNOWLEDGE message, the result for all the requested E-RABs in the following way:

- a list of E-RABs which are successfully established shall be included in the *E-RABs Admitted To Be Added List* IE;
- a list of E-RABs which failed to be established shall be included in the *E-RABs Not Admitted List* IE.

NOTE: The MeNB may trigger the SgNB Addition Preparation procedure in the course of the Inter-MeNB handover without SgNB change procedure as described in TS 37.340 [32]. The deleted E-RABs are not included in the *E-RABs To Be Added List* IE in the SGNB ADDITION REQUEST message, from MeNB point of view. If the en-gNB reports a certain E-RAB to be successfully established, respective SCG resources, from an en-gNB point of view, may be actually successfully established or modified or kept; if a certain E-RAB is reported to be failed to be established, respective SCG resources, from an en-gNB point of view, may be actually failed to be established or modified or kept.

For each E-RAB for which allocation of the PDCP entity is requested at the en-gNB:

- the MeNB may propose to apply forwarding of downlink data by including the *DL Forwarding* IE within the *E-RABs To be Added Item* IE of the SGNB ADDITION REQUEST message. For each E-RAB that it has decided to admit, the en-gNB may include the *DL Forwarding GTP Tunnel Endpoint* IE within the *E-RABs Admitted To Be Added Item* IE of the SGNB ADDITION REQUEST ACKNOWLEDGE message to indicate that it accepts the proposed forwarding of downlink data for this bearer. This GTP tunnel endpoint may be different from the corresponding *DL GTP TEID* IE in the *E-RAB To Be Modified List* IE of the E-RAB MODIFICATION INDICATION message (see TS 36.413 [4]) depending on implementation choice;
- the en-gNB may include for each bearer in the *E-RABs Admitted To Be Added List* IE the *UL Forwarding GTP Tunnel Endpoint* IE to indicate that it requests data forwarding of uplink packets to be performed for that bearer.
- the en-gNB shall use the *S1 UL GTP Tunnel Endpoint* IE of the SGNB ADDITION REQUEST message as the UL S1-U address.
- the MeNB shall use the *SgNB UL GTP TEID at PDCP* IE of the SGNB ADDITION REQUEST ACKNOWLEDGE message as the UL X2-U address.
- if the SGNB ADDITION REQUEST message contains for an E-RAB to be added which is requested to be configured with MCG resources the *MeNB DL GTP TEID at MCG* IE the en-gNB shall use it as the DL X2-U address for delivery of DL PDCP PDUs.
- the en-gNB shall include in the SGNB ADDITION REQUEST ACKNOWLEDGE message the *S1 DL GTP TEID at the SgNB* IE.
- the en-gNB shall include in the SGNB ADDITION REQUEST ACKNOWLEDGE message the *RLC Mode* IE.

Upon reception of the SGNB ADDITION REQUEST ACKNOWLEDGE message the MeNB shall stop the timer T_{DCprep}.

If the SGNB ADDITION ACKNOWLEDGE message contains the *SgNB Resource Coordination Information* IE, the MeNB may use it for the purpose of resource coordination with the en-gNB. The MeNB shall consider the received *UL Coordination Information* IE value valid until reception of a new update of the IE for the same UE. The MeNB shall consider the received *DL Coordination Information* IE value valid until reception of a new update of the IE for the same UE.

If the *SgNB UE X2AP ID* IE is contained in the SGNB ADDITION REQUEST message, the en-gNB shall, if supported, store this information and use it as defined in TS 37.340 [32].

If the SGNB ADDITION REQUEST message contains the *SGNB Addition Trigger Indication*, the en-gNB shall include the *RRC config indication* IE in the SGNB ADDITION REQUEST ACKNOWLEDGE message to inform the MeNB if the en-gNB applied full or delta configuration, as specified in TS 37.340 [32].

If the en-gNB receives for an E-RAB for which the PDCP entiy is allocated at the MeNB the *Secondary MeNB UL GTP TEID at PDCP* IE in the SGNB ADDITION REQUEST message, it may provide the *Secondary SgNB DL GTP TEID at SCG* IE to the MeNB in the SGNB ADDITION REQUEST ACKNOWLEDGE message if PDCP duplication is configured at the en-gNB.

Interactions with the MeNB initiated SgNB Modification procedure:

If the en-gNB provides for an E-RAB for which the PDCP entiy is allocated at the MeNB the *Secondary SgNB DL GTP TEID at SCG* IE to the MeNB in the SGNB ADDITION REQUEST ACKNOWLEDGE message and the MeNB has not provided the *Secondary MeNB UL GTP TEID at PDCP* IE in the SGNB ADDITION REQUEST message, the MeNB shall trigger the MeNB initiated SgNB Modification procedure to provide the *Secondary MeNB UL GTP TEID at PDCP* IE to the SgNB.

Interactions with the SgNB Reconfiguration Completion procedure:

If the en-gNB admits at least one E-RAB, the en-gNB shall start the timer $T_{DCoverall}$ when sending the SGNB ADDITION REQUEST ACKNOWLEDGE message to the MeNB. The reception of the SGNB RECONFIGURATION COMPLETE message shall stop the timer $T_{DCoverall}$.

8.7.4.3 Unsuccessful Operation

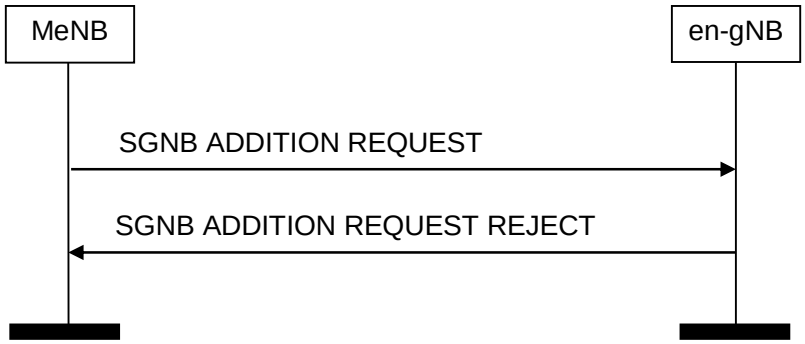


Figure 8.7.4.3-1: SgNB Addition Preparation, unsuccessful operation

If the en-gNB is not able to accept any of the bearers or a failure occurs during the SgNB Addition Preparation, the en-gNB sends the SGNB ADDITION REQUEST REJECT message with an appropriate cause value to the MeNB.

8.7.4.4 Abnormal Conditions

If the en-gNB receives a SGNB ADDITION REQUEST message containing multiple *E-RAB ID* IEs (in the *E-RABs To Be Added List* IE) set to the same value, the en-gNB shall consider the establishment of the corresponding E-RAB as failed.

If the en-gNB receives a SGNB ADDITION REQUEST message containing a *E-RAB Level QoS Parameters* IE which contains a *QCI* IE indicating a GBR bearer (as defined in TS 23.203 [13]), and which does not contain the *GBR QoS Information* IE, the en-gNB shall consider the establishment of the corresponding E-RAB as failed.

If the supported algorithms for encryption defined in the *NR Encryption Algorithms* IE in the *NR UE Security Capabilities* IE, plus the mandated support of NEA0 in all UEs (TS 33.401 [18]), do not match any algorithms defined

in the configured list of allowed encryption algorithms in the en-gNB (TS 33.401 [18]), the en-gNB shall reject the procedure using the SGNB ADDITION REQUEST REJECT message.

If the supported algorithms for integrity defined in the *NR Integrity Protection Algorithms* IE in the *NR UE Security Capabilities* IE do not match any algorithms defined in the configured list of allowed integrity protection algorithms in the en-gNB (TS 33.401 [18]), the en-gNB shall reject the procedure using the SGNB ADDITION REQUEST REJECT message.

If the en-gNB receives a SGNB ADDITION REQUEST message containing a *SgNB UE X2AP ID* IE that does not match any existing UE Context that has such ID, the en-gNB shall reject the procedure using the SGNB ADDITION REQUEST REJECT message.

If the MeNB has provided the en-gNB for an E-RAB for which the PDCP entiy is allocated at the MeNB the *Secondary MeNB UL GTP TEID at PDCP* IE in the SGNB ADDITION REQUEST message, and the en-gNB does not provide the *Secondary SgNB DL GTP TEID at SCG* IE to the MeNB in the SGNB ADDITION REQUEST ACKNOWLEDGE message, the MeNB shall assume that PDCP duplication was not configured at the en-gNB and releases duplication resources.

If the en-gNB provides for an E-RAB for which the PDCP entiy is allocated at the MeNB the *Secondary SgNB DL GTP TEID at SCG* IE to the MeNB in the SGNB ADDITION REQUEST ACKNOWLEDGE message and the MeNB has not provided the *Secondary MeNB UL GTP TEID at PDCP* IE in the SGNB ADDITION REQUEST message, and the MeNB does not trigger the MeNB initiated SgNB Modification procedure to provide the *Secondary MeNB UL GTP TEID at PDCP* IE to the SgNB the en-gNB before the SgNB Reconfigurationi Completion procedure was triggered, the en-gNB shall trigger the release of the concerned E-RAB.

Interactions with the SgNB Reconfiguration Completion and SgNB initiated SgNB Release procedure:

If the timer $T_{DCoverall}$ expires before the en-gNB has received the SGNB RECONFIGURATION COMPLETE or the SGNB RELEASE REQUEST message, the en-gNB shall regard the requested RRC connection reconfiguration as being not applied by the UE and shall trigger the SgNB initiated SgNB Release procedure.

Interactions with the MeNB initiated SgNB Release procedure:

If the timer T_{DCprep} expires before the MeNB has received the SGNB ADDITION REQUEST ACKNOWLEDGE message, the MeNB shall regard the SgNB Addition Preparation procedure as being failed and shall trigger the MeNB initiated SgNB Release procedure.

8.7.5 SgNB Reconfiguration Completion

8.7.5.1 General

The purpose of the SgNB Reconfiguration Completion procedure is to provide information to the en-gNB whether the requested configuration was successfully applied by the UE.

The procedure uses UE-associated signalling.

8.7.5.2 Successful Operation

Figure 8.7.5.2-1: SgNB Reconfiguration Complete procedure, successful operation.

The MeNB initiates the procedure by sending the SGNB RECONFIGURATION COMPLETE message to the en-gNB.

The SGNB RECONFIGURATION COMPLETE message may contain information that

- either the UE has successfully applied the configuration requested by the en-gNB. The MeNB may also provide NR *RRCReconfigurationComplete* message in the *MeNB to SgNB Container* IE.
- or the configuration requested by the en-gNB has been rejected. The MeNB shall provide information with sufficient precision in the included *Cause* IE to enable the en-gNB to know the reason for an unsuccessful reconfiguration.

Upon reception of the SGNB RECONFIGURATION COMPLETE message the en-gNB shall stop the timer $T_{DCoverall}$.

8.7.5.3 Abnormal Conditions

Void.

8.7.6 MeNB initiated SgNB Modification Preparation

8.7.6.1 General

This procedure is used to enable an MeNB to request an en-gNB to modify the UE context at the en-gNB, or to query the current SCG configuration for supporting delta signalling in MeNB initiated SgNB change, or to provide the S-RLF-related information to the en-gNB.

The procedure uses UE-associated signalling.

8.7.6.2 Successful Operation

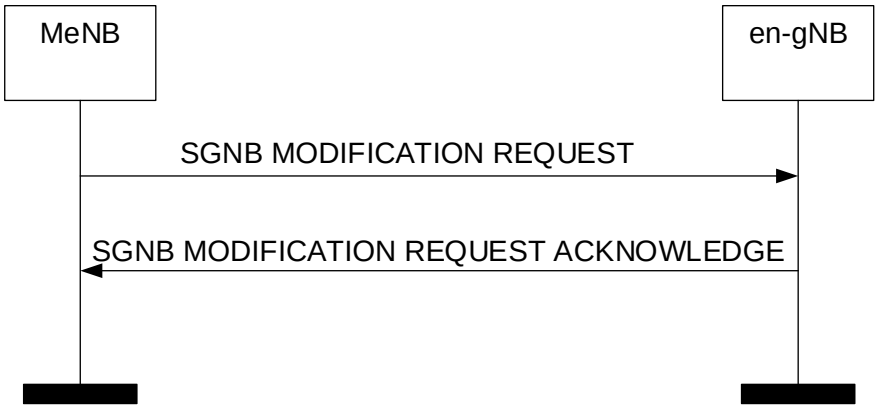


Figure 8.7.6.2-1: MeNB initiated SgNB Modification Preparation, successful operation

The MeNB initiates the procedure by sending the SGNB MODIFICATION REQUEST message to the en-gNB. When the MeNB sends the SGNB MODIFICATION REQUEST message, it shall start the timer T_{DCprep}.

The SGNB MODIFICATION REQUEST message may contain:

- within the *UE Context Information* IE (if the modification of the UE context at the en-gNB is requested);
  - E-RABs to be added within the *E-RABs To Be Added Item* IE;
  - E-RABs to be modified within the *E-RABs To Be Modified Item* IE;
  - E-RABs to be released within the *E-RABs To Be Released Item* IE;
  - the *SgNB UE Aggregate Maximum Bit Rate* IE;
- the *MeNB to SgNB Container* IE;
- the *SCG Configuration Query* IE;
- the *MeNB Resource Coordination Information* IE;
- the *Requested split SRBs IE*;

- the *Requested split SRBs release* IE.

If the SGNB MODIFICATION REQUEST message contains the *Serving PLMN* IE, the en-gNB may use it for RRM purposes.

If the SGNB MODIFICATION REQUEST message contains the *Handover Restriction List* IE, the en-gNB shall

- replace the previously provided Handover Restriction List by the received Handover Restriction List in the UE context;
- use this information to select an appropriate NR cell.

If the *SgNB UE Aggregate Maximum Bit Rate* IE is included in the SGNB MODIFICATION REQUEST message, the en-gNB shall:

- replace the previously provided SgNB UE Aggregate Maximum Bit Rate by the received SgNB UE Aggregate Maximum Bit Rate in the UE context;
- use the received SgNB UE Aggregate Maximum Bit Rate for non-GBR Bearers for the concerned UE as defined in TS 37.340 [32].

The allocation of resources according to the values of the *QCI* IE, *Allocation and Retention Priority* IE or *GBR QoS Information* IE included in the *Full E-RAB Level QoS Parameters* IE or in the *Maximum MCG admittable E-RAB Level QoS Parameters* IE or in the *Requested SCG E-RAB Level QoS Parameters* IE shall follow the principles described for the E-RAB Setup procedure in TS 36.413 [4].

If the SGNB MODIFICATION REQUEST message contains the *MeNB Resource Coordination Information* IE, the en-gNB should forward it to lower layers and it may use it for the purpose of resource coordination with the MeNB. The en-gNB shall consider the received *UL Coordination Information* IE value valid until reception of a new update of the IE for the same UE. The en-gNB shall consider the received *DL Coordination Information* IE value valid until reception of a new update of the IE for the same UE.

If at least one of the requested modifications is admitted by the en-gNB, the en-gNB shall modify the related part of the UE context accordingly and send the SGNB MODIFICATION REQUEST ACKNOWLEDGE message back to the MeNB.

The en-gNB shall include the E-RABs for which resources have been either added or modified or released at the en-gNB either in the *E-RABs Admitted To Be Added List* IE or the *E-RABs Admitted To Be Modified List* IE or the *E-RABs Admitted To Be Released List* IE. The en-gNB shall include the E-RABs that have not been admitted in the *E-RABs Not Admitted List* IE with an appropriate cause value.

The en-gNB shall, if included, choose the ciphering algorithm based on the information in the *NR UE Security Capabilities* IE and locally configured priority list of AS encryption algorithms and apply the key indicated in the *SgNB Security Key* IE as specified in the TS 33.401 [18].

For each E-RAB for which allocation of the PDCP entity is requested at the en-gNB:

- if applicable, the MeNB may propose to apply forwarding of downlink data by including the *DL Forwarding* IE within the *E-RABs To Be Added Item* IE of the SGNB MODIFICATION REQUEST message. For each E-RAB that it has decided to admit, the en-gNB may include the *DL Forwarding GTP Tunnel Endpoint* IE within the *E-RABs Admitted To Be Added Item* IE of the SGNB MODIFICATION REQUEST ACKNOWLEDGE message to indicate that it accepts the proposed forwarding of downlink data for this bearer. The MeNB may also provide for an applicable E-RAB to be released the *DL Forwarding GTP Tunnel Endpoint* IE and the *UL Forwarding GTP Tunnel Endpoint* IE within the *E-RABs To Be Released Item* IE of the SGNB MODIFICATION REQUEST message.
- if applicable, the en-gNB may include for each bearer in the *E-RABs Admitted To Be Added List* IE in the SGNB MODIFICATION REQUEST ACKNOWLEDGE message the *UL Forwarding GTP Tunnel Endpoint* IE to indicate that it requests data forwarding of uplink packets to be performed for that bearer.
- if applicable, the en-gNB may include for each bearer in the *E-RABs Admitted To Be Modified* List IE which is configured with the SN terminated split bearer option in the SGNB MODIFICATION REQUEST ACKNOWLEDGE message the *UL configuration* IE to indicate that the MCG UL configuration of the UE has changed.

For each E-RAB configured with SCG resources and the PDCP entity is hosted by the MeNB and

- requested to be modified,
  - if the SGNB MODIFICATION REQUEST message includes the *MeNB UL GTP TEID at PDCP* IE in the *E-RABs To Be Modified Item* IE, the en-gNB shall act as specified in TS 37.340 [32].
  - if the SGNB MODIFICATION REQUEST message contains the *MeNB UL GTP TEID at PDCP* IE the en-gNB shall use it as the new UL X2-U address.
  - the en-gNB may include in the SGNB MODIFICATION REQUEST ACKNOWLEDGE message the *SgNB DL GTP TEID at SCG* IE.

If, dependent on the configured bearer type, the *Full E-RAB Level QoS Parameters* IE or the *Maximum MCG admittable E-RAB Level QoS Parameters* IE or the *Requested SCG E-RAB level QoS Parameters* IE are included in the SGNB MODIFICATION REQUEST message for an E-RAB to be modified the en-gNB shall allocate respective resources and provide corresponding radio configuration information within the *SgNB to MeNB Container* IE as described in TS 37.340 [32].

If the SGNB MODIFICATION REQUEST message contains, for an E-RAB to be modified which is configured with the PDCP entity in the en-gNB, the *S1 UL GTP Tunnel Endpoint* IE, the en-gNB shall use it as the new UL S1-U address.

If the SGNB MODIFICATION REQUEST message contains an E-RAB to be modified which is configured with the MN terminated split bearer option, the MeNB may include the *UL configuration* IE to indicate that the SCG UL configuration of the UE has changed.

If the SGNB MODIFICATION REQUEST message contains for an E-RAB to be modified which is configured with the PDCP enitiy in the en-gNB and MCG resources the *MeNB DL GTP TEID at MCG* IE the en-gNB shall use it as the DL X2-U address.

If the SGNB MODIFICATION REQUEST message contains the *Subscriber Profile ID for RAT/Frequency Priority* IE, the en-gNB may use it for RRM purposes.

For an E-RAB to be modified which is configured with the PDCP entity in the en-gNB the en-gNB may include in the SGNB MODIFICATION REQUEST ACKNOWLEDGE message the *S1 DL GTP TEID at the SgNB* IE.

If the SGNB MODIFICATION REQUEST ACKNOWLEDGE message contains the *SgNB Resource Coordination Information* IE, the MeNB may use it for the purpose of resource coordination with the en-gNB. The MeNB shall consider the received *UL Coordination Information* IE value valid until reception of a new update of the IE for the same UE. The MeNB shall consider the received *DL Coordination Information* IE value valid until reception of a new update of the IE for the same UE.

Upon reception of the SGNB MODIFICATION REQUEST ACKNOWLEDGE message the MeNB shall stop the timer T_{DCprep}. If the SGNB MODIFICATION REQUEST ACKNOWLEDGE message has included the *SgNB to MeNB Container* IE the MeNB is then defined to have a Prepared SgNB Modification for that X2 UE-associated signalling.

If the *SCG Configuration Query* IE is included in the SGNB MODIFICATION REQUEST message, the en-gNB shall provide corresponding radio configuration information within the *SgNB to MeNB Container* IE as described in TS 37.340 [32].

If the SGNB MODIFICATION REQUEST message contains the *Requested split SRBs* IE, the en-gNB may use it to add split SRBs. If the SGNB MODIFICATION REQUEST message contains the *Requested split SRBs release* IE, the en-gNB may use it to release split SRBs.

If the en-gNB receives for an E-RAB to be setup for which the PDCP entiy is allocated at the MeNB the *Secondary MeNB UL GTP TEID at PDCP* IE in the SGNB MODIFICATION REQUEST message, it may provide the *Secondary SgNB DL GTP TEID at SCG* IE to the MeNB in the SGNB MODIFICATION REQUEST ACKNOWLEDGE message if PDCP duplication is configured at the en-gNB.

Interactions with the MeNB initiated SgNB Modification procedure:

If the en-gNB provides for an E-RAB to be setup for which the PDCP entiy is allocated at the MeNB the *Secondary SgNB DL GTP TEID at SCG* IE to the MeNB in the SGNB MODIFICATION REQUEST ACKNOWLEDGE message and the MeNB has not provided the *Secondary MeNB UL GTP TEID at PDCP* IE in the SGNB MODIFICATION

REQUEST message, the MeNB shall trigger the MeNB initiated SgNB Modification procedure to provide the *Secondary MeNB UL GTP TEID at PDCP* IE to the SgNB.

Interactions with the SgNB Reconfiguration Completion procedure:

If the en-gNB admits a modification of the UE context requiring the MeNB to report about the success of the RRC connection reconfiguration procedure, the en-gNB shall start the timer $T_{DCoverall}$ when sending the SGNB MODIFICATION REQUEST ACKNOWLEDGE message to the MeNB. The reception of the SGNB RECONFIGURATION COMPLETE message shall stop the timer $T_{DCoverall}$.

8.7.6.3 Unsuccessful Operation

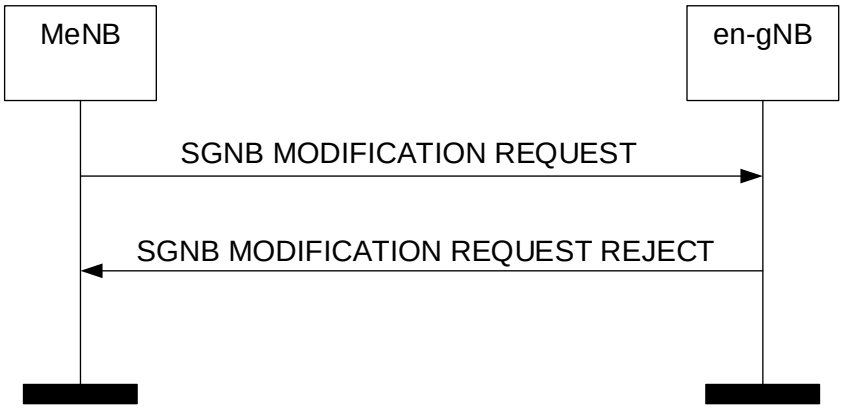


Figure 8.7.6.3-1: MeNB initiated SgNB Modification Preparation, unsuccessful operation

If the en-gNB does not admit any modification requested by the MeNB, or a failure occurs during the MeNB initiated SgNB Modfication Preparation, the en-gNB shall send the SGNB MODIFICATION REQUEST REJECT message to the MeNB. The message shall contain the *Cause* IE with an appropriate value.

If the en-gNB receives a SGNB MODIFICATION REQUEST message containing the *MeNB to SgNB Container* IE that does not include required information as specified in TS 38.331 [31], the en-gNB shall send the SGNB MODIFICATION REQUEST REJECT message to the MeNB.

8.7.6.4 Abnormal Conditions

If the en-gNB receives a SGNB MODIFICATION REQUEST message containing multiple *E-RAB ID* IEs (in the *E-RABs To Be Added List* IE and/or the *E-RABs To Be Modified List* IE) set to the same value, the en-gNB shall not admit the action requested for the corresponding E-RABs.

If the en-gNB receives an SGNB MODIFICATION REQUEST message containing multiple *E-RAB ID* IEs (in the *E-RAB To Be Released List* IE) set to the same value, the en-gNB shall initiate the release of one corresponding E-RAB and ignore the duplication of the instances of the selected corresponding E-RABs.

If the en-gNB receives a SGNB MODIFICATION REQUEST message containing, dependent on the configured bearer type, the *Full E-RAB Level QoS Parameters* IE or the *Maximum MCG admittable E-RAB Level QoS Parameters* IE or the *Requested SCG E-RAB Level QoS Parameters* IE which contains a *QCI* IE indicating a GBR bearer (as defined in TS 23.203 [13]), and which does not contain the *GBR QoS Information* IE, the en-gNB shall not admit the corresponding E-RAB.

If the supported algorithms for encryption defined in the *NR Encryption Algorithms* IE in the *NR UE Security Capabilities* IE in the *UE Context Information* IE, plus the mandated support of NEA0 in all UEs (TS 33.401 [18]), do not match any algorithms defined in the configured list of allowed encryption algorithms in the en-gNB (TS 33.401 [18]), the en-gNB shall reject the procedure using the SGNB MODIFICATION REQUEST REJECT message.

If the supported algorithms for integrity defined in the *NR Integrity Protection Algorithms* IE in the *NR UE Security Capabilities* IE in the *UE Context Information* IE do not match any algorithms defined in the configured list of allowed integrity protection algorithms in the en-gNB (TS 33.401 [18]), the en-gNB shall reject the procedure using the SGNB MODIFICATION REQUEST REJECT message.

If the timer T_{DCprep} expires before the MeNB has received the SGNB MODIFICATION REQUEST ACKNOWLEDGE message, the MeNB shall regard the MeNB initiated SgNB Modification Preparation procedure as being failed and shall release the UE Context at the en-gNB.

If the MeNB has provided the en-gNB for an E-RAB to be setupr which the PDCP entiy is allocated at the MeNB the *Secondary MeNB UL GTP TEID at PDCP* IE in the SGNB MODIFICATION REQUEST message, and the en-gNB does not provide the *Secondary SgNB DL GTP TEID at SCG* IE to the MeNB in the SGNB MODIFICATION REQUEST ACKNOWLEDGE message, the MeNB shall assume that PDCP duplication was not configured at the en-gNB and releases duplication resources.

If the en-gNB provides for an E-RAB to be setup for which the PDCP entiy is allocated at the MeNB the *Secondary SgNB DL GTP TEID at SCG* IE to the MeNB in the SGNB MODIFICATION REQUEST ACKNOWLEDGE message and the MeNB has not provided the *Secondary MeNB UL GTP TEID at PDCP* IE in the SGNB MODIFICATION REQUEST message, and the MeNB does not trigger the MeNB initiated SgNB Modification procedure to provide the *Secondary MeNB UL GTP TEID at PDCP* IE to the SgNB the en-gNB before the SgNB Reconfigurationi Completion procedure was triggered, the en-gNB shall trigger the release of the concerned E-RAB.

Interactions with the SgNB Reconfiguration Completion and SgNB initiated SgNB Release procedure:

If the timer $T_{DCoverall}$ expires before the en-gNB has received the SGNB RECONFIGURATION COMPLETE or the SGNB RELEASE REQUEST message, the en-gNB shall regard the requested modification RRC connection reconfiguration as being not applied by the UE and shall trigger the SgNB initiated SgNB Release procedure.

Interaction with the SgNB initiated SgNB Modification Preparation procedure:

If the MeNB, after having initiated the MeNB initiated SgNB Modification procedure, receives the SGNB MODIFICATION REQUIRED message, the MeNB shall refuse the SgNB initiated SgNB Modification procedure with an appropriate cause value in the *Cause* IE.

If the MeNB has a Prepared SgNB Modification and receives the SGNB MODIFICATION REQUIRED message, the MeNB shall respond with the SGNB MODIFICATION REFUSE message to the en-gNB with an appropriate cause value in the *Cause* IE.

Interactions with the MeNB initiated SgNB Release procedure:

If the timer T_{DCprep} expires before the MeNB has received the SGNB MODIFICATION REQUEST ACKNOWLEDGE message, the MeNB shall regard the SgNB Modification Preparation procedure as being failed and may trigger the MeNB initiated SgNB Release procedure.

8.7.7 SgNB initiated SgNB Modification

8.7.7.1 General

This procedure is used by the en-gNB to modify the UE context in the en-gNB.

The procedure uses UE-associated signalling.

8.7.7.2 Successful Operation

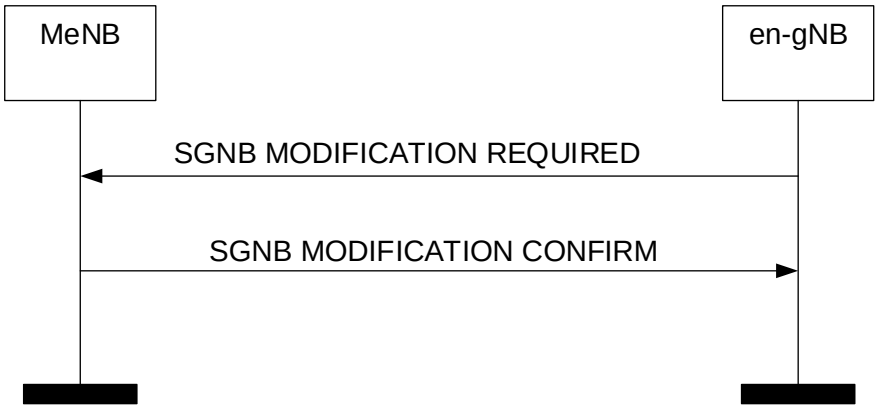


Figure 8.7.7.2-1: SgNB initiated SgNB Modification, successful operation.

The en-gNB initiates the procedure by sending the SGNB MODIFICATION REQUIRED message to the MeNB. When the en-gNB sends the SGNB MODIFICATION REQUIRED message, it shall start the timer $T_{DCoverall}$.

The SGNB MODIFICATION REQUIRED message may contain

- the *PDCP Change Indication* IE;
- the *SgNB to MeNB Container* IE.
- E-RABs to be modified within the *E-RABs To Be Modified Item* IE;
- E-RABs to be released within the *E-RABs To Be Released Item* IE;
- the *SgNB Resource Coordination Information* IE.

For the SN terminated split bearers, the en-gNB may include in the SGNB MODIFICATION REQUIRED message the *UL configuration* IE to indicate that the MCG UL configuration of the UE has changed.

If the MeNB is able to perform the change requested by the en-gNB, the MeNB shall send the SGNB MODIFICATION CONFIRM message to the en-gNB. The SGNB MODIFICATION CONFIRM message may contain the *MeNB to SgNB Container* IE.

If the SGNB MODIFICATION REQUIRED message contains the *SgNB Resource Coordination Information* IE, the MeNB may use it for the purpose of resource coordination with the en-gNB. The MeNB shall consider the received *UL Coordination Information* IE value valid until reception of a new update of the IE for the same UE. The MeNB shall consider the received *DL Coordination Information* IE value valid until reception of a new update of the IE for the same UE.

Upon reception of the SGNB MODIFICATION CONFIRM message the en-gNB shall stop the timer $T_{DCoverall}$.

If the SGNB MODIFICATION CONFIRM message contains the *MeNB Resource Coordination Information* IE, the en-gNB should forward it to lower layers and it may use it for the purpose of resource coordination with the MeNB. The en-gNB shall consider the received *UL Coordination Information* IE value valid until reception of a new update of the IE for the same UE. The en-gNB shall consider the received *DL Coordination Information* IE value valid until reception of a new update of the IE for the same UE.

If the MeNB receives for an E-RAB for which the PDCP entiy is allocated at the MeNB the *Secondary SgNB DL GTP TEID at SCG* IE in the SGNB MODIFICATION REQUIRED message, it shall provide the *Secondary MeNB UL GTP TEID at PDCP* IE to the en-gNB in the SGNB MODIFICATION CONFIRM message.

Interaction with the MeNB initiated SgNB Modification Preparation procedure:

If applicable, as specified in TS 37.340 [15], the en-gNB may receive, after having initiated the SgNB initiated SgNB Modification procedure, the SGNB MODIFICATION REQUEST message including the *DL Forwarding GTP Tunnel Endpoint* IE and the *UL Forwarding GTP Tunnel Endpoint* IE within the *E-RABs To Be Released List* IE.

If applicable, as specified in TS 37.340 [15], the en-gNB may receive, after having initiated the SgNB initiated SgNB Modification procedure, the SGNB MODIFICATION REQUEST message including the *SgNB Security Key* IE within the *UE Context Information* IE.

8.7.7.3 Unsuccessful Operation

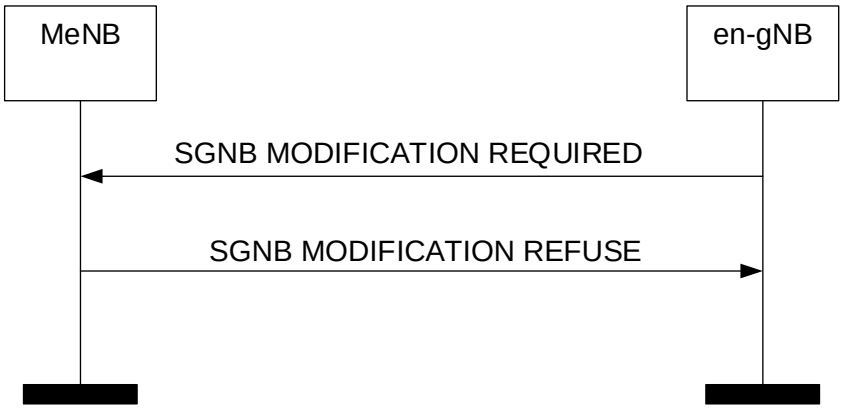


Figure 8.7.7.3-1: SgNB initiated SgNB Modification, unsuccessful operation.

In case the request modification cannot be performed successfully the MeNB shall respond with the SGNB MODIFICATION REFUSE message to the en-gNB with an appropriate cause value in the *Cause* IE.

The MeNB may also provide configuration information in the *MeNB to SgNB Container* IE.

8.7.7.4 Abnormal Conditions

If the timer $T_{DCoverall}$ expires before the en-gNB has received the SGNB MODIFICATION CONFIRM or the SGNB MODIFICATION REFUSE message, the en-gNB shall regard the requested modification as failed and may take further actions like triggering the SgNB initiated SgNB Release procedure to release all en-gNB resources allocated for the UE.

If the value received in the *E-RAB ID* IE of any of the *E-RABs To Be Released Items* IE is not known at the MeNB, the MeNB shall regard the procedure as failed and may take appropriate actions like triggering the MeNB initiated SgNB Release procedure.

If the en-gNB does not receives for an E-RAB for which the PDCP entiy is allocated at the MeNB the *Secondary MeNB UL GTP TEID at PDCP* IE to the en-gNB in the SGNB MODIFICATION CONFIRM message although the *Secondary SgNB DL GTP TEID at SCG* IE was provided to the MeNB in the SGNB MODIFICATION REQUIRED message, it shall assume the setup of the secondary X2-U bearer as being failed.

Interaction with the MeNB initiated SgNB Modification Preparation procedure:

If the en-gNB, after having initiated the SgNB initiated SgNB Modification procedure, receives the SGNB MODIFICATION REQUEST message including other IEs than an applicable *SgNB Security Key* IE and/or applicable forwarding addresses, the en-gNB shall

- regard the SgNB initiated SgNB Modification Procedure as being failed;
- stop the $T_{DCoverall}$, which was started to supervise the SgNB initiated SgNB Modification procedure;
- be prepared to receive the SGNB MODIFICATION REFUSE message from the MeNB and;
- continue with the MeNB initiated SgNB Modification Preparation procedure as specified in section 8.7.4.

Interaction with the MeNB initiated handover procedure:

If the MeNB, after having initiated the handover procedure, receives the SGNB MODIFICATION REQUIRED message, the MeNB shall refuse the SgNB modification procedure with an appropriate cause value in the *Cause* IE.

8.7.8 SgNB Change

8.7.8.1 General

This procedure is used by the en-gNB to change to another en-gNB.

The procedure uses UE-associated signalling.

8.7.8.2 Successful Operation

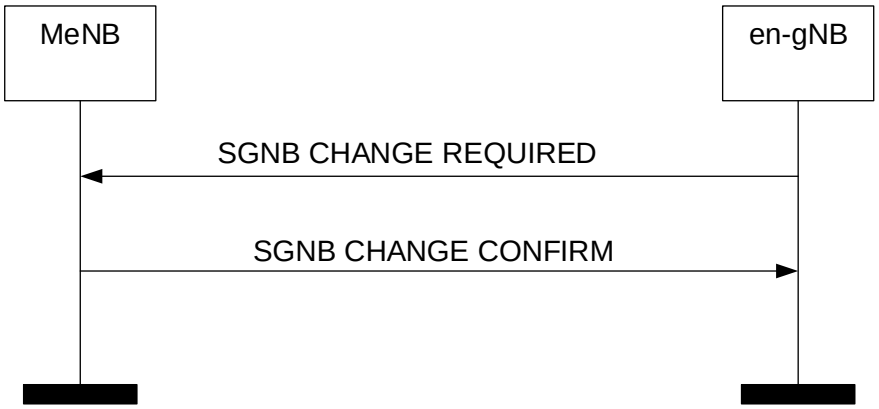


Figure 8.7.8.2-1: SgNB Change, successful operation.

The en-gNB initiates the procedure by sending the SGNB CHANGE REQUIRED message to the MeNB including the *Target SgNB ID Information IE*. When the en-gNB sends the SGNB CHANGE REQUIRED message, it shall start the timer $T_{DCoverall.}$

The SGNB CHANGE REQUIRED message may contain

- the *SgNB to MeNB Container* IE.

If the MeNB is able to perform the change requested by the en-gNB, the MeNB shall send the SGNB CHANGE CONFIRM message to the en-gNB. For each E-RAB configured with the PDCP entity in the en-gNB, the MeNB may include the *DL Forwarding GTP Tunnel Endpoint* IE and the *UL Forwarding GTP Tunnel Endpoint* IE within the *E-RABs To Be Released Item* IE to indicate that it requests data forwarding of uplink and downlink packets to be performed for that bearer.

The en-gNB may start data forwarding and stop providing user data to the UE and shall stop the timer $T_{DCoverall}$ upon reception of the SGNB CHANGE CONFIRM message.

8.7.8.3 Unsuccessful Operation

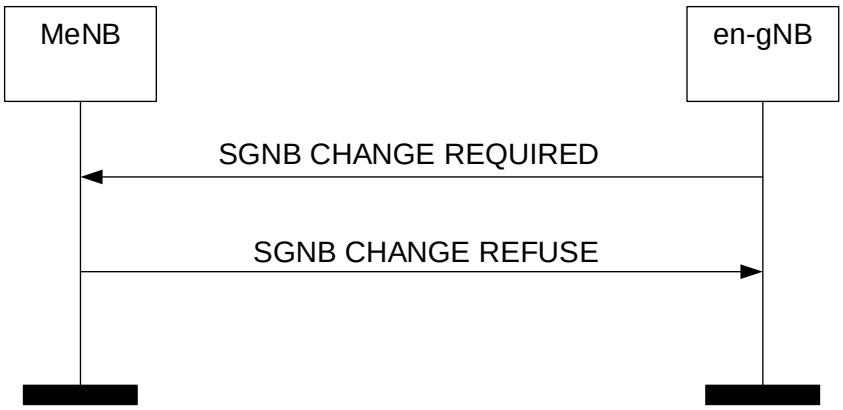


Figure 8.7.8.3-1: SgNB Change, unsuccessful operation.

In case the request change cannot be performed successfully the MeNB shall respond with the SGNB CHANGE REFUSE message to the en-gNB with an appropriate cause value in the *Cause* IE.

8.7.8.4 Abnormal Conditions

If the timer $T_{DCoverall}$ expires before the en-gNB has received the SGNB CHANGE CONFIRM or the SGNB CHANGE REFUSE message, the en-gNB shall regard the requested change as failed and may take further actions like triggering the SgNB initiated SgNB Release procedure to release all en-gNB resources allocated for the UE.

Interaction with the MeNB initiated handover procedure:

If the MeNB, after having initiated the handover procedure, receives the SGNB CHANGE REQUIRED message, the MeNB shall refuse the SgNB change procedure with an appropriate cause value in the Cause IE.

8.7.9 MeNB initiated SgNB Release

8.7.9.1 General

The MeNB initiated SgNB Release procedure is triggered by the MeNB to initiate the release of the resources for a specific UE.

The procedure uses UE-associated signalling.

8.7.9.2 Successful Operation

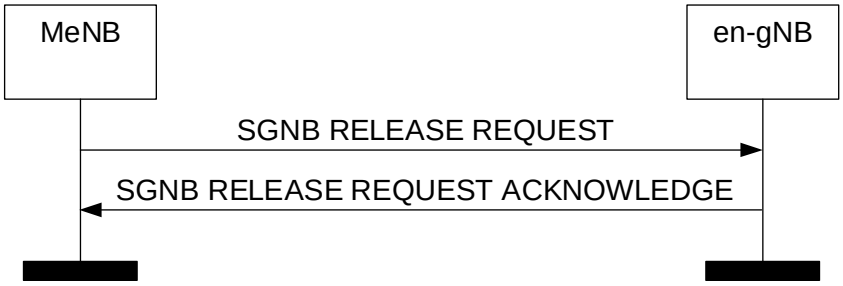


Figure 8.7.9.2-1: MeNB initiated SgNB Release, successful operation

The MeNB initiates the procedure by sending the SGNB RELEASE REQUEST message. Upon reception of the SGNB RELEASE REQUEST message the en-gNB shall stop providing user data to the UE. The *SgNB UE X2AP ID* IE shall be included if it has been obtained from the en-gNB.

If the bearer context in the en-gNB was configured with the PDCP entity in the en-gNB, for E-RAB for which the MeNB requests forwarding of uplink/downlink data, the MeNB includes the *UL Forwarding GTP Tunnel Endpoint*/ *DL Forwarding GTP Tunnel Endpoint* IE within the *E-RABs To Be Released Item* IE of the SGNB RELEASE REQUEST message to indicate that the en-gNB should perform data forwarding of uplink/downlink packets for that E-RAB.

Upon reception of the SGNB RELEASE REQUEST message containing *UE Context Kept Indicator* IE set to “True”, the en-gNB shall, if supported, only initiate the release of the resources related to the UE-associated signalling connection between the MeNB and the en-gNB.

If the en-gNB confirms the request to release en-gNB resources it shall send the SGNB RELEASE REQUEST ACKNOWLEDGE message to the MeNB.

8.7.9.3 Unsuccessful Operation

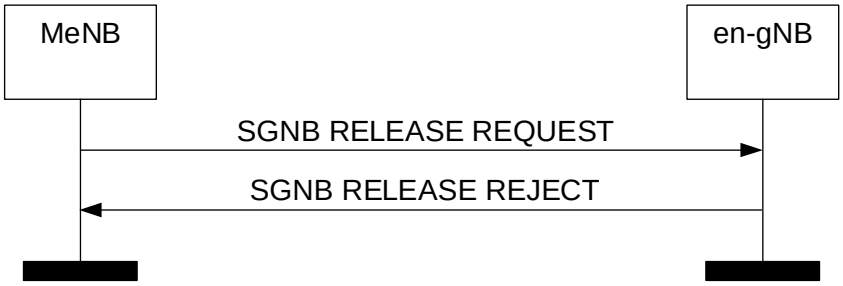


Figure 8.7.9.3-1: MeNB initiated SgNB Release, unsuccessful operation

If the en-gNB cannot confirm the request to release en-gNB resources it shall send the SGNB RELEASE REQUEST REJECT message to the MeNB with an appropriate cause indicated in the *Cause* IE.

8.7.9.4 Abnormal Conditions

If the SGNB RELEASE REQUEST message refer to a context that does not exist, the en-gNB shall ignore the message.

When the MeNB has initiated the procedure and did not include the *SgNB UE X2AP ID* IE the MeNB shall regard the resources for the UE at the en-gNB as being fully released.

Interactions with the UE Context Release procedure:

If the MeNB does not receive the reply from the en-gNB before it has to relase the EN-DC connection, or it receives SGNB RELEASE REQUEST REJECT, it may trigger the UE Context Release procedure. If the en-gNB received the UE CONTEXT RELEASE right after receiving the SGNB RELEASE REQUEST (and before or after responding to it), the en-gNB shall consider the related MeNB initiated SgNB Release procedure as being the resolution of abnormal conditions and release the related UE context immediately.

8.7.10 SgNB initiated SgNB Release

8.7.10.1 General

This procedure is triggered by the en-gNB to initiate the release of the resources for a specific UE.

The procedure uses UE-associated signalling.

8.7.10.2 Successful Operation

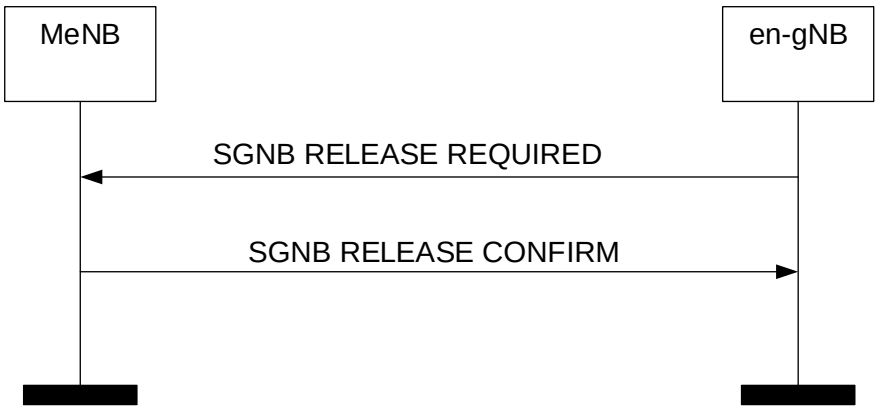


Figure 8.7.10.2-1: SgNB initiated SgNB Release, successful operation.

The en-gNB initiates the procedure by sending the SGNB RELEASE REQUIRED message to the MeNB.

Upon reception of the SGNB RELEASE REQUIRED message, the MeNB replies with the SGNB RELEASE CONFIRM message. For each E-RAB configured with the PDCP entity in the en-gNB, the MeNB may include the *DL Forwarding GTP Tunnel Endpoint* IE and the *UL Forwarding GTP Tunnel Endpoint* IE within the *E-RABs To Be Released Item* IE to indicate that it requests data forwarding of uplink and downlink packets to be performed for that bearer. For each E-RAB configured with the PDCP entity in the MeNB and SCG resources, the MeNB may include the *DL Forwarding GTP Tunnel Endpoint* IE within the *E-RABs To Be Released Item* IE to indicate that it requests data forwarding of downlink packets to be performed for that bearer.

The en-gNB may start data forwarding and stop providing user data to the UE upon reception of the SGNB RELEASE CONFIRM message.

8.7.10.3 Unsuccessful Operation

Not applicable.

8.7.10.4 Abnormal Conditions

Void.

8.7.11 SgNB Counter Check

8.7.11.1 General

This procedure is initiated by the en-gNB to request the MeNB to execute a counter check procedure to verify the value of the PDCP COUNTs associated with SN terminated bearers.

The procedure uses UE-associated signalling.

8.7.11.2 Successful Operation

Figure 8.7.11.2-1: SgNB Counter Check procedure, successful operation.

The en-gNB initiates the procedure by sending the SGNB COUNTER CHECK REQUEST message to the MeNB.

Upon reception of the SGNB COUNTER CHECK REQUEST message, the MeNB may perform the RRC counter check procedure as defined in TS 33.401 [18].

8.7.11.3 Unsuccessful Operation

Not applicable.

8.7.11.4 Abnormal Conditions

Not applicable.

8.7.12 RRC Transfer

8.7.12.1 General

The purpose of the RRC Transfer procedure is to deliver an LTE RRC message encapsulated in a PDCP-C PDU to the en-gNB so that it may then be forwarded to the UE, or from the en-gNB, if it was received from the UE. Delivery status may also be provided from the en-gNB to the MeNB using the RRC Transfer.

The procedure is also to enable transfer of the NR RRC message container with the NR measurements from the MeNB to the en-gNB, when received from the UE.

The procedure uses UE-associated signalling.

8.7.12.2 Successful Operation

Figure 8.7.12.2-1: RRC Transfer procedure, successful operation.

Either the MeNB initiates the procedure by sending the RRC TRANSFER message to the en-gNB or the en-gNB initiates the procedure by sending the RRC TRANSFER message to the MeNB.

If the en-gNB receives an RRC TRANSFER message without the *RRC Container* IE in the *Split SRB* IE, the *Delivery Status* IE in the *Split SRB* IE or the *RRC container* IE in *NR UE Measurement* IE, it shall ignore the message. If the en-gNB receives the *RRC Container* IE in the *MCG split SRB* IE, it shall deliver the contained RRC message to the UE.

If the MeNB receives the *Delivery Status* IE in the *split SRB* IE the MeNB shall consider RRC messages up to the indicated NR PDCP SN as having been successfully delivered to UE by en-gNB.

8.7.12.3 Abnormal Conditions

In case of the split SRBs, the receiving node may ignore the message, if the MeNB has not indicated possibility of RRC transfer at the bearer setup.

8.7.13 Secondary RAT Data Usage Report

8.7.13.1 General

This procedure is initiated by the en-gNB to report secondary RAT data volume.

The procedure uses UE-associated signalling.

8.7.13.2 Successful Operation

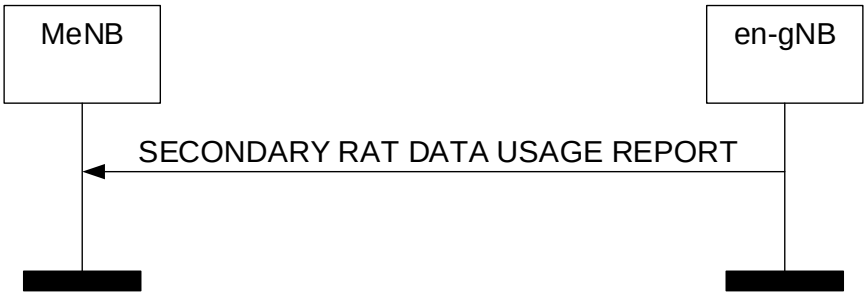


Figure 8.7.13.2-1: Secondary RAT Data Usage Report procedure, successful operation.

The en-gNB initiates the procedure by sending the SECONDARY RAT DATA USAGE REPORT message to the MeNB.

8.7.13.3 Unsuccessful Operation

Not applicable.

8.7.13.4 Abnormal Conditions

Not applicable.

8.7.14 Partial reset of EN-DC

8.7.14.1 General

This procedure is triggered by the en-gNB or the MeNB to initiate the reset of the resources for selected UEs.

The procedure uses non UE-associated signalling.

8.7.14.2 Successful Operation

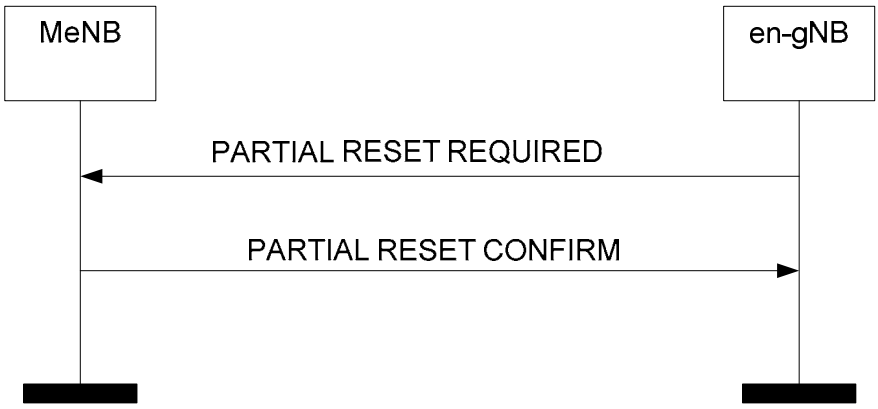


Figure 8.7.14.2-1: en-gNB initiated Partial Reset of EN-DC, successful operation.

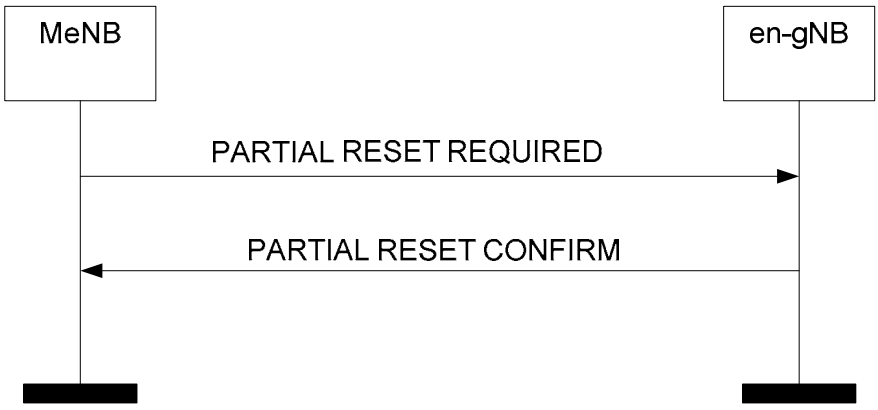


Figure 8.7.14.2-2: eNB initiated Partial Reset of EN-DC, successful operation.

The en-gNB or MeNB initiates the procedure by sending the PARTIAL RESET REQUIRED message to the MeNB or the en-gNB.

In case of the eNB-initiated Partial Reset, at reception of the PARTIAL RESET REQUIRED message, the en-gNB node shall release all allocated resources on X2 and Uu related to the UE association(s) indicated in the PARTIAL RESET REQUIRED message and remove the indicated UE contexts including X2AP ID.

In case of the en-gNB-initiated Partial Reset, at reception of the PARTIAL RESET REQUIRED message, the eNB may decide to release all allocated resources on X2 and Uu related to the UE association(s) indicated in the PARTIAL RESET REQUIRED message and remove the indicated UE contexts including X2AP ID, or to reconfigure the UEs for MN-terminated MCG bearers.

After the receiving node has released or reconfigured all assigned X2 resources and the UE X2AP IDs for all indicated UE associations which can be used for new UE-associated logical X2-connections over the X2 interface, the receiving node shall respond with the PARTIAL RESET CONFIRM message. The node receiving the request does not need to wait for the release or reconfiguration of radio resources to be completed before returning the PARTIAL RESET CONFIRM message.

The node initiating the procedure shall include the *SgNB UE X2AP ID* IE in the PARTIAL RESET REQUIRED message if it has already been allocated for the UE. The node receiving the request shall use the *SgNB UE X2AP ID* IE (if included) and/or the *MeNB UE S1AP ID* IE (and the *MeNB UE S1AP ID Extension* IE, if included) to identify the UE association(s) to be released. If the *SgNB UE X2AP ID* IE was included in the PARTIAL RESET REQUIRED message, the receiving node shall include it also in the PARTIAL RESET CONFIRM message.

The node receiving the request shall include in the PARTIAL RESET CONFIRM message, for each UE association to be released, the same list of UE-associated logical X2-connections over X2. The list shall be in the same order as received in the PARTIAL RESET REQUIRED message and shall include also unknown UE-associated logical X2-connections.

Interactions with other procedures:

If the PARTIAL RESET REQUIRED message is received, any other ongoing procedure (except for a Reset or another Partial Reset of EN-DC procedures) on the same X2 interface related to a UE association, indicated in the PARTIAL RESET REQUIRED message, shall be aborted.

8.7.14.3 Unsuccessful Operation

Not applicable.

8.7.14.4 Abnormal Conditions

Void.

8.7.15 E-UTRA – NR Cell Resource Coordination

8.7.15.1 General

The purpose of the E-UTRA – NR Cell Resource Coordination procedure is to enable coordination of radio resource allocation between an eNB and an en-gNB that are sharing spectrum and whose coverage areas are fully or partially overlapping. During the procedure, the eNB and en-gNB shall exchange their intended resource allocations for data traffic, and, if possible, converge to a shared resource.

The procedure uses non-UE-associated signalling.

8.7.15.2 Successful Operation

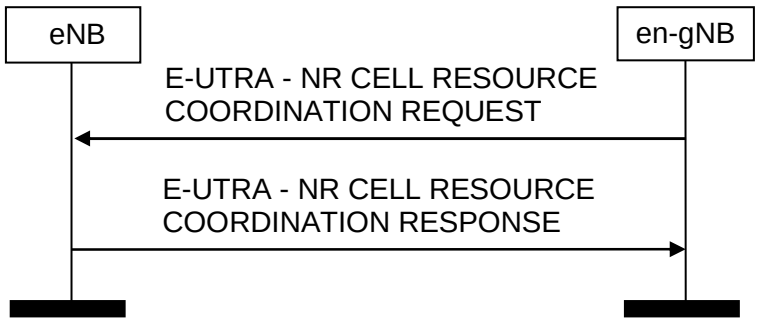


Figure 8.7.15.2-1: eNB-initiated E-UTRA – NR Cell Resource Coordination request, successful operation

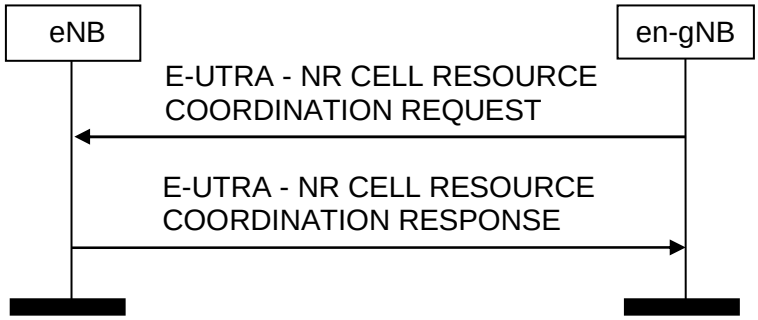


Figure 8.7.15.2-2: en-gNB-initiated E-UTRA – NR Cell Resource Coordination request, successful operation

eNB initiated E-UTRA – NR Cell Resource Coordination:

An eNB initiates the procedure by sending the E-UTRA – NR CELL RESOURCE COORDINATION REQUEST message to an en-gNB over the X2 interface. The en-gNB extracts the *Data Traffic Resource Indication* IE and it replies by sending the E-UTRA – NR CELL RESOURCE COORDINATION RESPONSE message. The en-gNB shall calculate the full eNB resource allocation by combining the *Data Traffic Resource Indication* IE and the *Protected E-UTRA Resource Indication* IE that were most recently received from the eNB.

In case of conflict between the most recently received *Data Traffic Resource Indication* IE and the most recently received *Protected E-UTRA Resource Indication* IE, the en-gNB shall give priority to the *Protected E-UTRA Resource Indication* IE.

en-gNB initiated E-UTRA – NR Cell Resource Coordination:

An en-gNB initiates the procedure by sending the E-UTRA – NR CELL RESOURCE COORDINATION REQUEST message to an eNB. The eNB replies with the E-UTRA – NR CELL RESOURCE COORDINATION RESPONSE message.

In case of conflict between the most recently received *Data Traffic Resource Indication* IE and the most recently received *Protected E-UTRA Resource Indication* IE, the en-gNB shall give priority to the *Protected E-UTRA Resource Indication* IE.

8.7.16 SgNB Activity Notification

8.7.16.1 General

The purpose of the SgNB Activity Notification procedure is to allow an en-gNB to send a notification to an eNB concerning user data traffic activity of already established E-RABs. The procedure uses UE-associated signalling.

8.7.16.2 Successful Operation

Figure 8.7.16.2-1: Activity Notification procedure, successful operation

The en-gNB initiates the procedure by sending an SGNB ACTIVITY NOTIFICATION message to the eNB.

The SGNB ACTIVITY NOTIFICATION message may contain notification for UE context level user plane activity in the *UE Context level user plane activity report* IE.

The NOTIFY message may contain notification for activity of E-RABs.

8.7.16.3 Abnormal Conditions

Void,

9 Elements for X2AP Communication

9.0 General

Sub clauses 9.1 and 9.2 describe the structure of the messages and information elements required for the X2AP protocol in tabular format. Sub clause 9.3 provides the corresponding ASN.1 definition.

The following attributes are used for the tabular description of the messages and information elements: Presence, Range Criticality and Assigned Criticality. Their definition and use can be found in TS 36.413 [4].

NOTE: The messages have been defined in accordance to the guidelines specified in TR 25.921 [30].

9.1 Message Functional Definition and Content

9.1.1 Messages for Basic Mobility Procedures

9.1.1.1 HANDOVER REQUEST

This message is sent by the source eNB to the target eNB to request the preparation of resources for a handover.

Direction: source eNB → target eNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
Old eNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the source eNB	YES	reject
Cause	M		9.2.6		YES	ignore
Target Cell ID	M		ECGI 9.2.14		YES	reject
GUMMEI	M		9.2.16		YES	reject
UE Context Information		*1*			YES	reject
>MME UE S1AP ID	M		INTEGER (0..2^{32} -1)	MME UE S1AP ID allocated at the MME	–	–
>UE Security Capabilities	M		9.2.29		–	–
>AS Security Information	M		9.2.30		–	–
>UE Aggregate Maximum Bit Rate	M		9.2.12		–	–
>Subscriber Profile ID for RAT/Frequency priority	O		9.2.25		–	–
>E-RABs To Be Setup List		*1*			–	–
>>E-RABs To Be Setup Item		*1 .. <maxnoof Bearers>*			EACH	ignore
>>>E-RAB ID	M		9.2.23		–	–
>>>E-RAB Level QoS Parameters	M		9.2.9	Includes necessary QoS parameters	–	–
>>>DL Forwarding	O		9.2.5		–	–
>>>UL GTP Tunnel Endpoint	M		GTP Tunnel Endpoint 9.2.1	SGW endpoint of the S1 transport bearer. For delivery of UL PDUs.	–	–
>>>Bearer Type	O		9.2.92		YES	reject
>RRC Context	M		OCTET STRING	Includes the RRC *HandoverPreparationInformation* message as defined in subclause 10.2.2 of TS 36.331 [9], or the RRC *HandoverPreparationInformation-NB* message as defined in 10.6.2 of TS 36.331 [9].	–	–
>Handover Restriction List	O		9.2.3		–	–
>Location Reporting Information	O		9.2.21	Includes the necessary parameters for location reporting	–	–
>Management Based MDT Allowed	O		9.2.59		YES	ignore
>Management Based MDT PLMN List	O		MDT PLMN List 9.2.64		YES	ignore
>UE Sidelink Aggregate Maximum Bit Rate	O		9.2.97	This IE applies only if the UE is authorized for V2X services.	YES	Ignore
UE History Information	M		9.2.38	Same definition as in TS 36.413 [4]	YES	ignore
Trace Activation	O		9.2.2		YES	ignore
SRVCC Operation Possible	O		9.2.33		YES	ignore
CSG Membership Status	O		9.2.52		YES	reject

Mobility Information	O		BIT STRING (SIZE (32))	Information related to the handover; the source eNB provides it in order to enable later analysis of the conditions that led to a wrong HO.	YES	ignore
Masked IMEISV	O		9.2.69		YES	ignore
UE History Information from the UE	O		OCTET STRING	VisitedCellInfoList contained in the UEInformationResponse message (TS 36.331 [9])	YES	ignore
Expected UE Behaviour	O		9.2.70		YES	ignore
ProSe Authorized	O		9.2.78		YES	ignore
UE Context Reference at the SeNB	O				YES	ignore
>Global SeNB ID	M		Global eNB ID 9.2.22			
>SeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the SeNB		
>SeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the SeNB		
Old eNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the source eNB	YES	reject
V2X Services Authorized	O		9.2.93		YES	ignore
UE Context Reference at the WT	O				YES	ignore
>WT ID	M		9.2.95			
>WT UE XwAP ID	M		9.2.96			
UE Context Reference at the SgNB	O				YES	ignore
>Global en-gNB ID	M		9.2.112			
>SgNB UE X2AP ID	M		en-gNB UE X2AP ID 9.2.100	Allocated at the SgNB.	–	–
NR UE Security Capabilities	O		9.2.107		YES	ignore
Aerial UE subscription information	O		9.2.129		YES	ignore

Range bound	Explanation
maxnoofBearers	Maximum no. of E-RABs. Value is 256
maxnoofMDTPLMNs	PLMNs in the Management Based MDT PLMN list. Value is 16.

9.1.1.2 HANDOVER REQUEST ACKNOWLEDGE

This message is sent by the target eNB to inform the source eNB about the prepared resources at the target.

Direction: target eNB → source eNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
Old eNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the source eNB	YES	ignore
New eNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the target eNB	YES	ignore
E-RABs Admitted List		*1*			YES	ignore
> E-RABs Admitted Item		*1 .. <maxnoof Bearers>*			EACH	ignore
>>E-RAB ID	M		9.2.23		–	–
>>UL GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	Identifies the X2 transport bearer used for forwarding of UL PDUs	–	–
>>DL GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	Identifies the X2 transport bearer. used for forwarding of DL PDUs	–	–
E-RABs Not Admitted List	O		E-RAB List 9.2.28	A value for *E-RAB ID* shall only be present once in *E-RABs Admitted List* IE and in *E-RABs Not Admitted List* IE.	YES	ignore
Target eNB To Source eNB Transparent Container	M		OCTET STRING	Includes the RRC E-UTRA Handover Command message as defined in subclause 10.2.2 in TS 36.331 [9]	YES	ignore
Criticality Diagnostics	O		9.2.7		YES	ignore
UE Context Kept Indicator	O		9.2.85		YES	ignore
Old eNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the source eNB	YES	ignore
New eNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the target eNB	YES	reject
WT UE Context Kept Indicator	O		UE Context Kept Indicator 9.2.85	Indicates that the WT has acknowledged to keep the UE context	YES	ignore

Range bound	Explanation
maxnoofBearers	Maximum no. of E-RABs. Value is 256

9.1.1.3 HANDOVER PREPARATION FAILURE

This message is sent by the target eNB to inform the source eNB that the Handover Preparation has failed.

Direction: target eNB → source eNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
Old eNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the source eNB	YES	ignore
Cause	M		9.2.6		YES	ignore
Criticality Diagnostics	O		9.2.7		YES	ignore
Old eNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the source eNB	YES	ignore

9.1.1.4 SN STATUS TRANSFER

This message is sent by the source eNB to the target eNB to transfer the uplink/downlink PDCP SN and HFN status during a handover or for EN-DC.

Direction: source eNB → target eNB (handover), eNB from which the E-RAB context is transferred → eNB to which the E-RAB context is transferred (dual connectivity), eNB/en-gNB from which the E-RAB context is transferred → en-gNB/eNB to which the E-RAB context is transferred (EN-DC).

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	ignore
Old eNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated for handover at the source eNB and for dual connectivity/EN-DC at the eNB from which the E-RAB context is transferred	YES	reject
New eNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated for handover at the target eNB and for dual connectivity/EN-DC at the eNB to which the E-RAB context is transferred	YES	reject
E-RABs Subject To Status Transfer List		*1*			YES	ignore
>E-RABs Subject To Status Transfer Item		*1 .. <maxnoof Bearers>*			EACH	ignore
>>E-RAB ID	M		9.2.23		–	–
>>Receive Status Of UL PDCP SDUs	O		BIT STRING (4096)	PDCP Sequence Number = (First Missing SDU Number + bit position) modulo 4096 0: PDCP SDU has not been received. 1: PDCP SDU has been received correctly.	–	–
>>UL COUNT Value	M		COUNT Value 9.2.15	PDCP-SN and Hyper Frame Number of the first missing UL SDU in case of 12 bit long PDCP-SN	–	–
>>DL COUNT Value	M		COUNT Value 9.2.15	PDCP-SN and Hyper frame number that the target eNB/en-gNB should assign for the next DL SDU not having an SN yet in case of 12 bit long PDCP-SN	–	–
>>Receive Status Of UL PDCP SDUs Extended	O		BIT STRING (1..16384)	The IE is used in case of 15 bit long PDCP-SN in this release. The first bit indicates the status of the SDU after the First Missing UL PDCP SDU. The N^{th} bit indicates the status of the UL PDCP SDU in position (N + First Missing SDU Number) modulo (1 + the maximum value of the PDCP-SN). 0: PDCP SDU has not been received. 1: PDCP SDU has been received correctly.	YES	ignore

>>UL COUNT Value Extended	O		COUNT Value Extended 9.2.66	PDCP-SN and Hyper Frame Number of the first missing UL SDU in case of 15 bit long PDCP-SN	YES	ignore
>>DL COUNT Value Extended	O		COUNT Value Extended 9.2.66	PDCP-SN and Hyper Frame Number that the target eNB/en-gNB should assign for the next DL SDU not having an SN yet in case of 15 bit long PDCP-SN	YES	ignore
>>Receive Status Of UL PDCP SDUs for PDCP SN Length 18	O		BIT STRING (1..131072)	The IE is used in case of 18 bit long PDCP-SN. The first bit indicates the status of the SDU after the First Missing UL PDCP SDU. The Nth bit indicates the status of the UL PDCP SDU in position (N + First Missing SDU Number) modulo (1 + the maximum value of the PDCP-SN). 0: PDCP SDU has not been received. 1: PDCP SDU has been received correctly.	YES	ignore
>>UL COUNT Value for PDCP SN Length 18	O		COUNT Value for PDCP SN Length 18 9.2.82	PDCP-SN and Hyper Frame Number of the first missing UL SDU in case of 18 bit long PDCP-SN	YES	ignore
>>DL COUNT Value for PDCP SN Length 18	O		COUNT Value for PDCP SN Length 18 9.2.82	PDCP-SN and Hyper Frame Number that the target eNB/en-gNB should assign for the next DL SDU not having an SN yet in case of 18 bit long PDCP-SN	YES	ignore
Old eNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated for handover at the source eNB and for dual connectivity/EN-DC at the eNB from which the E-RAB context is transferred.	YES	reject
New eNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated for handover at the target eNB and for dual connectivity/EN-DC at the eNB to which the E-RAB context is transferred.	YES	reject
SgNB UE X2AP ID	O		en-gNB UE X2AP ID 9.2.100	Allocated for EN-DC at the SgNB.	YES	ignore

Range bound	Explanation
maxnoofBearers	Maximum no. of E-RABs. Value is 256.

9.1.1.5 UE CONTEXT RELEASE

This message is sent by the target eNB to the source eNB to indicate that resources can be released.

Direction: target eNB → source eNB (handover), MeNB → SeNB (dual connectivity), MeNB → en-gNB (EN-DC).

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	ignore
Old eNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated for handover at the source eNB and for dual connectivity at the SeNB.	YES	reject
New eNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated for handover at the target eNB and for dual connectivity/EN-DC at the MeNB.	YES	reject
Old eNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated for handover at the source eNB and for dual connectivity at the SeNB.	YES	reject
New eNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated for handover at the source eNB and for dual connectivity/EN-DC at the MeNB.	YES	reject
SIPTO Bearer Deactivation Indication	O		ENUMERATED (True, …,)	Indicates that SIPTO@LN PDN connection deactivation is needed.	YES	ignore
SgNB UE X2AP ID	O		en-gNB UE X2AP ID 9.2.100	Allocated for EN-DC at the SgNB.	YES	ignore

9.1.1.6 HANDOVER CANCEL

This message is sent by the source eNB to the target eNB to cancel an ongoing handover.

Direction: source eNB → target eNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	ignore
Old eNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the source eNB	YES	reject
New eNB UE X2AP ID	O		eNB UE X2AP ID 9.2.24	Allocated at the target eNB	YES	ignore
Cause	M		9.2.6		YES	ignore
Old eNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the source eNB	YES	reject
New eNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the target eNB	YES	ignore

9.1.2 Messages for global procedures

9.1.2.1 LOAD INFORMATION

This message is sent by an eNB to neighbouring eNBs to transfer load and interference co-ordination information.

Direction: $eNB_1 \rightarrow eNB_2$.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	ignore
Cell Information	M				YES	ignore
>Cell Information Item		*1 .. <maxCellineNB>*			EACH	ignore
>>Cell ID	M		ECGI 9.2.14	Id of the source cell	–	–
>>UL Interference Overload Indication	O		9.2.17		–	–
>>UL High Interference Information		*0 .. <maxCellineNB>*			–	–
>>>Target Cell ID	M		ECGI 9.2.14	Id of the cell for which the HII is meant	–	–
>>>UL High Interference Indication	M		9.2.18		–	–
>>Relative Narrowband Tx Power (RNTP)	O		9.2.19		–	–
>>ABS Information	O		9.2.54		YES	ignore
>>Invoke Indication	O		9.2.55		YES	ignore
>>Intended UL-DL Configuration	O		ENUMERATED(sa0, sa1, sa2, sa3, sa4, sa5, sa6,…)	One of the UL-DL configurations defined in TS 36.211 [10]. The UL subframe(s) in the indicated configuration is subset of those in SIB1 UL-DL configuration. This IE applies to TDD only.	YES	ignore
>>Extended UL Interference Overload Info	O		9.2.67	This IE applies to TDD only.	YES	ignore
>>CoMP Information	O		9.2.74		YES	ignore
>>Dynamic DL transmission information	O		9.2.77		YES	ignore

Range bound	Explanation
maxCellineNB	Maximum no. cells that can be served by an eNB. Value is 256.

9.1.2.2 ERROR INDICATION

This message is used to indicate that some error has been detected in the eNB/en-gNB.

Direction: $eNB_1 \rightarrow eNB_2$ or eNB → en-gNB or en-gNB → eNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	ignore
Old eNB UE X2AP ID	O		eNB UE X2AP ID 9.2.24	Allocated for handover at the source eNB and for dual connectivity at the SeNB or the eNB from which the E-RAB context is transferred.	YES	ignore
New eNB UE X2AP ID	O		eNB UE X2AP ID 9.2.24	Allocated for handover at the target eNB and for dual connectivity/EN-DC at the MeNB or the eNB to which the E-RAB context is transferred.	YES	ignore
Cause	O		9.2.6		YES	ignore
Criticality Diagnostics	O		9.2.7		YES	ignore
Old eNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated for handover at the source eNB and for dual connectivity at the SeNB or the eNB from which the E-RAB context is transferred.	YES	ignore
New eNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated for handover at the target eNB and for dual connectivity at the MeNB or the eNB to which the E-RAB context is transferred.	YES	ignore
Old en-gNB UE X2AP ID	O		en-gNB UE X2AP ID 9.2.100	Allocated for EN-DC at the en-gNB.	YES	ignore

9.1.2.3 X2 SETUP REQUEST

This message is sent by an eNB to a neighbouring eNB to transfer the initialization information for a TNL association.

Direction: $eNB_1 \rightarrow eNB_2$.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
Global eNB ID	M		9.2.22		YES	reject
Served Cells		*1 .. <maxCellineNB>*		Complete list of cells served by the eNB	YES	reject
>Served Cell Information	M		9.2.8		–	–
>Neighbour Information		*0 .. <maxnoofNeighbours>*			–	–
>>ECGI	M		ECGI 9.2.14	E-UTRAN Cell Global Identifier of the neighbour cell	–	–
>>PCI	M		INTEGER (0..503, …)	Physical Cell Identifier of the neighbour cell	–	–
>>EARFCN	M		9.2.26	DL EARFCN for FDD or EARFCN for TDD	–	–
>>TAC	O		OCTET STRING (2)	Tracking Area Code	YES	ignore
>>EARFCN Extension	O		9.2.65	DL EARFCN for FDD or EARFCN for TDD. If this IE is present, the value signalled in the *EARFCN* IE is ignored.	YES	reject
GU Group Id List		*0 .. <maxfPools>*		List of all the pools to which the eNB belongs	GLOBAL	reject
>GU Group Id	M		9.2.20		-	-
LHN ID	O		9.2.83		YES	ignore

Range bound	Explanation
maxCellineNB	Maximum no. cells that can be served by an eNB. Value is 256.
maxnoofNeighbours	Maximum no. of neighbour cells associated to a given served cell. Value is 512.
maxPools	Maximum no. of pools an eNB can belong to. Value is 16.

9.1.2.4 X2 SETUP RESPONSE

This message is sent by an eNB to a neighbouring eNB to transfer the initialization information for a TNL association.

Direction: $eNB_2 \rightarrow eNB_1$.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
Global eNB ID	M		9.2.22		YES	reject
Served Cells		*1 .. <maxCellineNB>*		Complete list of cells served by the eNB	GLOBAL	reject
>Served Cell Information	M		9.2.8		–	–
>Neighbour Information		*0 .. <maxnoofNeighbours>*			–	–
>>ECGI	M		ECGI 9.2.14	E-UTRAN Cell Global Identifier of the neighbour cell	–	–
>>PCI	M		INTEGER (0..503, …)	Physical Cell Identifier of the neighbour cell	–	–
>>EARFCN	M		9.2.26	DL EARFCN for FDD or EARFCN for TDD	–	–
>>TAC	O		OCTET STRING (2)	Tracking Area Code	YES	ignore
>>EARFCN Extension	O		9.2.65	DL EARFCN for FDD or EARFCN for TDD. If this IE is present, the value signalled in the *EARFCN* IE is ignored.	YES	reject
GU Group Id List		*0 .. <maxPools>*		List of all the pools to which the eNB belongs	GLOBAL	reject
>GU Group Id	M		9.2.20		-	-
Criticality Diagnostics	O		9.2.7		YES	ignore
LHN ID	O		9.2.83		YES	ignore

Range bound	Explanation
maxCellineNB	Maximum no. cells that can be served by an eNB. Value is 256.
maxnoofNeighbours	Maximum no. of neighbour cells associated to a given served cell. Value is 512.
maxPools	Maximum no. of pools an eNB can belong to. Value is 16.

9.1.2.5 X2 SETUP FAILURE

This message is sent by the eNB to indicate X2 Setup failure.

Direction: $eNB_2 \rightarrow eNB_1$.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
Cause	M		9.2.6		YES	ignore
Time To Wait	O		9.2.32		YES	ignore
Criticality Diagnostics	O		9.2.7		YES	ignore

9.1.2.6 RESET REQUEST

This message is sent from one eNB to another eNB/en-gNB or from en-gNB to an eNB and is used to request the X2 interface between the two eNB or between an eNB and an en-gNB to be reset.

Direction: $eNB_1 \rightarrow eNB_2$, eNB → en-gNB, en-gNB → eNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
Cause	M		9.2.6		YES	ignore

9.1.2.7 RESET RESPONSE

This message is sent by a eNB/en-gNB as a response to a RESET REQUEST message.

Direction: $eNB_2 \rightarrow eNB_1$, eNB → en-gNB, en-gNB → eNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
Criticality Diagnostics	O		9.2.7		YES	ignore

9.1.2.8 ENB CONFIGURATION UPDATE

This message is sent by an eNB to a peer eNB to transfer updated information for a TNL association.

Direction: $eNB_1 \rightarrow eNB_2$.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
Served Cells To Add		*0 .. <maxCellineNB>*		Complete list of added cells served by the eNB	GLOBAL	reject
>Served Cell Information	M		9.2.8		–	–
>Neighbour Information		*0 .. <maxnoofNeighbours>*			–	–
>>ECGI	M		ECGI 9.2.14	E-UTRAN Cell Global Identifier of the neighbour cell	–	–
>>PCI	M		INTEGER (0..503, …)	Physical Cell Identifier of the neighbour cell	–	–
>>EARFCN	M		9.2.26	DL EARFCN for FDD or EARFCN for TDD	–	–
>>TAC	O		OCTET STRING (2)	Tracking Area Code	YES	ignore
>>EARFCN Extension	O		9.2.65	DL EARFCN for FDD or EARFCN for TDD. If this IE is present, the value signalled in the *EARFCN* IE is ignored.	YES	reject
Served Cells To Modify		*0 .. <maxCellineNB>*		Complete list of modified cells served by the eNB	GLOBAL	reject
>Old ECGI	M		ECGI 9.2.14	Old E-UTRAN Cell Global Identifier	-	-
>Served Cell Information	M		9.2.8		–	–
>Neighbour Information		*0 .. <maxnoofNeighbours>*			–	–
>>ECGI	M		ECGI 9.2.14	E-UTRAN Cell Global Identifier of the neighbour cell	–	–
>>PCI	M		INTEGER (0..503, …)	Physical Cell Identifier of the neighbour cell	–	–
>>EARFCN	M		9.2.26	DL EARFCN for FDD or EARFCN for TDD	–	–
>>TAC	O		OCTET STRING (2)	Tracking Area Code	YES	ignore
>>EARFCN Extension	O		9.2.65	DL EARFCN for FDD or EARFCN for TDD. If this IE is present, the value signalled in the *EARFCN* IE is ignored.	YES	reject

>Deactivation Indication	O		ENUMERATED(deactivated, …)	Indicates that the concerned cell is switched off for energy saving reasons	YES	ignore
Served Cells To Delete		*0 .. <maxCellineNB>*		Complete list of deleted cells served by the eNB	GLOBAL	reject
>Old ECGI	M		ECGI 9.2.14	Old E-UTRAN Cell Global Identifier of the cell to be deleted	-	-
GU Group Id To Add List		*0 .. <maxPools>*			GLOBAL	reject
>GU Group Id	M		9.2.20		-	-
GU Group Id To Delete List		*0 .. <maxPools>*			GLOBAL	reject
>GU Group Id	M		9.2.20		-	-
Coverage Modification List		*0 .. <maxCellineNB>*		List of cells with modified coverage	GLOBAL	reject
>ECGI	M		ECGI 9.2.14	E-UTRAN Cell Global Identifier of the cell to be modified	-	-
>Cell Coverage State	M		INTEGER (0..15, …)	Value ‘0’ indicates that the cell is inactive. Other values Indicates that the cell is active and also indicates the coverage configuration of the concerned cell	-	-
>Cell Deployment Status Indicator	O		ENUMERATED(pre-change-notification, ...)	Indicates the Cell Coverage State is planned to be used at the next reconfiguration		
>Cell Replacing Info	C-ifCellDeploymentStatusIndicatorPresent					
>>Replacing Cells		*0 .. <maxCellineNB>*				
>>>ECGI			ECGI 9.2.14	E-UTRAN Cell Global Identifier of a cell that may replace all or part of the coverage of the cell to be modified		

Range bound	Explanation
maxCellineNB	Maximum no. cells that can be served by an eNB. Value is 256.
maxnoofNeighbours	Maximum no. of neighbour cells associated to a given served cell. Value is 512.
maxPools	Maximum no. of pools an eNB can belong to. Value is 16.

Condition	Explanation
ifCellDeploymentStatusIndicatorPresent	This IE shall be present if the *Cell Deployment Status Indicator* IE is present.

9.1.2.9 ENB CONFIGURATION UPDATE ACKNOWLEDGE

This message is sent by an eNB to a peer eNB to acknowledge update of information for a TNL association.

Direction: $eNB_2 \rightarrow eNB_1$.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
Criticality Diagnostics	O		9.2.7		YES	ignore

9.1.2.10 ENB CONFIGURATION UPDATE FAILURE

This message is sent by an eNB to a peer eNB to indicate eNB Configuration Update Failure.

Direction: $eNB_2 \rightarrow eNB_1$.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
Cause	M		9.2.6		YES	ignore
Time To Wait	O		9.2.32		YES	ignore
Criticality Diagnostics	O		9.2.7		YES	ignore

9.1.2.11 RESOURCE STATUS REQUEST

This message is sent by an eNB_1 to neighbouring eNB_2 to initiate the requested measurement according to the parameters given in the message.

Direction: $eNB_1 \rightarrow eNB_2$.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
eNB1 Measurement ID	M		INTEGER (1..4095,...)	Allocated by eNB_1	YES	reject
eNB2 Measurement ID	C-ifRegistrationRequestStoporPartialStoporAdd		INTEGER (1..4095,...)	Allocated by eNB_2	YES	ignore
Registration Request	M		ENUMERATED(start, stop, …, partial stop, add)	Type of request for which the resource status is required.	YES	reject
Report Characteristics	O		BITSTRING (SIZE(32))	Each position in the bitmap indicates measurement object the eNB_2 is requested to report. First Bit = PRB Periodic, Second Bit = TNL load Ind Periodic, Third Bit = HW Load Ind Periodic, Fourth Bit = Composite Available Capacity Periodic, this bit should be set to 1 if at least one of the First, Second or Third bits is set to 1, Fifth Bit = ABS Status Periodic, Sixth Bit = RSRP Measurement Report Periodic, Seventh Bit = CSI Report Periodic. Other bits shall be ignored by the eNB_2.	YES	reject
Cell To Report		*1*		Cell ID list to which the request applies.	YES	ignore
>Cell To Report Item		*1 .. <maxCellineNB>*			EACH	ignore
>>Cell ID	M		ECGI 9.2.14		–	–
Reporting Periodicity	O		ENUMERATED(1000ms, 2000ms, 5000ms,10000ms, …)	Periodicity that can be used for reporting of PRB Periodic, TNL Load Ind Periodic, HW Load Ind Periodic, Composite Available Capacity Periodic or ABS Status Periodic.	YES	ignore
Partial Success Indicator	O		ENUMERATED(partial success allowed, ...)	Included if partial success is allowed	YES	ignore
Reporting Periodicity of RSRP Measurement Report	O		ENUMERATED(120ms, 240ms, 480ms, 640ms, ...)	Periodicity that can be used for the reporting of RSRP Measurement Report Periodic.	YES	ignore

Reporting Periodicity of CSI Report	O		ENUMERATED(5ms, 10ms, 20ms, 40ms, 80ms, ...)	Periodicity that can be used for the reporting of CSI Report Periodic.	YES	ignore

Range bound	Explanation
maxCellineNB	Maximum no. cells that can be served by an eNB. Value is 256.

Condition	Explanation
ifRegistrationRequestStoporPartialStoporAdd	This IE shall be present if the *Registration Request* IE is set to the value “stop”, “partial stop” or “add”.

9.1.2.12 RESOURCE STATUS RESPONSE

This message is sent by the eNB_2 to indicate that the requested measurement, for all or for a subset of the measurement objects included in the measurement is successfully initiated.

Direction: $eNB_2 \rightarrow eNB_1$.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
eNB1 Measurement ID	M		INTEGER (1..4095,...)	Allocated by eNB_1	YES	reject
eNB2 Measurement ID	M		INTEGER (1..4095,...)	Allocated by eNB_2	YES	reject
Criticality Diagnostics	O		9.2.7		YES	ignore
Measurement Initiation Result		*0..1*		List of all cells in which measurement objects were requested, included when indicating partial success	YES	ignore
>**Measurement Initiation Result Item**		*1 .. <maxCellineNB>*			EACH	ignore
>>Cell ID	M		ECGI 9.2.14		–	–
>>**Measurement Failure Cause List**		*0..1*		Indicates that eNB_2 could not initiate the measurement for at least one of the requested measurement objects in the cell	–	–
>>>**Measurement Failure Cause Item**		*1 .. <maxFailedMeasObjects>*			EACH	ignore
>>>>Measurement Failed Report Characteristics	M		BITSTRING (SIZE(32))	Each position in the bitmap indicates measurement object that failed to be initiated in the eNB_2. First Bit = PRB Periodic, Second Bit = TNL load Ind Periodic, Third Bit = HW Load Ind Periodic, Fourth Bit = Composite Available Capacity Periodic, Fifth Bit = ABS Status Periodic, Sixth Bit = RSRP Measurement Report Periodic, Seventh Bit = CSI Report Periodic. Other bits shall be ignored by the eNB_1.	–	–
>>>>Cause	M		9.2.6	Failure cause for measurement objects for which the measurement cannot be initiated	–	–

Range bound	Explanation
maxFailedMeasObjects	Maximum number of measurement objects that can fail per measurement. Value is 32.
maxCellineNB	Maximum no. cells that can be served by an eNB. Value is 256.

9.1.2.13 RESOURCE STATUS FAILURE

This message is sent by the eNB_2 to indicate that for none of the requested measurement objects the measurement can be initiated.

Direction: $eNB_2 \rightarrow eNB_1$.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
eNB1 Measurement ID	M		INTEGER (1..4095,...)	Allocated by eNB_1	YES	reject
eNB2 Measurement ID	M		INTEGER (1..4095,...)	Allocated by eNB_2	YES	reject
Cause	M		9.2.6	Ignored by the receiver when the Complete Failure Cause Information IE is included	YES	ignore
Criticality Diagnostics	O		9.2.7		YES	ignore
Complete Failure Cause Information		*0..1*		Complete list of failure causes for all requested cells	YES	ignore
>**Complete Failure Cause Information Item**		*1 .. <maxCellineNB>*			EACH	ignore
>>Cell ID	M		ECGI 9.2.14		–	–
>>**Measurement Failure Cause List**		*1*			–	–
>>>**Measurement Failure Cause Item**		*1 .. <maxFailedMeasObjects>*			EACH	ignore
>>>>Measurement Failed Report Characteristics	M		BITSTRING (SIZE(32))	Each position in the bitmap indicates measurement object that failed to be initiated in the eNB_2. First Bit = PRB Periodic, Second Bit = TNL load Ind Periodic, Third Bit = HW Load Ind Periodic, Fourth Bit = Composite Available Capacity Periodic, Fifth Bit = ABS Status Periodic, Sixth Bit = RSRP Measurement Report Periodic, Seventh Bit = CSI Report Periodic. Other bits shall be ignored by the eNB_1.	–	–
>>>>Cause	M		9.2.6	Failure cause for measurements that cannot be initiated	–	–

Range bound	Explanation
maxCellineNB	Maximum no. cells that can be served by an eNB. Value is 256.
maxFailedMeasObjects	Max number of measurement objects that can fail per measurement. Value is 32.

9.1.2.14 RESOURCE STATUS UPDATE

This message is sent by eNB_2 to neighbouring eNB_1 to report the results of the requested measurements.

Direction: $eNB_2 \rightarrow eNB_1$.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	ignore
eNB1 Measurement ID	M		INTEGER (1..4095,...)	Allocated by eNB_1	YES	reject
eNB2 Measurement ID	M		INTEGER (1..4095,...)	Allocated by eNB_2	YES	reject
Cell Measurement Result		*1*			YES	ignore
>Cell Measurement Result Item		*1 .. <maxCellineNB>*			EACH	ignore
>>Cell ID	M		ECGI 9.2.14			
>>Hardware Load Indicator	O		9.2.34			
>>S1 TNL Load Indicator	O		9.2.35			
>>Radio Resource Status	O		9.2.37			
>>Composite Available Capacity Group	O		9.2.44		YES	ignore
>>ABS Status	O		9.2.58		YES	ignore
>>RSRP Measurement Report List	O		9.2.76		YES	ignore
>>CSI Report	O		9.2.79		YES	ignore
>>Cell Reporting Indicator	O		ENUMERATED(stop request, ...)		YES	ignore

Range bound	Explanation
maxCellineNB	Maximum no. cells that can be served by an eNB. Value is 256.

9.1.2.15 MOBILITY CHANGE REQUEST

This message is sent by an eNB_1 to neighbouring eNB_2 to initiate adaptation of mobility parameters.

Direction: $eNB_1 \rightarrow eNB_2$.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
eNB1 Cell ID	M		ECGI 9.2.14		YES	reject
eNB2 Cell ID	M		ECGI 9.2.14		YES	reject
eNB1 Mobility Parameters	O		Mobility Parameters Information 9.2.48	Configuration change in eNB_1 cell	YES	ignore
eNB2 Proposed Mobility Parameters	M		Mobility Parameters Information 9.2.48	Proposed configuration change in eNB_2 cell	YES	reject
Cause	M		9.2.6		YES	reject

9.1.2.16 MOBILITY CHANGE ACKNOWLEDGE

This message is sent by the eNB_2 to indicate that the eNB_2 Proposed Mobility Parameter proposed by eNB_1 was accepted.

Direction: $eNB_2 \rightarrow eNB_1$.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
eNB1 Cell ID	M		ECGI 9.2.14		YES	reject
eNB2 Cell ID	M		ECGI 9.2.14		YES	reject
Criticality Diagnostics	O		9.2.7		YES	ignore

9.1.2.17 MOBILITY CHANGE FAILURE

This message is sent by the eNB_2 to indicate that the eNB_2 Proposed Mobility Parameter proposed by eNB_1 was refused.

Direction: $eNB_2 \rightarrow eNB_1$.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
eNB1 Cell ID	M		ECGI 9.2.14		YES	ignore
eNB2 Cell ID	M		ECGI 9.2.14		YES	ignore
Cause	M		9.2.6		YES	ignore
Mobility Parameters Modification Range	O		9.2.49		YES	ignore
Criticality Diagnostics	O		9.2.7		YES	ignore

9.1.2.18 RLF INDICATION

This message is sent by the eNB_2 to indicate an RRC re-establishment attempt or a reception of an RLF Report from a UE that suffered a connection failure at eNB_1.

Direction: $eNB_2 \rightarrow eNB_1$.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	ignore
Failure cell PCI	M		INTEGER (0..503, …)	Physical Cell Identifier	YES	ignore
Re-establishment cell ECGI	M		ECGI 9.2.14		YES	ignore
C-RNTI	M		BIT STRING (SIZE (16))	C-RNTI contained in the RRC Re-establishment Request message (TS 36.331 [9])	YES	ignore
ShortMAC-I	O		BIT STRING (SIZE (16))	ShortMAC-I contained in the RRC Re-establishment Request message (TS 36.331 [9])	YES	ignore
UE RLF Report Container	O		OCTET STRING	*RLF -Report-r9* IE contained in the UEInformationResponse message (TS 36.331 [9])	YES	ignore
RRC Conn Setup Indicator	O		ENUMERATED(RRC Conn Setup, ...)	Included if the RLF Report within the *UE RLF Report Container* IE is retrieved after an RRC connection setup or an incoming successful handover	YES	reject
RRC Conn Reestab Indicator	O		ENUMERATED(reconfigurationFailure, handoverFailure, otherFailure, ...)	The ReestablishmentCause in RRCConnectionReestablishmentRequest message(TS 36.331 [9])	YES	ignore
UE RLF Report Container for extended bands	O		OCTET STRING	*RLF-Report-v9e0* IE contained in the UEInformationResponse message (TS 36.331 [9])	YES	ignore

9.1.2.19 HANDOVER REPORT

This message is sent by the eNB_1 to report a handover failure event or other critical mobility problem.

Direction: $eNB_1 \rightarrow eNB_2$.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	ignore
Handover Report Type	M		ENUMERATED (HO too early, HO to wrong cell, …, InterRAT ping-pong)		YES	ignore
Handover Cause	M		Cause 9.2.6	Indicates handover cause employed for handover from eNB_2	YES	ignore
Source cell ECGI	M		ECGI 9.2.14	ECGI of source cell for handover procedure (in eNB_2)	YES	ignore
Failure cell ECGI	M		ECGI 9.2.14	ECGI of target cell for handover procedure (in eNB_1)	YES	ignore
Re-establishment cell ECGI	C-ifHandoverReportType HoToWrongCell		ECGI 9.2.14	ECGI of cell where UE attempted re-establishment	YES	ignore
Target cell in UTRAN	C-ifHandoverReportType InterRATpingpong		OCTET STRING	Encoded according to *UTRAN Cell ID* in the *Last Visited UTRAN Cell Information* IE, as defined in in TS 25.413 [24]	YES	ignore
Source cell C-RNTI	O		BIT STRING (SIZE (16))	C-RNTI allocated at the source eNB (in eNB_2) contained in the AS-config (TS 36.331 [9]).	YES	ignore
Mobility Information	O		BIT STRING (SIZE (32))	Information provided in the HANDOVER REQUEST message from eNB_2.	YES	ignore
UE RLF Report Container	O		OCTET STRING	The UE RLF Report Container IE received in the RLF INDICATION message.	YES	ignore
UE RLF Report Container for extended bands	O		OCTET STRING	The *UE RLF Report Container for extended bands* IE received in the RLF INDICATION message.	YES	ignore

Condition	Explanation
ifHandoverReportType HoToWrongCell	This IE shall be present if the *Handover Report Type* IE is set to the value "HO to wrong cell"
ifHandoverReportType InterRATpingpong	This IE shall be present if the *Handover Report Type* IE is set to the value "InterRAT ping-pong"

9.1.2.20 CELL ACTIVATION REQUEST

This message is sent by an eNB to a peer eNB to request a previously switched-off cell(s) to be re-activated.

Direction: $eNB_1 \rightarrow eNB_2$.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
Served Cells To Activate		*1 .. <maxCellineNB>*			GLOBAL	reject
>**ECGI**	M		9.2.14		-	-

Range bound	Explanation
maxCellineNB	Maximum no. cells that can be served by an eNB. Value is 256.

9.1.2.21 CELL ACTIVATION RESPONSE

This message is sent by an eNB to a peer eNB to indicate that one or more cell(s) previously switched-off has(have) been activated.

Direction: $eNB_2 \rightarrow eNB_1$.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
Activated Cell List		*1 .. <maxCellineNB>*			GLOBAL	ignore
>ECGI	M		9.2.14		-	-
Criticality Diagnostics	O		9.2.7		YES	ignore

Range bound	Explanation
maxCellineNB	Maximum no. cells that can be served by an eNB. Value is 256.

9.1.2.22 CELL ACTIVATION FAILURE

This message is sent by an eNB to a peer eNB to indicate cell activation failure.

Direction: $eNB_2 \rightarrow eNB_1$.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
Cause	M		9.2.6		YES	ignore
Criticality Diagnostics	O		9.2.7		YES	ignore

9.1.2.23 X2 RELEASE

This message is used to indicate that the signalling connection to an eNB is unavailable.

Direction: $eNB_1 \rightarrow eNB_2$.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
Global eNB ID	M		9.2.22		YES	reject

9.1.2.24 X2AP MESSAGE TRANSFER

This message is used for indirect transport of an X2AP message (except the X2AP MESSAGE TRANSFER message) between two eNBs, and to allow an eNB to perform registration.

Direction: $eNB_1 \rightarrow eNB_2$.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
RNL Header	M		9.2.68		YES	reject
X2AP Message	O		OCTET STRING	Includes any X2AP message except the X2AP MESSAGE TRANSFER message	YES	reject

9.1.2.25 X2 REMOVAL REQUEST

This message is sent by an eNB to a neighbouring eNB to initiate the removal of the signaling connection.

Direction: $eNB_1 \rightarrow eNB_2$.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
Global eNB ID	M		9.2.22		YES	reject
X2 Removal Threshold	O		X2 Benefit Value 9.2.90		YES	reject

9.1.2.26 X2 REMOVAL RESPONSE

This message is sent by an eNB to a neighbouring eNB to acknowledge the initiation of removal of the signaling connection.

Direction: $eNB_2 \rightarrow eNB_1$.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
Global eNB ID	M		9.2.22		YES	reject
Criticality Diagnostics	O		9.2.7		YES	ignore

9.1.2.27 X2 REMOVAL FAILURE

This message is sent by the eNB to indicate that removing the signaling connection cannot be accepted.

Direction: $eNB_2 \rightarrow eNB_1$.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
Cause	M		9.2.6		YES	ignore
Criticality Diagnostics	O		9.2.7		YES	ignore

9.1.2.28 RETRIEVE UE CONTEXT REQUEST

This message is sent by the new eNB to request the old eNB to transfer the UE Context to the new eNB.

Direction: new eNB → old eNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	ignore
New eNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the new eNB	YES	reject
New eNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the new eNB	YES	reject
Resume ID	M		9.2.91		YES	reject
ShortMAC-I	M		BIT STRING (SIZE (16))	ShortResumeMAC-I contained in the RRCConnectionResumeRequest message (TS 36.331 [9])	YES	reject
New E-UTRAN Cell Identifier	M		BIT STRING (SIZE (28))	The E-UTRAN Cell Identifier of the cell where the RRC connection has been requested to be resumed.	YES	reject
C-RNTI	O		BIT STRING (SIZE (16))	C-RNTI contained in the RRC Re-establishment Request message (TS 36.331 [9]). If this IE is present, the Resume ID IE is ignored	YES	reject
Failure cell PCI	O		INTEGER (0..503, …)	Physical Cell Identifier	YES	reject

9.1.2.29 RETRIEVE UE CONTEXT RESPONSE

This message is sent by the old eNB to transfer the UE context to the new eNB.

Direction: old eNB → new eNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	ignore
New eNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the new eNB	YES	ignore
New eNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the new eNB	YES	ignore
Old eNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the old eNB	YES	ignore
Old eNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the old eNB	YES	ignore
GUMMEI	M		9.2.16		YES	reject
UE Context Information		1			YES	reject
>MME UE S1AP ID	M		INTEGER (0..2^{32} - 1)	MME UE S1AP ID allocated at the MME	–	–
>UE Security Capabilities	M		9.2.29		–	–
>AS Security Information	M		9.2.30		–	–
>UE Aggregate Maximum Bit Rate	M		9.2.12		–	–
>Subscriber Profile ID for RAT/Frequency priority	O		9.2.25		–	–
>E-RABs To Be Setup List		1			–	–
>>E-RABs To Be Setup Item		1 .. <maxno of Bearers>			EACH	ignore
>>>E-RAB ID	M		9.2.23		–	–
>>>E-RAB Level QoS Parameters	M		9.2.9	Includes necessary QoS parameters	–	–
>>>Bearer Type	O		9.2.92		–	–
>>>UL GTP Tunnel Endpoint	M		GTP Tunnel Endpoint 9.2.1	SGW endpoint of the S1 transport bearer. For delivery of UL PDUs.	YES	reject
>RRC Context	M		OCTET STRING	Includes either the RRC Handover Preparation Information message as defined in subclause 10.2.2 of TS 36.331 [9], or the *HandoverPreparationInformation-NB* message as defined in subclause 10.6.2 of TS 36.331 [9].	–	–
>Handover Restriction List	O		9.2.3		–	–
>Location Reporting Information	O		9.2.21	Includes the necessary parameters for location reporting	–	–

>Management Based MDT Allowed	O		9.2.59		–	–
>Management Based MDT PLMN List	O		MDT PLMN List 9.2.64		–	–
>UE Sidelink Aggregate Maximum Bit Rate	O		9.2.97	This IE applies only if the UE is authorized for V2X services.	YES	ignore
Trace Activation	O		9.2.2		YES	ignore
SRVCC Operation Possible	O		9.2.33		YES	ignore
Masked IMEISV	O		9.2.69		YES	ignore
Expected UE Behaviour	O		9.2.70		YES	ignore
ProSe Authorized	O		9.2.78		YES	ignore
Criticality Diagnostics	O		9.2.7		YES	ignore
V2X Services Authorized	O		9.2.93		YES	ignore
Aerial UE subscription information	O		9.2.129		YES	ignore

Range bound	Explanation
maxnoofBearers	Maximum no. of E-RABs. Value is 256

9.1.2.30 RETRIEVE UE CONTEXT FAILURE

This message is sent by the old eNB to inform the new eNB that the Retrieve UE Context procedure has failed.

Direction: old eNB → new eNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
New eNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the new eNB	YES	ignore
New eNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the new eNB	YES	ignore
Cause	M		9.2.6		YES	ignore
Criticality Diagnostics	O		9.2.7		YES	ignore

9.1.2.31 EN-DC X2 SETUP REQUEST

This message is sent by an initiating node to a neighbouring node, both nodes able to interact for EN-DC, to transfer the initialization information for a TNL association.

Direction: eNB → en-gNB, en-gNB → eNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
CHOICE Initiating NodeType	M					
>eNB						
>>Global eNB ID	M		9.2.22		YES	reject
>>List of Served E-UTRA Cells		*1 .. <maxCellineNB>*		Complete list of cells served by the eNB	YES	reject
>>>Served E-UTRA Cell Information	M		Served Cell Information 9.2.8		–	–
>>>NR Neighbour Information	O		9.2.98	NR neighbours	YES	ignore
>en-gNB						
>>Global en-gNB ID	M		9.2.112		YES	reject
>>List of Served NR Cells		*1 .. <maxCellinengNB>*		Complete list of cells served by the engNB.	YES	reject
>>>Served NR Cell Information	M		9.2.110		–	
>>>NR Neighbour Information	O		9.2.98	NR neighbours.	YES	ignore

Range bound	Explanation
maxCellineNB	Maximum no. cells that can be served by an eNB. Value is 256.
maxCellinengNB	Maximum no. cells that can be served by an en-gNB. Value is 16384.

9.1.2.32 EN-DC X2 SETUP RESPONSE

This message is sent by a neighbouring node to an initiating node, both nodes able to interact for EN-DC, to transfer the initialization information for a TNL association.

Direction: eNB → en-gNB, en-gNB → eNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
CHOICE Responding NodeType	M					
>eNB						
>>Global eNB ID	M		9.2.22		YES	reject
>>List of Served E-UTRA Cells		*1 .. <maxCellineNB>*		Complete list of cells served by the eNB	YES	reject
>>>Served E-UTRA Cell Information	M		Served Cell Information 9.2.8		–	–
>>>NR Neighbour Information	O		9.2.98	NR neighbours	YES	ignore
>en-gNB						
>>Global en-gNB ID	M		9.2.112		YES	reject
>>List of Served NR Cells		*1 .. <maxCellinengNB>*		Complete list of cells served by the en-gNB	YES	reject
>>>Served NR Cell Information	M		9.2.110		–	
>>>NR Neighbour Information	O		9.2.98	NR neighbours	YES	ignore

Range bound	Explanation
maxCellineNB	Maximum no. cells that can be served by an eNB. Value is 256.
maxCellinengNB	Maximum no. cells that can be served by an en-gNB. Value is 16384.

9.1.2.33 EN-DC X2 SETUP FAILURE

This message is sent by the neighbouring node to indicate EN-DC X2 Setup failure.

Direction: eNB → en-gNB, en-gNB → eNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
Cause	M		9.2.6		YES	ignore
Criticality Diagnostics	O		9.2.7		YES	ignore

9.1.2.34 EN-DC CONFIGURATION UPDATE

This message is sent by an initiating node to a peer neighbouring node, both nodes able to interact for EN-DC, to transfer updated information for a TNL association.

Direction: eNB → en-gNB, en-gNB → eNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
CHOICE Initiating NodeType	M					
>eNB						
>>Cell Assistance Information	O		9.2.115		YES	ignore
>>Served E-UTRA Cells To Add		*0 .. <maxCellineNB>*			GLOBAL	reject
>>>Served E-UTRA Cell Information	M		Served Cell Information 9.2.8		–	–
>>>NR Neighbour Information	O		9.2.98	NR neighbours	YES	ignore
>>Served E-UTRA Cells To Modify		*0 .. <maxCellineNB>*		Complete list of modified cells served by the eNB	GLOBAL	reject
>>>Old ECGI	M		ECGI 9.2.14	Old E-UTRAN Cell Global Identifier	–	–
>>>Served E-UTRA Cell Information	M		Served Cell Information 9.2.8		–	–
>>>NR Neighbour Information	O		9.2.98	NR neighbours	YES	ignore
>>Served E-UTRA Cells To Delete		*0 .. <maxCellineNB>*		Complete list of deleted cells served by the eNB	GLOBAL	reject
>>>Old ECGI	M		ECGI 9.2.14	Old E-UTRAN Cell Global Identifier of the cell to be deleted	-	-
>en-gNB						
>>Served NR Cells To Add		*0 .. <maxCellinen-gNB>*			GLOBAL	reject
>>>Served NR Cell Information	M		9.2.110		–	
>>>NR Neighbour Information	O		9.2.98	NR neighbours	YES	ignore
>>Served NR Cells To Modify		*0 .. <maxCellinen-gNB>*			GLOBAL	reject
>>>Old NR-CGI	M		9.2.111		-	
>>>Served NR Cell Information	M		9.2.110		–	
>>>NR Deactivation Indication	O		ENUMERATED(deactivated, …)	Indicates that the concerned NR cell is switched off for energy saving reasons. If this IE is not included, indicates that the concerned cell is activated.	YES	ignore
>>>NR Neighbour Information	O		9.2.98	NR neighbours	YES	ignore

>>Served NR Cells To Delete		*0 .. <maxCellinen-gNB>*			GLOBAL	reject
>>>Old NR-CGI	M		9.2.111		-	

Range bound	Explanation
maxCellineNB	Maximum no. cells that can be served by an eNB. Value is 256.
maxCellinengNB	Maximum no. cells that can be served by an en-gNB. Value is 16384.

9.1.2.35 EN-DC CONFIGURATION UPDATE ACKNOWLEDGE

This message is sent by a neighbouring node to a peer node, both nodes able to interact for EN-DC, to acknowledge update of information for a TNL association.

Direction: en-gNB → eNB, eNB → en-gNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
CHOICE Responding NodeType	M					
>eNB						
>en-gNB						
>>List of Served NR Cells		0 .. <maxCellinengNB>		Complete or limited list of cells served by the en-gNB, if requested by the eNB.		
>>>Served NR Cell Information	M		9.2.110			
>>>NR Neighbour Information	O		9.2.98	NR neighbours.	YES	ignore
Criticality Diagnostics	O		9.2.7		YES	ignore

Range bound	Explanation
maxCellinengNB	Maximum no. cells that can be served by an en-gNB. Value is 16384.

9.1.2.36 EN-DC CONFIGURATION UPDATE FAILURE

This message is sent by a neighbouring node to a peer node to indicate EN-DC eNB Configuration Update Failure.

Direction: en-gNB → eNB, eNB → en-gNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
Cause	M		9.2.6		YES	ignore
Criticality Diagnostics	O		9.2.7		YES	ignore

9.1.2.37 EN-DC CELL ACTIVATION REQUEST

This message is sent by an eNB to a peer en-gNB to request a previously switched-off cell(s) to be re-activated.

Direction: eNB → en-gNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
Served NR Cells To Activate		*1*			GLOBAL	reject
>Served NR Cells To Activate Item		*1 .. < maxCellinengNB >*				
>>**NR CGI**	M		9.2.111		-	-
Activation ID	M		INTEGER (0..255)	Allocated by the eNB	YES	reject

Range bound	Explanation
maxCellinengNB	Maximum no. cells that can be served by an en-gNB. Value is 16384.

9.1.2.38 EN-DC CELL ACTIVATION RESPONSE

This message is sent by an en-gNB to a peer eNB to indicate that one or more cell(s) previously switched-off has (have) been activated.

Direction: en-gNB → eNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
Activated NR Cell List		*1*			GLOBAL	ignore
>Activated NR Cell Item		*1 .. < maxCellinengNB >*				
>>NR CGI	M		9.2.111		-	-
Activation ID	M		INTEGER (0..255)	Allocated by the eNB	YES	reject
Criticality Diagnostics	O		9.2.7		YES	ignore

Range bound	Explanation
maxCellinengNB	Maximum no. cells that can be served by an en-gNB. Value is 16384.

9.1.2.39 EN-DC CELL ACTIVATION FAILURE

This message is sent by an en-gNB to a peer eNB to indicate cell activation failure.

Direction: en-gNB → eNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
Activation ID	M		INTEGER (0..255)	Allocated by the eNB	YES	reject
Cause	M		9.2.6		YES	ignore
Criticality Diagnostics	O		9.2.7		YES	ignore

9.1.2.40 EN-DC X2 REMOVAL REQUEST

This message is sent by an initiating node to a neighbouring node to initiate the removal of the signaling connection.

Direction: eNB → en-gNB, en-gNB → eNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
CHOICE *Initiating Node Type*	M					
>eNB						
>>Global eNB ID	M		9.2.22		YES	reject
>en-gNB						
>>Global en-gNB ID	M		9.2.112			
X2 Removal Threshold	O		X2 Benefit Value 9.2.90		YES	reject

9.1.2.41 EN-DC X2 REMOVAL RESPONSE

This message is sent by an initiating node to a neighbouring node to acknowledge the initiation of removal of the signaling connection.

Direction: eNB → en-gNB, en-gNB → eNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
CHOICE *Initiating Node Type*	M					
>eNB						
>>Global eNB ID	M		9.2.22		YES	reject
>en-gNB						
>>Global en-gNB ID	M		9.2.112		YES	reject
Criticality Diagnostics	O		9.2.7		YES	ignore

9.1.2.42 EN-DC X2 REMOVAL FAILURE

This message is sent by the initiating node to indicate that removing the signaling connection cannot be accepted.

Direction: eNB → en-gNB, en-gNB → eNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
Cause	M		9.2.6		YES	ignore
Criticality Diagnostics	O		9.2.7		YES	ignore

9.1.3 Messages for Dual Connectivity Procedures

9.1.3.1 SENB ADDITION REQUEST

This message is sent by the MeNB to the SeNB to request the preparation of resources for dual connectivity operation for a specific UE

Direction: MeNB → SeNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB	YES	reject
UE Security Capabilities	C-ifSCGBearerOption		9.2.29		YES	reject
SeNB Security Key	C-ifSCGBearerOption		9.2.72	The S-KeNB which is provided by the MeNB, see TS 33.401 [18].	YES	reject
SeNB UE Aggregate Maximum Bit Rate	M		UE Aggregate Maximum Bit Rate 9.2.12	The UE Aggregate Maximum Bit Rate is split into MeNB UE Aggregate Maximum Bit Rate and SeNB UE Aggregate Maximum Bit Rate which are enforced by MeNB and SeNB respectively.	YES	reject
Serving PLMN	O		PLMN Identity 9.2.4	The serving PLMN of the SCG in the SeNB.	YES	ignore
E-RABs To Be Added List		*1*			YES	reject
>E-RABs To Be Added Item		*1 .. <maxnoof Bearers>*			EACH	reject
>>CHOICE Bearer Option	M					
>>>SCG Bearer						
>>>>E-RAB ID	M		9.2.23		–	–
>>>>E-RAB Level QoS Parameters	M		9.2.9	Includes necessary QoS parameters	–	–
>>>>DL Forwarding	O		9.2.5		–	–
>>>>S1 UL GTP Tunnel Endpoint	M		GTP Tunnel Endpoint 9.2.1	SGW endpoint of the S1 transport bearer. For delivery of UL PDUs.	–	–
>>>>Correlation ID	O		Correlation ID 9.2.84		–	–
>>>>SIPTO Correlation ID	O		Correlation ID 9.2.84		–	–
>>>Split Bearer						
>>>>E-RAB ID	M		9.2.23		–	–
>>>>E-RAB Level QoS Parameters	M		9.2.9	Includes necessary QoS parameters	–	–
>>>>MeNB GTP Tunnel Endpoint	M		GTP Tunnel Endpoint 9.2.1	MeNB endpoint of the X2 transport bearer. For delivery of UL PDUs.	–	–
MeNB to SeNB Container	M		OCTET STRING	Includes the *SCG-ConfigInfo* message as defined in TS 36.331 [9]	YES	reject
CSG Membership Status	O		9.2.52		YES	reject
SeNB UE X2AP ID	O		eNB UE X2AP ID 9.2.24	Allocated at the SeNB	YES	reject

SeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the SeNB	YES	reject
Expected UE Behaviour	O		9.2.70		YES	ignore
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB	YES	reject

Range bound	Explanation
maxnoofBearers	Maximum no. of E-RABs. Value is 256

Condition	Explanation
ifSCGBearerOption	This IE shall be present if the *Bearer Option* IE is set to the value "SCG bearer".

9.1.3.2 SENB ADDITION REQUEST ACKNOWLEDGE

This message is sent by the SeNB to confirm the MeNB about the SeNB addition preparation.

Direction: SeNB → MeNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB	YES	reject
SeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the SeNB	YES	reject
E-RABs Admitted To Be Added List		*1*			YES	ignore
>E-RABs Admitted To Be Added Item		*1 .. <maxnoof Bearers>*			EACH	ignore
>>CHOICE Bearer Option	M					
>>>SCG Bearer						
>>>>E-RAB ID	M		9.2.23		–	–
>>>>S1 DL GTP Tunnel Endpoint	M		GTP Tunnel Endpoint 9.2.1	SeNB endpoint of the S1 transport bearer. For delivery of DL PDUs.	–	–
>>>>DL Forwarding GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	Identifies the X2 transport bearer used for forwarding of DL PDUs	–	–
>>>>UL Forwarding GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	Identifies the X2 transport bearer used for forwarding of UL PDUs	–	–
>>>Split Bearer						
>>>>E-RAB ID	M		9.2.23		–	–
>>>>SeNB GTP Tunnel Endpoint	M		GTP Tunnel Endpoint 9.2.1	Endpoint of the X2 transport bearer at the SeNB.	–	–
E-RABs Not Admitted List	O		E-RAB List 9.2.28	A value for *E-RAB ID* shall only be present once in *E-RABs Admitted List* IE and in *E-RABs Not Admitted List* IE.	YES	ignore
SeNB to MeNB Container	M		OCTET STRING	Includes the *SCG-Config* message as defined in TS 36.331 [9]	YES	reject
Criticality Diagnostics	O		9.2.7		YES	ignore
GW Transport Layer Address	O		BIT STRING (1..160, ...)	Indicating GW Transport Layer Address.	YES	ignore
SIPTO L-GW Transport Layer Address	O		BIT STRING (1..160, ...)	Indicating SIPTO L-GW Transport Layer Address.	YES	ignore
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB	YES	reject
SeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the SeNB	YES	reject
Tunnel Information for BBF	O		Tunnel Information 9.2.89	Indicating eNB's Local IP Address assigned by the broadband access provider, UDP port Number.	YES	ignore

Range bound	Explanation
maxnoofBearers	Maximum no. of E-RABs. Value is 256

9.1.3.3 SENB ADDITION REQUEST REJECT

This message is sent by the SeNB to inform the MeNB that the SeNB Addition Preparation has failed.

Direction: SeNB → MeNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB	YES	reject
SeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the SeNB	YES	reject
Cause	M		9.2.6		YES	ignore
Criticality Diagnostics	O		9.2.7		YES	ignore
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB	YES	reject
SeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the SeNB	YES	reject

9.1.3.4 SENB RECONFIGURATION COMPLETE

This message is sent by the MeNB to the SeNB to indicate whether the configuration requested by the SeNB was applied by the UE.

Direction: MeNB → SeNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	ignore
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB	YES	reject
SeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the SeNB	YES	reject
Response Information	M				YES	ignore
>CHOICE *Response Type*	M					
>>Configuration successfully applied						
>>>MeNB to SeNB Container	O		OCTET STRING	Includes the *SCG-ConfigInfo* message as defined in TS 36.331 [9]	-	-
>>Configuration rejected by the MeNB						
>>>Cause	M		9.2.6		-	-
>>>MeNB to SeNB Container	O		OCTET STRING	Includes the *SCG-ConfigInfo* message as defined in TS 36.331 [9]	-	-
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB	YES	reject
SeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the SeNB	YES	reject

9.1.3.5 SENB MODIFICATION REQUEST

This message is sent by the MeNB to the SeNB to request the preparation to modify SeNB resources for a specific UE.

Direction: MeNB → SeNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB	YES	reject
SeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the SeNB	YES	reject
Cause	M		9.2.6		YES	ignore
SCG Change Indication	O		9.2.73		YES	ignore
Serving PLMN	O		PLMN Identity 9.2.4	The serving PLMN of the SCG in the SeNB.	YES	ignore
UE Context Information		*0..1*			YES	reject
>UE Security Capabilities	O		9.2.29		–	–
>SeNB Security Key	O		9.2.72		–	–
>SeNB UE Aggregate Maximum Bit Rate	O		UE Aggregate Maximum Bit Rate 9.2.12		–	–
>E-RABs To Be Added List		*0..1*			–	–
>>E-RABs To Be Added Item		*1 .. <maxnoof Bearers>*			EACH	ignore
>>>CHOICE *Bearer Option*	M					
>>>>*SCG Bearer*						
>>>>>E-RAB ID	M		9.2.23		–	–
>>>>>E-RAB Level QoS Parameters	M		9.2.9	Includes necessary QoS parameters	–	–
>>>>>DL Forwarding	O		9.2.5		–	–
>>>>>S1 UL GTP Tunnel Endpoint	M		GTP Tunnel Endpoint 9.2.1	SGW endpoint of the S1 transport bearer. For delivery of UL PDUs.	–	–
>>>>>Correlation ID	O		Correlation ID 9.2.84		–	–
>>>>>SIPTO Correlation ID	O		Correlation ID 9.2.84		–	–
>>>>*Split Bearer*						
>>>>>E-RAB ID	M		9.2.23		–	–
>>>>>E-RAB Level QoS Parameters	M		9.2.9	Includes necessary QoS parameters	–	–
>>>>>MeNB GTP Tunnel Endpoint	M		GTP Tunnel Endpoint 9.2.1	MeNB endpoint of the X2 transport bearer. For delivery of UL PDUs.	–	–
>E-RABs To Be Modified List		*0..1*			–	–
>>E-RABs To Be Modified Item		*1 .. <maxnoof Bearers>*			EACH	ignore
>>>CHOICE *Bearer Option*	M					
>>>>*SCG Bearer*						
>>>>>E-RAB ID	M		9.2.23		–	–
>>>>>E-RAB Level QoS Parameters	O		9.2.9	Includes QoS parameters to be modified	–	–
>>>>>S1 UL GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	SGW endpoint of the S1 transport bearer. For delivery of UL PDUs.	–	–

>>>>*Split Bearer*						
>>>>>E-RAB ID	M		9.2.23		–	–
>>>>>E-RAB Level QoS Parameters	O		9.2.9	Includes QoS parameters to be modified	–	–
>>>>>MeNB GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	MeNB endpoint of the X2 transport bearer. For delivery of UL PDUs.	–	–
>E-RABs To Be Released List		*0..1*			–	–
>>E-RABs To Be Released Item		*1 .. <maxnoof Bearers>*			EACH	ignore
>>>CHOICE *Bearer Option*	M					
>>>>*SCG Bearer*						
>>>>>E-RAB ID	M		9.2.23		–	–
>>>>>DL Forwarding GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	Identifies the X2 transport bearer used for forwarding of DL PDUs	–	–
>>>>>UL Forwarding GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	Identifies the X2 transport bearer. used for forwarding of UL PDUs	–	–
>>>>*Split Bearer*						
>>>>>E-RAB ID	M		9.2.23		–	–
>>>>>DL Forwarding GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	Identifies the X2 transport bearer used for forwarding of DL PDUs	–	–
MeNB to SeNB Container	O		OCTET STRING	Includes the *SCG-ConfigInfo* message as defined in TS 36.331 [9]	YES	ignore
CSG Membership Status	O		9.2.52		YES	reject
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB	YES	reject
SeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the SeNB	YES	reject

Range bound	Explanation
maxnoofBearers	Maximum no. of E-RABs. Value is 256

9.1.3.6 SENB MODIFICATION REQUEST ACKNOWLEDGE

This message is sent by the SeNB to confirm the MeNB's request to modify the SeNB resources for a specific UE.

Direction: SeNB → MeNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB	YES	ignore
SeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the SeNB	YES	ignore
E-RABs Admitted List		*0..1*			YES	ignore
>E-RABs Admitted To Be Added List		*1*			–	–
>>E-RABs Admitted To Be Added Item		*1 .. <maxnoof Bearers>*			EACH	ignore
>>>CHOICE *Bearer Option*	M					
>>>>*SCG Bearer*						
>>>>>E-RAB ID	M		9.2.23		–	–
>>>>>S1 DL GTP Tunnel Endpoint	M		GTP Tunnel Endpoint 9.2.1	SeNB endpoint of the S1 transport bearer. For delivery of DL PDUs.	–	–
>>>>>DL Forwarding GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	Identifies the X2 transport bearer used for forwarding of DL PDUs	–	–
>>>>>UL Forwarding GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	Identifies the X2 transport bearer used for forwarding of UL PDUs	–	–
>>>>*Split Bearer*						
>>>>>E-RAB ID	M		9.2.23		–	–
>>>>>SeNB GTP Tunnel Endpoint	M		GTP Tunnel Endpoint 9.2.1	Endpoint of the X2 transport bearer at the SeNB.	–	–
>E-RABs Admitted To Be Modified List		*0..1*			–	–
>>E-RABs Admitted To Be Modified Item		*1 .. <maxnoof Bearers>*			EACH	ignore
>>>CHOICE *Bearer Option*	M					
>>>>*SCG Bearer*						
>>>>>E-RAB ID	M		9.2.23		–	–
>>>>>S1 DL GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	SeNB endpoint of the S1 transport bearer. For delivery of DL PDUs.	–	–
>>>>*Split Bearer*						
>>>>>E-RAB ID	M		9.2.23		–	–
>>>>>SeNB GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	Endpoint of the X2 transport bearer at the SeNB.	–	–

>E-RABs Admitted To Be Released List		*0..1*			–	–
>>E-RABs Admitted To Be Released Item		*1 .. <maxnoof Bearers>*			EACH	ignore
>>>CHOICE *Bearer Option*	M					
>>>>*SCG Bearer*						
>>>>>E-RAB ID	M		9.2.23		–	–
>>>>*Split Bearer*						
>>>>>E-RAB ID	M		9.2.23		–	–
E-RABs Not Admitted List	O		E-RAB List 9.2.28	A value for *E-RAB ID* shall only be present once in *E-RABs Admitted List* IE and in *E-RABs Not Admitted List* IE.	YES	ignore
SeNB to MeNB Container	O		OCTET STRING	Includes the *SCG-Config* message as defined in TS 36.331 [9]	YES	ignore
Criticality Diagnostics	O		9.2.7		YES	ignore
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB	YES	ignore
SeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the SeNB	YES	Ignore

Range bound	Explanation
maxnoofBearers	Maximum no. of E-RABs. Value is 256

9.1.3.7 SENB MODIFICATION REQUEST REJECT

This message is sent by the SeNB to inform the MeNB that the MeNB initiated SeNB Modification Preparation has failed.

Direction: SeNB → MeNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB	YES	ignore
SeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the SeNB	YES	ignore
Cause	M		9.2.6		YES	ignore
Criticality Diagnostics	O		9.2.7		YES	ignore
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB	YES	ignore
SeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the SeNB	YES	ignore

9.1.3.8 SENB MODIFICATION REQUIRED

This message is sent by the SeNB to the MeNB to request the modification of SeNB resources for a specific UE.

Direction: SeNB → MeNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB	YES	reject
SeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the SeNB	YES	reject
Cause	M		9.2.6		YES	ignore
SCG Change Indication	O		9.2.73		YES	ignore
E-RABs To Be Released List		*0..1*			YES	ignore
>E-RABs To Be Released Item		*1 .. <maxnoof Bearers>*			EACH	ignore
>>E-RAB ID	M		9.2.23		–	–
>>Cause	M		9.2.6		–	–
SeNB to MeNB Container	O		OCTET STRING	Includes the *SCG-Config* message as defined in TS 36.331 [9]	YES	ignore
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB	YES	reject
SeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the SeNB	YES	reject

Range bound	Explanation
maxnoofBearers	Maximum no. of E-RABs. Value is 256

9.1.3.9 SENB MODIFICATION CONFIRM

This message is sent by the MeNB to inform the SeNB about the successful modification.

Direction: MeNB → SeNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB	YES	ignore
SeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the SeNB	YES	ignore
MeNB to SeNB Container	O		OCTET STRING	Includes the *SCG-ConfigInfo* message as defined in TS 36.331 [9]	YES	ignore
Criticality Diagnostics	O		9.2.7		YES	ignore
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB	YES	ignore
SeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the SeNB	YES	ignore

Range bound	Explanation
maxnoofBearers	Maximum no. of E-RABs. Value is 256

9.1.3.10 SENB MODIFICATION REFUSE

This message is sent by the MeNB to inform the SeNB that the SeNB initiated SeNB Modification has failed.

Direction: MeNB → SeNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB	YES	ignore
SeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the SeNB	YES	ignore
Cause	M		9.2.6		YES	ignore
MeNB to SeNB Container	O		OCTET STRING	Includes the *SCG-ConfigInfo* message as defined in TS 36.331 [9]	YES	ignore
Criticality Diagnostics	O		9.2.7		YES	ignore
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB	YES	ignore
SeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the SeNB	YES	ignore

9.1.3.11 SENB RELEASE REQUEST

This message is sent by the MeNB to the SeNB to request the release of resources.

Direction: MeNB → SeNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	ignore
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB	YES	reject
SeNB UE X2AP ID	O		eNB UE X2AP ID 9.2.24	Allocated at the SeNB	YES	reject
Cause	O		9.2.6		YES	ignore
E-RABs To Be Released List		*0..1*			YES	ignore
> E-RABs To Be Released Item		*1 .. <maxnoof Bearers>*			EACH	ignore
>>CHOICE *Bearer Option*	M					
>>>*SCG Bearer*						
>>>>E-RAB ID	M		9.2.23		–	–
>>>>UL Forwarding GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	Identifies the X2 transport bearer used for forwarding of UL PDUs	–	–
>>>>DL Forwarding GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	Identifies the X2 transport bearer. used for forwarding of DL PDUs	–	–
>>>*Split Bearer*						
>>>>E-RAB ID	M		9.2.23		–	–
>>>>DL Forwarding GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	Identifies the X2 transport bearer. used for forwarding of DL PDUs	–	–
UE Context Kept Indicator	O		9.2.85		YES	ignore
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB	YES	reject
SeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the SeNB	YES	reject
MakeBeforeBreak Indicator	O		ENUMERATED (True, …,)		YES	ignore

Range bound	Explanation
maxnoofBearers	Maximum no. of E-RABs. Value is 256

9.1.3.12 SENB RELEASE REQUIRED

This message is sent by the SeNB to request the release of all resources for a specific UE at the SeNB.

Direction: SeNB → MeNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB	YES	reject
SeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the SeNB	YES	reject
Cause	M		9.2.6		YES	ignore
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB	YES	reject
SeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the SeNB	YES	reject

9.1.3.13 SENB RELEASE CONFIRM

This message is sent by the MeNB to confirm the release of all resources for a specific UE at the SeNB.

Direction: MeNB → SeNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB	YES	ignore
SeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the SeNB	YES	ignore
E-RABs to be Released List		*0..1*			YES	ignore
>E-RABs To Be Released Item		*1 .. <maxnoof Bearers>*			–	–
>>CHOICE *Bearer Option*	M					
>>>SCG Bearer						
>>>>E-RAB ID	M		9.2.23		–	–
>>>>UL Forwarding GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	Identifies the X2 transport bearer used for forwarding of UL PDUs	–	–
>>>>DL Forwarding GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	Identifies the X2 transport bearer used for forwarding of DL PDUs	–	–
>>>Split Bearer						
>>>>E-RAB ID	M		9.2.23		–	–
>>>>DL Forwarding GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	Identifies the X2 transport bearer used for forwarding of DL PDUs	–	–
Criticality Diagnostics	O		9.2.7		YES	ignore
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB	YES	ignore
SeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the SeNB	YES	ignore

Range bound	Explanation
maxnoofBearers	Maximum no. of E-RABs. Value is 256

9.1.3.14 SENB COUNTER CHECK REQUEST

This message is sent by the SeNB to request the verification of the value of the PDCP COUNTs associated with SCG bearers established in the SeNB.

Direction: SeNB → MeNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB	YES	ignore
SeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the SeNB	YES	ignore
E-RABs Subject to Counter Check List		*1*			YES	ignore
>E-RABs Subject to Counter Check Item		*1 .. <maxnoof Bearers>*			EACH	ignore
>>E-RAB ID	M		9.2.23		-	-
>>UL COUNT	M	*INTEGER(0.. 4294967295)*		Indicates the value of uplink COUNT associated to this E-RAB.	-	-
>>DL COUNT	M	*INTEGER(0.. 4294967295)*		Indicates the value of downlink COUNT associated to this E-RAB.	-	-
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB	YES	ignore
SeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the SeNB	YES	ignore

Range bound	Explanation
maxnoofBearers	Maximum no. of E-RABs. Value is 256

9.1.4 Messages for E-UTRAN-NR Dual Connectivity Procedures

9.1.4.1 SGNB ADDITION REQUEST

This message is sent by the MeNB to the en-gNB to request the preparation of resources for EN-DC operation for a specific UE

Direction: MeNB → en-gNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB	YES	reject
NR UE Security Capabilities	M		9.2.107		YES	reject
SgNB Security Key	M		9.2.101	The S-KgNB which is provided by the MeNB, see TS 33.401 [18].	YES	reject
SgNB UE Aggregate Maximum Bit Rate	M		UE Aggregate Maximum Bit Rate 9.2.12	The UE Aggregate Maximum Bit Rate is split into MeNB UE Aggregate Maximum Bit Rate and SgNB UE Aggregate Maximum Bit Rate which are enforced by MeNB and en-gNB respectively.	YES	reject
Selected PLMN	O		PLMN Identity 9.2.4	The selected PLMN of the SCG in the en-gNB.	YES	ignore
Handover Restriction List	O		9.2.3		YES	ignore
E-RABs To Be Added List		*1*			YES	reject
>E-RABs To Be Added Item		*1 .. <maxnoof Bearers>*			EACH	reject
>>E-RAB ID	M		9.2.23		–	
>>DRB ID	M		9.2.122		–	
>>EN-DC Resource Configuration	M		EN-DC Resource Configuration 9.2.108	Indicates the PDCP and Lower Layer MCG/SCG configuration.	–	
>>CHOICE *Resource Configuration*	M					
>>>PDCP present in SN				This choice tag is used if the *PDCP at SgNB* IE in the *EN-DC Resource Configuration* IE is set to the value "present".		
>>>>Full E-RAB Level QoS Parameters	M		E-RAB Level QoS Parameters 9.2.9	Includes the E-RAB level QoS parameters as received on S1-MME.	–	
>>>>Maximum MCG admittable E-RAB Level QoS Parameters	C-ifMCGandSCGpresent_GBR		GBR QoS Information 9.2.10	Includes the GBR QoS Information admittable by the MCG.	–	
>>>>DL Forwarding	O		9.2.5		–	
>>>>MeNB DL GTP TEID at MCG	C-ifMCGpresent		GTP Tunnel Endpoint 9.2.1	MeNB endpoint of the X2-U transport bearer at MCG. For delivery of DL PDCP PDUs.	–	
>>>>S1 UL GTP Tunnel Endpoint	M		GTP Tunnel Endpoint 9.2.1	SGW endpoint of the S1-U transport bearer. For delivery of UL PDUs from the en-gNB.	–	

>>>PDCP not present in SN				This choice tag is used if the *PDCP at SgNB* IE in the *EN-DC Resource Configuration* IE is set to the value "not present".		
>>>>Requested SCG E-RAB Level QoS Parameters	M		E-RAB Level QoS Parameters 9.2.9	Includes E-RAB level QoS parameters requested to be provided by the SCG.	–	
>>>>MeNB UL GTP TEID at PDCP	M		GTP Tunnel Endpoint 9.2.1	MeNB endpoint of the X2-U transport bearer. For delivery of UL PDCP PDUs.	–	
>>>>Secondary MeNB UL GTP TEID at PDCP	O		GTP Tunnel Endpoint 9.2.1	MeNB endpoint of the X2-U transport bearer. For delivery of UL PDCP PDUs in case of PDCP duplication.	–	
>>>>RLC Mode	M		RLC Mode 9.2.119	Indicates the RLC mode.	–	
>>>>UL configuration	C-ifMCGandSCGpresent		9.2.118	Information about UL usage in the en-gNB.	–	
MeNB to SgNB Container	M		OCTET STRING	Includes the *CG-ConfigInfo* message as defined in TS 38.331 [31].	YES	reject
SgNB UE X2AP ID	O		en-gNB UE X2AP ID 9.2.100	Allocated at the en-gNB.	YES	reject
Expected UE Behaviour	O		9.2.70		YES	ignore
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB.	YES	reject
Requested split SRBs	O		ENUMERATED (srb1, srb2, srb1&2, ...)	Indicates that resources for Split SRB are requested.	YES	reject
MeNB Resource Coordination Information	O		9.2.116	Information used to coordinate resources utilisation between MeNB and en-gNB.	YES	ignore
SGNB Addition Trigger Indication	O		ENUMERATED (SN change, inter-eNB HO, intra-eNB HO, ...)	This IE indicates the trigger for SGNB Addition procedure.	YES	reject
Subscriber Profile ID for RAT/Frequency priority	O		9.2.25		YES	ignore
MeNB Cell ID	M		ECGI 9.2.14	Indicates the cell ID for PCell in MeNB.	YES	reject

Range bound	Explanation
maxnoofBearers	Maximum no. of E-RABs. Value is 256.

Condition	Explanation
ifMCGandSCGpresent	This IE shall be present if, for the E-RAB requested to be added, the *MCG resources* and *SCG resources* IEs in the *EN-DC Resource Configuration* IE are set to the value "present".
ifMCGpresent	This IE shall be present if, for the E-RAB requested to be added, the *MCG resources* IE in the *EN-DC Resource Configuration* IE is set to the value "present".
C-ifMCGandSCGpresent_GBR	This IE shall be present if, for the E-RAB requested to be added, the *MCG resources* and *SCG resources* IEs in the *EN-DC Resource Configuration* IE are set to the value "present", and *GBR QoS Information* IE is present in *Full E-RAB Level QoS Parameters* IE.

9.1.4.2 SGNB ADDITION REQUEST ACKNOWLEDGE

This message is sent by the en-gNB to confirm the MeNB about the SgNB addition preparation.

Direction: en-gNB → MeNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB.	YES	reject
SgNB UE X2AP ID	M		en-gNB UE X2AP ID 9.2.100	Allocated at the en-gNB.	YES	reject
E-RABs Admitted To Be Added List		*1*			YES	ignore
>E-RABs Admitted To Be Added Item		*1 .. <maxnoof Bearers>*			EACH	ignore
>>E-RAB ID	M		9.2.23		–	
>>EN-DC Resource Configuration	M		EN-DC Resource Configuration 9.2.108	Indicates the PDCP and Lower Layer MCG/SCG configuration.	–	
>>CHOICE *Resource Configuration*	M					
>>>PDCP present in SN				This choice tag is used if the *PDCP at SgNB* IE in the *EN-DC Resource Configuration* IE is set to the value "present".		
>>>>S1 DL GTP TEID at the SgNB	M		GTP Tunnel Endpoint 9.2.1	en-gNB endpoint of the S1 transport bearer. For delivery of DL PDUs.	–	
>>>>SgNB UL GTP TEID at PDCP	C-ifMCGpresent		GTP Tunnel Endpoint 9.2.1	en-gNB endpoint of the X2-U transport bearer at PDCP. For delivery of UL PDCP PDUs.	–	
>>>>RLC Mode	C-ifMCGpresent		RLC Mode 9.2.119	Indicates the RLC mode.	–	
>>>>DL Forwarding GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	Identifies the X2 transport bearer used for forwarding of DL PDUs	–	
>>>>UL Forwarding GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	Identifies the X2 transport bearer used for forwarding of UL PDUs	–	
>>>>Requested MCG E-RAB Level QoS Parameters	C-ifMCGandSCGpresent_GBRpresent		E-RAB Level QoS Parameters 9.2.9	Includes E-RAB level QoS parameters requested to be provided by the MCG.	–	
>>>>UL configuration	C-ifMCGandSCGpresent		9.2.118	Information about UL usage in the MeNB.	–	
>>>PDCP not present in SN				This choice tag is used if the *PDCP at SgNB* IE in the *EN-DC Resource Configuration* IE is set to the value "not present".		

>>>>SgNB DL GTP TEID at SCG	M		GTP Tunnel Endpoint 9.2.1	SgNB endpoint of the X2-U transport bearer at the SCG. For delivery of DL PDCP PDUs.	–	–
>>>>Secondary SgNB DL GTP TEID at SCG	O		GTP Tunnel Endpoint 9.2.1	SgNB endpoint of the X2-U transport bearer at the SCG. For delivery of DL PDCP PDUs in case of PDCP duplication	–	–
E-RABs Not Admitted List	O		E-RAB List 9.2.28	A value for *E-RAB ID* shall only be present once in *E-RABs Admitted List* IE and in *E-RABs Not Admitted List* IE.	YES	ignore
SgNB to MeNB Container	M		OCTET STRING	Includes the *CG-Config* message as defined in TS 38.331[31].	YES	reject
Criticality Diagnostics	O		9.2.7		YES	ignore
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB	YES	reject
Admitted split SRBs	O		ENUMERATED (srb1, srb2, srb1&2, ...)	Indicates admitted SRBs	YES	reject
SgNB Resource Coordination Information	O		9.2.117	Information used to coordinate resources utilisation between en-gNB and MeNB.	YES	ignore
RRC config indication	O		ENUMERATED (full config, delta config, ...)	Indicates the type of RRC configuration used at the en-gNB.	YES	reject

Range bound	Explanation
maxnoofBearers	Maximum no. of E-RABs. Value is 256

Condition	Explanation
ifMCGpresent	This IE shall be present if, for the E-RAB admitted to be added, the *MCG resources* IE in the *EN-DC Resource Configuration* IE is set to the value "present".
ifMCGandSCGpresent	This IE shall be present if, for the E-RAB admitted to be added, the *MCG resources* and *SCG resources* IEs in the *EN-DC Resource Configuration* IE are set to the value "present".
C-ifMCGandSCGpresent_GBRpresent	This IE shall be present if, for the E-RAB admitted to be added, the *MCG resources* and *SCG resources* IEs in the *EN-DC Resource Configuration* IE are set to the value "present", and the *GBR QoS Information* IE is present in the *Requested MCG E-RAB Level QoS Parameters* IE.

9.1.4.3 SGNB ADDITION REQUEST REJECT

This message is sent by the en-gNB to inform the MeNB that the SgNB Addition Preparation has failed.

Direction: en-gNB → MeNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB.	YES	reject
SgNB UE X2AP ID	O		en-gNB UE X2AP ID 9.2.100	Allocated at the en-gNB.	YES	reject
Cause	M		9.2.6		YES	ignore
Criticality Diagnostics	O		9.2.7		YES	ignore
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB.	YES	reject

9.1.4.4 SGNB RECONFIGURATION COMPLETE

This message is sent by the MeNB to the en-gNB to indicate whether the configuration requested by the en-gNB was applied by the UE.

Direction: MeNB → en-gNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	ignore
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB.	YES	reject
SgNB UE X2AP ID	M		en-gNB UE X2AP ID 9.2.100	Allocated at the en-gNB.	YES	reject
Response Information	M				YES	ignore
>CHOICE *Response Type*	M					
>>*Configuration successfully applied*						
>>>MeNB to SgNB Container	O		OCTET STRING	Includes the NR *RRCReconfiguration Complete* message as defined in TS 38.331 [31].	-	
>>*Configuration rejected*						
>>>Cause	M		9.2.6		-	
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB	YES	reject

9.1.4.5 SGNB MODIFICATION REQUEST

This message is sent by the MeNB to the en-gNB to request the preparation to modify en-gNB resources for a specific UE, to query for the current SCG configuration, or to provide the S-RLF-related information to the en-gNB.

Direction: MeNB → en-gNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB.	YES	reject
SgNB UE X2AP ID	M		en-gNB UE X2AP ID 9.2.100	Allocated at the en-gNB.	YES	reject
Cause	M		9.2.6		YES	ignore
Selected PLMN	O		PLMN Identity 9.2.4	The selected PLMN of the SCG in the en-gNB.	YES	ignore
Handover Restriction List	O		9.2.3		YES	ignore
SCG Configuration Query	O		9.2.103		YES	ignore
UE Context Information		*0..1*			YES	reject
>NR UE Security Capabilities	O		9.2.107		–	
>SgNB Security Key	O		9.2.101		–	
>SgNB UE Aggregate Maximum Bit Rate	O		UE Aggregate Maximum Bit Rate 9.2.12		–	
>E-RABs To Be Added List		*0..1*			–	
>>E-RABs To Be Added Item		*1 .. <maxnoof Bearers>*			EACH	ignore
>>>E-RAB ID	M		9.2.23		–	
>>>DRB ID	M		9.2.122		–	
>>>EN-DC Resource Configuration	M		EN-DC Resource Configuration 9.2.108	Indicates the PDCP and Lower Layer MCG/SCG configuration.	–	
>>>CHOICE *Resource Configuration*	M					
>>>>*PDCP present in SN*				This choice tag is used if the *PDCP at SgNB* IE in the *EN-DC Resource Configuration* IE is set to the value "present".	–	
>>>>>Full E-RAB Level QoS Parameters	M		E-RAB Level QoS Parameters 9.2.9	Includes E-RAB level QoS parameters as received on S1-MME.	–	
>>>>>Maximum MCG admittable E-RAB Level QoS Parameters	C-ifMCGandSCGpresent_GBR		GBR QoS Information 9.2.10	Includes the GBR QoS Information admittable by the MCG.	–	
>>>>>DL Forwarding	O		9.2.5		–	
>>>>>MeNB DL GTP TEID at MCG	C-ifMCGpresent		GTP Tunnel Endpoint 9.2.1	MeNB endpoint of the X2-U transport bearer at MCG. For delivery of DL PDCP PDUs.	–	
>>>>>S1 UL GTP Tunnel Endpoint	M		GTP Tunnel Endpoint 9.2.1	SGW endpoint of the S1-U transport bearer. For delivery of UL PDUs from the en-gNB.	–	

>>>>PDCP not present in SN				This choice tag is used if the *PDCP at SgNB* IE in the *EN-DC Resource Configuration* IE is set to the value "present".		
>>>>>Requested SCG E-RAB Level QoS Parameters	M		E-RAB Level QoS Parameters 9.2.9	Includes necessary E-RAB level QoS parameters requested to be provided by the SCG.	–	
>>>>>MeNB UL GTP TEID at PDCP	M		GTP Tunnel Endpoint 9.2.1	MeNB endpoint of the X2-U transport bearer. For delivery of UL PDCP PDUs.	–	
>>>>>Secondary MeNB UL GTP TEID at PDCP	O		GTP Tunnel Endpoint 9.2.1	MeNB endpoint of the X2-U transport bearer. For delivery of UL PDCP PDUs in case of PDCP duplication.	–	
>>>>>RLC Mode	M		RLC Mode 9.2.119	Indicates the RLC mode.	–	
>>>>>UL configuration	C-ifMCGandSCGpresent		9.2.118	Information about UL usage in the en-gNB.	–	
>E-RABs To Be Modified List		*0..1*			–	
>>E-RABs To Be Modified Item		*1 .. <maxnoof Bearers>*			EACH	ignore
>>>E-RAB ID	M		9.2.23		–	
>>>EN-DC Resource Configuration	M		EN-DC Resource Configuration 9.2.108	Indicates the PDCP and Lower Layer MCG/SCG configuration.	–	
>>>CHOICE *Resource Configuration*	M					
>>>>PDCP present in SN				This choice tag is used if the *PDCP at SgNB* IE in the *EN-DC Resource Configuration* IE is set to the value "present".		
>>>>>Full E-RAB Level QoS Parameters	O		E-RAB Level QoS Parameters 9.2.9	Includes E-RAB level QoS parameters to be modified as received on S1-MME	–	
>>>>>Maximum MCG admittable E-RAB Level QoS Parameters	O		E-RAB Level QoS Parameters 9.2.9	Includes the E-RAB Level QoS parameters admittable by the MCG	–	
>>>>>MeNB GTP TEID at MCG	O		GTP Tunnel Endpoint 9.2.1	MeNB endpoint of the X2-U transport bearer at MCG. For delivery of DL PDCP PDUs.	–	

>>>>>S1 UL GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	SGW endpoint of the S1-U transport bearer. For delivery of UL PDUs from the en-gNB.	–	
>>>>*PDCP not present in SN*				This choice tag is used if the *PDCP at SgNB* IE in the *EN-DC Resource Configuration* IE is set to the value "not present".		
>>>>>Requested SCG E-RAB Level QoS Parameters	O		E-RAB Level QoS Parameters 9.2.9	Includes E-RAB level QoS parameters requested to be provided by the SCG.	–	
>>>>>MeNB UL GTP TEID at PDCP	O		GTP Tunnel Endpoint 9.2.1	MeNB endpoint of the X2-U transport bearer. For delivery of UL PDCP PDUs.	–	
>>>>>UL configuration	O		9.2.118	Information about UL usage in the en-gNB.	–	–
>E-RABs To Be Released List		*0..1*			–	
>>E-RABs To Be Released Item		*1 .. <maxnoof Bearers>*			EACH	ignore
>>E-RAB ID	M		9.2.23		–	
>>>EN-DC Resource Configuration	M		EN-DC Resource Configuration 9.2.108	Indicates the PDCP and Lower Layer MCG/SCG configuration.	–	
>>>CHOICE *Resource Configuration*	M					
>>>>*PDCP present in SN*				This choice tag is used if the *PDCP at SgNB* IE in the *EN-DC Resource Configuration* IE is set to the value "present".		
>>>>>DL Forwarding GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	Identifies the X2 transport bearer used for forwarding of DL PDUs	–	
>>>>>UL Forwarding GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	Identifies the X2 transport bearer. used for forwarding of UL PDUs	–	
>>>>*PDCP not present in SN*				This choice tag is used if the *PDCP at SgNB* IE in the *EN-DC Resource Configuration* IE is set to the value "not present".		
>Subscriber Profile ID for RAT/Frequency priority	O		9.2.25		-	-
MeNB to SgNB Container	O		OCTET STRING	Includes the *CG-ConfigInfo* message as defined in TS 38.331 [31].	YES	reject

MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB	YES	reject
MeNB Resource Coordination Information	O		9.2.116	Information used to coordinate resources utilisation between MeNB and en-gNB.	YES	ignore
Requested split SRBs	O		ENUMERATED (srb1, srb2, srb1&2, ...)	Indicates that resources for Split SRB are requested.	YES	ignore
Requested split SRBs release	O		ENUMERATED (srb1, srb2, srb1&2, ...)	Indicates that resources for Split SRB are requested to be released.	YES	ignore

Range bound	Explanation
maxnoofBearers	Maximum no. of E-RABs. Value is 256

Condition	Explanation
ifMCGandSCGpresent	This IE shall be present if, for the E-RAB requested to be added, the *MCG resources* and *SCG resources* IEs in the *EN-DC Resource Configuration* IE are set to the value "present".
ifMCGpresent	This IE shall be present if, for the E-RAB requested to be added, the *MCG resources* IE in the *EN-DC Resource Configuration* IE is set to the value "present".
C-ifMCGandSCGpresent_GBR	This IE shall be present if, for the E-RAB requested to be added, the *MCG resources* and *SCG resources* IEs in the *EN-DC Resource Configuration* IE are set to the value "present", and *GBR QoS Information* IE is present in *Full E-RAB Level QoS Parameters* IE.

9.1.4.6 SGNB MODIFICATION REQUEST ACKNOWLEDGE

This message is sent by the en-gNB to confirm the MeNB's request to modify the en-gNB resources for a specific UE.

Direction: en-gNB → MeNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB.	YES	ignore
SgNB UE X2AP ID	M		en-gNB UE X2AP ID 9.2.100	Allocated at the en-gNB.	YES	ignore
E-RABs Admitted List		*0..1*			YES	ignore
>E-RABs Admitted To Be Added List		*1*			–	
>>E-RABs Admitted To Be Added Item		*1 .. <maxnoof Bearers>*			EACH	ignore
>>>E-RAB ID	M		9.2.23		–	
>>>EN-DC Resource Configuration	M		EN-DC Resource Configuration 9.2.108	Indicates the PDCP and Lower Layer MCG/SCG configuration.	–	
>>>CHOICE *Resource Configuration*	M					
>>>>PDCP present in SN				This choice tag is used if the *PDCP at SgNB* IE in the *EN-DC Resource Configuration* IE is set to the value "present".		
>>>>>S1 DL GTP TEID at the SgNB	M		GTP Tunnel Endpoint 9.2.1	SgNB endpoint of the S1 transport bearer. For delivery of DL PDUs.	–	
>>>>>SgNB UL GTP TEID at PDCP	C-ifMCGpresent		GTP Tunnel Endpoint 9.2.1	SgNB endpoint of the X2-U transport bearer at PDCP. For delivery of UL PDCP PDUs.	–	
>>>>>RLC Mode	C-ifMCGpresent		RLC Mode 9.2.119	Indicates the RLC mode.	–	
>>>>>DL Forwarding GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	Identifies the X2 transport bearer used for forwarding of DL PDUs	–	
>>>>>UL Forwarding GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	Identifies the X2 transport bearer used for forwarding of UL PDUs	–	
>>>>>Requested MCG E-RAB Level QoS Parameters	C-ifMCGandSCGpresent_GBRpresent		E-RAB Level QoS Parameters 9.2.9	Includes E-RAB level QoS parameters requested to be provided by the MCG.	–	
>>>>>UL configuration	C-ifMCGandSCGpresent		9.2.118	Information about UL usage in the MeNB.	–	
>>>>PDCP not present in SN				This choice tag is used if the *PDCP at SgNB* IE in the *EN-DC Resource Configuration* IE is set to the value "not present".		
>>>>>SgNB DL GTP TEID at SCG	M		GTP Tunnel Endpoint 9.2.1	Endpoint of the X2-U transport bearer at the SCG. For delivery of DL PDCP PDUs.	–	–

>>>>>Secondary SgNB DL GTP TEID at SCG	O		GTP Tunnel Endpoint 9.2.1	Endpoint of the X2-U transport bearer at the SCG. For delivery of DL PDCP PDUs in case of PDCP duplication.	–	–
>E-RABs Admitted To Be Modified List		*0..1*			–	
>>E-RABs Admitted To Be Modified Item		*1 .. <maxnoof Bearers>*			EACH	ignore
>>>E-RAB ID	M		9.2.23		–	
>>>EN-DC Resource Configuration	M		EN-DC Resource Configuration 9.2.108	Indicates the PDCP and Lower Layer MCG/SCG configuration.	–	
>>>CHOICE *Resource Configuration*	M					
>>>>*PDCP present in SN*				This choice tag is used if the *PDCP at SgNB* IE in the *EN-DC Resource Configuration* IE is set to the value "present".		
>>>>>S1 DL GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	SgNB endpoint of the S1 transport bearer. For delivery of DL PDUs.	–	
>>>>>SgNB UL GTP TEID at PDCP	O		GTP Tunnel Endpoint 9.2.1	SgNB endpoint of the X2-U transport bearer at PDCP. For delivery of UL PDCP PDUs.	–	
>>>>>Requested MCG E-RAB Level QoS Parameters	O		E-RAB Level QoS Parameters 9.2.9	Includes E-RAB level QoS parameters requested to be provided by the MCG.	–	
>>>>>UL configuration	O		9.2.118	Information about UL usage in the MeNB.	–	–
>>>>*PDCP not present in SN*				This choice tag is used if the *PDCP at SgNB* IE in the *EN-DC Resource Configuration* IE is set to the value "not present".		
>>>>>SgNB DL GTP TEID at SCG	O		GTP Tunnel Endpoint 9.2.1	SgNB endpoint of the X2-U transport bearer at the SCG. For delivery of DL PDCP PDUs.	–	
>E-RABs Admitted To Be Released List		*0..1*			–	
>>E-RABs Admitted To Be Released Item		*1 .. <maxnoof Bearers>*			EACH	ignore
>>>E-RAB ID	M		9.2.23		–	
>>>EN-DC Resource Configuration	M		EN-DC Resource Configuration 9.2.108	Indicates the PDCP and Lower Layer MCG/SCG configuration.	–	
>>>CHOICE *Resource Configuration*	M			Note: no further information contained in the IE container		

E-RABs Not Admitted List	O		E-RAB List 9.2.28	A value for *E-RAB ID* shall only be present once in *E-RABs Admitted List* IE and in *E-RABs Not Admitted List* IE.	YES	ignore
SgNB to MeNB Container	O		OCTET STRING	Includes the NR *CG-Config* message as defined in TS 38.331 [31].	YES	ignore
Criticality Diagnostics	O		9.2.7		YES	ignore
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB	YES	ignore
SgNB Resource Coordination Information	O		9.2.117	Information used to coordinate resources utilisation between en-gNB and MeNB.	YES	ignore
Admitted split SRBs	O		ENUMERATED (srb1, srb2, srb1&2, ...)	Indicates admitted SRBs	YES	ignore
Admitted split SRBs release	O		ENUMERATED (srb1, srb2, srb1&2, ...)	Indicates admitted SRBs release	YES	ignore

Range bound	Explanation
maxnoofBearers	Maximum no. of E-RABs. Value is 256

Condition	Explanation
ifMCGandSCGpresent	This IE shall be present if, for the E-RAB admitted to be added, the *MCG resources* and *SCG resources* IEs in the *EN-DC Resource Configuration* IE are set to the value "present".
ifMCGpresent	This IE shall be present if, for the E-RAB admitted to be added, the *MCG resources* IE in the *EN-DC Resource Configuration* IE is set to the value "present".
C-ifMCGandSCGpresent_GBRpresent	This IE shall be present if, for the E-RAB admitted to be added, the *MCG resources* and *SCG resources* IEs in the *EN-DC Resource Configuration* IE are set to the value "present", and the *GBR QoS Information* IE is present in the *Requested MCG E-RAB Level QoS Parameters* IE.

9.1.4.7 SGNB MODIFICATION REQUEST REJECT

This message is sent by the en-gNB to inform the MeNB that the MeNB initiated SgNB Modification Preparation has failed.

Direction: en-gNB → MeNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB.	YES	ignore
SgNB UE X2AP ID	M		en-gNB UE X2AP ID 9.2.100	Allocated at the en-gNB.	YES	ignore
Cause	M		9.2.6		YES	ignore
Criticality Diagnostics	O		9.2.7		YES	ignore
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB.	YES	ignore

9.1.4.8 SGNB MODIFICATION REQUIRED

This message is sent by the en-gNB to the MeNB to request the modification of en-gNB resources for a specific UE.

Direction: en-gNB → MeNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB.	YES	reject
SgNB UE X2AP ID	M		en-gNB UE X2AP ID 9.2.100	Allocated at the en-gNB.	YES	reject
Cause	M		9.2.6		YES	ignore
PDCP Change Indication	O		9.2.109		YES	ignore
E-RABs To Be Released List		*0..1*			YES	ignore
>E-RABs To Be Released Item		*1 .. <maxnoof Bearers>*			EACH	ignore
>>E-RAB ID	M		9.2.23		–	
>>Cause	M		9.2.6		–	
SgNB to MeNB Container	O		OCTET STRING	Includes the NR *CG-Config* message as defined in TS 38.331 [31].	YES	ignore
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB	YES	reject
E-RABs To Be Modified List		*0..1*			YES	ignore
>E-RABs To Be Modified Item		*1 .. <maxnoof Bearers>*			EACH	ignore
>>E-RAB ID	M		9.2.23		–	
>>EN-DC Resource Configuration	M		EN-DC Resource Configuration 9.2.108	Indicates the PDCP and Lower Layer MCG/SCG configuration.	–	
>>CHOICE *Resource Configuration*	M					
>>>PDCP present in SN				This choice tag is used if the *PDCP at SgNB* IE in the *EN-DC Resource Configuration* IE is set to the value "present".		
>>>>Requested MCG E-RAB Level QoS Parameters	O		E-RAB Level QoS Parameters 9.2.9	Includes E-RAB level QoS parameters requested to be provided by the MCG.	–	
>>>>UL configuration	O		9.2.118	Information about UL usage in the MeNB.	–	–
>>>>SgNB UL GTP TEID at PDCP	O		GTP Tunnel Endpoint 9.2.1	SgNB endpoint of the X2-U transport bearer at PDCP. For delivery of UL PDCP PDUs.	–	
>>>>S1 DL GTP TEID at the SgNB	O		GTP Tunnel Endpoint 9.2.1	en-gNB endpoint of the S1 transport bearer. For delivery of DL PDUs.	–	

>>>PDCP not present in SN				This choice tag is used if the *PDCP at SgNB* IE in the *EN-DC Resource Configuration* IE is set to the value "not present".		
>>>>SgNB DL GTP TEID at SCG	O		GTP Tunnel Endpoint 9.2.1	SgNB endpoint of the X2-U transport bearer at the SCG. For delivery of DL PDCP PDUs.	–	
>>>>>Secondary SgNB DL GTP TEID at SCG	O		GTP Tunnel Endpoint 9.2.1	SgNB endpoint of the X2-U transport bearer at the SCG. For delivery of DL PDCP PDUs for PDCP duplication.	–	
SgNB Resource Coordination Information	O		9.2.117	Information used to coordinate resources utilisation between the en-gNB and the MeNB.	YES	ignore

Range bound	Explanation
maxnoofBearers	Maximum no. of E-RABs. Value is 256

9.1.4.9 SGNB MODIFICATION CONFIRM

This message is sent by the MeNB to inform the en-gNB about the successful modification.

Direction: MeNB → en-gNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB.	YES	ignore
SgNB UE X2AP ID	M		en-gNB UE X2AP ID 9.2.100	Allocated at the en-gNB.	YES	ignore
E-RABs Admitted To Be Modified List		*0..1*			YES	ignore
>E-RABs To Be Modified Item		*1 .. <maxnoof Bearers>*			EACH	ignore
>>E-RAB ID	M		9.2.23		–	
>>EN-DC Resource Configuration	M		EN-DC Resource Configuration 9.2.108	Indicates the PDCP and Lower Layer MCG/SCG configuration.	–	
>>CHOICE *Resource Configuration*	M					
>>>PDCP not present in SN				This choice tag is used if the *PDCP at SgNB* IE in the *EN-DC Resource Configuration* IE is set to the value "not present".		
>>>>>Secondary MeNB UL GTP TEID at PDCP	O		GTP Tunnel Endpoint 9.2.1	MeNB endpoint of the X2-U transport bearer at the PDCP. For delivery of UL PDCP PDUs for PDCP duplication.	–	
MeNB to SgNB Container	O		OCTET STRING	Includes the NR *RRCReconfigurationComplete* message as defined in TS 38.331 [31].	YES	ignore
Criticality Diagnostics	O		9.2.7		YES	ignore
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB.	YES	ignore
MeNB Resource Coordination Information	O		9.2.116	Information used to coordinate resources utilisation between the MeNB and the en-gNB.	YES	ignore

Range bound	Explanation
maxnoofBearers	Maximum no. of E-RABs. Value is 256

9.1.4.10 SGNB MODIFICATION REFUSE

This message is sent by the MeNB to inform the en-gNB that the SgNB initiated SgNB Modification has failed.

Direction: MeNB → en-gNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB.	YES	ignore
SgNB UE X2AP ID	M		en-gNB UE X2AP ID 9.2.100	Allocated at the en-gNB.	YES	ignore
Cause	M		9.2.6		YES	ignore
MeNB to SgNB Container	O		OCTET STRING	Includes the *CG-ConfigInfo* message as defined in TS 38.331 [31].	YES	ignore
Criticality Diagnostics	O		9.2.7		YES	ignore
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB.	YES	ignore

9.1.4.11 SGNB RELEASE REQUEST

This message is sent by the MeNB to the en-gNB to request the release of resources.

Direction: MeNB → en-gNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	ignore
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB.	YES	reject
SgNB UE X2AP ID	O		en-gNB UE X2AP ID 9.2.100	Allocated at the en-gNB.	YES	reject
Cause	M		9.2.6		YES	ignore
E-RABs To Be Released List		*0..1*			YES	ignore
> E-RABs To Be Released Item		*1 .. <maxnoof Bearers>*			EACH	ignore
>>E-RAB ID	M		9.2.23		–	
>>EN-DC Resource Configuration	M		EN-DC Resource Configuration 9.2.108	Indicates the PDCP and Lower Layer MCG/SCG configuration.	–	
>>CHOICE *Resource Configuration*	M					
>>>PDCP present in SN				This choice tag is used if the *PDCP at SgNB* IE in the *EN-DC Resource Configuration* IE is set to the value "present".		
>>>>UL Forwarding GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	Identifies the X2 transport bearer used for forwarding of UL PDUs	–	
>>>>DL Forwarding GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	Identifies the X2 transport bearer. used for forwarding of DL PDUs	–	
>>>PDCP not present in SN				This choice tag is used if the *PDCP at SgNB* IE in the *EN-DC Resource Configuration* IE is set to the value "not present".		
UE Context Kept Indicator	O		9.2.85		YES	ignore
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB	YES	reject
MeNB to SgNB Container	O		OCTET STRING	Includes the *CG-ConfigInfo* message as defined in TS 38.331 [31].	YES	reject

Range bound	Explanation
maxnoofBearers	Maximum no. of E-RABs. Value is 256

9.1.4.12 SGNB RELEASE REQUEST ACKNOWLEDGE

This message is sent by the en-gNB to the MeNB to confirme the request to release en-gNB resources.

Direction: en-gNB → MeNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	ignore
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB.	YES	reject
SgNB UE X2AP ID	M		en-gNB UE X2AP ID 9.2.100	Allocated at the en-gNB.	YES	reject
Criticality Diagnostics	O		9.2.7		YES	ignore
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB.	YES	reject

9.1.4.13 SGNB RELEASE REQUEST REJECT

This message is sent by the en-gNB to the MeNB to reject the request to release en-gNB resources.

Direction: en-gNB → MeNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	ignore
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB.	YES	reject
SgNB UE X2AP ID	O		en-gNB UE X2AP ID 9.2.100	Allocated at the en-gNB.	YES	reject
Cause	M		9.2.6		YES	ignore
Criticality Diagnostics	O		9.2.7		YES	ignore
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB.	YES	reject

9.1.4.14 SGNB RELEASE REQUIRED

This message is sent by the en-gNB to request the release of all resources for a specific UE at the en-gNB.

Direction: en-gNB → MeNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB.	YES	reject
SgNB UE X2AP ID	M		en-gNB UE X2AP ID 9.2.100	Allocated at the en-gNB.	YES	reject
Cause	M		9.2.6		YES	ignore
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB.	YES	reject

9.1.4.15 SGNB RELEASE CONFIRM

This message is sent by the MeNB to confirm the release of all resources for a specific UE at the en-gNB.

Direction: MeNB → en-gNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB.	YES	ignore
SgNB UE X2AP ID	M		en-gNB UE X2AP ID 9.2.100	Allocated at the en-gNB.	YES	ignore
E-RABs to be Released List		*0..1*			YES	ignore
>E-RABs To Be Released Item		*1 .. <maxnoof Bearers>*			–	
>>E-RAB ID	M		9.2.23		–	
>>EN-DC Resource Configuration	M		EN-DC Resource Configuration 9.2.108	Indicates the PDCP and Lower Layer MCG/SCG configuration.	–	
>>CHOICE *Resource Configuration*	M					
>>>PDCP present in SN				This choice tag is used if the *PDCP at SgNB* IE in the *EN-DC Resource Configuration* IE is set to the value "present".		
>>>>DL Forwarding GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	Identifies the X2 transport bearer used for forwarding of DL PDUs	–	
>>>>UL Forwarding GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	Identifies the X2 transport bearer used for forwarding of UL PDUs	–	
>>>PDCP not present in SN				This choice tag is used if the *PDCP at SgNB* IE in the *EN-DC Resource Configuration* IE is set to the value "not present".		
Criticality Diagnostics	O		9.2.7		YES	ignore
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB	YES	ignore

Range bound	Explanation
maxnoofBearers	Maximum no. of E-RABs. Value is 256

9.1.4.16 SGNB COUNTER CHECK REQUEST

This message is sent by the en-gNB to request the verification of the value of the PDCP COUNTs associated with the bearers established in the en-gNB.

Direction: en-gNB → MeNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB.	YES	ignore
SgNB UE X2AP ID	M		en-gNB UE X2AP ID 9.2.100	Allocated at the en-gNB.	YES	ignore
E-RABs Subject to Counter Check List		*1*			YES	ignore
>E-RABs Subject to Counter Check Item		*1 .. <maxnoof Bearers>*			EACH	ignore
>>E-RAB ID	M		9.2.23		-	
>>UL COUNT	M	*INTEGER(0.. 4294967295)*		Indicates the value of uplink COUNT associated to this E-RAB.	-	
>>DL COUNT	M	*INTEGER(0.. 4294967295)*		Indicates the value of downlink COUNT associated to this E-RAB.	-	
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB	YES	ignore

Range bound	Explanation
maxnoofBearers	Maximum no. of E-RABs. Value is 256

9.1.4.17 SGNB CHANGE REQUIRED

This message is sent by the en-gNB to the MeNB to request the change of en-gNB for a specific UE.

Direction: en-gNB → MeNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB.	YES	reject
SgNB UE X2AP ID	M		en-gNB UE X2AP ID 9.2.100	Allocated at the en-gNB.	YES	reject
Target SgNB ID Information	M		9.2.102		YES	reject
Cause	M		9.2.6		YES	ignore
SgNB to MeNB Container	O		OCTET STRING	Includes the *CG-Config* message as defined in TS 38.331 [31].	YES	reject
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB.	YES	reject

9.1.4.18 SGNB CHANGE CONFIRM

This message is sent by the MeNB to inform the en-gNB about the successful change.

Direction: MeNB → en-gNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB.	YES	ignore
SgNB UE X2AP ID	M		en-gNB UE X2AP ID 9.2.100	Allocated at the en-gNB.	YES	ignore
E-RABs to be Released List		*0..1*			YES	ignore
>E-RABs To Be Released Item		*1 .. <maxnoof Bearers>*			–	
>>E-RAB ID	M		9.2.23		–	
>>EN-DC Resource Configuration	M		EN-DC Resource Configuration 9.2.108	Indicates the PDCP and Lower Layer MCG/SCG configuration.	–	
>>CHOICE *Resource Configuration*	M					
>>>PDCP present in SN				This choice tag is used if the *PDCP at SgNB* IE in the *EN-DC Resource Configuration* IE is set to the value "present".		
>>>>DL Forwarding GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	Identifies the X2 transport bearer used for forwarding of DL PDUs	–	
>>>>UL Forwarding GTP Tunnel Endpoint	O		GTP Tunnel Endpoint 9.2.1	Identifies the X2 transport bearer used for forwarding of UL PDUs	–	
>>>PDCP not present in SN				This choice tag is used if the *PDCP at SgNB* IE in the *EN-DC Resource Configuration* IE is set to the value "not present".		
Criticality Diagnostics	O		9.2.7		YES	ignore
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB	YES	ignore

Range bound	Explanation
maxnoofBearers	Maximum no. of E-RABs. Value is 256

9.1.4.19 SGNB CHANGE REFUSE

This message is sent by the MeNB to inform the en-gNB that the SgNB initiated SgNB Change has failed.

Direction: MeNB → en-gNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB.	YES	ignore
SgNB UE X2AP ID	M		en-gNB UE X2AP ID 9.2.100	Allocated at the en-gNB.	YES	ignore
Cause	M		9.2.6		YES	ignore
Criticality Diagnostics	O		9.2.7		YES	ignore
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB.	YES	reject

9.1.4.20 SECONDARY RAT DATA USAGE REPORT

This message is sent by the en-gNB to report data volumes for secondary RAT.

Direction: en-gNB → MeNB

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB	YES	reject
SgNB UE X2AP ID	M		en-gNB UE X2AP ID 9.2.100	Allocated at the en-gNB.	YES	reject
Secondary RAT Usage Report list	M		9.2.120		YES	ignore
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB.	YES	reject

9.1.4.21 RRC TRANSFER

This message is sent by the MeNB to the en-gNB or by the en-gNB to the MeNB to transfer an RRC message.

Direction: MeNB → en-gNB or en-gNB → MeNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB.	YES	reject
SgNB UE X2AP ID	M		en-gNB UE X2AP ID 9.2.100	Allocated at the en-gNB.	YES	reject
split SRB		*0..1*				
> RRC Container	O		OCTET STRING	RRC message encapsulated in a PDCP-C PDU and ciphered with the key of the MeNB	YES	reject
> SRB Type	M		ENUMERATED (srb1, srb2, ...)	The SRB type	YES	reject
> Delivery status	O		9.2.104	DL RRC delivery status of split SRB	YES	reject
NR UE Measurement Report		*0..1*				
> RRC Container	M		OCTET STRING	Includes the UL-DCCH-Message as defined in subclause 6.2.1 of TS 38.331 [31] containing the MeasurementReport message.	YES	reject
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB.	YES	reject

9.1.4.22 PARTIAL RESET REQUIRED

This message is sent by an initiating node to a neighbouring node, both nodes able to interact for EN-DC, to release all the resources for selected UEs.

Direction: en-gNB → MeNB, MeNB → en-gNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigne Criticalit
Message Type	M		9.2.13		YES	reject
UEs to be Reset List		*1*			YES	reject
>UEs To Be Reset Item		*1 .. <maxnoof UEs>*				
>>MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB.		
>>SgNB UE X2AP ID	O		en-gNB UE X2AP ID 9.2.100	Allocated at the en-gNB.		
>>MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB.		
Cause	M		9.2.6		YES	ignore

Range bound	Explanation
maxnoofUEs	Maximum no. of UEs. Value is 8192.

9.1.4.23 PARTIAL RESET CONFIRM

This message is sent by an initiating node to a neighbouring node, both nodes able to interact for EN-DC, to confirm the release all the resources for selected UEs.

Direction: en-gNB → MeNB, MeNB → en-gNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
UEs Admitted to be Reset List		*1*			YES	reject
>UEs Admitted To Be Reset Item		*1 .. <maxnoofUEsinengNBDU>*				
>>MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB.		
>>SgNB UE X2AP ID	O		en-gNB UE X2AP ID 9.2.100	Allocated at the en-gNB.		
>>MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB.		

Range bound	Explanation
maxnoofUEsinengNBDU	Maximum no. of UEs. Value is 8192.

9.1.4.24 E-UTRA – NR CELL RESOURCE COORDINATION REQUEST

Direction: eNB → en-gNB, en-gNB → eNB.

This message is sent by a neighbouring eNB to a peer en-gNB or by a neighbouring en-gNB to a peer eNB, both nodes able to interact for EN-DC, to express the desired resource allocation for data traffic, for the sake of E-UTRA - NR Cell Resource Coordination.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
CHOICE *Initiating Node Type*	M				-	
>*eNB*						
>>Data Traffic Resource Indication	M		9.2.126	Indicates resource allocations for data traffic.	YES	reject
>>Spectrum Sharing Group ID	M		INTEGER (1.. maxCellineNB)	Indicates the E-UTRA cells involved in resource coordination with the NR cells affiliated with the same *Spectrum Sharing Group ID.*	YES	reject
>>List of E-UTRA Cells in E-UTRA Coordination Request		*0 .. <maxCellineNB>*		List of applicable E-UTRA cells.	YES	reject
>>>EUTRA Cell ID	M		ECGI 9.2.14		-	-
>*en-gNB*						
>>Data Traffic Resource Indication	M		9.2.126	Indicates resource allocations for data traffic.	YES	reject
>>List of E-UTRA Cells in NR Coordination Request		*1 .. <maxCellineNB>*		List of applicable E-UTRA cells	YES	reject
>>>EUTRA Cell ID	M		ECGI 9.2.14		–	–
>>Spectrum Sharing Group ID	M		INTEGER (1.. maxCellineNB)	Indicates the NR cells involved in resource coordination with the E-UTRA cells affiliated with the same *Spectrum Sharing Group ID.*	YES	reject
>>List of NR Cells in NR Coordination Request		*0 .. <* maxnoNRcellsSpectrumSharingwithE-UTRA >		List of applicable NR cells	YES	reject
>>>NR-Cell ID	M		NR-CGI 9.2.105		-	

Range bound	Explanation
maxCellineNB	Maximum no. of E-UTRA cells in eNB. Value is 256.
maxnoNRcellsSpectrumSharingwithE-UTRA	Maximum no. of NR cells involved in spectrum sharing with an eNB. Value is 64.

9.1.4.25 E-UTRA – NR CELL RESOURCE COORDINATION RESPONSE

Direction: eNB → en-gNB, en-gNB → eNB.

This message is sent by a neighbouring eNB to a peer en-gNB or by a neighbouring en-gNB to a peer eNB, both nodes able to interact for EN-DC, as a response to the E-UTRA – NR CELL RESOURCE COORDINATION REQUEST.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
CHOICE *Responding NodeType*	M				-	
>*eNB*						
>>Data Traffic Resource Indication	M		9.2.126	Indicates resource allocations for data traffic.	YES	reject
>>Spectrum Sharing Group ID	M		INTEGER (1.. maxCellineNB)	Indicates the E-UTRA cells involved in resource coordination with the NR cells affiliated with the same *Spectrum Sharing Group ID.*	YES	reject
>>List of E-UTRA Cells in E-UTRA Coordination Response		*1 .. <maxCellineNB>*		List of applicable E-UTRA cells	YES	reject
>>>EUTRA Cell ID	M		ECGI 9.2.14		-	-
>*en-gNB*						
>>Data Traffic Resource Indication	M		9.2.126	Indicates resource allocations for data traffic.	YES	reject
>>Spectrum Sharing Group ID	M		INTEGER (1.. maxCellineNB)	Indicates the NR cells involved in resource coordination with the E-UTRA cells affiliated with the same *Spectrum Sharing Group ID.*	YES	reject
>>List of NR Cells in NR Coordination Response		*1 .. < maxnoNRcellsSpectrumSharingwithE-UTRA >*		List of applicable NR cells	YES	reject
>>>NR Cell ID	M		NR-CGI 9.2.105		-	

Range bound	Explanation
maxCellineNB	Maximum no. of E-UTRA cells in eNB. Value is 256.
maxnoNRcellsSpectrumSharingwithE-UTRA	Maximum no. of NR cells involved in spectrum sharing with an eNB. Value is 64.

9.1.4.26 SGNB ACTIVITY NOTIFICATION

This message is sent by the en-gNB to inform the MeNB that resources for E-RABs controlled by the en-gNB have not been used or are in use again.

Direction: en-gNB → MeNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.13		YES	reject
MeNB UE X2AP ID	M		eNB UE X2AP ID 9.2.24	Allocated at the MeNB.	YES	ignore
SgNB UE X2AP ID	M		en-gNB UE X2AP ID 9.2.100	Allocated at the en-gNB.	YES	ignore
UE Context level user plane activity report	O		User plane traffic activity report 9.2.130		YES	ignore
E-RAB Activity Notify Item List		*0..<maxnoofBearers>*			EACH	ignore
>E-RAB ID	M		9.2.23		–	
>User plane traffic activity report	M		9.2.130		–	
MeNB UE X2AP ID Extension	O		Extended eNB UE X2AP ID 9.2.86	Allocated at the MeNB.	YES	reject

Range bound	Explanation
maxnoofBearers	Maximum no. of E-RABs. Value is 256

9.2 Information Element definitions

9.2.0 General

When specifying information elements which are to be represented by bit strings, if not otherwise specifically stated in the semantics description of the concerned IE or elsewhere, the following principle applies with regards to the ordering of bits:

- The first bit (leftmost bit) contains the most significant bit (MSB);
- The last bit (rightmost bit) contains the least significant bit (LSB);
- When importing bit strings from other specifications, the first bit of the bit string contains the first bit of the concerned information.

9.2.1 GTP Tunnel Endpoint

The *GTP Tunnel Endpoint* IE identifies an X2 transport bearer or the S-GW endpoint of the S1 transport bearer associated to an E-RAB. It contains a Transport Layer Address and a GTP Tunnel Endpoint Identifier. The Transport Layer Address is an IP address to be used for the X2 user plane transport (see TS 36.424 [8]) or for the S1 user plane transport (see TS 36.414 [19]). The GTP Tunnel Endpoint Identifier is to be used for the user plane transport between eNB and the S-GW, between eNBs, between eNB and en-gNB, or between en-gNBs.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Transport Layer Address	M		BIT STRING (1..160, ...)	For details on the Transport Layer Address, see TS 36.424 [8], TS 36.414 [19]	–	–
GTP TEID	M		OCTET STRING (4)	For details and range, see TS 29.281 [26]	–	–

9.2.2 Trace Activation

Defines parameters related to trace activation.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
E-UTRAN Trace ID	M		OCTET STRING (8)	The E-UTRAN Trace ID IE is composed of the following: Trace Reference defined in TS 32.422 [6] (leftmost 6 octets, with PLMN information coded as in 9.2.4), and Trace Recording Session Reference defined in TS 32.422 [6] (last 2 octets)	–	–
Interfaces To Trace	M		BIT STRING (8)	Each position in the bitmap represents a eNB interface: first bit =S1-MME, second bit =X2, third bit =Uu. Other bits reserved for future use. Value '1' indicates 'should be traced'. Value '0' indicates 'should not be traced'.	–	–
Trace Depth	M		ENUMERATED(minimum, medium, maximum, MinimumWithoutVendorSpecificExtension, MediumWithoutVendorSpecificExtension, MaximumWithoutVendorSpecificExtension, ...)	Defined in TS 32.421 [7]	–	–
Trace Collection Entity IP Address	M		BIT STRING (1..160,…)	For details on the Transport Layer Address, see TS 36.424 [8], TS 36.414 [19]	–	–
MDT Configuration	O		9.2.56		YES	ignore
UE Application layer measurement configuration	O		9.2.121		YES	ignore

9.2.3 Handover Restriction List

This IE defines roaming or access restrictions for subsequent mobility action for which the eNB provides information about the target of the mobility action towards the UE, e.g., handover and CCO, or for SCG selection during dual connectivity operation.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Serving PLMN	M		PLMN Identity 9.2.4		–	–
Equivalent PLMNs		*0..<maxnoof EPLMNs>*		Allowed PLMNs in addition to Serving PLMN. This list corresponds to the list of "equivalent PLMNs list" as defined in TS 24.301 [14]. This list is part of the roaming restriction information. Roaming restrictions apply to PLMNs other than the serving PLMN and Equivalent PLMNs.	–	–
>PLMN Identity	M		9.2.4		–	–
Forbidden TAs		*0..<maxnoof EPLMNsPlus One>*		intra E-UTRAN roaming restrictions	–	–
>PLMN Identity	M		9.2.4	The PLMN of forbidden TACs	–	–
>Forbidden TACs		*1..<maxnoof ForbTACs>*			–	–
>>TAC	M		OCTET STRING(2)	The forbidden TAC	–	–
Forbidden LAs		*0..<maxnoof EPLMNsPlus One>*		inter-3GPP RAT roaming restrictions	–	–
>PLMN Identity	M		9.2.4		–	–
>Forbidden LACs		*1..<maxnoof ForbLACs>*			–	–
>>LAC	M		OCTET STRING(2)		–	–
Forbidden inter RATs	O		ENUMERATED(ALL, GERAN, UTRAN, CDMA2000, …,GERAN and UTRAN, CDMA2000 and UTRAN)	inter-3GPP and 3GPP2 RAT access restrictions. "ALL" means that all RATs mentioned in the enumeration of this IE are restricted.	–	–
NR restriction	O		ENUMERATED(NRrestricted, …)	Restriction to use NR.	YES	ignore
Core Network Type Restrictions		*0..<maxnoof EPLMNsPlus One>*		Core network type restriction information as specified in TS 23.501 [38].		
>PLMN Identity			9.2.4	The PLMN of forbidden core network.		
>Core Network Type			ENUMERATED (5GCForbiddden, …)	The indication indicates whether UE is allowed to connect to 5GC for this PLMN.		

Range bound	Explanation
maxnoofEPLMNs	Maximum no. of equivalent PLMN Ids. Value is 15.
maxnoofEPLMNsPlusOne	Maximum no. of equivalent PLMN Ids plus one. Value is 16.
maxnoofForbTACs	Maximum no. of forbidden Tracking Area Codes. Value is 4096.
maxnoofForbLACs	Maximum no. of forbidden Location Area Codes. Value is 4096.

9.2.4 PLMN Identity

This information element indicates the PLMN Identity.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
PLMN Identity	M		OCTET STRING (3)	- digits 0 to 9, encoded 0000 to 1001, - 1111 used as filler digit, two digits per octet, - bits 4 to 1 of octet n encoding digit 2n-1 - bits 8 to 5 of octet n encoding digit 2n -The PLMN identity consists of 3 digits from MCC followed by either -a filler digit plus 2 digits from MNC (in case of 2 digit MNC) or -3 digits from MNC (in case of a 3 digit MNC).

9.2.5 DL Forwarding

This element indicates that the E-RAB is proposed for forwarding of downlink packets.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
DL Forwarding	M		ENUMERATED (DL forwarding proposed, …)	

9.2.6 Cause

The purpose of the cause information element is to indicate the reason for a particular event for the whole protocol.

IE/Group Name	Presence	Range	IE Type and Reference	Semantics Description
CHOICE *Cause Group*	M			
>Radio Network Layer				
>>Radio Network Layer Cause	M		ENUMERATED (Handover Desirable for Radio Reasons, Time Critical Handover, Resource Optimisation Handover, Reduce Load in Serving Cell, Partial Handover, Unknown New eNB UE X2AP ID, Unknown Old eNB UE X2AP ID, Unknown Pair of UE X2AP ID, HO Target not Allowed, $TX2_{RELOCoverall}$ Expiry, $T_{RELOCprep}$ Expiry, Cell not Available, No Radio Resources Available in Target Cell, Invalid MME Group ID, Unknown MME Code, Encryption And/Or Integrity Protection Algorithms Not Supported, ReportCharacteristicsEmpty, NoReportPeriodicity, ExistingMeasurementID, Unknown eNB Measurement ID, Measurement Temporarily not Available, Unspecified,...,Load Balancing, Handover Optimisation, Value out of allowed range, Multiple E-RAB ID instances, Switch Off Ongoing, Not supported QCI value, Measurement not supported for the object,$T_{DCoverall}$ Expiry, T_{DCprep} Expiry, Action Desirable for Radio Reasons, Reduce Load, Resource Optimisation, Time Critical action, Target not Allowed, No Radio Resources Available, Invalid QoS combination, Encryption Algorithms Not Supported, Procedure cancelled, RRM purpose, Improve user bit rate, User Inactivity, Radio Connection With UE Lost, Failure in the Radio Interface Procedure, Bearer Option not Supported, MCG Mobility, SCG Mobility, Count reaches max value, Unknown Old en-gNB UE X2AP ID, PDCP Overload)	
>Transport Layer				
>>Transport Layer Cause	M		ENUMERATED (Transport Resource Unavailable, Unspecified,...)	
>Protocol				

>>Protocol Cause	M		ENUMERATED (Transfer Syntax Error,Abstract Syntax Error (Reject),Abstract Syntax Error (Ignore and Notify),Message not Compatible with Receiver State,Semantic Error,Unspecified,Abstract Syntax Error (Falsely Constructed Message),...)	
>Misc				
>>Miscellaneous Cause	M		ENUMERATED (Control Processing Overload, Hardware Failure,O&M Intervention,Not enough User Plane Processing Resources,Unspecified,...)	

The meaning of the different cause values is described in the following table. In general, "not supported" cause values indicate that the concerned capability is missing. On the other hand, "not available" cause values indicate that the concerned capability is present, but insufficient resources were available to perform the requested action.

Radio Network Layer cause	Meaning
Cell not Available	The concerned cell is not available.
Handover Desirable for Radio Reasons	The reason for requesting handover is radio related.
Handover Target not Allowed	Handover to the indicated target cell is not allowed for the UE in question
Invalid MME Group ID	The target eNB doesn't belong to the same pool area of the source eNB i.e. S1 handovers should be attempted instead.
No Radio Resources Available in Target Cell	The target cell doesn't have sufficient radio resources available.
Partial Handover	Provides a reason for the handover cancellation. The target eNB did not admit all E-RABs included in the HANDOVER REQUEST and the source eNB estimated service continuity for the UE would be better by not proceeding with handover towards this particular target eNB.
Reduce Load in Serving Cell	Load in serving cell needs to be reduced. When applied to handover preparation, it indicates the handover is triggered due to load balancing.
Resource Optimisation Handover	The reason for requesting handover is to improve the load distribution with the neighbour cells.
Time Critical Handover	Handover is requested for time critical reason i.e. this cause value is reserved to represent all critical cases where the connection is likely to be dropped if handover is not performed.
$TX2_{RELOCoverall}$ Expiry	The reason for the action is expiry of timer $TX2_{RELOCoverall}$.
$T_{RELOCprep}$ Expiry	Handover Preparation procedure is cancelled when timer $T_{RELOCprep}$ expires.
Unknown MME Code	The target eNB belongs to the same pool area of the source eNB and recognizes the MME Group ID. However, the MME Code is unknown to the target eNB.
Unknown New eNB UE X2AP ID	The action failed because the New eNB UE X2AP ID or the MeNB UE X2AP ID is unknown.
Unknown Old eNB UE X2AP ID	The action failed because the Old eNB UE X2AP ID or the SeNB UE X2AP ID is unknown.
Unknown Pair of UE X2AP ID	The action failed because the pair of UE X2 AP IDs is unknown.
Encryption And/Or Integrity Protection Algorithms Not Supported	The target eNB is unable to support any of the encryption and/or integrity protection algorithms supported by the UE, or the en-gNB is unable to support any of the NR encryption and/or integrity protection algorithms supported by the UE for EN-DC operation.
ReportCharacteristicsEmpty	The action failed because there is no characteristic reported.
NoReportPeriodicity	The action failed because the periodicity is not defined.
ExistingMeasurementID	The action failed because measurement-ID is already used.
Unknown eNB Measurement ID	The action failed because some eNB Measurement-ID is unknown.
Measurement Temporarily not Available	The eNB can temporarily not provide the requested measurement object.
Load Balancing	The reason for mobility settings change is load balancing.
Handover Optimisation	The reason for mobility settings change is handover optimisation.
Value out of allowed range	The action failed because the proposed Handover Trigger parameter change in the eNB_2 Proposed Mobility Parameters IE is too low or too high.
Multiple E-RAB ID Instances	The action failed because multiple instances of the same E-RAB had been provided to the eNB.
Switch Off Ongoing	The reason for the action is an ongoing switch off i.e. the concerned cell will be switched off after offloading and not be available. It aides the receiving eNB in taking subsequent actions, e.g. selecting the target cell for subsequent handovers.
Not supported QCI value	The action failed because the requested QCI is not supported.
Unspecified	Sent when none of the above cause values applies but still the cause is Radio Network Layer related.
Measurement not Supported For The Object	At least one of the concerned cell(s) does not support the requested measurement.
$T_{DCoverall}$ Expiry	The reason for the action is expiry of timer $T_{DCoverall}$.
T_{DCprep} Expiry	The reason for the action is expiry of timer T_{DCprep}.
Action Desirable for Radio Reasons	The reason for requesting the action is radio related. In the current version of this specification applicable for Dual Connectivity only.
Reduce Load	Load in the cell(group) served by the requesting node needs to be reduced. In the current version of this specification applicable for Dual Connectivity only.

Resource Optimisation	The reason for requesting this action is to improve the load distribution with the neighbour cells. In the current version of this specification applicable for Dual Connectivity only.
Time Critical action	The action is requested for time critical reason i.e. this cause value is reserved to represent all critical cases where radio resources are likely to be dropped if the requested action is not performed. In the current version of this specification applicable for Dual Connectivity only.
Target not Allowed	Requested action towards the indicated target cell is not allowed for the UE in question. In the current version of this specification applicable for Dual Connectivity only.
No Radio Resources Available	The cell(s) in the requested node don't have sufficient radio resources available. In the current version of this specification applicable for Dual Connectivity only.
Invalid QoS combination	The action was failed because of invalid QoS combination. In the current version of this specification applicable for Dual Connectivity only.
Encryption Algorithms Not Supported	The requested eNB is unable to support any of the encryption algorithms supported by the UE. In the current version of this specification applicable for Dual Connectivity only.
Procedure cancelled	The sending node cancelled the procedure due to other urgent actions to be performed. In the current version of this specification applicable for Dual Connectivity only.
RRM purpose	The procedure is initiated due to node internal RRM purposes. In the current version of this specification applicable for Dual Connectivity only.
Improve User Bit Rate	The reason for requesting this action is to improve the user bit rate. In the current version of this specification applicable for Dual Connectivity only.
User Inactivity	The action is requested due to user inactivity on all E-RABs, e.g., S1 is requested to be released in order to optimise the radio resources; or SeNB/en-gNB didn't see activity on the DRB recently. In the current version of this specification applicable for Dual Connectivity only.
Radio Connection With UE Lost	The action is requested due to losing the radio connection to the UE. In the current version of this specification applicable for Dual Connectivity only.
Failure in the Radio Interface Procedure	Radio interface procedure has failed. In the current version of this specification applicable for Dual Connectivity only.
Bearer Option not Supported	The requested bearer option is not supported by the sending node. In the current version of this specification applicable for Dual Connectivity only.
MCG Mobility	The procedure is initiated due to mobility related at MCG radio resource.
SCG Mobility	The procedure is initiated due to mobility related at SCG radio resource.
Count reaches max value	Indicates the PDCP COUNT for UL or DL reached the max value and the bearer may be released.
Unknown Old en-gNB UE X2AP ID	The action failed because the Old en-gNB UE X2AP ID or the SeNB UE X2AP ID is unknown.
PDCP Overload	The procedure is initiated due to PDCP/SDAP resource limitation.

Transport Network Layer cause	Meaning
Transport resource unavailable	The required transport resources are not available.
Unspecified	Sent when none of the above cause values applies but still the cause is Transport Network Layer related

Protocol cause	Meaning
Abstract Syntax Error (Reject)	The received message included an abstract syntax error and the concerned criticality indicated "reject" (see sub clause 10.3 of TS 36.413 [4]).
Abstract Syntax Error (Ignore and Notify)	The received message included an abstract syntax error and the concerned criticality indicated "ignore and notify" (see sub clause 10.3 of TS 36.413 [4]).
Abstract syntax error (falsely constructed message)	The received message contained IEs or IE groups in wrong order or with too many occurrences (see sub clause 10.3 of TS 36.413 [4]).
Message not Compatible with Receiver State	The received message was not compatible with the receiver state (see sub clause 10.4 of TS 36.413 [4]).
Semantic Error	The received message included a semantic error (see sub clause 10.4 of TS 36.413 [4]).
Transfer Syntax Error	The received message included a transfer syntax error (see sub clause 10.2 of TS 36.413 [4]).
Unspecified	Sent when none of the above cause values applies but still the cause is Protocol related

Miscellaneous cause	Meaning
Control Processing Overload	eNB control processing overload
Hardware Failure	eNB hardware failure
Not enough User Plane Processing Resources	eNB has insufficient user plane processing resources available.
O&M Intervention	Operation and Maintenance intervention related to eNB equipment
Unspecified	Sent when none of the above cause values applies and the cause is not related to any of the categories Radio Network Layer, Transport Network Layer or Protocol

9.2.7 Criticality Diagnostics

The *Criticality Diagnostics* IE is sent by the eNB/en-gNB when parts of a received message have not been comprehended or were missing, or if the message contained logical errors. When applicable, it contains information about which IEs were not comprehended or were missing.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Procedure Code	O		INTEGER (0..255)	Procedure Code is to be used if Criticality Diagnostics is part of Error Indication procedure, and not within the response message of the same procedure that caused the error.
Triggering Message	O		ENUMERATED(initiating message, successful outcome, unsuccessful outcome)	The Triggering Message is used only if the Criticality Diagnostics is part of Error Indication procedure.
Procedure Criticality	O		ENUMERATED(reject, ignore, notify)	This Procedure Criticality is used for reporting the Criticality of the Triggering message (Procedure).
Information Element Criticality Diagnostics		*0..<maxNrOfErrors>*		
>IE Criticality	M		ENUMERATED(reject, ignore, notify)	The IE Criticality is used for reporting the criticality of the triggering IE. The value "ignore"' shall not be used.
>IE ID	M		INTEGER (0..65535)	The IE ID of the not understood or missing IE
>Type Of Error	M		ENUMERATED(not understood, missing, …)	

Range bound	Explanation
maxNrOfErrors	Maximum no. of IE errors allowed to be reported with a single message. The value for maxnooferrors is 256.

9.2.8 Served Cell Information

This IE contains cell configuration information of a cell that a neighbour eNB may need for the X2 AP interface.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
PCI	M		INTEGER (0..503, …)	Physical Cell ID	–	–
Cell ID	M		ECGI 9.2.14		–	–
TAC	M		OCTET STRING(2)	Tracking Area Code	–	–
Broadcast PLMNs		*1..<maxnoof BPLMNs>*		Broadcast PLMNs	–	–
>PLMN Identity	M		9.2.4		–	–
CHOICE *EUTRA-Mode-Info*	M				–	–
>FDD						
>>FDD Info		*1*			–	–
>>>UL EARFCN	M		EARFCN 9.2.26	Corresponds to N_{UL} in TS 36.104 [16] for E-UTRA operating bands for which it is defined; ignored for E-UTRA operating bands for which N_{UL} is not defined	–	–
>>>DL EARFCN	M		EARFCN 9.2.26	Corresponds to N_{DL} in TS 36.104 [16]	–	–
>>>UL Transmission Bandwidth	M		Transmission Bandwidth 9.2.27	Same as DL Transmission Bandwidth in this release; ignored in case UL EARFCN value is ignored	–	–
>>>DL Transmission Bandwidth	M		Transmission Bandwidth 9.2.27		–	–
>>>UL EARFCN Extension	O		EARFCN Extension 9.2.65	If this IE is present, the value signalled in the *UL EARFCN* IE is ignored.	YES	reject
>>>DL EARFCN Extension	O		EARFCN Extension 9.2.65	If this IE is present, the value signalled in the *DL EARFCN* IE is ignored.	YES	reject
>>>Offset of NB-IoT Channel Number to DL EARFCN	O		Offset of NB-IoT Channel Number to EARFCN 9.2.94	Corresponds to M_{DL} in TS 36.104 [16]	YES	reject
>>>Offset of NB-IoT Channel Number to UL EARFCN	O		Offset of NB-IoT Channel Number to EARFCN 9.2.94	Corresponds to M_{UL} in TS 36.104 [16]	YES	reject
>>>NRS-NSSS-PowerOffset	O		ENUMERATED (-3, 0, 3, …)	NRS to NSSS power ratio, as defined in TS6.213 [11].	YES	Ignore

>>>NSSS-NumOccasionDifferentPrecoder	O		ENUMERATED (2, 4, 8, …)	The number of consecutive NSSS occasions that use different precoders for NSSS transmission, as defined in TS6.213 [11].	YES	ignore
>TDD					–	–
>>TDD Info		*1*			–	–
>>>EARFCN	M		9.2.26	Corresponds to N_{DL}/N_{UL} in TS 36.104 [16]	–	–
>>>Transmission Bandwidth	M		Transmission Bandwidth 9.2.27		–	–
>>>Subframe Assignment	M		ENUMERATED (sa0, sa1, sa2, sa3, sa4, sa5, sa6,…)	Uplink-downlink subframe configuration information defined in TS 36.211 [10]. In NB-IOT, sa0 and sa6 are not applicable.	–	–
>>>Special Subframe Info		*1*		Special subframe configuration information defined in TS 36.211 [10]	–	–
>>>>Special Subframe Patterns	M		ENUMERATED (ssp0, ssp1, ssp2, ssp3, ssp4, ssp5, ssp6, ssp7, ssp8, …)		–	–
>>>>Cyclic Prefix DL	M		ENUMERATED (Normal, Extended,…)		–	–
>>>>Cyclic Prefix UL	M		ENUMERATED (Normal, Extended,…)		–	–
>>>Additional Special Subframe Info	O			Special subframe configuration information defined in TS 36.211 [10]. Only for newly defined configuration of special subframe from Release 11.	YES	ignore
>>>>Additional Special Subframe Patterns	M		ENUMERATED (ssp0, ssp1, ssp2, ssp3, ssp4, ssp5, ssp6, ssp7, ssp8, ssp9, …)		–	–
>>>>Cyclic Prefix DL	M		ENUMERATED (Normal, Extended,…)		–	–

>>>>Cyclic Prefix UL	M		ENUMERATED (Normal, Extended,…)		–	–
>>>EARFCN Extension	O		9.2.65	If this IE is present, the value signalled in the *EARFCN* IE is ignored.	YES	reject
>>>Additional Special Subframe Extension Info	O			Special subframe configuration information defined in TS 36.211 [10]. Only for newly defined configuration of special subframe from Release 14.	YES	ignore
>>>>Additional Special Subframe Patterns Extension	M		ENUMERATED (ssp10, …)		–	–
>>>>Cyclic Prefix DL	M		ENUMERATED (Normal, Extended,…)		–	–
>>>>Cyclic Prefix UL	M		ENUMERATED (Normal, Extended,…)		–	–
Number of Antenna Ports	O		9.2.43		YES	ignore
PRACH Configuration	O		PRACH Configuration 9.2.50		YES	ignore
MBSFN Subframe Info		*0..<maxnoof MBSFN>*		MBSFN subframe defined in TS 36.331 [9]	GLOBAL	ignore
>Radioframe Allocation Period	M		ENUMERATED (n1, n2, n4, n8, n16, n32, …)		–	–
>Radioframe Allocation Offset	M		INTEGER (0..7, ...)		–	–
>Subframe Allocation	M		9.2.51		–	–
CSG ID	O		9.2.53		YES	ignore
MBMS Service Area Identity List		*0..<maxnoof MBMSServiceAreaIdentities >*		Supported MBMS Service Area Identities in the cell	GLOBAL	ignore
>MBMS Service Area Identity			OCTET STRING(2)	MBMS Service Area Identities as defined in TS 23.003 [29]		
MultibandInfoList	O		9.2.60		YES	ignore
FreqBandIndicatorPriority	O		ENUMERATED (not-broadcasted, broadcasted, ...)	This IE indicates that the eNodeB supports *FreqBandIndicationPriority*, and whether *FreqBandIndicatorPriority* is broadcasted in SIB 1 (see TS 36.331 [9])	YES	ignore

BandwidthReducedSI	O		ENUMERATED (scheduled, ...)	This IE indicates that the SystemInformationBlockType1-BR is scheduled in the cell (see TS 36.331 [9])	YES	ignore
Protected E-UTRA Resource Indication	O		9.2.125	This IE indicates which E-UTRA control/reference signal resources are protected and are not subject to E-UTRA - NR Cell Resource Coordination.	YES	ignore

Range bound	Explanation
maxnoofBPLMNs	Maximum no. of Broadcast PLMN Ids. Value is 6.
maxnoofMBSFN	Maximum no. of MBSFN frame allocation with different offset. Value is 8.
maxnoofMBMSServiceAreaIdentities	Maximum no. of MBMS Service Area Identities. Value is 256.

9.2.9 E-RAB Level QoS Parameters

This IE defines the QoS to be applied to an E-RAB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
QCI	M		INTEGER (0..255)	QoS Class Identifier defined in TS 23.401 [12]. Logical range and coding specified in TS 23.203 [13].	–	–
Allocation and Retention Priority	M		9.2.31		–	–
GBR QoS Information	O		9.2.10	This IE applies to GBR bearers only and shall be ignored otherwise.	–	–
Downlink Maximum Packet Loss Rate	O		Packet Loss Rate 9.2.124	This IE applies only to bearers with specific QCI (see TS 23.401 [12]) and indicates the maximum allowed packet loss rate for downlink as specified in TS 23.401 [12].	YES	ignore
Uplink Maximum Packet Loss Rate	O		Packet Loss Rate 9.2.124	This IE applies only to bearers with specific QCI (see TS 23.401 [12]) and indicates the maximum allowed packet loss rate for uplink as specified in TS 23.401 [12].	YES	ignore

9.2.10 GBR QoS Information

This IE indicates the maximum and guaranteed bit rates of a GBR E-RAB for downlink and uplink.

NOTE: For LTE DC, the SeNB regards the *GBR QoS Information* IE as an E-RAB level parameter also for E-RABs configured with the split bearer option, although for the split bearer option the bitrates signalled by the MeNB are typically not equal to the bitrates signalled by the MME for that E-RAB (see TS 36.300 [15]).

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
E-RAB Maximum Bit Rate Downlink	M		Bit Rate 9.2.11	Maximum Bit Rate in DL (i.e. from EPC to E-UTRAN) for the bearer. Details in TS 23.401 [12]. If the *Extended E-RAB Maximum Bit Rate Downlink* IE is included, the *E-RAB Maximum Bit Rate Downlink* IE shall be ignored.	–	–
E-RAB Maximum Bit Rate Uplink	M		Bit Rate 9.2.11	Maximum Bit Rate in UL (i.e. from E-UTRAN to EPC) for the bearer. Details in TS 23.401 [12]. If the *Extended E-RAB Maximum Bit Rate Uplink* IE is included, the *E-RAB Maximum Bit Rate Uplink* IE shall be ignored.	–	–
E-RAB Guaranteed Bit Rate Downlink	M		Bit Rate 9.2.11	Guaranteed Bit Rate (provided that there is data to deliver) in DL (i.e. from EPC to E-UTRAN) for the bearer. Details in TS 23.401 [12]. If the *Extended E-RAB Guaranteed Bit Rate Downlink* IE is included, the *E-RAB Guaranteed Bit Rate Downlink* IE shall be ignored.	–	–
E-RAB Guaranteed Bit Rate Uplink	M		Bit Rate 9.2.11	Guaranteed Bit Rate (provided that there is data to deliver) in UL (i.e. from E-UTRAN to EPC) for the bearer. Details in TS 23.401 [12]. If the *Extended E-RAB Guaranteed Bit Rate Uplink* IE is included, the *E-RAB Guaranteed Bit Rate Uplink* IE shall be ignored.	–	–
Extended E-RAB Maximum Bit Rate Downlink	O		Extended Bit Rate 9.2.99	Maximum Bit Rate in DL (i.e. from EPC to E-UTRAN) for the bearer. Details in TS 23.401 [12].	–	–

Extended E-RAB Maximum Bit Rate Uplink	O		Extended Bit Rate 9.2.99	Maximum Bit Rate in UL (i.e. from E-UTRAN to EPC) for the bearer. Details in TS 23.401 [12].	–	–
Extended E-RAB Guaranteed Bit Rate Downlink	O		Extended Bit Rate 9.2.99	Guaranteed Bit Rate (provided that there is data to deliver) in DL (i.e. from EPC to E-UTRAN) for the bearer. Details in TS 23.401 [12].	–	–
Extended E-RAB Guaranteed Bit Rate Uplink	O		Extended Bit Rate 9.2.99	Guaranteed Bit Rate (provided that there is data to deliver) in UL (i.e. from E-UTRAN to EPC) for the bearer. Details in TS 23.401 [12].	–	–

9.2.11 Bit Rate

This IE indicates the number of bits delivered by E-UTRAN in UL or to E-UTRAN in DL or by UE in sidelink within a period of time, divided by the duration of the period. It is used, for example, to indicate the maximum or guaranteed bit rate for a GBR E-RAB, or an aggregated maximum bit rate.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Bit Rate	M		INTEGER (0..10,000,000,000)	The unit is: bit/s

9.2.12 UE Aggregate Maximum Bit Rate

On Handover Aggregate Maximum Bitrate is transferred to the target eNB. In Dual Connectivity, UE Aggregate Maximum Bit Rate is split into MeNB UE Aggregate Maximum Bit Rate and SeNB UE Aggregate Maximum Bit Rate which are enforced by MeNB and SeNB respectively as specified in TS 36.300 [15]. The UE Aggregate Maximum Bitrate is applicable for all Non-GBR bearers per UE which is defined for the Downlink and the Uplink direction and provided by the MME to the eNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
UE Aggregate Maximum Bit Rate Downlink	M		Bit Rate 9.2.11	If the *Extended UE Aggregate Maximum Bit Rate Downlink* IE is included, the *UE Aggregate Maximum Bit Rate Downlink* IE shall be ignored.	–	–
UE Aggregate Maximum Bit Rate Uplink	M		Bit Rate 9.2.11	If the *Extended UE Aggregate Maximum Bit Rate Uplink* IE is included, the *UE Aggregate Maximum Bit Rate Uplink* IE shall be ignored.	–	–
Extended UE Aggregate Maximum Bit Rate Downlink	O		Extended Bit Rate 9.2.99	UE Aggregate Maximum Bit Rate in DL. Details in TS 23.401 [12].	–	–
Extended UE Aggregate Maximum Bit Rate Uplink	O		Extended Bit Rate 9.2.99	UE Aggregate Maximum Bit Rate in UL. Details in TS 23.401 [12].	–	–

9.2.13 Message Type

The *Message Type* IE uniquely identifies the message being sent. It is mandatory for all messages.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Procedure Code	M		INTEGER (0..255)	
Type of Message	M		CHOICE (Initiating Message, Successful Outcome, Unsuccessful Outcome, …)	

9.2.14 ECGI

The E-UTRAN Cell Global Identifier (ECGI) is used to globally identify a cell (see TS 36.401 [2]).

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
PLMN Identity	M		9.2.4		–	–
E-UTRAN Cell Identifier	M		BIT STRING (28)	The leftmost bits of the *E-UTRAN Cell Identifier* IE value correspond to the value of the *eNB ID* IE contained in the *Global eNB ID* IE (defined in section 9.2.22) identifying the eNB that controls the cell.	–	–

9.2.15 COUNT Value

This information element indicates the 12 bit PDCP sequence number and the corresponding 20 bit Hyper frame number.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
PDCP-SN	M		INTEGER (0..4095)		–	–
HFN	M		INTEGER (0..1048575)		–	–

9.2.16 GUMMEI

This information element indicates the globally unique MME identity.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
GU Group Id	M		9.2.20		–	–
MME code	M		OCTET STRING (1)		–	–

9.2.17 UL Interference Overload Indication

This IE provides, per PRB, a report on interference overload. The interaction between the indication of UL Interference Overload and UL High Interference is implementation specific.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
UL Interference Overload Indication List		*1..<maxnoofPRBs>*		
>UL Interference Overload Indication	M		ENUMERATED (high interference, medium interference, low interference, …)	Each PRB is identified by its position in the list: the first element in the list corresponds to PRB 0, the second to PRB 1, etc.

Range bound	Explanation
maxnoofPRBs	Maximum no. Physical Resource Blocks. Value is 110.

9.2.18 UL High Interference Indication

This IE provides, per PRB, a 2 level report on interference sensitivity. The interaction between the indication of UL Overload and UL High Interference is implementation specific.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
HII	M		BIT STRING (1..110, …)	Each position in the bitmap represents a PRB (first bit=PRB 0 and so on), for which value '"1" indicates 'high interference sensitivity' and value "0" indicates 'low interference sensitivity'. The maximum number of Physical Resource Blocks is 110.

9.2.19 Relative Narrowband Tx Power (RNTP)

This IE provides an indication on DL power restriction per PRB or per subframe per PRB (Enhanced RNTP) in a cell and other information needed by a neighbour eNB for interference aware scheduling.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
RNTP Per PRB	M		BIT STRING (6..110, …)	Each position in the bitmap represents a n_{PRB} value (i.e. first bit=PRB 0 and so on), for which the bit value represents *RNTP (n_{PRB})*, defined in TS 36.213 [11]. Value 0 indicates "Tx not exceeding RNTP threshold". Value 1 indicates "no promise on the Tx power is given". The IE is ignored if the *Enhanced RNTP* IE is included.	–	–
RNTP Threshold	M		ENUMERATED (-∞, -11, -10, -9, -8, -7, -6, -5, -4, -3, -2, -1, 0, 1, 2, 3, …)	$RNTP_{threshold}$ is defined in TS 36.213 [11].	–	–
Number Of Cell-specific Antenna Ports	M		ENUMERATED (1, 2, 4, …)	*P* (number of antenna ports for cell-specific reference signals) defined in TS 36.211 [10]	–	–
P_B	M		INTEGER (0..3, …)	P_B is defined in TS 36.213 [11].	–	–
PDCCH Interference Impact	M		INTEGER (0..4, …)	Measured by Predicted Number Of Occupied PDCCH OFDM Symbols (see TS 36.211 [10]). Value 0 means "no prediction is available".	–	–
Enhanced RNTP	O				YES	ignore

>*Enhanced RNTP Bitmap*	M		BIT STRING (12..8800, …)	Each position in the bitmap represents a PRB in a subframe; value “00” indicates "Tx not exceeding RNTP Threshold", value “01” indicates "Tx not exceeding RNTP High Power Threshold", value “11” indicates that "no promise on the Tx power is given". Value "10" is ignored by the receiver”. Each position is applicable only in positions corresponding to DL subframes. The first 2 bits correspond to PRB 0 of the first subframe for which the IE is valid, the following 2 bits correspond to PRB 1 of the first subframe for which the IE is valid, and so on. The bit string may span across multiple contiguous subframes (maximum 40). The length of the bit string is an integer multiple of $2\times N_{\mathrm{RB}}^{\mathrm{DL}}$. $N_{\mathrm{RB}}^{\mathrm{DL}}$ is defined in TS 36.211 [10]. The Enhanced RNTP pattern is continuously repeated.		
>*RNTP High Power Threshold*	M		ENUMERATED (-∞, -11, -10, -9, -8, -7, -6, -5, -4, -3, -2, -1, 0, 1, 2, 3, …)	Defined as the $\mathrm{RNTP}_{\mathrm{threshold}}$ in TS 36.213 [11].		
>Enhanced RNTP Start Time		0..1				
>>Start SFN	M		INTEGER (0..1023, …)	SFN of the radio frame containing the first subframe when the *Enhanced RNTP* IE is valid.		
>>Start Subframe Number	M		INTEGER (0..9, …)	Subframe number, within the radio frame indicated by the *Start SFN* IE, of the first subframe when the *Enhanced RNTP* IE is valid.		

9.2.20 GU Group Id

The *GU Group Id* IE is the globally unique group id corresponding to a pool area.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
PLMN Id	M		PLMN Identity 9.2.4		–	–
MME Group Id	M		OCTET STRING(2)		–	–

9.2.21 Location Reporting Information

This information element indicates how the location information should be reported.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Event	M		ENUMERATED (Change of serving cell, …)		–	–
Report Area	M		ENUMERATED (ECGI, …)		–	–

9.2.22 Global eNB ID

This IE is used to globally identify an eNB (see TS 36.401 [2]).

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
PLMN Identity	M		9.2.4		–	–
CHOICE *eNB ID*	M				–	–
>*Macro eNB ID*	M		BIT STRING (20)	Equal to the 20 leftmost bits of the value of the *E-UTRAN Cell Identifier* IE contained in the *ECGI* IE (see section 9.2.14) identifying each cell controlled by the eNB	–	–
>*Home eNB ID*	M		BIT STRING (28)	Equal to the value of the *E-UTRAN Cell Identifier* IE contained in the *ECGI* IE (see section 9.2.14) identifying the cell controlled by the eNB	–	–
>*Short Macro eNB ID*	M		BIT STRING (SIZE(18))	Equal to the 18 leftmost bits of the value of the *E-UTRAN Cell Identifier* IE contained in the *ECGI* IE (see section 9.2.14) identifying each cell controlled by the eNB.	–	–
>*Long Macro eNB ID*	M		BIT STRING (SIZE(21))	Equal to the 21 leftmost bits of the value of the *E-UTRAN Cell Identifier* IE contained in the *ECGI* IE (see section 9.2.14) identifying each cell controlled by the eNB.	–	–

9.2.23 E-RAB ID

This IE uniquely identifies an E-RAB for a UE.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
E-RAB ID	M		INTEGER (0..15, ...)	

9.2.24 eNB UE X2AP ID

This information element, combined with the eNB UE X2AP ID Extension when present regardless its value, uniquely identifies an UE over the X2 interface within an eNB.

The usage of this IE is defined in TS 36.401 [2].

IE/Group Name	Presence	Range	IE type and reference	Semantics description
eNB UE X2AP ID	M		INTEGER (0..4095)	

9.2.25 Subscriber Profile ID for RAT/Frequency priority

The *Subscriber Profile ID* IE for RAT/Frequency Selection Priority is used to define camp priorities in Idle mode and to control inter-RAT/inter-frequency handover in Active mode (TS 36.300 [15]).

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Subscriber Profile ID for RAT/Frequency Priority	M		INTEGER (1..256)	

9.2.26 EARFCN

The E-UTRA Absolute Radio Frequency Channel Number defines the carrier frequency used in a cell for a given direction (UL or DL) in FDD or for both UL and DL directions in TDD.

IE/Group Name	Presence	Range	IE Type and Reference	Semantics Description
EARFCN	M		INTEGER (0..maxEARFCN)	The relation between EARFCN and carrier frequency (in MHz) are defined in TS 36.104 [16].

Range bound	Explanation
maxEARFCN	Maximum value of EARFCNs. Value is 65535.

9.2.27 Transmission Bandwidth

The *Transmission Bandwidth* IE is used to indicate the UL or DL transmission bandwidth expressed in units of resource blocks " N_{RB} " (TS 36.104 [16]). The values bw1, bw6, bw15, bw25, bw50, bw75, bw100 correspond to the number of resource blocks "N_{RB}" 6, 15, 25, 50, 75, 100.

IE/Group Name	Presence	Range	IE Type and Reference	Semantics Description
Transmission Bandwidth	**M**		ENUMERATED (bw6, bw15, bw25, bw50, bw75, bw100,... , bw1)	

9.2.28 E-RAB List

The IE contains a list of E-RAB identities with a cause value. It is used for example to indicate not admitted bearers.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
E-RAB List Item		*1..<maxnoofBearers>*			EACH	ignore
>E-RAB ID	M		9.2.23		–	–
>Cause	M		9.2.6		–	–

Range bound	Explanation
maxnoofBearers	Maximum no. of E-RABs. Value is 256.

9.2.29 UE Security Capabilities

The *UE Security Capabilities* IE defines the supported algorithms for encryption and integrity protection in the UE.

IE/Group Name	Presence	Range	IE Type and Reference	Semantics Description
Encryption Algorithms	M		BIT STRING (16, ...)	Each position in the bitmap represents an encryption algorithm: "all bits equal to 0" - UE supports no other algorithm than EEA0 "first bit" - 128-EEA1, "second bit" - 128-EEA2, "third bit" - 128-EEA3, other bits reserved for future use. Value '1' indicates support and value "0" indicates no support of the algorithm. Algorithms are defined in TS 33.401 [18].
Integrity Protection Algorithms	M		BIT STRING (16, ...)	Each position in the bitmap represents an integrity protection algorithm: all bits equal to 0" - UE supports no other algorithm than EIA0 (TS 33.401 [18]) "first bit" - 128-EIA1, "second bit" - 128-EIA2, "third bit" - 128-EIA3, other bits reserved for future use. Value '1' indicates support and value "0" indicates no support of the algorithm. Algorithms are defined in TS 33.401 [18].

9.2.30 AS Security Information

The *AS Security Information* IE is used to generate the key material to be used for AS security with the UE.

IE/Group Name	Presence	Range	IE Type and Reference	Semantics Description
Key eNodeB Star	M		BIT STRING (256)	KeNB* defined in TS 33.401 [18]. If the target cell belongs to multiple frequency bands, the source eNB selects the DL-EARFCN for KeNB* calculation as specified in section 10.3 of TS 36.331 [9].
Next Hop Chaining Count	M		INTEGER (0..7)	Next Hop Chaining Count (NCC) defined in TS 33.401 [18]

9.2.31 Allocation and Retention Priority

This IE specifies the relative importance compared to other E-RABs for allocation and retention of the E-UTRAN Radio Access Bearer.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Priority Level	M		INTEGER (0..15)	**Desc.:** This IE should be understood as "priority of allocation and retention" (see TS 23.401 [12]). **Usage:** Value 15 means "no priority". Values between 1 and 14 are ordered in decreasing order of priority, i.e. 1 is the highest and 14 the lowest. Value 0 shall be treated as a logical error if received.
Pre-emption Capability	M		ENUMERATED(shall not trigger pre-emption, may trigger pre-emption)	**Descr.:** This IE indicates the pre-emption capability of the request on other E-RABs **Usage:** The E-RAB shall not pre-empt other E-RABs or, the E-RAB may pre-empt other E-RABs The Pre-emption Capability indicator applies to the allocation of resources for an E-RAB and as such it provides the trigger to the pre-emption procedures/processes of the eNB.
Pre-emption Vulnerability	M		ENUMERATED(not pre-emptable, pre-emptable)	**Desc.:** This IE indicates the vulnerability of the E-RAB to pre-emption of other E-RABs. **Usage**: The E-RAB shall not be pre-empted by other E-RABs or the E-RAB may be pre-empted by other RABs. Pre-emption Vulnerability indicator applies for the entire duration of the E-RAB, unless modified, and as such indicates whether the E-RAB is a target of the pre-emption procedures/processes of the eNB.

9.2.32 Time To Wait

This IE defines the minimum allowed waiting times.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Time To Wait	M		ENUMERATED(1s, 2s, 5s, 10s, 20s, 60s, …)	

9.2.33 SRVCC Operation Possible

The IE indicates that both the UE and the MME are SRVCC-capable. E-UTRAN behaviour on reception of this is specified in TS 23.216 [20].

IE/Group Name	Presence	Range	IE type and reference	Semantics description
SRVCC Operation Possible	M		ENUMERATED(Possible, …)	

9.2.34 Hardware Load Indicator

The *Hardware Load Indicator* IE indicates the status of the Hardware Load experienced by the cell.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
DL Hardware Load Indicator	M		Load Indicator 9.2.36	
UL Hardware Load Indicator	M		Load Indicator 9.2.36	

9.2.35 S1 TNL Load Indicator

The *S1 TNL Load Indicator* IE indicates the status of the S1 Transport Network Load experienced by the cell.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
DL S1TNL Load Indicator	M		Load Indicator 9.2.36	
UL S1TNL Load Indicator	M		Load Indicator 9.2.36	

9.2.36 Load Indicator

The *Load Indicator* IE indicates the status of Load.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Load Indicator	M		ENUMERATED (LowLoad, MediumLoad, HighLoad, Overload, ...)	

9.2.37 Radio Resource Status

The *Radio Resource Status* IE indicates the usage of the PRBs for all traffic in Downlink and Uplink (TS 36.314 [22], TS 23.203 [13]) and the usage of PDCCH CCEs for Downlink and Uplink scheduling.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
DL GBR PRB usage	M		INTEGER (0..100)	
UL GBR PRB usage	M		INTEGER (0..100)	
DL non-GBR PRB usage	M		INTEGER (0..100)	
UL non-GBR PRB usage	M		INTEGER (0..100)	
DL Total PRB usage	M		INTEGER (0..100)	
UL Total PRB usage	M		INTEGER (0..100)	
DL scheduling PDCCH CCE usage	O		INTEGER (0..100)	
UL scheduling PDCCH CCE usage	O		INTEGER (0..100)	

9.2.38 UE History Information

The *UE History Information* IE contains information about cells that a UE has been served by in active state prior to the target cell. The overall mechanism is described in TS 36.300 [15].

NOTE: The definition of this IE is aligned with the definition of the *UE History Information* IE in TS 36.413 [4].

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Last Visited Cell List		*1..<maxnoofCells>*		Most recent information is added to the top of this list	–	–
>Last Visited Cell Information	M		9.2.39		–	–

Range bound	Explanation
maxnoofCells	Maximum number of last visited cell information records that can be reported in the IE. Value is 16.

9.2.39 Last Visited Cell Information

The Last Visited Cell Information may contain E-UTRAN or UTRAN or GERAN cell specific information.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
CHOICE *Last Visited Cell Information*	M				-	-
>E-UTRAN Cell					-	-
>>Last Visited E-UTRAN Cell Information	M		9.2.40		-	-
>UTRAN Cell					-	-
>>Last Visited UTRAN Cell Information	M		OCTET STRING	Defined in TS 25.413 [24]		
>GERAN Cell					-	-
>>Last Visited GERAN Cell Information	M		9.2.41		-	-

9.2.40 Last Visited E-UTRAN Cell Information

The Last Visited E-UTRAN Cell Information contains information about a cell that is to be used for RRM purposes.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Global Cell ID	M		ECGI 9.2.14		-	-
Cell Type	M		9.2.42		-	-
Time UE stayed in Cell	M		INTEGER (0..4095)	The duration of the time the UE stayed in the cell in seconds. If the UE stays in a cell more than 4095s, this IE is set to 4095.	-	-
Time UE stayed in Cell Enhanced Granularity	O		INTEGER (0..40950)	The duration of the time the UE stayed in the cell in 1/10 seconds. If the UE stays in a cell more than 4095s, this IE is set to 40950.	YES	ignore
HO Cause Value	O		Cause 9.2.6	The cause for the handover from the E-UTRAN cell.	YES	ignore

9.2.41 Last Visited GERAN Cell Information

The Last Visited Cell Information for GERAN is currently undefined.

NOTE: If in later Releases this is defined, the choice type may be extended with the actual GERAN specific information.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
CHOICE *Last Visited GERAN Cell Information*	M				-	-
>Undefined	M		NULL		-	-

9.2.42 Cell Type

The cell type provides the cell coverage area.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Cell Size	M		ENUMERATED (verysmall, small, medium, large, …)		-	-

9.2.43 Number of Antenna Ports

The *Number of Antenna Ports* IE is used to indicate the number of cell specific antenna ports.

IE/Group Name	Presence	Range	IE Type and Reference	Semantics Description
Number of Antenna Ports			ENUMERATED (an1, an2, an4,...)	an1 = One antenna port an2 = Two antenna ports an4 = Four antenna ports

9.2.44 Composite Available Capacity Group

The *Composite Available Capacity Group* IE indicates the overall available resource level in the cell in Downlink and Uplink.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Composite Available Capacity Downlink	M		Composite Available Capacity 9.2.45	For the Downlink	-	-
Composite Available Capacity Uplink	M		Composite Available Capacity 9.2.45	For the Uplink	-	-

9.2.45 Composite Available Capacity

The *Composite Available Capacity* IE indicates the overall available resource level in the cell in either Downlink or Uplink.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Cell Capacity Class Value	O		9.2.46		-	-
Capacity Value	M		9.2.47	‘0’ indicates no resource is available, Measured on a linear scale.	-	-

9.2.46 Cell Capacity Class Value

The *Cell Capacity Class Value* IE indicates the value that classifies the cell capacity with regards to the other cells. The *Cell Capacity Class Value* IE only indicates resources that are configured for traffic purposes.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Cell Capacity Class Value	M		INTEGER (1..100,...)	Value 1 shall indicate the minimum cell capacity, and 100 shall indicate the maximum cell capacity. There should be a linear relation between cell capacity and Cell Capacity Class Value.	-	-

9.2.47 Capacity Value

The *Capacity Value* IE indicates the amount of resources that are available relative to the total E-UTRAN resources. The capacity value should be measured and reported so that the minimum E-UTRAN resource usage of existing services is reserved according to implementation. The *Capacity Value* IE can be weighted according to the ratio of cell capacity class values, if available.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Capacity Value	M		INTEGER (0..100)	Value 0 shall indicate no available capacity, and 100 shall indicate maximum available capacity . Capacity Value should be measured on a linear scale.	-	-

9.2.48 Mobility Parameters Information

The *Mobility Parameters Information* IE contains the change of the Handover Trigger as compared to its current value. The Handover Trigger corresponds to the threshold at which a cell initialises the handover preparation procedure towards a specific neighbour cell. Positive value of the change means the handover is proposed to take place later.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Handover Trigger Change	M		INTEGER (-20..20)	The actual value is IE value * 0.5 dB.

9.2.49 Mobility Parameters Modification Range

The *Mobility Parameters Modification Range* IE contains the range of *Handover Trigger Change* values permitted by the eNB_2 at the moment the MOBILITY CHANGE FAILURE message is sent.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Handover Trigger Change Lower Limit	M		INTEGER (-20..20)	The actual value is IE value * 0.5 dB.
Handover Trigger Change Upper Limit	M		INTEGER (-20..20)	The actual value is IE value * 0.5 dB.

9.2.50 PRACH Configuration

This IE indicates the PRACH resources used in neighbor cell.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
RootSequenceIndex	M		INTEGER (0..837)	See section 5.7.2. in TS 36.211 [10]	–	–
ZeroCorrelationZoneConfiguration	M		INTEGER (0..15)	See section 5.7.2. in TS 36.211 [10]	–	–
HighSpeedFlag	M		BOOLEAN	TRUE corresponds to Restricted set and FALSE to Unrestricted set. See section 5.7.2 in TS 36.211 [10]	–	–
PRACH-FrequencyOffset	M		INTEGER (0..94)	See section 5.7.1 of TS 36.211 [10]	–	–
PRACH-ConfigurationIndex	O		INTEGER (0..63)	Mandatory for TDD, shall not be present for FDD. See section 5.7.1. in TS 36.211 [10]	–	–

9.2.51 Subframe Allocation

The *Subframe Allocation* IE is used to indicate the subframes that are allocated for MBSFN within the radio frame allocation period as defined in TS 36.331 [9].

IE/Group Name	Presence	Range	IE Type and Reference	Semantics Description
CHOICE *Subframe Allocation*	M			
>Oneframe	M		BITSTRING (SIZE(6))	
>Fourframes	M		BITSTRING (SIZE(24))	

9.2.52 CSG Membership Status

This element indicates the membership status of the UE to a particular CSG.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
CSG Membership Status	M		ENUMERATED (member, not-member)		-	-

9.2.53 CSG ID

This element indicates the identifier of the Closed Subscriber Group.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
CSG ID	M		BIT STRING (SIZE (27))		-	-

9.2.54 ABS Information

This IE provides information about which sub frames the sending eNB is configuring as almost blank subframes and which subset of almost blank subframes are recommended for configuring measurements towards the UE. Almost blank subframes are subframes with reduced power on some physical channels and/or reduced activity.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
CHOICE ABS Information	M		–	–
>*FDD*			–	–
>>ABS Pattern Info	M		BIT STRING (SIZE(40))	Each position in the bitmap represents a DL subframe, for which value "1" indicates 'ABS' and value "0" indicates 'non ABS'. The first position of the ABS pattern corresponds to subframe 0 in a radio frame where *SFN* = 0. The ABS pattern is continuously repeated in all radio frames. The maximum number of subframes is 40.
>>Number Of Cell-specific Antenna Ports	M		ENUMERATED (1, 2, 4, …)	*P* (number of antenna ports for cell-specific reference signals) defined in TS 36.211 [10]
>>Measurement Subset	M		BIT STRING (SIZE(40))	Indicates a subset of the ABS Pattern Info above, and is used to configure specific measurements towards the UE.
>*TDD*			–	–
>>ABS Pattern Info	M		BIT STRING (1..70, ...)	Each position in the bitmap represents a subframe. Value "1" indicates 'ABS' and value "0" indicates 'non ABS' which is applicable only in positions corresponding to the DL direction. The maximum number of subframes depends on UL/DL subframe configuration. The maximum number of subframes is 20 for UL/DL subframe configuration 1~5; 60 for UL/DL subframe configuration 6; 70 for UL/DL subframe configuration 0. UL/DL subframe configuration defined in TS 36.211 [10]. The first position of the ABS pattern corresponds to subframe 0 in a radio frame where *SFN* = 0. The ABS pattern is continuously repeated in all radio frames, and restarted each time *SFN* = 0.
>>Number Of Cell-specific Antenna Ports	M		ENUMERATED (1, 2, 4, …)	*P* (number of antenna ports for cell-specific reference signals) defined in TS 36.211 [10]
>>Measurement Subset	M		BIT STRING (1..70, ...)	Indicates a subset of the ABS Pattern Info above, and is used to configure specific measurements towards the UE

>ABS Inactive	M		NULL	Indicates that interference coordination by means of almost blank sub frames is not active

9.2.55 Invoke Indication

This IE provides an indication about which type of information the sending eNB would like the receiving eNB to send back.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Invoke Indication	M		ENUMERATED (ABS Information, …, Start NAICS Information, Stop NAICS Information)	–

9.2.56 MDT Configuration

The IE defines the MDT configuration parameters.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
MDT Activation	M		ENUMERATED(Immediate MDT only, Immediate MDT and Trace, …)		–	–
CHOICE *Area Scope of MDT*	M				–	–
>*Cell Based*					–	–
>>**Cell ID List for MDT**		*1..<maxnoofCellIDforMDT>*			–	–
>>>ECGI	M		9.2.14		–	–
>*TA Based*					–	–
>>**TA List for MDT**		*1..<maxnoofTAforMDT>*			–	–
>>>TAC	M		OCTET STRING (2)	Tracking Area Code. The TAI is derived using the current serving PLMN.	–	–
>*PLMN Wide*			NULL		–	–
>*TAI based*						
>>**TAI List for MDT**		*1..<maxnoofTAforMDT>*				
>>>TAC	M		OCTET STRING (2)	Tracking Area Code		
>>>PLMN Identity	M		9.2.4			
Measurements to Activate	M		BITSTRING (SIZE(8))	Each position in the bitmap indicates a MDT measurement, as defined in TS 37.320 [25]. First Bit = M1, Second Bit = M2, Third Bit = M3, Fourth Bit = M4, Fifth Bit = M5, Sixth Bit = logging of M1 from event triggered measurement reports according to existing RRM configuration. Seventh Bit = M6, Eighth Bit = M7. Value “1” indicates “activate” and value “0” indicates “do not activate”.	–	–
M1 Reporting Trigger	M		ENUMERATED (periodic, A2event-triggered, …, A2event-triggered periodic)	This IE shall be ignored if the *Measurements to Activate* IE has the first bit set to “0”.	–	–
M1 Threshold Event A2	C-ifM1A2trigger			Included in case of event-triggered or event-triggered periodic reporting for measurement M1	–	–
>CHOICE *Threshold*	M				–	–
>>*RSRP*					–	–
>>>Threshold RSRP	M		INTEGER (0..97)	This IE is defined in TS 36.331 [9].	–	–
>>*RSRQ*					–	–
>>>Threshold RSRQ	M		INTEGER (0..34)	This IE is defined in TS 36.331 [9].	–	–

M1 Periodic reporting	C-ifperiodic MDT			Included in case of periodic or event-triggered periodic reporting for measurement M1	–	–
>Report interval	M		ENUMERATED (ms120, ms240, ms480, ms640, ms1024, ms2048, ms5120, ms10240, min1, min6, min12, min30, min60)	This IE is defined in TS 36.331 [9].	–	–
>Report amount	M		ENUMERATED (1, 2, 4, 8, 16, 32, 64, infinity)	Number of reports	–	–
M3 Configuration	C-ifM3		9.2.61		YES	ignore
M4 Configuration	C-ifM4		9.2.62		YES	ignore
M5 Configuration	C-ifM5		9.2.63		YES	ignore
MDT Location Information	O		BITSTRING(SIZE(8))	Each position in the bitmap represents requested location information as defined in TS 37.320 [31]. First Bit = GNSS Second Bit = E-CID information. Other bits are reserved for future use and are ignored if received. Value “1” indicates “activate” and value “0” indicates “do not activate”. The eNB shall ignore the first bit unless the *Measurements to Activate* IE has the first bit or the sixth bit set to “1”.	YES	ignore
Signalling based MDT PLMN List	O		MDT PLMN List 9.2.64		YES	ignore
M6 Configuration	C-ifM6		9.2.87		YES	ignore
M7 Configuration	C-ifM7		9.2.88		YES	ignore

Range bound	Explanation
maxnoofCellIDforMDT	Maximum no. of Cell ID subject for MDT scope. Value is 32.
maxnoofTAforMDT	Maximum no. of TA subject for MDT scope. Value is 8.

Condition	Explanation
ifM1A2trigger	This IE shall be present if the *Measurements to Activate* IE has the first bit set to "1" and the *M1 Reporting Trigger* IE is set to "A2event-triggered" or to “A2event-triggered periodic”.
ifperiodicMDT	This IE shall be present if the *M1 Reporting Trigger* IE is set to "periodic" or to “A2event-triggered periodic”.
ifM3	This IE shall be present if the *Measurements to Activate* IE has the third bit set to “1”.
ifM4	This IE shall be present if the *Measurements to Activate* IE has the fourth bit set to “1”.
ifM5	This IE shall be present if the *Measurements to Activate* IE has the fifth bit set to “1”.
ifM6	This IE shall be present if the *Measurements to Activate* IE has the seventh bit set to “1”.
ifM7	This IE shall be present if the *Measurements to Activate* IE has the eighth bit set to “1”.

9.2.57 Void

9.2.58 ABS Status

The *ABS Status* IE is used to aid the eNB designating ABS to evaluate the need for modification of the ABS pattern.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
DL ABS status	M		INTEGER (0..100)	Percentage of used ABS resources. The numerator of the percentage calculation consists of resource blocks within the ABS indicated in the *Usable ABS Pattern Info* IE allocated by the eNB_2 for DL traffic needing protection by ABS from inter-cell interference for DL scheduling, or allocated by the eNB_2 for other reasons (e.g. some control channels). The denominator of the percentage calculation is the total quantity of resource blocks within the ABS indicated in the *Usable ABS Pattern Info* IE.
CHOICE *Usable ABS Information*	M		–	–
>FDD			–	–
>>Usable ABS Pattern Info	M		BIT STRING (SIZE(40))	Each position in the bitmap represents a subframe, for which value "1" indicates 'ABS that has been designated as protected from inter-cell interference by the eNB_1, and available to serve this purpose for DL scheduling in the eNB_2' and value "0" is used for all other subframes. The pattern represented by the bitmap is a subset of, or the same as, the corresponding *ABS Pattern Info* IE conveyed in the LOAD INFORMATION message from the eNB_1.
>TDD			–	–
>>Usable ABS Pattern Info	M		BIT STRING (1..70)	Each position in the bitmap represents a subframe, for which value "1" indicates 'ABS that has been designated as protected from inter-cell interference by the eNB_1, and available to serve this purpose for DL scheduling in the eNB_2' and value "0" is used for all other subframes. The pattern represented by the bitmap is a subset of, or the same as, the corresponding *ABS Pattern Info* IE conveyed in the LOAD INFORMATION message from the eNB_1.

9.2.59 Management Based MDT Allowed

This information element is used by the eNB to allow selection of the UE for management based MDT as described in TS 32.422 [6].

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Management Based MDT Allowed	M		ENUMERATED (Allowed, ...)	

9.2.60 MultibandInfoList

The *MultibandInfoList* IE contains the additional frequency band indicators that a cell belongs to listed in decreasing order of preference, see TS 36.331 [9].

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
BandInfo		*1..<maxnoofBands>*			–	–
>FrequencyBandIndicator	M		INTEGER (1.. 256, ...)	E-UTRA operating band as defined in TS 36.101 [42, table 5.5-1]	–	–

Range bound	Explanation
maxnoofBands	Maximum number of frequency bands that a cell belongs to. The value is 16.

9.2.61 M3 Configuration

This IE defines the parameters for M3 measurement collection.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
M3 Collection Period	M		ENUMERATED (ms100, ms1000, ms10000, …)	

9.2.62 M4 Configuration

This IE defines the parameters for M4 measurement collection.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
M4 Collection Period	M		ENUMERATED (ms1024, ms2048, ms5120, ms10240, min1, …)	
M4 Links to log	M		ENUMERATED(uplink, downlink, both-uplink-and-downlink, …)	

9.2.63 M5 Configuration

This IE defines the parameters for M5 measurement collection.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
M5 Collection Period	M		ENUMERATED (ms1024, ms2048, ms5120, ms10240, min1, …)	
M5 Links to log	M		ENUMERATED(uplink, downlink, both-uplink-and-downlink, …)	

9.2.64 MDT PLMN List

The purpose of the *MDT PLMN List* IE is to provide the list of PLMNs allowed for MDT.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
MDT PLMN List		*1..<maxnoofMDTPLMNs>*		
>PLMN Identity	M		9.2.4	

Range bound	Explanation
maxnoofMDTPLMNs	Maximum no. of PLMNs in the MDT PLMN list. Value is 16.

9.2.65 EARFCN Extension

The E-UTRA Absolute Radio Frequency Channel Number Extension defines the carrier frequency used in a cell for a given direction (UL or DL) in FDD or for both UL and DL directions in TDD.

IE/Group Name	Presence	Range	IE Type and Reference	Semantics Description
EARFCN Extension	M		INTEGER (maxEARFCN+1 .. newmaxEARFCN, ...)	The relation between EARFCN and carrier frequency (in MHz) are defined in TS 36.104 [16].

Range bound	Explanation
maxEARFCN	Maximum value of EARFCNs. Value is 65535.
newmaxEARFCN	New maximum value of EARFCNs. Value is 262143.

9.2.66 COUNT Value Extended

This information element indicates the 15 bit long PDCP SN and the corresponding 17 bit long Hyper Frame Number.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
PDCP-SN Extended	M		INTEGER (0..32767)		–	–
HFN Modified	M		INTEGER (0..131071)		–	–

9.2.67 Extended UL Interference Overload Info

This IE provides report on interference overload for the set of subframes that are subject to UL-DL subframe reconfiguration. This IE applies to TDD only.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Associated Subframes	M		BITSTRING (SIZE(5))	The set of subframe(s) to which the Extended UL interference overload indication is applicable. The bitmap from the least significant bit position to the most significant bit position represents subframes #{3, 4, 7, 8, 9} in a radio frame. Value "1" in a bit position indicates that the Extended UL interference overload indication is applicable to the corresponding subframe; and value "0" indicates otherwise.
Extended UL Interference Overload Indication	M		UL Interference Overload Indication 9.2.17	

9.2.68 RNL Header

The *RNL Header* IE indicates the target eNB ID and source eNB ID.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Source eNB ID	M		Global eNB ID 9.2.22		-	-
Target eNB ID	O		Global eNB ID 9.2.22		-	-

9.2.69 Masked IMEISV

This information element contains the IMEISV value with a mask, to identify a terminal model without identifying an individual Mobile Equipment.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Masked IMEISV	M		BIT STRING (SIZE(64))	Coded as the International Mobile station Equipment Identity and Software Version Number (IMEISV) defined in TS 23.003 [29] with the last 4 digits of the SNR masked by setting the corresponding bits to 1.

9.2.70 Expected UE Behaviour

This IE defines the behaviour of a UE with predictable activity and/or mobility behaviour, to assist the eNB/en-gNB in determining the optimum RRC connection time.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Expected UE Activity Behaviour	M		9.2.71	
Expected HO Interval	O		ENUMERATED (sec15, sec30, sec60, sec90, sec120, sec180, long-time, …)	Indicates the expected time interval between inter-eNB handovers. If "long-time" is included, the interval between inter-eNB handovers is expected to be longer than 180 seconds.

9.2.71 Expected UE Activity Behaviour

Indicates information about the expected "UE activity behaviour" as defined in TS 23.401 [12].

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Expected Activity Period	O		INTEGER (1..30|40|50|60|80|100|120|150|180|181, ...)	If this IE is set to "181" the expected activity time is longer than 180 seconds. The remaining values indicate the expected activity time in [seconds].
Expected Idle Period	O		INTEGER (1..30|40|50|60|80|100|120|150|180|181, ...)	If this IE is set to "181" the expected idle time is longer than 180 seconds. The remaining values indicate the expected idle time in [seconds].
Source of UE Activity Behaviour Information	O		ENUMERATED (subscription information, statistics, ...)	If "subscription information" is indicated, the information contained in the *Expected Activity Period* IE and the *Expected Idle Period* IE, if present, is derived from subscription information. If "statistics" is indicated, the information contained in the *Expected Activity Period* IE and the *Expected Idle Period* IE, if present, is derived from statistical information.

9.2.72 SeNB Security Key

The *SeNB Security Key* IE is used to apply security in the SeNB as defined in TS 33.401 [18].

IE/Group Name	Presence	Range	IE Type and Reference	Semantics Description
SeNB Security Key	M		BIT STRING (SIZE(256))	The S-KeNB which is provided by the MeNB, see TS 33.401 [18].

9.2.73 SCG Change Indication

The *SCG Change Indication* IE is either used to request the SeNB to prepare the SCG Change in the SeNB or to request the MeNB to initiate the SCG Change towards the UE (see TS 36.300 [15]).

IE/Group Name	Presence	Range	IE Type and Reference	Semantics Description
SCG Change Indication	M		ENUMERATED (PDCPCountWrapAround, PSCellChange, other, …)	

9.2.74 CoMP Information

This IE provides the list of CoMP hypothesis sets, where each CoMP hypothesis set is the collection of CoMP hypothesis(es) of one or multiple cells and each CoMP hypothesis set is associated with a benefit metric.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
CoMP Information Item		*1 .. <maxnoofCoMPHypothesisSet>*		
>CoMP Hypothesis Set	M		9.2.75	
>Benefit Metric	M		INTEGER (-101..100, …)	Value -100 indicates the maximum cost, and 100 indicates the maximum benefit. Value -101 indicates unknown benefit. Values from -100 to 100 should be calculated on a linear scale.
CoMP Information Start Time		*0..1*		
>Start SFN	M		INTEGER (0..1023, …)	SFN of the radio frame containing the first subframe when the *CoMP Information* IE is valid.
>Start Subframe Number	M		INTEGER (0..9, …)	Subframe number, within the radio frame indicated by the *Start SFN* IE, of the first subframe when the *CoMP Information* IE is valid.

Range bound	Explanation
maxnoofCoMPHypothesisSet	Maximum number of CoMP Hypothesis sets. The value is 256.

9.2.75 CoMP Hypothesis Set

This IE provides a set of CoMP hypotheses. A CoMP hypothesis is hypothetical PRB-specific resource allocation information for a cell.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
CoMP Hypothesis Set Item		*1..<maxnoofCoMPCells>*		
>Cell ID	M		ECGI 9.2.14	ID of the cell for which the *CoMP Hypothesis* IE is applied.
>CoMP Hypothesis	M		BIT STRING (6..4400, …)	Each position in the bitmap represents a PRB in a subframe, for which value "1" indicates 'interference protected resource' and value "0" indicates 'resource with no utilization constraints,' which is applicable only in positions corresponding to the DL direction. The first bit corresponds to PRB 0 of the first subframe for which the IE is valid, the second bit corresponds to PRB 1 of the first subframe for which the IE is valid, and so on. The bit string may span across multiple contiguous subframes. The length of the bit string is an integer (maximum 40) multiple of N_{RB}^{DL}. N_{RB}^{DL} is defined in TS 36.211 [10]. The CoMP hypothesis pattern is continuously repeated.

Range bound	Explanation
maxnoofCoMPCells	Maximum number of cells in a CoMP hypothesis set. Value is 32.

9.2.76 RSRP Measurement Report List

This IE provides RSRP measurement reports of UEs served by the sending eNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
RSRP Measurement Report Item		*1 .. <maxUEReport>*		
>RSRP Measurement Result		*1 .. <maxCellReport>*		
>>RSRP Cell ID	M		ECGI 9.2.14	ID of the cell on which the RSRP is measured.
>>RSRP Measured	M		INTEGER (0..97, ...)	Measured RSRP. Defined in TS 36.331 [9].
>UE ID	O		BIT STRING (SIZE(16))	ID assigned by eNB_2 for the UE.

Range bound	Explanation
maxUEReport	Maximum number of UE measurement reports. Value is 128.
maxCellReport	Maximum number of reported cells. The value is 9.

9.2.77 Dynamic DL transmission information

This IE contains assistance information for DL interference mitigation.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
CHOICE *NAICS Information*	M			
>NAICS Active				
>>Transmission Modes	O		BIT STRING (SIZE(8))	The set bits indicate some or all transmission modes: 1, 2, 3, 4, 6, 8, 9, 10, as defined in TS 36.213 [23, 7.1]. The first/ leftmost bit is for transmission mode 1, the second bit is for transmission mode 2, and so on.
>>P_B	O		INTEGER (0..3)	See TS 36.213 [23, Table 5.2-1]
>>P_A_list		*0 .. <maxnoofPA>*		
>>>P_A	M		ENUMERATED (dB-6, dB-4dot77, dB-3, dB-1dot77, dB0, dB1, dB2, dB3,...)	See P_A TS 36.213 [23, 5.2]. Value dB-6 corresponds to -6 dB, dB-4dot77 corresponds to -4.77 dB etc.
>NAICS Inactive			NULL	

Range bound	Explanation
maxnoofPA	Maximum no of P_A values that can be configured. Value is 3.

9.2.78 ProSe Authorized

This IE provides information on the authorization status of the UE for ProSe service(s).

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
ProSe Direct Discovery	O		ENUMERATED (authorized, not authorized, ...)	Indicates whether the UE is authorized for ProSe Direct Discovery	-	-
ProSe Direct Communication	O		ENUMERATED (authorized, not authorized, ...)	Indicates whether the UE is authorized for ProSe Direct Communication	-	-
ProSe UE-to-Network Relaying	O		ENUMERATED (authorized, not authorized, ...)	Indicates whether the UE is authorized to act as ProSe UE-to-Network Relay	YES	ignore

9.2.79 CSI Report

This IE provides CSI reports of UEs served by the cell for which the information is provided.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
CSI Report per Cell		*1 .. <maxUEReport>*		
>UE ID	M		BIT STRING (SIZE(16))	ID assigned by eNB2 for the UE.
>CSI Report per CSI Process		*1 .. <maxCSIProcess>*		
>>CSI Process Configuration Index	M		INTEGER (1..7, …)	Indicates one of the possible CSI Process configurations in the serving cell.
>>CSI Report per CSI Process Item		*1.. <maxCSIReport>*		
>>>RI	M		INTEGER (1..8, …)	The RI corresponding to the CQI being reported for this CSI process item. Value defined in TS 36.213 [11].
>>>Wideband CQI	M		9.2.80	
>>>Subband Size	M		ENUMERATED (2, 3, 4, 6, 8, …)	Corresponds to a value of subband size *k* defined in TS 36.213 [11] for the system bandwidth $N_{\mathrm{RB}}^{\mathrm{DL}}$.
>>>Subband CQI List		*0 .. <maxSubband>*		
>>>>Subband CQI	M		9.2.81	
>>>>Subband Index	M		INTEGER (0..27, …)	

Range bound	Explanation
maxUEReport	Maximum number of UE. Value is 128.
maxCSIProcess	Maximum number of CSI processes per UE. The value is 4.
maxCSIReport	Maximum number of CSI Reports per CSI Process. The value is 2.
maxSubband	Maximum number of subbands. The value is 14.

9.2.80 Wideband CQI

This IE indicates the Wideband CQI as defined in TS 36.213 [11].

IE/Group Name	Presence	Range	IE Type and Reference	Semantics Description
Wideband CQI Codeword 0	M		INTEGER (0..15, …)	Value defined in TS 36.213 [11].
CHOICE *Wideband CQI Codeword 1*	O			
>4-bit CQI	M		INTEGER (0..15, …)	Value defined in TS 36.213 [11].
>3-bit spatial differential CQI	M		INTEGER (0..7, …)	Value defined in TS 36.213 [11].

9.2.81 Subband CQI

This IE indicates the Subband CQI as defined in TS 36.213 [11].

IE/Group Name	Presence	Range	IE Type and Reference	Semantics Description
CHOICE *Subband CQI Codeword 0*	M			
>4-bit CQI	M		INTEGER (0..15, …)	Value defined in TS 36.213 [11].
>2-bit Subband differential CQI	M		INTEGER (0..3, …)	Value defined in TS 36.213 [11].
>2-bit differential CQI	M		INTEGER (0..3, …)	Value defined in TS 36.213 [11].
CHOICE *Subband CQI Codeword 1*	O			
>4-bit CQI	M		INTEGER (0..15, …)	Value defined in TS 36.213 [11].
>3-bit spatial differential CQI	M		INTEGER (0..7, …)	Value defined in TS 36.213 [11].
>2-bit Subband differential CQI	M		INTEGER (0..3, …)	Value defined in TS 36.213 [11].
>2-bit differential CQI	M		INTEGER (0..3, …)	Value defined in TS 36.213 [11].

9.2.82 COUNT Value for PDCP SN Length 18

This information element indicates the 18 bit long PDCP SN and the corresponding 14 bit long Hyper Frame Number.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
PDCP-SN Length 18	M		INTEGER (0..262143)		–	–
HFN for PDCP-SN Length 18	M		INTEGER (0..16383)		–	–

9.2.83 LHN ID

The *LHN ID* IE is used to indicate the LHN ID of the eNB, as defined in TS 23.003 [21].

IE/Group Name	Presence	Range	IE Type and Reference	Semantics Description
Local Home Network ID	M		OCTET STRING (SIZE (32..256))	Identifies the Local Home Network.

9.2.84 Correlation ID

This information element is the GTP Tunnel Endpoint Identifier or GRE key to be used for the user plane transport between eNB and the L-GW described in TS 23.401 [12].

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Correlation ID	M		OCTET STRING (SIZE(4))	

9.2.85 UE Context Kept Indicator

This IE indicates that the UE Context at the SeNB is kept in case of inter-MeNB handover without SeNB/SgNB Change procedure, as specified in TS 36.300 [15] or TS37.340 [32].

IE/Group Name	Presence	Range	IE type and reference	Semantics description
UE Context Kept Indicator	M		ENUMERATED (True, …)	

9.2.86 eNB UE X2AP ID Extension

This information element combined with the eNB UE X2AP ID uniquely identifies an UE over the X2 interface within an eNB. If the setup of an UE associcated signalling connection was initiated including the eNB UE X2AP ID Extension,

the eNB UE X2AP ID Extension shall be used by both peers for the life-time of the respective UE-associated signalling connection.

The usage of this IE is defined in TS 36.401 [2].

IE/Group Name	Presence	Range	IE type and reference	Semantics description
eNB UE X2AP ID Extension	M		INTEGER (0..4095,…)	

9.2.87 M6 Configuration

This IE defines the parameters for M6 measurement collection.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
M6 Report Interval	M		ENUMERATED (ms1024, ms2048, ms5120, ms10240, …)	
M6 Delay Threshold	C-ifUL		ENUMERATED (ms30, ms40, ms50, ms60, ms70, ms80, ms90, ms100, ms150, ms300, ms500, ms750, …)	
M6 Links to log	M		ENUMERATED(uplink, downlink, both-uplink-and-downlink, …)	

Condition	Explanation
ifUL	This IE shall be present if the *M6 Links to log* IE is set to “uplink” or to “both-uplink-and-downlink”.

9.2.88 M7 Configuration

This IE defines the parameters for M7 measurement collection.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
M7 Collection Period	M		INTEGER (1..60, …)	Unit: minutes
M7 Links to log	M		ENUMERATED(uplink, downlink, both-uplink-and-downlink, …)	

9.2.89 Tunnel Information

The *Tunnel Information* IE indicates the transport layer address and UDP port number.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Transport Layer Address	M		BIT STRING (1..160, ...)	eNB’s Transport Layer Address.
UDP Port Numbers	O		OCTET STRING (SIZE(2))	UDP Port Numbers if NAT/NAPT is deployed in the BBF access network.

9.2.90 X2 Benefit Value

The *X2 Benefit Value* IE indicates the quantified benefit of the signalling connection.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
X2 Benefit Value	M		INTEGER (1..8, …)	Value 1 indicates low benefit, and 8 indicates high benefit.

9.2.91 Resume ID

The *Resume ID* IE is used to address a suspended UE Context within an eNB.

IE/Group Name	Presence	Range	IE Type and Reference	Semantics Description
CHOICE *Resume ID*	M			
>Resume ID not truncated				
>>Resume ID not truncated	M		BIT STRING (SIZE (40))	40 bit Resume Resume Identity contained in the RRCConnection ResumeRequest message (TS 36.331 [9]) . The 20 most significant bits refer to the eNB ID of the eNB that allocated the Resume ID, the 20 least significant bits identify the UE Context stored at the eNB that allocated the Resume ID.
>Resume ID truncated				
>>Resume ID truncated	M		BIT STRING (SIZE (24))	24 bit Resume Identity contained in the RRCConnection ResumeRequest message (TS 36.331 [9]). The 12 most significant bits refer to the 12 least significant bits of the eNB ID of the eNB that allocated the Resume ID. The 12 least significant bits refer to the 12 least significant bits that identify the UE Context stored at the eNB that allocated the Resume ID.

9.2.92 Bearer Type

This IE is used to support Non-IP data as specified in TS 23.401 [11].

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Bearer Type	M		ENUMERATED (non IP, …)	

9.2.93 V2X Services Authorized

This IE provides information on the authorization status of the UE to use the sidelink for V2X services.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Vehicle UE	O		ENUMERATED (authorized, not authorized, ...)	Indicates whether the UE is authorized as Vehicle UE	-	-
Pedestrian UE	O		ENUMERATED (authorized, not authorized, ...)	Indicates whether the UE is authorized as Pedestrian UE	-	-

9.2.94 Offset of NB-IoT Channel Number to EARFCN

This IE is used to indicate the offset of the NB-IoT Channel Number to the EARFCN (TS 36.104 [16]).

IE/Group Name	Presence	Range	IE Type and Reference	Semantics Description
Offset of NB-IoT Channel Number to EARFCN	**M**		ENUMERATED (-10,-9,-8,-7,-6,-5,-4,-3,-2,-1,-0.5,0,1,2,3,4,5,6,7,8,9,...)	

9.2.95 WT ID

This IE is used to identify a WT.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
CHOICE *WT ID Type*	M			
>WT ID Type 1				
>>PLMN ID	M		PLMN Identity 9.2.4	
>>Short WT ID	M		BIT STRING (24)	
>WT ID Type 2				
>>Long WT ID	M		BIT STRING (48)	

9.2.96 WT UE XwAP ID

The WT UE XwAP ID is allocated by the WT and uniquely identifies a UE over the Xw interface.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
WT UE XwAP ID	M		OCTET STRING (SIZE(3))	

9.2.97 UE Sidelink Aggregate Maximum Bit Rate

This IE indicates the aggregate maximum bit rate for all radio bearers per UE in the sidelink for V2X services.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
UE Sidelink Aggregate Maximum Bit Rate	M		Bit Rate 9.2.11	Value 0 shall be considered as a logical error by the receiving eNB.

9.2.98 NR Neighbour Information

This IE contains cell configuration information of NR cells that a neighbour node may need for the X2 AP interface.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
NR Neighbour Information		*1 .. <maxnoofNR Neighbours>*			–	
>NR Neighbour Information						
>>NRPCI	M		INTEGER (0..1007)	NR Physical Cell ID	–	
>>NR-CGI	M		9.2.111		–	
>>CHOICE *NR-Neighbour-Mode-Info*	M				–	–
>>>FDD						
>>>>FDD Info		*1*			–	–
>>>>>UL ARFCNFreqInfo	M		NR ARFCN Frequency Info 9.2.106		–	–
>>>>DL ARFCNFreqInfo	M		NR ARFCN Frequency Info 9.2.106		–	–
>>>TDD						
>>>>TDD Info		*1*			–	–
>>>>>ARFCNNRFreqInfo	M		NR ARFCN Frequency Info 9.2.106		–	–
>>5GS-TAC	M		OCTET STRING(3)	Broadcast 5GS Tracking Area Code	–	
>>Configured TAC	O		TAC 9.2.3.7	This is the TAC configured in the en-gNB, different from the 5GS TAC broadcast in the NR cell and enables application of Roaming and Access Restrictions for EN-DC as specified in TS 37.340 [32].	–	
>>Measurement Timing Configuration	M		OCTET STRING	Contains the MeasurementTimingConfiguration inter-node message for the neighbour cell, as defined in TS 38.331 [31].	–	–

Range bound	Explanation
maxnoofNRNeighbours	Maximum no. of neighbour NR cells associated to a given served cell. Value is 1024.

9.2.99 Extended Bit Rate

This IE indicates the number of bits delivered by E-UTRAN in UL or to E-UTRAN in DL within a period of time, divided by the duration of the period. It is used, for example, to indicate the maximum or guaranteed bit rate for a GBR bearer, or an aggregated maximum bit rate.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Extended Bit Rate			INTEGER (10,000,000,001..4,000,000,000,000,...)	The unit is: bit/s

9.2.100 en-gNB UE X2AP ID

This information element uniquely identifies an UE over the X2 interface within an en-gNB.

The usage of this IE is defined in TS 36.401 [2].

IE/Group Name	Presence	Range	IE type and reference	Semantics description
en-gNB UE X2AP ID	M		INTEGER (0.. 2^{32} -1)	

9.2.101 SgNB Security Key

The *SgNB Security Key* IE is used to apply security in the en-gNB as defined in TS 33.401 [18].

IE/Group Name	Presence	Range	IE Type and Reference	Semantics Description
SgNB Security Key	M		BIT STRING (SIZE(256))	The S-KgNB which is provided by the MeNB, see TS 33.401 [18].

9.2.102 Target SgNB ID Information

This IE contains the target SgNB ID used by MeNB to find the target en-gNB.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Target SgNB ID	M		9.2.112			

9.2.103 SCG Configuration Query

The *SCG Configuration Query* IE is used to request the en-gNB to provide current SCG configuration.

IE/Group Name	Presence	Range	IE Type and Reference	Semantics Description
SCG Configuration Query	M		ENUMERATED (True, …)	

9.2.104 Delivery Status

This IE defines the Delivery Status IE of RRC Transfer message.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Highest successfully delivered NR PDCP Sequence Number	M	0..2^{12}-1	INTEGER (0..2^{12}-1)	Highest successfully delivered NR PDCP SN, as defined in 38.323 [33].	–	

9.2.105 Void

Void

9.2.106 NR Frequency Info

The NR Frequency Info defines the carrier frequency and bands used in a cell for a given direction (UL or DL) in FDD or for both UL and DL directions in TDD.

IE/Group Name	Presence	Range	IE Type and Reference	Semantics Description
NRARFCN	M		INTEGER (0..maxNRARFCN)	RF Reference Frequency as defined in TS 38.104 [37] section 5.4.2.1. The frequency provided in this IE identifies the absolute frequency position of the reference resource block (Common RB 0) of the carrier. Its lowest subcarrier is also known as Point A.
SUL Information	O		9.2.123	
Frequency Band List		*1*		
>Frequency Band Item		*1..<maxnoofNrCellBands>*		
>>NR Frequency Band	M		INTEGER (1..1024, ...)	Primary NR Operating Band as defined in TS38.104 [37] section 5.4.2.3. The value 1 corresponds e n1, value 2 corresponds to NR operating band n2, etc.
>>Supported SUL band List		*0..<maxnoofNrCellBands>*		
>>>Supported SUL band Item	M		INTEGER (1..1024, ...)	Supplementary NR Operating Band as defined in TS 38.104 [37] section 5.4.2.3 that can be used for SUL duplex mode as per TS 38.101-1 table 5.2.-1. The value 80 corresponds to NR operating band n80, value 81 corresponds to NR operating band n81, etc.

Range bound	Explanation
maxNRARFCN	Maximum value of NRARFCNs. Value is 3279165.
maxnoofNrCellBands	Maximum no. of frequency bands supported for a NR cell. Value is 32.

9.2.107 NR UE Security Capabilities

This IE defines the supported algorithms for encryption and integrity protection in NR as defined in TS 33.401 [18].

IE/Group Name	Presence	Range	IE type and reference	Semantics description
NR Encryption Algorithms	M		BIT STRING (SIZE(16, …))	Each position in the bitmap represents an encryption algorithm: “all bits equal to 0” – UE supports no other NR algorithm than NEA0, “first bit” – 128-NEA1, “second bit” – 128-NEA2, “third bit” – 128-NEA3, other bits reserved for future use. Value ‘1’ indicates support and value ‘0’ indicates no support of the algorithm. Algorithms are defined in TS 33.401 [18].
NR Integrity Protection Algorithms	M		BIT STRING (SIZE(16, …))	Each position in the bitmap represents an integrity protection algorithm: “all bits equal to 0” – UE supports no other NR algorithm than NIA0, “first bit” – 128-NIA1, “second bit” – 128-NIA2, “third bit” – 128-NIA3, other bits reserved for future use. Value ‘1’ indicates support and value ‘0’ indicates no support of the algorithm. Algorithms are defined in TS 33.401 [18].

9.2.108 EN-DC Resource Configuration

This IE contains the EN-DC resource configuration for an E-RAB, indicating the presence of PDCP at the en-gNB and Lower Layers at MCG and SCG.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
PDCP at SgNB	M		ENUMERATED (present, not present)		–	
MCG resources	M		ENUMERATED (present, not present)		–	
SCG resources	M		ENUMERATED (present, not present)		–	

9.2.109 PDCP Change Indication

The *PDCP Change Indication* IE is used to require the MeNB to either initiate the security key update or to perform PDCP data recovery towards the UE (see TS 37.340 [15]).

IE/Group Name	Presence	Range	IE Type and Reference	Semantics Description
PDCP Change Indication	M		ENUMERATED (S-KgNB update required, PDCP data recovery required, …)	The value of S-KgNB update required indicates that the security key in en-gNB needs to be updated. The value of PDCP data recovery required indicates that MeNB needs to perform PDCP data recovery.

9.2.110 Served NR Cell Information

This IE contains cell configuration information of an NR cell that a neighbour eNB may need for the X2 AP interface.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
NR-PCI	M		INTEGER (0..1007, …)	NR Physical Cell ID	–	–
Cell ID	M		NR CGI 9.2.111		–	–
5GS-TAC	M		OCTET STRING(3)	Broadcast 5GS Tracking Area Code	–	–
Configured TAC	O		OCTET STRING (2)	This is the TAC configured in the en-gNB, different from the 5GS TAC broadcast in the NR cell and enables application of Roaming and Access Restrictions for EN-DC as specified in TS 37.340 [32].	–	
Served PLMNs		*1..<maxnoofBPLMNs>*		Broadcast PLMNs	–	–
>PLMN Identity	M		9.2.4		–	–
CHOICE *NR-Mode-Info*	M				–	–
>FDD						
>>FDD Info		*1*			–	–
>>>UL FreqInfo	M		NR Frequency Info 9.2.106		–	–
>>>DL FreqInfo	M		NR Frequency Info 9.2.106		–	–
>>>UL Transmission Bandwidth	M		NR Transmission Bandwidth 9.2.114		–	–
>>>DL Transmission Bandwidth	M		NR Transmission Bandwidth 9.2.114		–	–
>TDD						
>>TDD Info		*1*			–	–
>>>NRFreqInfo	M		NR Frequency Info 9.2.106		–	–
>>> Transmission Bandwidth	M		NR Transmission Bandwidth 9.2.114		–	–
Measurement Timing Configuration	M		OCTET STRING	Contains the *MeasurementTimingConfiguration* inter-node message for the served cell, as defined in TS 38.331 [31].	–	–

Range bound	Explanation
maxnoofBPLMNs	Maximum no. of broadcast PLMN Ids. Value is 6.

9.2.111 NR CGI

The NR Cell Global Identifier (NR CGI) is used to globally identify an NR cell (see TS 38.401 [34]).

IE/Group Name	Presence	Range	IE type and reference	Semantics description
PLMN Identity	M		9.2.4	
NR Cell Identity	M		BIT STRING (36)	The leftmost bits of the *NR Cell Identity* IE value correspond to the value of the *en-gNB ID* IE contained in the *Global en-gNB ID* IE (defined in section 9.2.112) identifying the en-gNB that controls the cell.

9.2.112 Global en-gNB ID

This IE is used to globally identify an en-gNB (see TS 37.340 [32]).

IE/Group Name	Presence	Range	IE type and reference	Semantics description
PLMN Identity	M		9.2.4	
CHOICE *en-gNB ID*	M			
>en-gNB ID				
>>en-gNB ID	M		BIT STRING (SIZE(22..32))	Equal to the leftmost bits of the *NR Cell Identity* IE contained in the *NR CGI* IE of each cell served by the en-gNB.

9.2.113 NR Carrier Information

This IE contains information for an NR carrier that a neighbour eNB may need to configure inter-RAT measurements.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Broadcast PLMNs		*1..<maxnoofBPLMNsingNB>*		Broadcast PLMNs	–	–
>PLMN Identity	M		9.2.4		–	–
CHOICE *NR-Mode-Info*	M				–	–
>FDD						
>>FDD Info		*1*			–	–
>>>UL ARFCN	M		NR ARFCN 9.2.106		–	–
>>>DL ARFCN	M		NR ARFCN 9.2.106		–	–
>>TDD Info		*1*			–	–
>>>ARFCN	M		NR ARFCN 9.2.106		–	–

Range bound	Explanation
maxnoofBPLMNsingNB	Maximum no. of broadcast PLMN Ids in the gNB. Value is 6

9.2.114 NR Transmission Bandwidth

The *NR Transmission Bandwidth* IE is used to indicate the UL or DL transmission bandwidth.

IE/Group Name	Presence	Range	IE Type and Reference	Semantics Description
NR SCS	M		ENUMERATED (scs15, scs30, scs60, scs120, …)	The values scs15, scs30, scs60 and scs120 corresponds to the sub carrier spacing in TS 38.104 [37].
NR NRB	M		ENUMERATED (nrb11, nrb18, nrb24, nrb25, nrb31, nrb32, nrb38, nrb51, nrb52, nrb65, nrb66, nrb78, nrb79, nrb93, nrb106, nrb107, nrb121, nrb132, nrb133, nrb135, nrb160, nrb162, nrb189, nrb216, nrb217, nrb245, nrb264, nrb270, nrb273, ...)	This IE is used to indicate the UL or DL transmission bandwidth expressed in units of resource blocks "N_{RB}" (TS 38.104 [37]). The values nrb11, nrb18, etc. correspond to the number of resource blocks "N_{RB}" 11, 18, etc.

9.2.115 Cell Assistance Information

The *Cell Assistance Information* IE is used by the eNB to request information about NR cells.

IE/Group Name	Presence	Range	IE Type and Reference	Semantics Description
CHOICE Cell Assistance Type	M			This IE may be refined.
>Limited List				
>>List of Requested NR Cells		*1 .. < maxCellinengNB >*		Included when the eNB requests a limited list of served NR cells.
>>>NR-CGI	M		9.2.111	NR cell for which served NR cell information is requested.
>Full List				
>>Complete Information Request Indicator	M		ENUMERATED (allServedNRCells, …)	Included when the eNB requests the complete list of served NR cells.

Range bound	Explanation
maxCellinengNB	Maximum no. cells that can be served by an en-gNB. Value is 16384.

9.2.116 MeNB Resource Coordination Information

The *MeNB Resource Coordination Information* IE is LTE resource allocation at MeNB and used at the en-gNB to coordinate resource utilisation between the MeNB and the en-gNB.

IE/Group Name	Presence	Range	IE Type and Reference	Semantics Description
EUTRA Cell ID	M		ECGI 9.2.14	
UL Coordination Information	M		BIT STRING (6..4400, …)	Each position in the bitmap represents a PRB pair in a subframe; value "0" indicates "resource not intended to be used for transmission", value "1" indicates "resource intended to be used for transmission ". The bit string spans from the first PRB pair of the first represented subframe to the last PRB pair of the same subframe and then moves to the following PRBs in the following subframes in the same order. Each position is applicable only in positions corresponding to UL subframes. The bit string may span across multiple contiguous subframes (maximum 40). The first position of the *UL Coordination Information* corresponds to subframe 0 in a radio frame where *SFN* = 0. The length of the bit string is an integer multiple of $N_{\mathrm{RB}}^{\mathrm{UL}}$. $N_{\mathrm{RB}}^{\mathrm{UL}}$ is defined in TS 36.211 [10]. The UL Coordination Information is continuously repeated.

DL Coordination Information	O		BIT STRING (6..4400, …)	Each position in the bitmap represents a PRB pair in a subframe; value "0" indicates "resource not intended to be used for transmission", value "1" indicates "resource intended to be used for transmission ". The bit string spans from the first PRB pair of the first represented subframe to the last PRB pair of the same subframe and then moves to the following PRBs in the following subframes in the same order. Each position is applicable only in positions corresponding to DL subframes. The bit string may span across multiple contiguous subframes (maximum 40). The first position of the *DL Coordination Information* corresponds to the receiving node's subframe 0 in a receiving node's radio frame where *SFN* = 0. The length of the bit string is an integer multiple of N_{RB}^{DL}. N_{RB}^{DL} is defined in TS 36.211 [10]. The DL Coordination Information is continuously repeated.

9.2.117 SgNB Resource Coordination Information

The *SgNB Resource Coordination Information* IE is LTE resource allocation at MeNB and used at the MeNB to coordinate resource utilisation between the en-gNB and the MeNB.

IE/Group Name	Presence	Range	IE Type and Reference	Semantics Description
NR CGI	M		9.2.111	
UL Coordination Information	M		BIT STRING (6..4400, …)	Each position in the bitmap represents a PRB pair in a subframe; value "0" indicates "resource not intended to be used for transmission", value "1" indicates "resource intended to be used for transmission ". The bit string spans from the first PRB pair of the first represented subframe to the last PRB pair of the same subframe and then moves to the following PRBs in the following subframes in the same order. Each position is applicable only in positions corresponding to UL subframes. The bit string may span across multiple contiguous subframes (maximum 40). The first position of the *UL Coordination Information* corresponds to the receiving node's subframe 0 in a receiving node's radio frame where *SFN* = 0. The length of the bit string is an integer multiple of $N_{\mathrm{RB}}^{\mathrm{UL}}$. $N_{\mathrm{RB}}^{\mathrm{UL}}$ is defined in TS 36.211 [10]. The UL Coordination Information is continuously repeated.

DL Coordination Information	O		BIT STRING (6..4400, …)	Each position in the bitmap represents a PRB in a subframe; value "0" indicates "resource not intended to be used for transmission", value "1" indicates "resource intended to be used for transmission ". The bit string spans from the first PRB pair of the first represented subframe to the last PRB pair of the same subframe and then moves to the following PRBs in the following subframes in the same order. Each position is applicable only in positions corresponding to DL subframes. The bit string may span across multiple contiguous subframes (maximum 40). The first position of the *DL Coordination Information* corresponds to the receiving node's subframe 0 in a receiving node's radio frame where *SFN* = 0. The length of the bit string is an integer multiple of N_{RB}^{DL}. N_{RB}^{DL} is defined in TS 36.211 [10]. The DL Coordination Information is continuously repeated.

9.2.118 UL Configuration

This IE indicates how the UL PDCP is configured for the assisting node.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
UL UE Configuration	M		ENUMERATED (no-data, shared, only, ...)	Indicates how the UE uses the UL at the assisting node.

9.2.119 RLC Mode

The *RLC Mode* IE indicates the RLC Mode used for an E-RAB.

IE/Group Name	Presence	Range	IE Type and Reference	Semantics Description
RLC Mode	M		ENUMERATED (RLC-AM, RLC-UM)	

9.2.120 Secondary RAT Usage Report List

This IE provides information on the NR resources used with EN-DC.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Secondary RAT usage report Item		1 .. <maxnoofE-RABs>			EACH	ignore
>E-RAB ID	M		9.2.23		-	-
>Secondary RAT Type	M		ENUMERATED (nR, …)		-	-
>E-RAB Usage Report List		1			-	-
>>E-RAB Usage Report Item		1.. <maxnoof time periods>			EACH	ignore
>>>Start timestamp	M		OCTET STRING (SIZE(4))	encoded in the same format as the first four octets of the 64-bit timestamp format as defined in section 6 of IETF RFC 5905 [35]. It indicates the UTC time when the recording of the Secondary RAT Data Volume was started.	-	-
>>>End timestamp	M		OCTET STRING (SIZE(4))	encoded in the same format as the first four octets of the 64-bit timestamp format as defined in section 6 of IETF RFC 5905 [35]. It indicates the UTC time when the recording of the Secondary RAT Data Volume was ended.	-	-
>>>Usage count UL	M		INTEGER (0..2^{64}-1)	The unit is: octets.	-	-
>>>Usage count DL	M		INTEGER (0..2^{64}-1)	The unit is: octets.	-	-

Range bound	Explanation
maxnoofbearers	Maximum no. of E-RABs. Value is 256.
maxnoof time periods	Maximum no. of time reporting periods. Value is 2.

9.2.121 UE Application layer measurement configuration

The IE defines configuration information for the QoE Measurement Collection (QMC) function.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigne Criticalit
Container for application layer measurement configuration	M		Octet string (1..1000)	Indicates application layer measurement configuration, see Annex L in [36].	-	-
CHOICE *Area Scope of QMC*	M				-	-
>Cell based						-
>>**Cell ID List for QMC**		*1 .. <maxnoofCellIDforQMC>*				-
>>>E-CGI	M		9.2.1.38		-	-
>TA based						-
>>**TA List for QMC**		*1 .. <maxnoofTAforQMC>*				-
>>>TAC	M		9.2.3.7	The TAI is derived using the current serving PLMN.	-	-
>TAI based					-	-
>>**TAI List for QMC**		*1 .. <maxnoofTAforQMC>*			-	-
>>>TAI	M		9.2.3.16		-	-
>PLMN area based						-
>>**PLMN List for QMC**		*1 .. <maxnoofPLMNforQMC>*				-
>>>PLMN Identity	M		9.2.3.8		-	-
Service Type	M		ENUMERATED (QMC for streaming service, QMC for MTSI service, ...)	This IE indicates the service type of UE application layer measurements.	-	-

Range bound	Explanation
maxnoofCellIDforQMC	Maximum no. of Cell ID subject for QMC scope. Value is 32.
maxnoofTAforQMC	Maximum no. of TA subject for QMC scope. Value is 8.
maxnoofPLMNforQMC	Maximum no. of PLMNs in the PLMN list for QMC scope. Value is 16.

9.2.122 DRB ID

This information element uniquely identifies a DRB over the X2 interface within an en-gNB.

The usage of this IE is defined in TS 36.331 [9].

IE/Group Name	Presence	Range	IE type and reference	Semantics description
DRB ID	M		INTEGER (1..32)	

9.2.123 SUL Information

This IE provides information about the SUL carrier.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
SUL ARFCN	M		INTEGER (0..maxNRARFCN)	RF Reference Frequency as defined in TS 38.104 [37] section 5.4.2.1. The frequency provided in this IE identifies the absolute frequency position of the reference resource block (Common RB 0) of the SUL carrier. Its lowest subcarrier is also known as Point A.
SUL Transmission Bandwidth	M		NR Transmission Bandwidth 9.2.114	

Range bound	Explanation
maxNRARFCN	Maximum value of NRARFCNs. Value is 3279165.

9.2.124 Packet Loss Rate

This IE indicates the packet loss rate.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Packet Loss Rate	M		INTEGER(0..1000)	Ratio of lost packets per number of packets sent, expressed in tenth of percent.	-	-

9.2.125 Protected E-UTRA Resource Indication

This IE indicates the resources allocated for E-UTRA DL and UL reference and control signals (hereby referred to as protected resources). This information is used in the process of E-UTRA – NR Cell Resource Coordination.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Activation SFN	M		INTEGER (0..1023)	Indicates from which SFN of the receiving node the resource allocation is valid.		
Protected Resource List		*1..<maxnoofProtectedResourcePatterns>*		The protected resource pattern is continuously repeated, and it is valid until stated otherwise or until replaced by a new pattern. The pattern does not apply in reserved subframes.	YES	ignore
>Protected Resource List Item				Each item describes one transmission pattern. A pattern may comprise several control signals.	EACH	ignore
>>Resource Type	M		ENUMERATED (downlinknonCRS,CRS, uplink…)	Indicates whether the protected resource is E-UTRA DL non-CRS, E-UTRA CRS or E-UTRA UL.	-	-

>>Intra-PRB Protected Resource Footprint	M		BIT STRING (84,..)	The bitmap of REs occupied by the protected signal within one PRB. Each position in the bitmap represents an RE in one PRB; value “0” indicates "resource not protected", value “1” indicates "resource protected ". The first bit of the string corresponds to the RE with the smallest time and frequency index in the PRB, where the indexing first goes into the frequency domain. The length of the bit string equals the product of N_{RB}^{SC} and the length of PRB in time dimension, measured in REs. N_{RB}^{SC} is defined in TS 36.211 [10]. The intra-PRB pattern consisting of all “1”s is equivalent to PRB-level granularity.		

>>Protected Footprint Frequency Pattern	M		BIT STRING(6..110..)	The bit string indicates in which PRBs inside carrier bandwidth the Intra-PRB Protected Resource Footprint applies. How often in time dimension this frequency pattern applies, depends on time periodicity of Intra-PRB Protected Resource Footprint. The first bit of the bit string corresponds to the PRB occupying the lowest subcarrier frequencies of the carrier bandwidth, where the indexing first goes into the frequency domain. Each position in the string represents a PRB; value “0” indicates " Intra-PRB Protected Resource Footprint does not appear in PRB", value “1” indicates "Intra-PRB Protected Resource Footprint appears in PRB". The length of the bit string equals the number of PRBs in the carrier bandwidth.	-	-
>>Protected Footprint Time Pattern	M			The description of time periodicity of the Intra-PRB Protected Resource Footprint.		

>>>Protected Footprint Time-periodicity	M		INTEGER(1..80..)	Periodicity with which the periodic Intra-PRB Protected Resource Footprint repeats in time-dimension (1= every PRB (i.e. slot), 2=every other PRB (i.e. slot) etc.	-	-
>>>Protected Footprint Start Time	M		INTEGER(1..20..)	The time-position of the PRB inside the frame in which the periodic Intra-PRB Protected Resource Footprint appears for the first time. The value “1” corresponds to the receiving node’s slot 0 in subframe 0 in the receiving node’s radio frame where SFN = Activation SFN.	-	-
MBSFN Control Region Length	O		INTEGER(0..3)	Length of control region in MBSFN subframes. Expressed in REs, in the time dimension.		
PDCCH Region Length	M		INTEGER(1..3)	Length of PDCCH region in regular subframes. Expressed in REs, in the time dimension.		

Range bound	Explanation
maxnoofProtectedResourcePatterns	Maximum no. protected resource patterns. Value is 16.

9.2.126 Data Traffic Resource Indication

This IE indicates the intended data traffic resource allocation for E-UTRA - NR Cell Resource Coordination.

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Activation SFN	M		INTEGER (0..1023)	Indicates from which SFN of the receiving node the agreement is valid.		
CHOICE *Shared Resource Type*	M				-	-
>*UL Only Sharing*						
>>UL Resource Bitmap	M		Data Traffic Resources 9.2.127		-	-
>*UL and DL Sharing*						
>>CHOICE *UL Resources*	M					
>>>*Unchanged*			NULL			
>>>*Changed*						
>>>>UL Resource Bitmap	M		Data Traffic Resources 9.2.127			
>>CHOICE *DL Resources*	M					
>>>*Unchanged*			NULL			
>>>*Changed*						
>>>>DL Resource Bitmap	M		Data Traffic Resources 9.2.127			
Reserved Subframe Pattern	O		9.2.128	Indicates subframes in which the resource allocation does not hold.		

9.2.127 Data Traffic Resources

The *Data Traffic Resources* IE indicates the intended data traffic resource allocation for E-UTRA - NR Cell Resource Coordination.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Data Traffic Resources	M		BIT STRING (12..8800)	The indication of resources allocated to E-UTRA PDSCH/PUSCH. Each position in the bitmap represents a PRB in a subframe; value “0” indicates "resource not intended to be used for transmission", value “1” indicates "resource intended to be used for transmission ". The first bit of the bit string corresponds to the PRB occupying the lowest subcarrier frequencies of the carrier, where the indexing first goes into the frequency domain. The bit string may span across multiple contiguous subframes (maximum 40). The first position of the Data Traffic Resource Indication corresponds to the receiving node’s subframe 0 in a receiving node’s radio frame where SFN = Activation SFN. The length of the bit string is an integer multiple of N_{RB}^{DL} or N_{RB}^{UL}, defined in TS 36.211 [10]. Data Traffic Resource Indication is continuously repeated, and it is valid until stated otherwise, or until replaced by a new pattern.

9.2.128 Reserved Subframe Pattern

The *Reserved Subframe Pattern* IE indicates the pattern of subframes in which the *Protected E-UTRA Resource Indication* and *Data Traffic Resource Indication* do not hold.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Subframe Type	M		ENUMERATED(MBSFN,non-MBSFN,…)	Indicates what type of non-regular subframes the *Reserved Subframe Pattern* refers to (e.g. MBSFN).
Reserved Subframe Pattern	M		BIT STRING (10..40)	Each position in the bitmap represents a subframe. Value '0' indicates "regular subframe". Value '1' indicates "reserved subframe". For MBSFN subframes, the exception refers only to the non-control region of the subframe. The bit string may span across multiple contiguous subframes (maximum 40). The first position of the Subframe Configuration IE corresponds to the receiving node's subframe 0 in a receiving node's radio frame where SFN = Activation SFN. The IE is ignored if received by the eNB.
MBSFN Control Region Length	O		INTEGER(0..3)	Length of control region in MBSFN subframes. Expressed in REs, in the time dimension.

9.2.129 Aerial UE subscription information

This information element is used by the eNB to know if the UE is allowed to use aerial UE function, refer to TS 23.401[12].

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Aerial UE subscription information	M		ENUMERATED (allowed, not allowed, ...)	

9.2.130 User plane traffic activity report

This IE is used to indicate user plane traffic activity.

IE/Group Name	Presence	Range	IE type and reference	Semantics description
User plane traffic activity report	M		ENUMERATED (inactive, re-activated, …)	"re-activated" shall be only set after "inactive" has been reported for the concerned reporting object

9.3 Message and Information Element Abstract Syntax (with ASN.1)

9.3.1 General

X2AP ASN.1 definition conforms to ITU-T Rec. X.680 [27] and ITU-T Rec. X.681 [28].

Sub clause 9.3 presents the Abstract Syntax of the X2AP protocol with ASN.1. In case there is contradiction between the ASN.1 definition in this sub clause and the tabular format in sub clause 9.1 and 9.2, the ASN.1 shall take precedence, except for the definition of conditions for the presence of conditional elements, in which the tabular format shall take precedence.

The ASN.1 definition specifies the structure and content of X2AP messages. X2AP messages can contain any IEs specified in the object set definitions for that message without the order or number of occurrence being restricted by ASN.1. However, for this version of the standard, a sending entity shall construct an X2AP message according to the PDU definitions module and with the following additional rules:

- IEs shall be ordered (in an IE container) in the order they appear in object set definitions.

- Object set definitions specify how many times IEs may appear. An IE shall appear exactly once if the presence field in an object has value "mandatory". An IE may appear at most once if the presence field in an object has value "optional" or "conditional". If in a tabular format there is multiplicity specified for an IE (i.e. an IE list) then in the corresponding ASN.1 definition the list definition is separated into two parts. The first part defines an IE container list in which the list elements reside. The second part defines list elements. The IE container list appears as an IE of its own. For this version of the standard an IE container list may contain only one kind of list elements.

NOTE: In the above, "IE" means an IE in the object set with an explicit ID. If one IE needs to appear more than once in one object set, then the different occurrences have different IE IDs.

If an X2AP message that is not constructed as defined above is received, this shall be considered as Abstract Syntax Error, and the message shall be handled as defined for Abstract Syntax Error in clause 10.

9.3.2 Usage of Private Message Mechanism for Non-standard Use

The private message mechanism for non-standard use may be used:

- for special operator (and/or vendor) specific features considered not to be part of the basic functionality, i.e. the functionality required for a complete and high-quality specification in order to guarantee multivendor inter-operability.

- by vendors for research purposes, e.g. to implement and evaluate new algorithms/features before such features are proposed for standardisation.

The private message mechanism shall not be used for basic functionality. Such functionality shall be standardised.

9.3.3 Elementary Procedure Definitions

```
-- **************************************************************
--
-- Elementary Procedure definitions
--
```

```
-- **************************************************************

X2AP-PDU-Descriptions {
itu-t (0) identified-organization (4) etsi (0) mobileDomain (0)
eps-Access (21) modules (3) x2ap (2) version1 (1) x2ap-PDU-Descriptions (0) }

DEFINITIONS AUTOMATIC TAGS ::=

BEGIN

-- **************************************************************
--
-- IE parameter types from other modules.
--
-- **************************************************************

IMPORTS
    Criticality,
    ProcedureCode

FROM X2AP-CommonDataTypes

    CellActivationRequest,
    CellActivationResponse,
    CellActivationFailure,
    ENBConfigurationUpdate,
    ENBConfigurationUpdateAcknowledge,
    ENBConfigurationUpdateFailure,
    ErrorIndication,
    HandoverCancel,
    HandoverReport,
    HandoverPreparationFailure,
    HandoverRequest,
    HandoverRequestAcknowledge,
    LoadInformation,
    PrivateMessage,
    ResetRequest,
    ResetResponse,
    ResourceStatusFailure,
    ResourceStatusRequest,
    ResourceStatusResponse,
    ResourceStatusUpdate,
    RLFIndication,
    SNStatusTransfer,
    UEContextRelease,
    X2SetupFailure,
    X2SetupRequest,
    X2SetupResponse,
    MobilityChangeRequest,
    MobilityChangeAcknowledge,
    MobilityChangeFailure,
    X2Release,
    X2APMessageTransfer,
    SeNBAdditionRequest,
```

```
    SeNBAdditionRequestAcknowledge,
    SeNBAdditionRequestReject,
    SeNBReconfigurationComplete,
    SeNBModificationRequest,
    SeNBModificationRequestAcknowledge,
    SeNBModificationRequestReject,
    SeNBModificationRequired,
    SeNBModificationConfirm,
    SeNBModificationRefuse,
    SeNBReleaseRequest,
    SeNBReleaseRequired,
    SeNBReleaseConfirm,
    SeNBCounterCheckRequest,
    X2RemovalFailure,
    X2RemovalRequest,
    X2RemovalResponse,
    RetrieveUEContextRequest,
    RetrieveUEContextResponse,
    RetrieveUEContextFailure,
    SgNBAdditionRequest,
    SgNBAdditionRequestAcknowledge,
    SgNBAdditionRequestReject,
    SgNBReconfigurationComplete,
    SgNBModificationRequest,
    SgNBModificationRequestAcknowledge,
    SgNBModificationRequestReject,
    SgNBModificationRequired,
    SgNBModificationConfirm,
    SgNBModificationRefuse,
    SgNBReleaseRequest,
    SgNBReleaseRequestAcknowledge,
    SgNBReleaseRequestReject,
    SgNBReleaseRequired,
    SgNBReleaseConfirm,
    SgNBCounterCheckRequest,
    SgNBChangeRequired,
    SgNBChangeConfirm,
    SgNBChangeRefuse,
    RRCTransfer,
    ENDCX2SetupRequest,
    ENDCX2SetupResponse,
    ENDCX2SetupFailure,
    ENDCConfigurationUpdate,
    ENDCConfigurationUpdateAcknowledge,
    ENDCConfigurationUpdateFailure,
    SecondaryRATDataUsageReport,
    ENDCCellActivationRequest,
    ENDCCellActivationResponse,
    ENDCCellActivationFailure,
    ENDCPartialResetRequired,
    ENDCPartialResetConfirm,
    EUTRANRCellResourceCoordinationRequest,
    EUTRANRCellResourceCoordinationResponse,
    SgNBActivityNotification,
```

```
    ENDCX2RemovalRequest,
    ENDCX2RemovalResponse,
    ENDCX2RemovalFailure


FROM X2AP-PDU-Contents

    id-cellActivation,
    id-eNBConfigurationUpdate,
    id-errorIndication,
    id-handoverCancel,
    id-handoverReport,
    id-handoverPreparation,

    id-loadIndication,
    id-privateMessage,
    id-reset,

    id-resourceStatusReporting,
    id-resourceStatusReportingInitiation,
    id-rLFIndication,
    id-snStatusTransfer,
    id-uEContextRelease,
    id-x2Setup,
    id-mobilitySettingsChange,
    id-x2Release,
    id-x2APMessageTransfer,
    id-seNBAdditionPreparation,
    id-seNBReconfigurationCompletion,
    id-meNBinitiatedSeNBModificationPreparation,
    id-seNBinitiatedSeNBModification,
    id-meNBinitiatedSeNBRelease,
    id-seNBinitiatedSeNBRelease,
    id-seNBCounterCheck,
    id-x2Removal,
    id-retrieveUEContext,
    id-sgNBAdditionPreparation,
    id-sgNBReconfigurationCompletion,
    id-meNBinitiatedSgNBModificationPreparation,
    id-sgNBinitiatedSgNBModification,
    id-meNBinitiatedSgNBRelease,
    id-sgNBinitiatedSgNBRelease,
    id-sgNBChange,
    id-sgNBCounterCheck,
    id-rRCTransfer,
    id-endcX2Setup,
    id-endcConfigurationUpdate,
    id-secondaryRATDataUsageReport,
    id-endcCellActivation,
    id-endcPartialReset,
    id-eUTRANRCellResourceCoordination,
    id-SgNBActivityNotification,
    id-endcX2Removal
```

```
FROM X2AP-Constants;

-- ************************************************************
--
-- Interface Elementary Procedure Class
--
-- ************************************************************

X2AP-ELEMENTARY-PROCEDURE ::= CLASS {
    &InitiatingMessage              ,
    &SuccessfulOutcome              OPTIONAL,
    &UnsuccessfulOutcome                OPTIONAL,
    &procedureCode          ProcedureCode   UNIQUE,
    &criticality            Criticality     DEFAULT ignore
}
WITH SYNTAX {
    INITIATING MESSAGE      &InitiatingMessage
    [SUCCESSFUL OUTCOME     &SuccessfulOutcome]
    [UNSUCCESSFUL OUTCOME       &UnsuccessfulOutcome]
    PROCEDURE CODE          &procedureCode
    [CRITICALITY            &criticality]
}

-- ************************************************************
--
-- Interface PDU Definition
--
-- ************************************************************

X2AP-PDU ::= CHOICE {
    initiatingMessage   InitiatingMessage,
    successfulOutcome   SuccessfulOutcome,
    unsuccessfulOutcome UnsuccessfulOutcome,
    ...
}

InitiatingMessage ::= SEQUENCE {
    procedureCode   X2AP-ELEMENTARY-PROCEDURE.&procedureCode        ({X2AP-ELEMENTARY-PROCEDURES}),
    criticality     X2AP-ELEMENTARY-PROCEDURE.&criticality          ({X2AP-ELEMENTARY-PROCEDURES}{@procedureCode}),
    value           X2AP-ELEMENTARY-PROCEDURE.&InitiatingMessage    ({X2AP-ELEMENTARY-PROCEDURES}{@procedureCode})
}

SuccessfulOutcome ::= SEQUENCE {
    procedureCode   X2AP-ELEMENTARY-PROCEDURE.&procedureCode        ({X2AP-ELEMENTARY-PROCEDURES}),
    criticality     X2AP-ELEMENTARY-PROCEDURE.&criticality          ({X2AP-ELEMENTARY-PROCEDURES}{@procedureCode}),
    value           X2AP-ELEMENTARY-PROCEDURE.&SuccessfulOutcome    ({X2AP-ELEMENTARY-PROCEDURES}{@procedureCode})
}

UnsuccessfulOutcome ::= SEQUENCE {
    procedureCode   X2AP-ELEMENTARY-PROCEDURE.&procedureCode        ({X2AP-ELEMENTARY-PROCEDURES}),
    criticality     X2AP-ELEMENTARY-PROCEDURE.&criticality          ({X2AP-ELEMENTARY-PROCEDURES}{@procedureCode}),
    value           X2AP-ELEMENTARY-PROCEDURE.&UnsuccessfulOutcome  ({X2AP-ELEMENTARY-PROCEDURES}{@procedureCode})
}
```

```
-- ************************************************************
--
-- Interface Elementary Procedure List
--
-- ************************************************************

X2AP-ELEMENTARY-PROCEDURES X2AP-ELEMENTARY-PROCEDURE ::= {
    X2AP-ELEMENTARY-PROCEDURES-CLASS-1          |
    X2AP-ELEMENTARY-PROCEDURES-CLASS-2          ,
    ...
}

X2AP-ELEMENTARY-PROCEDURES-CLASS-1 X2AP-ELEMENTARY-PROCEDURE ::= {
    handoverPreparation                                     |
    reset                                                   |
    x2Setup                                                 |
    resourceStatusReportingInitiation                       |
    eNBConfigurationUpdate                                  |
    mobilitySettingsChange                                  |
    cellActivation                                          |
    seNBAdditionPreparation                                 |
    meNBinitiatedSeNBModificationPreparation                |
    seNBinitiatedSeNBModification                           |
    seNBinitiatedSeNBRelease                                |
    x2Removal                                               |
    retrieveUEContext                                       |
    sgNBAdditionPreparation                                 |
    meNBinitiatedSgNBModificationPreparation                    |
    sgNBinitiatedSgNBModification                           |
    meNBinitiatedSgNBRelease                                    |
    sgNBinitiatedSgNBRelease                                    |
    sgNBChange                                              |
    endcX2Setup                                             |
    endcConfigurationUpdate                                 |
    endcCellActivation                                      |
    endcPartialReset                                            |
    eUTRANRCellResourceCoordination                         |
    endcX2Removal                                           ,
    ...
}

X2AP-ELEMENTARY-PROCEDURES-CLASS-2 X2AP-ELEMENTARY-PROCEDURE ::= {
    snStatusTransfer                        |
    uEContextRelease                        |
    handoverCancel                          |
    errorIndication                         |
    resourceStatusReporting                 |
    loadIndication                          |
    privateMessage                          |
    rLFIndication                           |
    handoverReport                          |
    x2Release                               |
    x2APMessageTransfer                     |
```

```
    seNBReconfigurationCompletion           |
    meNBinitiatedSeNBRelease                |
    seNBCounterCheck                        |
    sgNBReconfigurationCompletion           |
    sgNBCounterCheck                            |
    rRCTransfer                             |
    secondaryRATDataUsageReport             |
    sgNBActivityNotification
,
    ...

}

-- **************************************************************
--
-- Interface Elementary Procedures
--
-- **************************************************************

handoverPreparation X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      HandoverRequest
    SUCCESSFUL OUTCOME      HandoverRequestAcknowledge
    UNSUCCESSFUL OUTCOME    HandoverPreparationFailure
    PROCEDURE CODE          id-handoverPreparation
    CRITICALITY             reject
}

snStatusTransfer X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      SNStatusTransfer
    PROCEDURE CODE          id-snStatusTransfer
    CRITICALITY             ignore
}

uEContextRelease X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      UEContextRelease
    PROCEDURE CODE          id-uEContextRelease
    CRITICALITY             ignore
}


handoverCancel X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      HandoverCancel
    PROCEDURE CODE          id-handoverCancel
    CRITICALITY             ignore
}

handoverReport X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      HandoverReport
    PROCEDURE CODE          id-handoverReport
    CRITICALITY             ignore
}

errorIndication X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      ErrorIndication
```

```
    PROCEDURE CODE          id-errorIndication
    CRITICALITY             ignore
}

reset   X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      ResetRequest
    SUCCESSFUL OUTCOME      ResetResponse
    PROCEDURE CODE          id-reset
    CRITICALITY             reject
}

x2Setup X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      X2SetupRequest
    SUCCESSFUL OUTCOME      X2SetupResponse
    UNSUCCESSFUL OUTCOME    X2SetupFailure
    PROCEDURE CODE          id-x2Setup
    CRITICALITY             reject
}


loadIndication X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      LoadInformation
    PROCEDURE CODE          id-loadIndication
    CRITICALITY             ignore
}

eNBConfigurationUpdate      X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      ENBConfigurationUpdate
    SUCCESSFUL OUTCOME      ENBConfigurationUpdateAcknowledge
    UNSUCCESSFUL OUTCOME    ENBConfigurationUpdateFailure
    PROCEDURE CODE          id-eNBConfigurationUpdate
    CRITICALITY             reject
}

resourceStatusReportingInitiation   X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE              ResourceStatusRequest
    SUCCESSFUL OUTCOME              ResourceStatusResponse
    UNSUCCESSFUL OUTCOME            ResourceStatusFailure
    PROCEDURE CODE                  id-resourceStatusReportingInitiation
    CRITICALITY                     reject
}

resourceStatusReporting X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      ResourceStatusUpdate
    PROCEDURE CODE          id-resourceStatusReporting
    CRITICALITY             ignore
}

rLFIndication X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      RLFIndication
    PROCEDURE CODE          id-rLFIndication
    CRITICALITY             ignore
}
```

```
privateMessage          X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      PrivateMessage
    PROCEDURE CODE          id-privateMessage
    CRITICALITY             ignore
}

mobilitySettingsChange  X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      MobilityChangeRequest
    SUCCESSFUL OUTCOME      MobilityChangeAcknowledge
    UNSUCCESSFUL OUTCOME    MobilityChangeFailure
    PROCEDURE CODE          id-mobilitySettingsChange
    CRITICALITY             reject
}

cellActivation  X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      CellActivationRequest
    SUCCESSFUL OUTCOME      CellActivationResponse
    UNSUCCESSFUL OUTCOME    CellActivationFailure
    PROCEDURE CODE          id-cellActivation
    CRITICALITY             reject
}

x2Release X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      X2Release
    PROCEDURE CODE          id-x2Release
    CRITICALITY             reject
}

x2APMessageTransfer X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      X2APMessageTransfer
    PROCEDURE CODE          id-x2APMessageTransfer
    CRITICALITY             reject
}

seNBAdditionPreparation X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      SeNBAdditionRequest
    SUCCESSFUL OUTCOME      SeNBAdditionRequestAcknowledge
    UNSUCCESSFUL OUTCOME    SeNBAdditionRequestReject
    PROCEDURE CODE          id-seNBAdditionPreparation
    CRITICALITY             reject
}

seNBReconfigurationCompletion   X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      SeNBReconfigurationComplete
    PROCEDURE CODE          id-seNBReconfigurationCompletion
    CRITICALITY             ignore
}

meNBinitiatedSeNBModificationPreparation    X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      SeNBModificationRequest
    SUCCESSFUL OUTCOME      SeNBModificationRequestAcknowledge
    UNSUCCESSFUL OUTCOME    SeNBModificationRequestReject
    PROCEDURE CODE          id-meNBinitiatedSeNBModificationPreparation
    CRITICALITY             reject
```

```
}

seNBinitiatedSeNBModification   X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      SeNBModificationRequired
    SUCCESSFUL OUTCOME      SeNBModificationConfirm
    UNSUCCESSFUL OUTCOME    SeNBModificationRefuse
    PROCEDURE CODE          id-seNBinitiatedSeNBModification
    CRITICALITY             reject
}

meNBinitiatedSeNBRelease    X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      SeNBReleaseRequest
    PROCEDURE CODE          id-meNBinitiatedSeNBRelease
    CRITICALITY             ignore
}

seNBinitiatedSeNBRelease    X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      SeNBReleaseRequired
    SUCCESSFUL OUTCOME      SeNBReleaseConfirm
    PROCEDURE CODE          id-seNBinitiatedSeNBRelease
    CRITICALITY             reject
}

seNBCounterCheck    X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      SeNBCounterCheckRequest
    PROCEDURE CODE          id-seNBCounterCheck
    CRITICALITY             reject
}

x2Removal   X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      X2RemovalRequest
    SUCCESSFUL OUTCOME      X2RemovalResponse
    UNSUCCESSFUL OUTCOME    X2RemovalFailure
    PROCEDURE CODE          id-x2Removal
    CRITICALITY             reject
}

retrieveUEContext   X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      RetrieveUEContextRequest
    SUCCESSFUL OUTCOME      RetrieveUEContextResponse
    UNSUCCESSFUL OUTCOME    RetrieveUEContextFailure
    PROCEDURE CODE          id-retrieveUEContext
    CRITICALITY             reject
}

sgNBAdditionPreparation     X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      SgNBAdditionRequest
    SUCCESSFUL OUTCOME      SgNBAdditionRequestAcknowledge
    UNSUCCESSFUL OUTCOME    SgNBAdditionRequestReject
    PROCEDURE CODE          id-sgNBAdditionPreparation
    CRITICALITY             reject
}

sgNBReconfigurationCompletion   X2AP-ELEMENTARY-PROCEDURE ::= {
```

```
    INITIATING MESSAGE      SgNBReconfigurationComplete
    PROCEDURE CODE          id-sgNBReconfigurationCompletion
    CRITICALITY             ignore
}

meNBinitiatedSgNBModificationPreparation    X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      SgNBModificationRequest
    SUCCESSFUL OUTCOME      SgNBModificationRequestAcknowledge
    UNSUCCESSFUL OUTCOME    SgNBModificationRequestReject
    PROCEDURE CODE          id-meNBinitiatedSgNBModificationPreparation
    CRITICALITY             reject
}

sgNBinitiatedSgNBModification       X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      SgNBModificationRequired
    SUCCESSFUL OUTCOME      SgNBModificationConfirm
    UNSUCCESSFUL OUTCOME    SgNBModificationRefuse
    PROCEDURE CODE          id-sgNBinitiatedSgNBModification
    CRITICALITY             reject
}

meNBinitiatedSgNBRelease    X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      SgNBReleaseRequest
    SUCCESSFUL OUTCOME      SgNBReleaseRequestAcknowledge
    UNSUCCESSFUL OUTCOME    SgNBReleaseRequestReject
    PROCEDURE CODE          id-meNBinitiatedSgNBRelease
    CRITICALITY             ignore
}

sgNBinitiatedSgNBRelease    X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      SgNBReleaseRequired
    SUCCESSFUL OUTCOME      SgNBReleaseConfirm
    PROCEDURE CODE          id-sgNBinitiatedSgNBRelease
    CRITICALITY             reject
}

sgNBCounterCheck    X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      SgNBCounterCheckRequest
    PROCEDURE CODE          id-sgNBCounterCheck
    CRITICALITY             reject
}

sgNBChange  X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      SgNBChangeRequired
    SUCCESSFUL OUTCOME      SgNBChangeConfirm
    UNSUCCESSFUL OUTCOME    SgNBChangeRefuse
    PROCEDURE CODE          id-sgNBChange
    CRITICALITY             reject
}

rRCTransfer X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      RRCTransfer
    PROCEDURE CODE          id-rRCTransfer
    CRITICALITY             reject
```

```
}

endcX2Setup X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      ENDCX2SetupRequest
    SUCCESSFUL OUTCOME      ENDCX2SetupResponse
    UNSUCCESSFUL OUTCOME    ENDCX2SetupFailure
    PROCEDURE CODE          id-endcX2Setup
    CRITICALITY             reject
}


endcConfigurationUpdate     X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      ENDCConfigurationUpdate
    SUCCESSFUL OUTCOME      ENDCConfigurationUpdateAcknowledge
    UNSUCCESSFUL OUTCOME    ENDCConfigurationUpdateFailure
    PROCEDURE CODE          id-endcConfigurationUpdate
    CRITICALITY             reject
}

secondaryRATDataUsageReport X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      SecondaryRATDataUsageReport
    PROCEDURE CODE          id-secondaryRATDataUsageReport
    CRITICALITY             reject
}

endcCellActivation  X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      ENDCCellActivationRequest
    SUCCESSFUL OUTCOME      ENDCCellActivationResponse
    UNSUCCESSFUL OUTCOME    ENDCCellActivationFailure
    PROCEDURE CODE          id-endcCellActivation
    CRITICALITY             reject
}

endcPartialReset    X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      ENDCPartialResetRequired
    SUCCESSFUL OUTCOME      ENDCPartialResetConfirm
    PROCEDURE CODE          id-endcPartialReset
    CRITICALITY             reject
}

eUTRANRCellResourceCoordination X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      EUTRANRCellResourceCoordinationRequest
    SUCCESSFUL OUTCOME      EUTRANRCellResourceCoordinationResponse
    PROCEDURE CODE          id-eUTRANRCellResourceCoordination
    CRITICALITY             reject
}

sgNBActivityNotification    X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      SgNBActivityNotification
    PROCEDURE CODE          id-SgNBActivityNotification
    CRITICALITY             reject
}
```

```
endcX2Removal   X2AP-ELEMENTARY-PROCEDURE ::= {
    INITIATING MESSAGE      ENDCX2RemovalRequest
    SUCCESSFUL OUTCOME      ENDCX2RemovalResponse
    UNSUCCESSFUL OUTCOME    ENDCX2RemovalFailure
    PROCEDURE CODE          id-endcX2Removal
    CRITICALITY             reject
}

END
```

9.3.4 PDU Definitions

```
-- **************************************************************
--
-- PDU definitions for X2AP.
--
-- **************************************************************

X2AP-PDU-Contents {
itu-t (0) identified-organization (4) etsi (0) mobileDomain (0)
eps-Access (21) modules (3) x2ap (2) version1 (1) x2ap-PDU-Contents (1) }

DEFINITIONS AUTOMATIC TAGS ::=

BEGIN

-- **************************************************************
--
-- IE parameter types from other modules.
--
-- **************************************************************

IMPORTS
    ABSInformation,
    ABS-Status,
    AS-SecurityInformation,
    BearerType,
    Cause,
    CompositeAvailableCapacityGroup,
    Correlation-ID,
    COUNTvalue,
    CellReportingIndicator,
    AerialUEsubscriptionInformation,
    CriticalityDiagnostics,
    CRNTI,
    CSGMembershipStatus,
    CSG-Id,
    DeactivationIndication,
    DL-Forwarding,
    DynamicDLTransmissionInformation,
    ECGI,
    E-RAB-ID,
    E-RAB-Level-QoS-Parameters,
```

```
    E-RAB-List,
    EUTRANTraceID,
    GlobalENB-ID,
    GTPtunnelEndpoint,
    GUGroupIDList,
    GUMMEI,
    HandoverReportType,
    HandoverRestrictionList,
    Masked-IMEISV,
    InvokeIndication,
    LocationReportingInformation,
    MDT-Configuration,
    ManagementBasedMDTallowed,
    MDTPLMNList,
    Neighbour-Information,
    PCI,
    PDCP-SN,
    PLMN-Identity,
    ReceiveStatusofULPDCPSDUs,
    Registration-Request,
    RelativeNarrowbandTxPower,
    RadioResourceStatus,
    RRCConnReestabIndicator,
    RRCConnSetupIndicator,
    UE-RLF-Report-Container,
    UEAppLayerMeasConfig,
    RRC-Context,
    ServedCell-Information,
    ServedCells,
    ShortMAC-I,
    SRVCCOperationPossible,
    SubscriberProfileIDforRFP,
    TargetCellInUTRAN,
    TargeteNBtoSource-eNBTransparentContainer,
    TimeToWait,
    TraceActivation,
    TraceDepth,
    TransportLayerAddress,
    UEAggregateMaximumBitRate,
    UE-HistoryInformation,
    UE-HistoryInformationFromTheUE,
    UE-S1AP-ID,
    UESecurityCapabilities,
    UEsToBeResetList,
    UE-X2AP-ID,
    UL-HighInterferenceIndicationInfo,
    UL-InterferenceOverloadIndication,
    HWLoadIndicator,
    S1TNLLoadIndicator,
    Measurement-ID,
    ReportCharacteristics,
    MobilityParametersInformation,
    MobilityParametersModificationRange,
    ReceiveStatusOfULPDCPSDUsExtended,
```

```
    COUNTValueExtended,
    SubframeAssignment,
    ExtendedULInterferenceOverloadInfo,
    ExpectedUEBehaviour,
    SeNBSecurityKey,
    MeNBtoSeNBContainer,
    SeNBtoMeNBContainer,
    SCGChangeIndication,
    CoMPInformation,
    ReportingPeriodicityRSRPMR,
    RSRPMRList,
    UE-RLF-Report-Container-for-extended-bands,
    ProSeAuthorized,
    CoverageModificationList,
    ReportingPeriodicityCSIR,
    CSIReportList,
    ReceiveStatusOfULPDCPSDUsPDCP-SNlength18,
    COUNTvaluePDCP-SNlength18,
    LHN-ID,
    UE-ContextKeptIndicator,
    UE-X2AP-ID-Extension,
    SIPTOBearerDeactivationIndication,
    TunnelInformation,
    V2XServicesAuthorized,
    X2BenefitValue,
    ResumeID,
    EUTRANCellIdentifier,
    MakeBeforeBreakIndicator,
    WTID,
    WT-UE-XwAP-ID,
    UESidelinkAggregateMaximumBitRate,
    SgNBSecurityKey,
    MeNBtoSgNBContainer,
    SgNBtoMeNBContainer,
    SplitSRBs,
    RRCContainer,
    SRBType,
    GlobalGNB-ID,
    GNB-ID,
    SCGConfigurationQuery,
    SplitSRB,
    UENRMeasurement,
    EN-DC-ResourceConfiguration,
    TAC,
    NRFreqInfo,
    NRCGI,
    NRPCI,
    NRUESecurityCapabilities,
    PDCPChangeIndication,
    ULConfiguration,
    SgNB-UE-X2AP-ID,
    SecondaryRATUsageReportList,
    ActivationID,
    MeNBResourceCoordinationInformation,
```

```
    SgNBResourceCoordinationInformation,
    NR-TxBW,
    BroadcastPLMNs-Item,
    RLCMode,
    GBR-QosInformation,
    DRB-ID,
    FiveGS-TAC,
    SULInformation,
    Packet-LossRate,
    ResourceType,
    DataTrafficResourceIndication,
    SpectrumSharingGroupID,
    RRC-Config-Ind,
    SGNB-Addition-Trigger-Ind,
    UserPlaneTrafficActivityReport,
    ERABActivityNotifyItemList


FROM X2AP-IEs

    PrivateIE-Container{},
    ProtocolExtensionContainer{},
    ProtocolIE-Container{},
    ProtocolIE-ContainerList{},
    ProtocolIE-ContainerPair{},
    ProtocolIE-ContainerPairList{},
    ProtocolIE-Single-Container{},
    X2AP-PRIVATE-IES,
    X2AP-PROTOCOL-EXTENSION,
    X2AP-PROTOCOL-IES,
    X2AP-PROTOCOL-IES-PAIR
FROM X2AP-Containers

    id-ABSInformation,
    id-ActivatedCellList,
    id-BearerType,
    id-Cause,
    id-CellInformation,
    id-CellInformation-Item,
    id-CellMeasurementResult,
    id-CellMeasurementResult-Item,
    id-CellToReport,
    id-CellToReport-Item,
    id-CompositeAvailableCapacityGroup,
    id-AerialUEsubscriptionInformation,
    id-CriticalityDiagnostics,
    id-DeactivationIndication,
    id-DynamicDLTransmissionInformation,
    id-E-RABs-Admitted-Item,
    id-E-RABs-Admitted-List,
    id-E-RABs-NotAdmitted-List,
    id-E-RABs-SubjectToStatusTransfer-List,
    id-E-RABs-SubjectToStatusTransfer-Item,
    id-E-RABs-ToBeSetup-Item,
```

```
    id-GlobalENB-ID,
    id-GUGroupIDList,
    id-GUGroupIDToAddList,
    id-GUGroupIDToDeleteList,
    id-GUMMEI-ID,
    id-Masked-IMEISV,
    id-InvokeIndication,
    id-New-eNB-UE-X2AP-ID,
    id-Old-eNB-UE-X2AP-ID,
    id-Registration-Request,
    id-ReportingPeriodicity,
    id-ServedCells,
    id-ServedCellsToActivate,
    id-ServedCellsToAdd,
    id-ServedCellsToModify,
    id-ServedCellsToDelete,
    id-SRVCCOperationPossible,
    id-TargetCell-ID,
    id-TargeteNBtoSource-eNBTransparentContainer,
    id-TimeToWait,
    id-TraceActivation,
    id-UE-ContextInformation,
    id-UE-HistoryInformation,
    id-UE-X2AP-ID,
    id-Measurement-ID,
    id-ReportCharacteristics,
    id-ENB1-Measurement-ID,
    id-ENB2-Measurement-ID,
    id-ENB1-Cell-ID,
    id-ENB2-Cell-ID,
    id-ENB2-Proposed-Mobility-Parameters,
    id-ENB1-Mobility-Parameters,
    id-ENB2-Mobility-Parameters-Modification-Range,
    id-FailureCellPCI,
    id-Re-establishmentCellECGI,
    id-FailureCellCRNTI,
    id-ShortMAC-I,
    id-SourceCellECGI,
    id-FailureCellECGI,
    id-HandoverReportType,
    id-UE-RLF-Report-Container,
    id-PartialSuccessIndicator,
    id-MeasurementInitiationResult-List,
    id-MeasurementInitiationResult-Item,
    id-MeasurementFailureCause-Item,
    id-CompleteFailureCauseInformation-List,
    id-CompleteFailureCauseInformation-Item,
    id-CSGMembershipStatus,
    id-CSG-Id,
    id-MDTConfiguration,
    id-ManagementBasedMDTallowed,
    id-ABS-Status,
    id-RRCConnSetupIndicator,
    id-RRCConnReestabIndicator,
```

```
    id-TargetCellInUTRAN,
    id-MobilityInformation,
    id-SourceCellCRNTI,
    id-ManagementBasedMDTPLMNList,
    id-ReceiveStatusOfULPDCPSDUsExtended,
    id-ULCOUNTValueExtended,
    id-DLCOUNTValueExtended,
    id-IntendedULDLConfiguration,
    id-ExtendedULInterferenceOverloadInfo,
    id-RNL-Header,
    id-x2APMessage,
    id-UE-HistoryInformationFromTheUE,
    id-ExpectedUEBehaviour,
    id-MeNB-UE-X2AP-ID,
    id-SeNB-UE-X2AP-ID,
    id-UE-SecurityCapabilities,
    id-SeNBSecurityKey,
    id-SeNBUEAggregateMaximumBitRate,
    id-ServingPLMN,
    id-E-RABs-ToBeAdded-List,
    id-E-RABs-ToBeAdded-Item,
    id-MeNBtoSeNBContainer,
    id-E-RABs-Admitted-ToBeAdded-List,
    id-E-RABs-Admitted-ToBeAdded-Item,
    id-SeNBtoMeNBContainer,
    id-ResponseInformationSeNBReconfComp,
    id-UE-ContextInformationSeNBModReq,
    id-E-RABs-ToBeAdded-ModReqItem,
    id-E-RABs-ToBeModified-ModReqItem,
    id-E-RABs-ToBeReleased-ModReqItem,
    id-E-RABs-Admitted-ToBeAdded-ModAckList,
    id-E-RABs-Admitted-ToBeModified-ModAckList,
    id-E-RABs-Admitted-ToBeReleased-ModAckList,
    id-E-RABs-Admitted-ToBeAdded-ModAckItem,
    id-E-RABs-Admitted-ToBeModified-ModAckItem,
    id-E-RABs-Admitted-ToBeReleased-ModAckItem,
    id-SCGChangeIndication,
    id-E-RABs-ToBeReleased-ModReqd,
    id-E-RABs-ToBeReleased-ModReqdItem,
    id-E-RABs-ToBeReleased-List-RelReq,
    id-E-RABs-ToBeReleased-RelReqItem,
    id-E-RABs-ToBeReleased-List-RelConf,
    id-E-RABs-ToBeReleased-RelConfItem,
    id-E-RABs-SubjectToCounterCheck-List,
    id-E-RABs-SubjectToCounterCheckItem,
    id-CoMPInformation,
    id-ReportingPeriodicityRSRPMR,
    id-RSRPMRList,
    id-UE-RLF-Report-Container-for-extended-bands,
    id-ProSeAuthorized,
    id-CoverageModificationList,
    id-ReportingPeriodicityCSIR,
    id-CSIReportList,
    id-ReceiveStatusOfULPDCPSDUsPDCP-SNlength18,
```

```
    id-ULCOUNTValuePDCP-SNlength18,
    id-DLCOUNTValuePDCP-SNlength18,
    id-LHN-ID,
    id-Correlation-ID,
    id-SIPTO-Correlation-ID,
    id-UE-ContextReferenceAtSeNB,
    id-UE-ContextReferenceAtWT,
    id-UE-ContextKeptIndicator,
    id-UEs-ToBeReset,
    id-UEs-Admitted-ToBeReset,
    id-WT-UE-ContextKeptIndicator,
    id-New-eNB-UE-X2AP-ID-Extension,
    id-Old-eNB-UE-X2AP-ID-Extension,
    id-MeNB-UE-X2AP-ID-Extension,
    id-SeNB-UE-X2AP-ID-Extension,
    id-SIPTO-BearerDeactivationIndication,
    id-Tunnel-Information-for-BBF,
    id-SIPTO-L-GW-TransportLayerAddress,
    id-GW-TransportLayerAddress,
    id-X2RemovalThreshold,
    id-CellReportingIndicator,
    id-V2XServicesAuthorized,
    id-resumeID,
    id-UE-ContextInformationRetrieve,
    id-E-RABs-ToBeSetupRetrieve-Item,
    id-NewEUTRANCellIdentifier,
    id-MakeBeforeBreakIndicator,
    id-UESidelinkAggregateMaximumBitRate,
    id-uL-GTPtunnelEndpoint,
    id-SgNBSecurityKey,
    id-SgNBUEAggregateMaximumBitRate,
    id-E-RABs-ToBeAdded-SgNBAddReqList,
    id-MeNBtoSgNBContainer,
    id-SgNB-UE-X2AP-ID,
    id-RequestedSplitSRBs,
    id-E-RABs-ToBeAdded-SgNBAddReq-Item,
    id-E-RABs-Admitted-ToBeAdded-SgNBAddReqAckList,
    id-SgNBtoMeNBContainer,
    id-AdmittedSplitSRBs    ,
    id-E-RABs-Admitted-ToBeAdded-SgNBAddReqAck-Item,
    id-ResponseInformationSgNBReconfComp,
    id-UE-ContextInformation-SgNBModReq,
    id-E-RABs-ToBeAdded-SgNBModReq-Item,
    id-E-RABs-ToBeModified-SgNBModReq-Item,
    id-E-RABs-ToBeReleased-SgNBModReq-Item,
    id-E-RABs-Admitted-ToBeAdded-SgNBModAckList,
    id-E-RABs-Admitted-ToBeModified-SgNBModAckList,
    id-E-RABs-Admitted-ToBeReleased-SgNBModAckList,
    id-E-RABs-Admitted-ToBeAdded-SgNBModAck-Item,
    id-E-RABs-Admitted-ToBeModified-SgNBModAck-Item,
    id-E-RABs-Admitted-ToBeReleased-SgNBModAck-Item,
    id-E-RABs-ToBeReleased-SgNBModReqdList,
    id-E-RABs-ToBeModified-SgNBModReqdList,
    id-E-RABs-ToBeReleased-SgNBModReqd-Item,
```

```
    id-E-RABs-ToBeModified-SgNBModReqd-Item,
    id-E-RABs-ToBeReleased-SgNBChaConfList,
    id-E-RABs-ToBeReleased-SgNBChaConf-Item,
    id-E-RABs-ToBeReleased-SgNBRelReqList,
    id-E-RABs-ToBeReleased-SgNBRelReq-Item,
    id-E-RABs-ToBeReleased-SgNBRelConfList,
    id-E-RABs-ToBeReleased-SgNBRelConf-Item,
    id-E-RABs-SubjectToSgNBCounterCheck-List,
    id-E-RABs-SubjectToSgNBCounterCheck-Item,
    id-Target-SgNB-ID,
    id-RRCContainer,
    id-SRBType,
    id-HandoverRestrictionList,
    id-SCGConfigurationQuery,
    id-SplitSRB,
    id-UENRMeasurement,
    id-InitiatingNodeType-EndcX2Setup,
    id-InitiatingNodeType-EndcConfigUpdate,
    id-RespondingNodeType-EndcX2Setup,
    id-RespondingNodeType-EndcConfigUpdate,
    id-NRUESecurityCapabilities,
    id-PDCPChangeIndication,
    id-ServedEUTRAcellsENDCX2ManagementList,
    id-ServedEUTRAcellsToModifyListENDCConfUpd,
    id-ServedEUTRAcellsToDeleteListENDCConfUpd,
    id-ServedNRcellsToModifyListENDCConfUpd,
    id-ServedNRcellsToDeleteListENDCConfUpd,
    id-CellAssistanceInformation,
    id-Globalen-gNB-ID,
    id-ServedNRcellsENDCX2ManagementList,
    id-Old-SgNB-UE-X2AP-ID,
    id-UE-ContextReferenceAtSgNB,
    id-SecondaryRATUsageReportList,
    id-ActivationID,
    id-ServedNRCellsToActivate,
    id-ActivatedNRCellList,
    id-MeNBResourceCoordinationInformation,
    id-SgNBResourceCoordinationInformation,
    id-UEAppLayerMeasConfig,
    id-SelectedPLMN,
    id-SubscriberProfileIDforRFP,
    id-InitiatingNodeType-EutranrCellResourceCoordination,
    id-RespondingNodeType-EutranrCellResourceCoordination,
    id-DataTrafficResourceIndication,
    id-SpectrumSharingGroupID,
    id-ListofEUTRACellsinEUTRACoordinationReq,
    id-ListofEUTRACellsinEUTRACoordinationResp,
    id-ListofEUTRACellsinNRCoordinationReq,
    id-ListofNRCellsinNRCoordinationReq,
    id-ListofNRCellsinNRCoordinationResp,
    id-RRCConfigIndication,
    id-SGNB-Addition-Trigger-Ind,
    id-RequestedSplitSRBsrelease,
    id-AdmittedSplitSRBsrelease,
```

```
    id-E-RABs-AdmittedToBeModified-SgNBModConfList,
    id-E-RABs-AdmittedToBeModified-SgNBModConf-Item,
    id-UEContextLevelUserPlaneActivity,
    id-ERABActivityNotifyItemList,
    id-MeNBCell-ID,
    id-InitiatingNodeType-EndcX2Removal,
    id-RespondingNodeType-EndcX2Removal,


    maxCellineNB,
    maxnoofBearers,
    maxnoofPDCP-SN,
    maxFailedMeasObjects,
    maxnoofCellIDforMDT,
    maxnoofTAforMDT,
    maxofNRNeighbours,
    maxCellinengNB,
    maxnoofCellIDforQMC,
    maxnoofTAforQMC,
    maxnoofPLMNforQMC,
    maxnoofProtectedResourcePatterns,
    maxnoNRcellsSpectrumSharingWithE-UTRA,
    maxnoofNrCellBands

FROM X2AP-Constants;

-- ************************************************************
--
-- HANDOVER REQUEST
--
-- ************************************************************

HandoverRequest ::= SEQUENCE {
    protocolIEs         ProtocolIE-Container    {{HandoverRequest-IEs}},
    ...
}

HandoverRequest-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-Old-eNB-UE-X2AP-ID                  CRITICALITY reject  TYPE UE-X2AP-ID                      PRESENCE mandatory}|
    { ID id-Cause                               CRITICALITY ignore  TYPE Cause                          PRESENCE mandatory}|
    { ID id-TargetCell-ID                       CRITICALITY reject  TYPE ECGI                           PRESENCE mandatory}|
    { ID id-GUMMEI-ID                           CRITICALITY reject  TYPE GUMMEI                         PRESENCE mandatory}|
    { ID id-UE-ContextInformation               CRITICALITY reject  TYPE UE-ContextInformation          PRESENCE mandatory}|
    { ID id-UE-HistoryInformation               CRITICALITY ignore  TYPE UE-HistoryInformation          PRESENCE mandatory}|
    { ID id-TraceActivation                     CRITICALITY ignore  TYPE TraceActivation                PRESENCE optional}|
    { ID id-SRVCCOperationPossible              CRITICALITY ignore  TYPE SRVCCOperationPossible         PRESENCE optional}|
    { ID id-CSGMembershipStatus                 CRITICALITY reject  TYPE CSGMembershipStatus            PRESENCE optional}|
    { ID id-MobilityInformation                 CRITICALITY ignore  TYPE MobilityInformation            PRESENCE optional}|
    { ID id-Masked-IMEISV                       CRITICALITY ignore  TYPE Masked-IMEISV                  PRESENCE optional}|
    { ID id-UE-HistoryInformationFromTheUE      CRITICALITY ignore  TYPE UE-HistoryInformationFromTheUE PRESENCE optional}|
    { ID id-ExpectedUEBehaviour                 CRITICALITY ignore  TYPE ExpectedUEBehaviour            PRESENCE optional}|
    { ID id-ProSeAuthorized                     CRITICALITY ignore  TYPE ProSeAuthorized                PRESENCE optional}|
    { ID id-UE-ContextReferenceAtSeNB           CRITICALITY ignore  TYPE UE-ContextReferenceAtSeNB      PRESENCE optional}|
    { ID id-Old-eNB-UE-X2AP-ID-Extension        CRITICALITY reject  TYPE UE-X2AP-ID-Extension           PRESENCE optional}|
```

```
    { ID id-V2XServicesAuthorized              CRITICALITY ignore  TYPE V2XServicesAuthorized            PRESENCE optional}|
    { ID id-UE-ContextReferenceAtWT            CRITICALITY ignore  TYPE UE-ContextReferenceAtWT          PRESENCE optional}|
    { ID id-NRUESecurityCapabilities               CRITICALITY ignore  TYPE NRUESecurityCapabilities          PRESENCE optional}|
    { ID id-UE-ContextReferenceAtSgNB          CRITICALITY ignore  TYPE UE-ContextReferenceAtSgNB        PRESENCE optional}|
    { ID id-AerialUEsubscriptionInformation    CRITICALITY ignore  TYPE AerialUEsubscriptionInformation  PRESENCE optional},
    ...
}

UE-ContextInformation ::= SEQUENCE {
    mME-UE-S1AP-ID                      UE-S1AP-ID,
    uESecurityCapabilities              UESecurityCapabilities,
    aS-SecurityInformation              AS-SecurityInformation,
    uEaggregateMaximumBitRate           UEAggregateMaximumBitRate,
    subscriberProfileIDforRFP           SubscriberProfileIDforRFP       OPTIONAL,
    e-RABs-ToBeSetup-List               E-RABs-ToBeSetup-List,
    rRC-Context                         RRC-Context,
    handoverRestrictionList             HandoverRestrictionList     OPTIONAL,
    locationReportingInformation        LocationReportingInformation    OPTIONAL,
    iE-Extensions                       ProtocolExtensionContainer { {UE-ContextInformation-ExtIEs} } OPTIONAL,
    ...
}

UE-ContextInformation-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
{ ID id-ManagementBasedMDTallowed           CRITICALITY ignore  EXTENSION ManagementBasedMDTallowed             PRESENCE optional }|
{ ID id-ManagementBasedMDTPLMNList          CRITICALITY ignore  EXTENSION MDTPLMNList                         PRESENCE optional }|
{ ID id-UESidelinkAggregateMaximumBitRate   CRITICALITY ignore  EXTENSION UESidelinkAggregateMaximumBitRate    PRESENCE optional},
    ...
}

E-RABs-ToBeSetup-List ::= SEQUENCE (SIZE(1..maxnoofBearers)) OF ProtocolIE-Single-Container { {E-RABs-ToBeSetup-ItemIEs} }

E-RABs-ToBeSetup-ItemIEs    X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-ToBeSetup-Item    CRITICALITY ignore     TYPE E-RABs-ToBeSetup-Item  PRESENCE mandatory },
    ...
}

E-RABs-ToBeSetup-Item ::= SEQUENCE {
    e-RAB-ID                    E-RAB-ID,
    e-RAB-Level-QoS-Parameters      E-RAB-Level-QoS-Parameters,
    dL-Forwarding                   DL-Forwarding                                                   OPTIONAL,
    uL-GTPtunnelEndpoint            GTPtunnelEndpoint,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeSetup-ItemExtIEs} } OPTIONAL,
    ...
}

E-RABs-ToBeSetup-ItemExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    { ID id-BearerType      CRITICALITY reject  EXTENSION BearerType        PRESENCE optional},
    ...
}

MobilityInformation ::= BIT STRING (SIZE(32))

UE-ContextReferenceAtSeNB ::= SEQUENCE {
    source-GlobalSeNB-ID        GlobalENB-ID,
```

```
    seNB-UE-X2AP-ID             UE-X2AP-ID,
    seNB-UE-X2AP-ID-Extension   UE-X2AP-ID-Extension,
    iE-Extensions               ProtocolExtensionContainer { {UE-ContextReferenceAtSeNB-ItemExtIEs} } OPTIONAL,
    ...
}

UE-ContextReferenceAtSeNB-ItemExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

UE-ContextReferenceAtWT ::= SEQUENCE {
    wTID                    WTID,
    wT-UE-XwAP-ID           WT-UE-XwAP-ID,
    iE-Extensions           ProtocolExtensionContainer { {UE-ContextReferenceAtWT-ItemExtIEs} } OPTIONAL,
    ...
}

UE-ContextReferenceAtWT-ItemExtIEs  X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

UE-ContextReferenceAtSgNB ::= SEQUENCE {
    source-GlobalSgNB-ID            GlobalGNB-ID,
    sgNB-UE-X2AP-ID             SgNB-UE-X2AP-ID,
    iE-Extensions               ProtocolExtensionContainer { {UE-ContextReferenceAtSgNB-ItemExtIEs} } OPTIONAL,
    ...
}

UE-ContextReferenceAtSgNB-ItemExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

-- **************************************************************
--
-- HANDOVER REQUEST ACKNOWLEDGE
--
-- **************************************************************

HandoverRequestAcknowledge ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{HandoverRequestAcknowledge-IEs}},
    ...
}

HandoverRequestAcknowledge-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-Old-eNB-UE-X2AP-ID                          CRITICALITY ignore  TYPE UE-X2AP-ID                                 PRESENCE mandatory}|
    { ID id-New-eNB-UE-X2AP-ID                          CRITICALITY ignore  TYPE UE-X2AP-ID                                 PRESENCE mandatory}|
    { ID id-E-RABs-Admitted-List                        CRITICALITY ignore  TYPE E-RABs-Admitted-List                       PRESENCE mandatory}|
    { ID id-E-RABs-NotAdmitted-List                     CRITICALITY ignore  TYPE E-RAB-List                                 PRESENCE optional}|
    { ID id-TargeteNBtoSource-eNBTransparentContainer   CRITICALITY ignore  TYPE TargeteNBtoSource-eNBTransparentContainer   PRESENCE mandatory}|
    { ID id-CriticalityDiagnostics                      CRITICALITY ignore  TYPE CriticalityDiagnostics                     PRESENCE optional}|
    { ID id-UE-ContextKeptIndicator                     CRITICALITY ignore  TYPE UE-ContextKeptIndicator                    PRESENCE optional}|
    { ID id-SeNB-UE-X2AP-ID-Extension                   CRITICALITY ignore  TYPE UE-X2AP-ID-Extension                       PRESENCE optional}|
    { ID id-Old-eNB-UE-X2AP-ID-Extension                CRITICALITY ignore  TYPE UE-X2AP-ID-Extension                       PRESENCE optional}|
    { ID id-New-eNB-UE-X2AP-ID-Extension                CRITICALITY reject  TYPE UE-X2AP-ID-Extension                       PRESENCE optional}|
```

```
    { ID id-WT-UE-ContextKeptIndicator                CRITICALITY ignore  TYPE UE-ContextKeptIndicator                    PRESENCE optional},
    ...
}

E-RABs-Admitted-List        ::= SEQUENCE (SIZE (1..maxnoofBearers)) OF ProtocolIE-Single-Container { {E-RABs-Admitted-ItemIEs} }

E-RABs-Admitted-ItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-Admitted-Item    CRITICALITY ignore  TYPE E-RABs-Admitted-Item   PRESENCE mandatory  }
}

E-RABs-Admitted-Item ::= SEQUENCE {
    e-RAB-ID                    E-RAB-ID,
    uL-GTP-TunnelEndpoint           GTPtunnelEndpoint                                       OPTIONAL,
    dL-GTP-TunnelEndpoint           GTPtunnelEndpoint                                       OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-Admitted-Item-ExtIEs} }   OPTIONAL,
    ...
}

E-RABs-Admitted-Item-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

-- **************************************************************
--
-- HANDOVER PREPARATION FAILURE
--
-- **************************************************************

HandoverPreparationFailure ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{HandoverPreparationFailure-IEs}},
    ...
}

HandoverPreparationFailure-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-Old-eNB-UE-X2AP-ID              CRITICALITY ignore  TYPE UE-X2AP-ID                 PRESENCE mandatory}|
    { ID id-Cause                           CRITICALITY ignore  TYPE Cause                      PRESENCE mandatory}|
    { ID id-CriticalityDiagnostics          CRITICALITY ignore  TYPE CriticalityDiagnostics     PRESENCE optional}|
    { ID id-Old-eNB-UE-X2AP-ID-Extension    CRITICALITY ignore  TYPE UE-X2AP-ID-Extension       PRESENCE optional},

    ...
}

-- **************************************************************
--
-- Handover Report
--
-- **************************************************************

HandoverReport ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{HandoverReport-IEs}},
    ...
}

HandoverReport-IEs X2AP-PROTOCOL-IES ::= {
```

```
    { ID id-HandoverReportType                          CRITICALITY ignore  TYPE HandoverReportType                          PRESENCE mandatory}|
    { ID id-Cause                                       CRITICALITY ignore  TYPE Cause                                   PRESENCE mandatory}|
    { ID id-SourceCellECGI                              CRITICALITY ignore  TYPE ECGI                                    PRESENCE mandatory}|
    { ID id-FailureCellECGI                             CRITICALITY ignore  TYPE ECGI                                    PRESENCE mandatory}|
    { ID id-Re-establishmentCellECGI                    CRITICALITY ignore  TYPE ECGI                                    PRESENCE conditional} -
- The IE shall be present if the Handover Report Type IE is set to “HO to Wrong Cell” -- |
    { ID id-TargetCellInUTRAN                           CRITICALITY ignore  TYPE TargetCellInUTRAN                        PRESENCE conditional} -
- The IE shall be present if the Handover Report Type IE is set to "InterRAT ping-pong" --|
    { ID id-SourceCellCRNTI                             CRITICALITY ignore  TYPE CRNTI                                   PRESENCE optional}|
    { ID id-MobilityInformation                         CRITICALITY ignore  TYPE MobilityInformation                     PRESENCE optional}|
    { ID id-UE-RLF-Report-Container                     CRITICALITY ignore  TYPE UE-RLF-Report-Container                  PRESENCE optional}|
    { ID id-UE-RLF-Report-Container-for-extended-bands  CRITICALITY ignore  TYPE UE-RLF-Report-Container-for-extended-bands PRESENCE optional},
    ...
}

-- **************************************************************
--
-- SN Status Transfer
--
-- **************************************************************

SNStatusTransfer ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{SNStatusTransfer-IEs}},
    ...
}

SNStatusTransfer-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-Old-eNB-UE-X2AP-ID                      CRITICALITY reject  TYPE UE-X2AP-ID                          PRESENCE mandatory}|
    { ID id-New-eNB-UE-X2AP-ID                      CRITICALITY reject  TYPE UE-X2AP-ID                          PRESENCE mandatory}|
    { ID id-E-RABs-SubjectToStatusTransfer-List     CRITICALITY ignore  TYPE E-RABs-SubjectToStatusTransfer-List  PRESENCE mandatory}|
    { ID id-Old-eNB-UE-X2AP-ID-Extension            CRITICALITY reject  TYPE UE-X2AP-ID-Extension                PRESENCE optional}|
    { ID id-New-eNB-UE-X2AP-ID-Extension            CRITICALITY reject  TYPE UE-X2AP-ID-Extension                PRESENCE optional}|
    { ID id-SgNB-UE-X2AP-ID                         CRITICALITY ignore  TYPE SgNB-UE-X2AP-ID                        PRESENCE optional},
    ...
}

E-RABs-SubjectToStatusTransfer-List ::= SEQUENCE (SIZE (1..maxnoofBearers)) OF ProtocolIE-Single-Container { { E-RABs-SubjectToStatusTransfer-
ItemIEs} }

E-RABs-SubjectToStatusTransfer-ItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-SubjectToStatusTransfer-Item CRITICALITY ignore  TYPE E-RABs-SubjectToStatusTransfer-Item  PRESENCE mandatory   }
}

E-RABs-SubjectToStatusTransfer-Item ::= SEQUENCE {
    e-RAB-ID                                E-RAB-ID,

    receiveStatusofULPDCPSDUs               ReceiveStatusofULPDCPSDUs           OPTIONAL,
    uL-COUNTvalue                   COUNTvalue,
    dL-COUNTvalue                   COUNTvalue,
    iE-Extensions                           ProtocolExtensionContainer { {E-RABs-SubjectToStatusTransfer-ItemExtIEs} } OPTIONAL,
    ...
}

E-RABs-SubjectToStatusTransfer-ItemExtIEs X2AP-PROTOCOL-EXTENSION ::= {
```

```
    { ID id-ReceiveStatusOfULPDCPSDUsExtended          CRITICALITY ignore  EXTENSION ReceiveStatusOfULPDCPSDUsExtended        PRESENCE optional}|
    { ID id-ULCOUNTValueExtended                       CRITICALITY ignore  EXTENSION COUNTValueExtended                       PRESENCE optional}|
    { ID id-DLCOUNTValueExtended                       CRITICALITY ignore  EXTENSION COUNTValueExtended                       PRESENCE optional}|
    { ID id-ReceiveStatusOfULPDCPSDUsPDCP-SNlength18   CRITICALITY ignore  EXTENSION ReceiveStatusOfULPDCPSDUsPDCP-SNlength18 PRESENCE optional}|
    { ID id-ULCOUNTValuePDCP-SNlength18                CRITICALITY ignore  EXTENSION COUNTvaluePDCP-SNlength18                PRESENCE optional}|
    { ID id-DLCOUNTValuePDCP-SNlength18                CRITICALITY ignore  EXTENSION COUNTvaluePDCP-SNlength18                PRESENCE optional},
    ...
}

-- **************************************************************
--
-- UE Context Release
--
-- **************************************************************

UEContextRelease ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{UEContextRelease-IEs}},
    ...
}

UEContextRelease-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-Old-eNB-UE-X2AP-ID                 CRITICALITY reject  TYPE UE-X2AP-ID                          PRESENCE mandatory}|
    { ID id-New-eNB-UE-X2AP-ID                 CRITICALITY reject  TYPE UE-X2AP-ID                          PRESENCE mandatory}|
    { ID id-Old-eNB-UE-X2AP-ID-Extension       CRITICALITY reject  TYPE UE-X2AP-ID-Extension                PRESENCE optional}|
    { ID id-New-eNB-UE-X2AP-ID-Extension       CRITICALITY reject  TYPE UE-X2AP-ID-Extension                PRESENCE optional}|
    { ID id-SIPTO-BearerDeactivationIndication CRITICALITY ignore  TYPE SIPTOBearerDeactivationIndication   PRESENCE optional}|
    { ID id-SgNB-UE-X2AP-ID                    CRITICALITY ignore  TYPE SgNB-UE-X2AP-ID                     PRESENCE optional},
    ...
}


-- **************************************************************
--
-- HANDOVER CANCEL
--
-- **************************************************************

HandoverCancel ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{HandoverCancel-IEs}},
    ...
}

HandoverCancel-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-Old-eNB-UE-X2AP-ID                 CRITICALITY reject  TYPE UE-X2AP-ID              PRESENCE mandatory}|
    { ID id-New-eNB-UE-X2AP-ID                 CRITICALITY ignore  TYPE UE-X2AP-ID              PRESENCE optional}|
    { ID id-Cause                              CRITICALITY ignore  TYPE Cause                   PRESENCE mandatory}|
    { ID id-Old-eNB-UE-X2AP-ID-Extension       CRITICALITY reject  TYPE UE-X2AP-ID-Extension    PRESENCE optional}|
    { ID id-New-eNB-UE-X2AP-ID-Extension       CRITICALITY ignore  TYPE UE-X2AP-ID-Extension    PRESENCE optional},
    ...
}

-- **************************************************************
--
-- ERROR INDICATION
```

```
--
-- **************************************************************

ErrorIndication ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{ErrorIndication-IEs}},
    ...
}

ErrorIndication-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-Old-eNB-UE-X2AP-ID                  CRITICALITY ignore  TYPE UE-X2AP-ID              PRESENCE optional}|
    { ID id-New-eNB-UE-X2AP-ID                  CRITICALITY ignore  TYPE UE-X2AP-ID              PRESENCE optional}|
    { ID id-Cause                               CRITICALITY ignore  TYPE Cause                   PRESENCE optional}|
    { ID id-CriticalityDiagnostics              CRITICALITY ignore  TYPE CriticalityDiagnostics  PRESENCE optional}|
    { ID id-Old-eNB-UE-X2AP-ID-Extension        CRITICALITY ignore  TYPE UE-X2AP-ID-Extension    PRESENCE optional}|
    { ID id-New-eNB-UE-X2AP-ID-Extension        CRITICALITY ignore  TYPE UE-X2AP-ID-Extension    PRESENCE optional}|
    { ID id-Old-SgNB-UE-X2AP-ID                 CRITICALITY ignore  TYPE SgNB-UE-X2AP-ID         PRESENCE optional},
    ...
}

-- **************************************************************
--
-- Reset Request
--
-- **************************************************************

ResetRequest ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{ResetRequest-IEs}},
    ...
}

ResetRequest-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-Cause               CRITICALITY ignore  TYPE Cause              PRESENCE mandatory},
    ...
}

-- **************************************************************
--
-- Reset Response
--
-- **************************************************************

ResetResponse ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{ResetResponse-IEs}},
    ...
}

ResetResponse-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-CriticalityDiagnostics  CRITICALITY ignore  TYPE CriticalityDiagnostics         PRESENCE optional },
    ...
}

-- **************************************************************
--
-- X2 SETUP REQUEST
```

```
--
-- **************************************************************

X2SetupRequest ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{X2SetupRequest-IEs}},
    ...
}

X2SetupRequest-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-GlobalENB-ID            CRITICALITY reject  TYPE GlobalENB-ID          PRESENCE mandatory}|
    { ID id-ServedCells             CRITICALITY reject  TYPE ServedCells           PRESENCE mandatory}|
    { ID id-GUGroupIDList           CRITICALITY reject  TYPE GUGroupIDList         PRESENCE optional}|
    { ID id-LHN-ID                  CRITICALITY ignore  TYPE LHN-ID                PRESENCE optional},
...
}



-- **************************************************************
--
-- X2 SETUP RESPONSE
--
-- **************************************************************

X2SetupResponse ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{X2SetupResponse-IEs}},
    ...
}

X2SetupResponse-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-GlobalENB-ID                CRITICALITY reject  TYPE GlobalENB-ID          PRESENCE mandatory}|
    { ID id-ServedCells                 CRITICALITY reject  TYPE ServedCells           PRESENCE mandatory}|
    { ID id-GUGroupIDList               CRITICALITY reject  TYPE GUGroupIDList         PRESENCE optional}|
    { ID id-CriticalityDiagnostics      CRITICALITY ignore  TYPE CriticalityDiagnostics PRESENCE optional}|
    { ID id-LHN-ID                      CRITICALITY ignore  TYPE LHN-ID                PRESENCE optional},
    ...
}



-- **************************************************************
--
-- X2 SETUP FAILURE
--
-- **************************************************************

X2SetupFailure ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{X2SetupFailure-IEs}},
    ...
}

X2SetupFailure-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-Cause                   CRITICALITY ignore      TYPE Cause                      PRESENCE mandatory} |
    { ID id-TimeToWait              CRITICALITY ignore      TYPE TimeToWait                 PRESENCE optional} |
```

```
    { ID id-CriticalityDiagnostics  CRITICALITY ignore      TYPE CriticalityDiagnostics          PRESENCE optional },

    ...
}



-- **************************************************************
--
-- LOAD INFORMATION
--
-- **************************************************************

LoadInformation ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{LoadInformation-IEs}},
    ...
}

LoadInformation-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-CellInformation             CRITICALITY ignore  TYPE CellInformation-List       PRESENCE mandatory} ,
    ...
}

CellInformation-List ::= SEQUENCE (SIZE (1..maxCellineNB)) OF ProtocolIE-Single-Container { {CellInformation-ItemIEs} }

CellInformation-ItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-CellInformation-Item    CRITICALITY ignore  TYPE CellInformation-Item   PRESENCE mandatory  }
}

CellInformation-Item ::= SEQUENCE {
    cell-ID                         ECGI,
    ul-InterferenceOverloadIndication       UL-InterferenceOverloadIndication                           OPTIONAL,
    ul-HighInterferenceIndicationInfo       UL-HighInterferenceIndicationInfo                           OPTIONAL,
    relativeNarrowbandTxPower               RelativeNarrowbandTxPower                                   OPTIONAL,
    iE-Extensions                           ProtocolExtensionContainer { {CellInformation-Item-ExtIEs} }   OPTIONAL,
    ...
}

CellInformation-Item-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
{ ID id-ABSInformation                      CRITICALITY ignore  EXTENSION ABSInformation                    PRESENCE optional }|
{ ID id-InvokeIndication                    CRITICALITY ignore  EXTENSION InvokeIndication                  PRESENCE optional }|
{ ID id-IntendedULDLConfiguration           CRITICALITY ignore  EXTENSION SubframeAssignment                PRESENCE optional }|
{ ID id-ExtendedULInterferenceOverloadInfo  CRITICALITY ignore  EXTENSION ExtendedULInterferenceOverloadInfo PRESENCE optional }|
{ ID id-CoMPInformation                     CRITICALITY ignore  EXTENSION CoMPInformation                   PRESENCE optional }|
{ ID id-DynamicDLTransmissionInformation    CRITICALITY ignore  EXTENSION DynamicDLTransmissionInformation  PRESENCE optional },
    ...
}

-- **************************************************************
--
-- ENB CONFIGURATION UPDATE
--
-- **************************************************************
```

```
ENBConfigurationUpdate ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{ENBConfigurationUpdate-IEs}},
    ...
}

ENBConfigurationUpdate-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-ServedCellsToAdd            CRITICALITY reject  TYPE ServedCells                  PRESENCE optional}|
    { ID id-ServedCellsToModify         CRITICALITY reject  TYPE ServedCellsToModify         PRESENCE optional}|
    { ID id-ServedCellsToDelete         CRITICALITY reject  TYPE Old-ECGIs                   PRESENCE optional}|
    { ID id-GUGroupIDToAddList          CRITICALITY reject  TYPE GUGroupIDList               PRESENCE optional}|
    { ID id-GUGroupIDToDeleteList       CRITICALITY reject  TYPE GUGroupIDList               PRESENCE optional}|
    { ID id-CoverageModificationList    CRITICALITY reject  TYPE CoverageModificationList    PRESENCE optional},
    ...
}

ServedCellsToModify::= SEQUENCE (SIZE (1..maxCellineNB)) OF ServedCellsToModify-Item

ServedCellsToModify-Item::= SEQUENCE {
    old-ecgi                        ECGI,
    servedCellInfo                  ServedCell-Information,
    neighbour-Info                  Neighbour-Information           OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { { ServedCellsToModify-Item-ExtIEs} } OPTIONAL,
    ...
}

ServedCellsToModify-Item-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
{ ID id-DeactivationIndication          CRITICALITY ignore  EXTENSION DeactivationIndication           PRESENCE optional },
    ...
}


Old-ECGIs::= SEQUENCE (SIZE (1..maxCellineNB)) OF ECGI

-- **************************************************************
--
-- ENB CONFIGURATION UPDATE ACKNOWLEDGE
--
-- **************************************************************

ENBConfigurationUpdateAcknowledge ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{ENBConfigurationUpdateAcknowledge-IEs}},
    ...
}

ENBConfigurationUpdateAcknowledge-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-CriticalityDiagnostics      CRITICALITY ignore  TYPE CriticalityDiagnostics        PRESENCE optional},
...
}

-- **************************************************************
--
-- ENB CONFIGURATION UPDATE FAIURE
--
-- **************************************************************
```

```
ENBConfigurationUpdateFailure ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{ENBConfigurationUpdateFailure-IEs}},
    ...
}

ENBConfigurationUpdateFailure-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-Cause                       CRITICALITY ignore  TYPE Cause                      PRESENCE mandatory}|
    { ID id-TimeToWait                  CRITICALITY ignore  TYPE TimeToWait                 PRESENCE optional}|
    { ID id-CriticalityDiagnostics      CRITICALITY ignore  TYPE CriticalityDiagnostics     PRESENCE optional},
    ...
}



-- **************************************************************
--
-- Resource Status Request
--
-- **************************************************************

ResourceStatusRequest ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{ResourceStatusRequest-IEs}},
    ...
}

ResourceStatusRequest-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-ENB1-Measurement-ID         CRITICALITY reject  TYPE Measurement-ID               PRESENCE mandatory}|
    { ID id-ENB2-Measurement-ID         CRITICALITY ignore  TYPE Measurement-ID               PRESENCE conditional}|-- The IE shall be present if
the Registration Request IE is set to “Stop”, “Partial stop” or to “Add”--
    { ID id-Registration-Request        CRITICALITY reject  TYPE Registration-Request         PRESENCE mandatory}|
    { ID id-ReportCharacteristics       CRITICALITY reject  TYPE ReportCharacteristics        PRESENCE optional}|
    { ID id-CellToReport                CRITICALITY ignore  TYPE CellToReport-List            PRESENCE mandatory}|
    { ID id-ReportingPeriodicity        CRITICALITY ignore  TYPE ReportingPeriodicity         PRESENCE optional}|
    { ID id-PartialSuccessIndicator     CRITICALITY ignore  TYPE PartialSuccessIndicator      PRESENCE optional}|
    { ID id-ReportingPeriodicityRSRPMR  CRITICALITY ignore  TYPE ReportingPeriodicityRSRPMR   PRESENCE optional}|
    { ID id-ReportingPeriodicityCSIR    CRITICALITY ignore  TYPE ReportingPeriodicityCSIR     PRESENCE optional},
    ...
}


CellToReport-List       ::= SEQUENCE (SIZE (1..maxCellineNB)) OF ProtocolIE-Single-Container { {CellToReport-ItemIEs} }

CellToReport-ItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-CellToReport-Item   CRITICALITY ignore  TYPE CellToReport-Item  PRESENCE mandatory}
}

CellToReport-Item ::= SEQUENCE {
    cell-ID                             ECGI,
    iE-Extensions                       ProtocolExtensionContainer { {CellToReport-Item-ExtIEs} } OPTIONAL,
    ...
}

CellToReport-Item-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
```

```
    ...
}


ReportingPeriodicity ::= ENUMERATED {
    one-thousand-ms,
    two-thousand-ms,
    five-thousand-ms,
    ten-thousand-ms,
...
}

PartialSuccessIndicator ::= ENUMERATED {
    partial-success-allowed,
...
}

-- **************************************************************
--
-- Resource Status Response
--
-- **************************************************************

ResourceStatusResponse ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{ResourceStatusResponse-IEs}},
    ...
}

ResourceStatusResponse-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-ENB1-Measurement-ID                CRITICALITY reject  TYPE Measurement-ID                   PRESENCE mandatory}|
    { ID id-ENB2-Measurement-ID                CRITICALITY reject  TYPE Measurement-ID                   PRESENCE mandatory}|
    { ID id-CriticalityDiagnostics             CRITICALITY ignore  TYPE CriticalityDiagnostics           PRESENCE optional}|
    { ID id-MeasurementInitiationResult-List   CRITICALITY ignore  TYPE MeasurementInitiationResult-List PRESENCE optional},
    ...
}


MeasurementInitiationResult-List ::= SEQUENCE (SIZE (1..maxCellineNB)) OF ProtocolIE-Single-Container { { MeasurementInitiationResult-ItemIEs} }

MeasurementInitiationResult-ItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeasurementInitiationResult-Item    CRITICALITY ignore  TYPE MeasurementInitiationResult-Item  PRESENCE mandatory}
}

MeasurementInitiationResult-Item ::= SEQUENCE {
    cell-ID                                     ECGI,
    measurementFailureCause-List                MeasurementFailureCause-List    OPTIONAL,
    iE-Extensions                               ProtocolExtensionContainer { { MeasurementInitiationResult-Item-ExtIEs} }  OPTIONAL,
    ...
}

MeasurementInitiationResult-Item-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}
```

```
MeasurementFailureCause-List ::= SEQUENCE (SIZE (1..maxFailedMeasObjects)) OF ProtocolIE-Single-Container { { MeasurementFailureCause-ItemIEs} }

MeasurementFailureCause-ItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeasurementFailureCause-Item    CRITICALITY ignore  TYPE MeasurementFailureCause-Item    PRESENCE mandatory}
}

MeasurementFailureCause-Item ::= SEQUENCE {
    measurementFailedReportCharacteristics          ReportCharacteristics,
    cause                                           Cause,
    iE-Extensions                                   ProtocolExtensionContainer { { MeasurementFailureCause-Item-ExtIEs} }OPTIONAL,
    ...
}

MeasurementFailureCause-Item-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

-- **************************************************************
--
-- Resource Status Failure
--
-- **************************************************************

ResourceStatusFailure ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{ResourceStatusFailure-IEs}},
    ...
}

ResourceStatusFailure-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-ENB1-Measurement-ID                     CRITICALITY reject  TYPE Measurement-ID                      PRESENCE mandatory}|
    { ID id-ENB2-Measurement-ID                     CRITICALITY reject  TYPE Measurement-ID                      PRESENCE mandatory}|
    { ID id-Cause                                   CRITICALITY ignore  TYPE Cause                               PRESENCE mandatory}|
    { ID id-CriticalityDiagnostics                  CRITICALITY ignore  TYPE CriticalityDiagnostics              PRESENCE optional}|
    { ID id-CompleteFailureCauseInformation-List    CRITICALITY ignore  TYPE CompleteFailureCauseInformation-List  PRESENCE optional},
    ...
}

CompleteFailureCauseInformation-List ::= SEQUENCE (SIZE (1..maxCellineNB)) OF ProtocolIE-Single-Container { {CompleteFailureCauseInformation-
ItemIEs} }

CompleteFailureCauseInformation-ItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-CompleteFailureCauseInformation-Item    CRITICALITY ignore  TYPE CompleteFailureCauseInformation-Item  PRESENCE mandatory}
}

CompleteFailureCauseInformation-Item ::= SEQUENCE {
    cell-ID                                         ECGI,
    measurementFailureCause-List                    MeasurementFailureCause-List,
    iE-Extensions                                   ProtocolExtensionContainer { { CompleteFailureCauseInformation-Item-ExtIEs} } OPTIONAL,
    ...
}

CompleteFailureCauseInformation-Item-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}
```

```
-- **************************************************************
--
-- Resource Status Update
--
-- **************************************************************

ResourceStatusUpdate ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{ResourceStatusUpdate-IEs}},
    ...
}

ResourceStatusUpdate-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-ENB1-Measurement-ID     CRITICALITY reject  TYPE Measurement-ID                PRESENCE mandatory}|
    { ID id-ENB2-Measurement-ID     CRITICALITY reject  TYPE Measurement-ID                PRESENCE mandatory}|
    { ID id-CellMeasurementResult   CRITICALITY ignore  TYPE CellMeasurementResult-List    PRESENCE mandatory},
    ...
}

CellMeasurementResult-List ::= SEQUENCE (SIZE (1..maxCellineNB)) OF ProtocolIE-Single-Container { {CellMeasurementResult-ItemIEs} }

CellMeasurementResult-ItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-CellMeasurementResult-Item  CRITICALITY ignore  TYPE CellMeasurementResult-Item PRESENCE mandatory}
}

CellMeasurementResult-Item ::= SEQUENCE {
    cell-ID                     ECGI,
    hWLoadIndicator             HWLoadIndicator     OPTIONAL,
    s1TNLLoadIndicator          S1TNLLoadIndicator  OPTIONAL,
    radioResourceStatus         RadioResourceStatus OPTIONAL,
    iE-Extensions               ProtocolExtensionContainer { {CellMeasurementResult-Item-ExtIEs} }       OPTIONAL,
    ...
}

CellMeasurementResult-Item-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    { ID id-CompositeAvailableCapacityGroup CRITICALITY ignore  EXTENSION CompositeAvailableCapacityGroup    PRESENCE optional}|
    { ID id-ABS-Status                      CRITICALITY ignore  EXTENSION ABS-Status                        PRESENCE optional}|
    { ID id-RSRPMRList                      CRITICALITY ignore  EXTENSION RSRPMRList                        PRESENCE optional}|
    { ID id-CSIReportList                   CRITICALITY ignore  EXTENSION CSIReportList                     PRESENCE optional}|
    { ID id-CellReportingIndicator          CRITICALITY ignore  EXTENSION CellReportingIndicator            PRESENCE optional},
    ...
}


-- **************************************************************
--
-- PRIVATE MESSAGE
--
-- **************************************************************

PrivateMessage ::= SEQUENCE {
    privateIEs      PrivateIE-Container {{PrivateMessage-IEs}},
    ...
}
```

```
PrivateMessage-IEs X2AP-PRIVATE-IES ::= {
    ...
}

-- **************************************************************
--
-- MOBILITY CHANGE REQUEST
--
-- **************************************************************

MobilityChangeRequest ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{MobilityChangeRequest-IEs}},
    ...
}

MobilityChangeRequest-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-ENB1-Cell-ID                        CRITICALITY reject  TYPE ECGI                                PRESENCE mandatory}|
    { ID id-ENB2-Cell-ID                        CRITICALITY reject  TYPE ECGI                                PRESENCE mandatory}|
    { ID id-ENB1-Mobility-Parameters            CRITICALITY ignore  TYPE MobilityParametersInformation       PRESENCE optional}|
    { ID id-ENB2-Proposed-Mobility-Parameters   CRITICALITY reject  TYPE MobilityParametersInformation       PRESENCE mandatory}|
    { ID id-Cause                               CRITICALITY reject  TYPE Cause                               PRESENCE mandatory},
    ...
}

-- **************************************************************
--
-- MOBILITY CHANGE ACKNOWLEDGE
--
-- **************************************************************

MobilityChangeAcknowledge ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{MobilityChangeAcknowledge-IEs}},
    ...
}

MobilityChangeAcknowledge-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-ENB1-Cell-ID            CRITICALITY reject  TYPE ECGI                       PRESENCE mandatory}|
    { ID id-ENB2-Cell-ID            CRITICALITY reject  TYPE ECGI                       PRESENCE mandatory}|
    { ID id-CriticalityDiagnostics  CRITICALITY ignore  TYPE CriticalityDiagnostics     PRESENCE optional},
    ...
}


-- **************************************************************
--
-- MOBILITY CHANGE FAILURE
--
-- **************************************************************

MobilityChangeFailure ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{MobilityChangeFailure-IEs}},
    ...
}
```

```
MobilityChangeFailure-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-ENB1-Cell-ID                                CRITICALITY ignore  TYPE ECGI                                PRESENCE mandatory}|
    { ID id-ENB2-Cell-ID                                CRITICALITY ignore  TYPE ECGI                                PRESENCE mandatory}|
    { ID id-Cause                                       CRITICALITY ignore  TYPE Cause                               PRESENCE mandatory}|
    { ID id-ENB2-Mobility-Parameters-Modification-Range  CRITICALITY ignore  TYPE MobilityParametersModificationRange  PRESENCE optional}|
    { ID id-CriticalityDiagnostics                      CRITICALITY ignore  TYPE CriticalityDiagnostics              PRESENCE optional},
    ...
}

-- **************************************************************
--
-- Radio Link Failure Indication
--
-- **************************************************************

RLFIndication ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{RLFIndication-IEs}},
    ...
}

RLFIndication-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-FailureCellPCI                              CRITICALITY ignore  TYPE PCI                                 PRESENCE mandatory}|
    { ID id-Re-establishmentCellECGI                    CRITICALITY ignore  TYPE ECGI                                PRESENCE mandatory}|
    { ID id-FailureCellCRNTI                            CRITICALITY ignore  TYPE CRNTI                               PRESENCE mandatory}|
    { ID id-ShortMAC-I                                  CRITICALITY ignore  TYPE ShortMAC-I                          PRESENCE optional}|
    { ID id-UE-RLF-Report-Container                     CRITICALITY ignore  TYPE UE-RLF-Report-Container             PRESENCE optional}|
    { ID id-RRCConnSetupIndicator                       CRITICALITY reject  TYPE RRCConnSetupIndicator               PRESENCE optional}|
    { ID id-RRCConnReestabIndicator                     CRITICALITY ignore  TYPE RRCConnReestabIndicator             PRESENCE optional}|
    { ID id-UE-RLF-Report-Container-for-extended-bands  CRITICALITY ignore  TYPE UE-RLF-Report-Container-for-extended-bands  PRESENCE optional},
    ...
}


-- **************************************************************
--
-- Cell Activation Request
--
-- **************************************************************

CellActivationRequest ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{CellActivationRequest-IEs}},
    ...
}

CellActivationRequest-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-ServedCellsToActivate   CRITICALITY reject  TYPE ServedCellsToActivate      PRESENCE mandatory},
    ...
}

ServedCellsToActivate::= SEQUENCE (SIZE (1..maxCellineNB)) OF ServedCellsToActivate-Item

ServedCellsToActivate-Item::= SEQUENCE {
    ecgi                        ECGI,
```

```
    iE-Extensions                   ProtocolExtensionContainer { { ServedCellsToActivate-Item-ExtIEs} } OPTIONAL,
    ...
}

ServedCellsToActivate-Item-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

-- **************************************************************
--
-- Cell Activation Response
--
-- **************************************************************

CellActivationResponse ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{CellActivationResponse-IEs}},
    ...
}

CellActivationResponse-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-ActivatedCellList       CRITICALITY ignore  TYPE ActivatedCellList              PRESENCE mandatory}|
    { ID id-CriticalityDiagnostics  CRITICALITY ignore  TYPE CriticalityDiagnostics         PRESENCE optional},
    ...
}

ActivatedCellList ::= SEQUENCE (SIZE (1..maxCellineNB)) OF ActivatedCellList-Item

ActivatedCellList-Item::= SEQUENCE {
    ecgi                            ECGI,
    iE-Extensions                   ProtocolExtensionContainer { { ActivatedCellList-Item-ExtIEs} } OPTIONAL,
    ...
}

ActivatedCellList-Item-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

--**************************************************************
--
-- CELL ACTIVATION FAILURE
--
-- **************************************************************

CellActivationFailure ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{CellActivationFailure-IEs}},
    ...
}

CellActivationFailure-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-Cause                   CRITICALITY ignore  TYPE Cause                  PRESENCE mandatory }|
    { ID id-CriticalityDiagnostics  CRITICALITY ignore  TYPE CriticalityDiagnostics PRESENCE optional },
    ...
}
```

```
-- **************************************************************
--
-- X2 RELEASE
--
-- **************************************************************

X2Release ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{X2Release-IEs}},
    ...
}

X2Release-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-GlobalENB-ID            CRITICALITY reject  TYPE GlobalENB-ID           PRESENCE mandatory},
...
}

-- **************************************************************
--
-- X2AP Message Transfer
--
-- **************************************************************

X2APMessageTransfer ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{X2APMessageTransfer-IEs}},
    ...
}

X2APMessageTransfer-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-RNL-Header  CRITICALITY reject  TYPE RNL-Header             PRESENCE mandatory}|
    { ID id-x2APMessage CRITICALITY reject  TYPE X2AP-Message           PRESENCE optional},
    ...
}

RNL-Header ::= SEQUENCE {
    source-GlobalENB-ID GlobalENB-ID,
    target-GlobalENB-ID GlobalENB-ID    OPTIONAL,
    iE-Extensions                       ProtocolExtensionContainer { { RNL-Header-Item-ExtIEs} } OPTIONAL,
    ...
}

RNL-Header-Item-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

X2AP-Message ::= OCTET STRING

-- **************************************************************
--
-- SENB ADDITION REQUEST
--
-- **************************************************************

SeNBAdditionRequest ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{SeNBAdditionRequest-IEs}},
```

```
    ...
}

SeNBAdditionRequest-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                 CRITICALITY reject  TYPE UE-X2AP-ID                    PRESENCE mandatory}|
    { ID id-UE-SecurityCapabilities         CRITICALITY reject  TYPE UESecurityCapabilities         PRESENCE conditional}|
    -- This IE shall be present if the Bearer Option IE is set to the value "SCG bearer" --
    { ID id-SeNBSecurityKey                 CRITICALITY reject  TYPE SeNBSecurityKey                 PRESENCE conditional}|
    -- This IE shall be present if the Bearer Option IE is set to the value "SCG bearer" --
    { ID id-SeNBUEAggregateMaximumBitRate   CRITICALITY reject  TYPE UEAggregateMaximumBitRate       PRESENCE mandatory}|
    { ID id-ServingPLMN                     CRITICALITY ignore  TYPE PLMN-Identity                   PRESENCE optional}|
    { ID id-E-RABs-ToBeAdded-List           CRITICALITY reject  TYPE E-RABs-ToBeAdded-List           PRESENCE mandatory}|
    { ID id-MeNBtoSeNBContainer             CRITICALITY reject  TYPE MeNBtoSeNBContainer             PRESENCE mandatory}|
    { ID id-CSGMembershipStatus             CRITICALITY reject  TYPE CSGMembershipStatus             PRESENCE optional}|
    { ID id-SeNB-UE-X2AP-ID                 CRITICALITY reject  TYPE UE-X2AP-ID                      PRESENCE optional}|
    { ID id-SeNB-UE-X2AP-ID-Extension       CRITICALITY reject  TYPE UE-X2AP-ID-Extension            PRESENCE optional}|
    { ID id-ExpectedUEBehaviour             CRITICALITY ignore  TYPE ExpectedUEBehaviour             PRESENCE optional}|
    { ID id-MeNB-UE-X2AP-ID-Extension       CRITICALITY reject  TYPE UE-X2AP-ID-Extension            PRESENCE optional},
    ...
}

E-RABs-ToBeAdded-List ::= SEQUENCE (SIZE(1..maxnoofBearers)) OF ProtocolIE-Single-Container { { E-RABs-ToBeAdded-ItemIEs} }

E-RABs-ToBeAdded-ItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-ToBeAdded-Item   CRITICALITY reject  TYPE E-RABs-ToBeAdded-Item      PRESENCE mandatory},
    ...
}

E-RABs-ToBeAdded-Item ::= CHOICE {
    sCG-Bearer      E-RABs-ToBeAdded-Item-SCG-Bearer,
    split-Bearer    E-RABs-ToBeAdded-Item-Split-Bearer,
    ...
}

E-RABs-ToBeAdded-Item-SCG-Bearer ::= SEQUENCE {
    e-RAB-ID                        E-RAB-ID,
    e-RAB-Level-QoS-Parameters      E-RAB-Level-QoS-Parameters,
    dL-Forwarding                   DL-Forwarding                                                   OPTIONAL,
    s1-UL-GTPtunnelEndpoint         GTPtunnelEndpoint,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeAdded-Item-SCG-BearerExtIEs} }   OPTIONAL,
    ...
}

E-RABs-ToBeAdded-Item-SCG-BearerExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    { ID id-Correlation-ID              CRITICALITY ignore  EXTENSION Correlation-ID        PRESENCE optional}|
    { ID id-SIPTO-Correlation-ID        CRITICALITY ignore  EXTENSION Correlation-ID        PRESENCE optional},
    ...
}

E-RABs-ToBeAdded-Item-Split-Bearer ::= SEQUENCE {
    e-RAB-ID                        E-RAB-ID,
    e-RAB-Level-QoS-Parameters      E-RAB-Level-QoS-Parameters,
    meNB-GTPtunnelEndpoint          GTPtunnelEndpoint,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeAdded-Item-Split-BearerExtIEs} } OPTIONAL,
```

```
    ...
}

E-RABs-ToBeAdded-Item-Split-BearerExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

-- **************************************************************
--
-- SENB ADDITION REQUEST ACKNOWLEDGE
--
-- **************************************************************

SeNBAdditionRequestAcknowledge ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{SeNBAdditionRequestAcknowledge-IEs}},
    ...
}

SeNBAdditionRequestAcknowledge-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                     CRITICALITY reject  TYPE UE-X2AP-ID                     PRESENCE mandatory}|
    { ID id-SeNB-UE-X2AP-ID                     CRITICALITY reject  TYPE UE-X2AP-ID                     PRESENCE mandatory}|
    { ID id-E-RABs-Admitted-ToBeAdded-List      CRITICALITY ignore  TYPE E-RABs-Admitted-ToBeAdded-List PRESENCE mandatory}|
    { ID id-E-RABs-NotAdmitted-List             CRITICALITY ignore  TYPE E-RAB-List                     PRESENCE optional}|
    { ID id-SeNBtoMeNBContainer                 CRITICALITY reject  TYPE SeNBtoMeNBContainer            PRESENCE mandatory}|
    { ID id-CriticalityDiagnostics              CRITICALITY ignore  TYPE CriticalityDiagnostics         PRESENCE optional}|
    { ID id-GW-TransportLayerAddress            CRITICALITY ignore  TYPE TransportLayerAddress          PRESENCE optional}|
    { ID id-SIPTO-L-GW-TransportLayerAddress    CRITICALITY ignore  TYPE TransportLayerAddress          PRESENCE optional}|
    { ID id-MeNB-UE-X2AP-ID-Extension           CRITICALITY reject  TYPE UE-X2AP-ID-Extension           PRESENCE optional}|
    { ID id-SeNB-UE-X2AP-ID-Extension           CRITICALITY reject  TYPE UE-X2AP-ID-Extension           PRESENCE optional}|
    { ID id-Tunnel-Information-for-BBF          CRITICALITY ignore  TYPE TunnelInformation              PRESENCE optional},
    ...
}

E-RABs-Admitted-ToBeAdded-List ::= SEQUENCE (SIZE (1..maxnoofBearers)) OF ProtocolIE-Single-Container { {E-RABs-Admitted-ToBeAdded-ItemIEs} }

E-RABs-Admitted-ToBeAdded-ItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-Admitted-ToBeAdded-Item  CRITICALITY ignore  TYPE E-RABs-Admitted-ToBeAdded-Item    PRESENCE mandatory}
}

E-RABs-Admitted-ToBeAdded-Item ::= CHOICE {
    sCG-Bearer      E-RABs-Admitted-ToBeAdded-Item-SCG-Bearer,
    split-Bearer    E-RABs-Admitted-ToBeAdded-Item-Split-Bearer,
    ...
}

E-RABs-Admitted-ToBeAdded-Item-SCG-Bearer ::= SEQUENCE {
    e-RAB-ID                            E-RAB-ID,
    s1-DL-GTPtunnelEndpoint             GTPtunnelEndpoint,
    dL-Forwarding-GTPtunnelEndpoint     GTPtunnelEndpoint                                                   OPTIONAL,
    uL-Forwarding-GTPtunnelEndpoint     GTPtunnelEndpoint                                                   OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-Admitted-ToBeAdded-Item-SCG-BearerExtIEs} }  OPTIONAL,
    ...
}
```

```
E-RABs-Admitted-ToBeAdded-Item-SCG-BearerExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-Admitted-ToBeAdded-Item-Split-Bearer ::= SEQUENCE {
    e-RAB-ID                        E-RAB-ID,
    seNB-GTPtunnelEndpoint          GTPtunnelEndpoint,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-Admitted-ToBeAdded-Item-Split-BearerExtIEs} } OPTIONAL,
    ...
}

E-RABs-Admitted-ToBeAdded-Item-Split-BearerExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

-- **************************************************************
--
-- SENB ADDITION REQUEST REJECT
--
-- **************************************************************

SeNBAdditionRequestReject ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{SeNBAdditionRequestReject-IEs}},
    ...
}

SeNBAdditionRequestReject-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                 CRITICALITY reject  TYPE UE-X2AP-ID                 PRESENCE mandatory}|
    { ID id-SeNB-UE-X2AP-ID                 CRITICALITY reject  TYPE UE-X2AP-ID                 PRESENCE mandatory}|
    { ID id-Cause                           CRITICALITY ignore  TYPE Cause                      PRESENCE mandatory}|
    { ID id-CriticalityDiagnostics          CRITICALITY ignore  TYPE CriticalityDiagnostics     PRESENCE optional}|
    { ID id-MeNB-UE-X2AP-ID-Extension       CRITICALITY reject  TYPE UE-X2AP-ID-Extension       PRESENCE optional}|
    { ID id-SeNB-UE-X2AP-ID-Extension       CRITICALITY reject  TYPE UE-X2AP-ID-Extension       PRESENCE optional},
    ...
}

-- **************************************************************
--
-- SENB RECONFIGURATION COMPLETE
--
-- **************************************************************

SeNBReconfigurationComplete ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{SeNBReconfigurationComplete-IEs}},
    ...
}

SeNBReconfigurationComplete-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                         CRITICALITY reject  TYPE UE-X2AP-ID                         PRESENCE mandatory}|
    { ID id-SeNB-UE-X2AP-ID                         CRITICALITY reject  TYPE UE-X2AP-ID                         PRESENCE mandatory}|
    { ID id-ResponseInformationSeNBReconfComp       CRITICALITY ignore  TYPE ResponseInformationSeNBReconfComp  PRESENCE mandatory}|
    { ID id-MeNB-UE-X2AP-ID-Extension               CRITICALITY reject  TYPE UE-X2AP-ID-Extension               PRESENCE optional}|
    { ID id-SeNB-UE-X2AP-ID-Extension               CRITICALITY reject  TYPE UE-X2AP-ID-Extension               PRESENCE optional},
    ...
```

```
}

ResponseInformationSeNBReconfComp ::= CHOICE {
    success             ResponseInformationSeNBReconfComp-SuccessItem,
    reject-by-MeNB      ResponseInformationSeNBReconfComp-RejectByMeNBItem,
    ...
}

ResponseInformationSeNBReconfComp-SuccessItem ::= SEQUENCE {
    meNBtoSeNBContainer             MeNBtoSeNBContainer OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { {ResponseInformationSeNBReconfComp-SuccessItemExtIEs} } OPTIONAL,
    ...
}

ResponseInformationSeNBReconfComp-SuccessItemExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

ResponseInformationSeNBReconfComp-RejectByMeNBItem ::= SEQUENCE {
    cause                           Cause,
    meNBtoSeNBContainer             MeNBtoSeNBContainer                                                                 OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { { ResponseInformationSeNBReconfComp-RejectByMeNBItemExtIEs} } OPTIONAL,
    ...
}

ResponseInformationSeNBReconfComp-RejectByMeNBItemExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

-- **************************************************************
--
-- SENB MODIFICATION REQUEST
--
-- **************************************************************

SeNBModificationRequest ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{ SeNBModificationRequest-IEs}},
    ...
}

SeNBModificationRequest-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                     CRITICALITY reject  TYPE UE-X2AP-ID                     PRESENCE mandatory}|
    { ID id-SeNB-UE-X2AP-ID                     CRITICALITY reject  TYPE UE-X2AP-ID                     PRESENCE mandatory}|
    { ID id-Cause                               CRITICALITY ignore  TYPE Cause                          PRESENCE mandatory}|
    { ID id-SCGChangeIndication                 CRITICALITY ignore  TYPE SCGChangeIndication            PRESENCE optional}|
    { ID id-ServingPLMN                         CRITICALITY ignore  TYPE PLMN-Identity                  PRESENCE optional}|
    { ID id-UE-ContextInformationSeNBModReq     CRITICALITY reject  TYPE UE-ContextInformationSeNBModReq PRESENCE optional}|
    { ID id-MeNBtoSeNBContainer                 CRITICALITY ignore  TYPE MeNBtoSeNBContainer            PRESENCE optional}|
    { ID id-CSGMembershipStatus                 CRITICALITY reject  TYPE CSGMembershipStatus            PRESENCE optional}|
    { ID id-MeNB-UE-X2AP-ID-Extension           CRITICALITY reject  TYPE UE-X2AP-ID-Extension           PRESENCE optional}|
    { ID id-SeNB-UE-X2AP-ID-Extension           CRITICALITY reject  TYPE UE-X2AP-ID-Extension           PRESENCE optional},
    ...
}
```

```
UE-ContextInformationSeNBModReq ::= SEQUENCE {
    uE-SecurityCapabilities         UESecurityCapabilities                                          OPTIONAL,
    seNB-SecurityKey                SeNBSecurityKey                                                 OPTIONAL,
    seNBUEAggregateMaximumBitRate   UEAggregateMaximumBitRate                                       OPTIONAL,
    e-RABs-ToBeAdded                E-RABs-ToBeAdded-List-ModReq                                    OPTIONAL,
    e-RABs-ToBeModified             E-RABs-ToBeModified-List-ModReq                                 OPTIONAL,
    e-RABs-ToBeReleased             E-RABs-ToBeReleased-List-ModReq                                 OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { { UE-ContextInformationSeNBModReqExtIEs} }  OPTIONAL,
    ...
}

UE-ContextInformationSeNBModReqExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-ToBeAdded-List-ModReq ::= SEQUENCE (SIZE(1..maxnoofBearers)) OF ProtocolIE-Single-Container { {E-RABs-ToBeAdded-ModReqItemIEs} }

E-RABs-ToBeAdded-ModReqItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-ToBeAdded-ModReqItem CRITICALITY ignore  TYPE E-RABs-ToBeAdded-ModReqItem    PRESENCE mandatory},
    ...
}

E-RABs-ToBeAdded-ModReqItem ::= CHOICE {
    sCG-Bearer      E-RABs-ToBeAdded-ModReqItem-SCG-Bearer,
    split-Bearer    E-RABs-ToBeAdded-ModReqItem-Split-Bearer,
    ...
}

E-RABs-ToBeAdded-ModReqItem-SCG-Bearer ::= SEQUENCE {
    e-RAB-ID                        E-RAB-ID,
    e-RAB-Level-QoS-Parameters      E-RAB-Level-QoS-Parameters,
    dL-Forwarding                   DL-Forwarding                                                   OPTIONAL,
    s1-UL-GTPtunnelEndpoint         GTPtunnelEndpoint,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeAdded-ModReqItem-SCG-BearerExtIEs} } OPTIONAL,
    ...
}

E-RABs-ToBeAdded-ModReqItem-SCG-BearerExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    { ID id-Correlation-ID              CRITICALITY ignore  EXTENSION Correlation-ID        PRESENCE optional}|
    { ID id-SIPTO-Correlation-ID        CRITICALITY ignore  EXTENSION Correlation-ID        PRESENCE optional},
    ...
}

E-RABs-ToBeAdded-ModReqItem-Split-Bearer ::= SEQUENCE {
    e-RAB-ID                        E-RAB-ID,
    e-RAB-Level-QoS-Parameters      E-RAB-Level-QoS-Parameters,
    meNB-GTPtunnelEndpoint          GTPtunnelEndpoint,
    iE-Extensions           ProtocolExtensionContainer { {E-RABs-ToBeAdded-ModReqItem-Split-BearerExtIEs} } OPTIONAL,
    ...
}

E-RABs-ToBeAdded-ModReqItem-Split-BearerExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}
```

```
E-RABs-ToBeModified-List-ModReq ::= SEQUENCE (SIZE(1..maxnoofBearers)) OF ProtocolIE-Single-Container { {E-RABs-ToBeModified-ModReqItemIEs} }

E-RABs-ToBeModified-ModReqItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-ToBeModified-ModReqItem  CRITICALITY ignore  TYPE E-RABs-ToBeModified-ModReqItem    PRESENCE mandatory},
    ...
}


E-RABs-ToBeModified-ModReqItem ::= CHOICE {
    sCG-Bearer      E-RABs-ToBeModified-ModReqItem-SCG-Bearer,
    split-Bearer    E-RABs-ToBeModified-ModReqItem-Split-Bearer,
    ...
}

E-RABs-ToBeModified-ModReqItem-SCG-Bearer ::= SEQUENCE {
    e-RAB-ID                        E-RAB-ID,
    e-RAB-Level-QoS-Parameters      E-RAB-Level-QoS-Parameters                                      OPTIONAL,
    s1-UL-GTPtunnelEndpoint         GTPtunnelEndpoint                                               OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeModified-ModReqItem-SCG-BearerExtIEs} } OPTIONAL,
    ...
}

E-RABs-ToBeModified-ModReqItem-SCG-BearerExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-ToBeModified-ModReqItem-Split-Bearer ::= SEQUENCE {
    e-RAB-ID                        E-RAB-ID,
    e-RAB-Level-QoS-Parameters      E-RAB-Level-QoS-Parameters                                  OPTIONAL,
    meNB-GTPtunnelEndpoint          GTPtunnelEndpoint                                           OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeModified-ModReqItem-Split-BearerExtIEs} } OPTIONAL,
    ...
}

E-RABs-ToBeModified-ModReqItem-Split-BearerExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-ToBeReleased-List-ModReq ::= SEQUENCE (SIZE(1..maxnoofBearers)) OF ProtocolIE-Single-Container { {E-RABs-ToBeReleased-ModReqItemIEs} }

E-RABs-ToBeReleased-ModReqItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-ToBeReleased-ModReqItem  CRITICALITY ignore  TYPE E-RABs-ToBeReleased-ModReqItem    PRESENCE mandatory},
    ...
}

E-RABs-ToBeReleased-ModReqItem ::= CHOICE {
    sCG-Bearer      E-RABs-ToBeReleased-ModReqItem-SCG-Bearer,
    split-Bearer    E-RABs-ToBeReleased-ModReqItem-Split-Bearer,
    ...
}

E-RABs-ToBeReleased-ModReqItem-SCG-Bearer ::= SEQUENCE {
    e-RAB-ID                        E-RAB-ID,
```

```
    dL-Forwarding-GTPtunnelEndpoint         GTPtunnelEndpoint                                       OPTIONAL,
    uL-Forwarding-GTPtunnelEndpoint         GTPtunnelEndpoint                                       OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeReleased-ModReqItem-SCG-BearerExtIEs} } OPTIONAL,
    ...
}

E-RABs-ToBeReleased-ModReqItem-SCG-BearerExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-ToBeReleased-ModReqItem-Split-Bearer ::= SEQUENCE {
    e-RAB-ID                        E-RAB-ID,
    dL-Forwarding-GTPtunnelEndpoint         GTPtunnelEndpoint                                       OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeReleased-ModReqItem-Split-BearerExtIEs} } OPTIONAL,
    ...
}

E-RABs-ToBeReleased-ModReqItem-Split-BearerExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

-- **************************************************************
--
-- SENB MODIFICATION REQUEST ACKNOWLEDGE
--
-- **************************************************************

SeNBModificationRequestAcknowledge ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{SeNBModificationRequestAcknowledge-IEs}},
    ...
}

SeNBModificationRequestAcknowledge-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                             CRITICALITY ignore  TYPE UE-X2AP-ID                             PRESENCE mandatory}|
    { ID id-SeNB-UE-X2AP-ID                             CRITICALITY ignore  TYPE UE-X2AP-ID                             PRESENCE mandatory}|
    { ID id-E-RABs-Admitted-ToBeAdded-ModAckList        CRITICALITY ignore  TYPE E-RABs-Admitted-ToBeAdded-ModAckList    PRESENCE optional}|
    { ID id-E-RABs-Admitted-ToBeModified-ModAckList     CRITICALITY ignore  TYPE E-RABs-Admitted-ToBeModified-ModAckList PRESENCE optional}|
    { ID id-E-RABs-Admitted-ToBeReleased-ModAckList     CRITICALITY ignore  TYPE E-RABs-Admitted-ToBeReleased-ModAckList PRESENCE optional}|
    { ID id-E-RABs-NotAdmitted-List                     CRITICALITY ignore  TYPE E-RAB-List                             PRESENCE optional}|
    { ID id-SeNBtoMeNBContainer                         CRITICALITY ignore  TYPE SeNBtoMeNBContainer                    PRESENCE optional}|
    { ID id-CriticalityDiagnostics                      CRITICALITY ignore  TYPE CriticalityDiagnostics                 PRESENCE optional}|
    { ID id-MeNB-UE-X2AP-ID-Extension                   CRITICALITY ignore  TYPE UE-X2AP-ID-Extension                   PRESENCE optional}|
    { ID id-SeNB-UE-X2AP-ID-Extension                   CRITICALITY ignore  TYPE UE-X2AP-ID-Extension                   PRESENCE optional},
    ...
}

E-RABs-Admitted-ToBeAdded-ModAckList ::= SEQUENCE (SIZE (1..maxnoofBearers)) OF ProtocolIE-Single-Container { {E-RABs-Admitted-ToBeAdded-
ModAckItemIEs} }

E-RABs-Admitted-ToBeAdded-ModAckItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-Admitted-ToBeAdded-ModAckItem    CRITICALITY ignore  TYPE E-RABs-Admitted-ToBeAdded-ModAckItem     PRESENCE mandatory}
}

E-RABs-Admitted-ToBeAdded-ModAckItem ::= CHOICE {
```

```
    sCG-Bearer      E-RABs-Admitted-ToBeAdded-ModAckItem-SCG-Bearer,
    split-Bearer    E-RABs-Admitted-ToBeAdded-ModAckItem-Split-Bearer,
    ...
}

E-RABs-Admitted-ToBeAdded-ModAckItem-SCG-Bearer ::= SEQUENCE {
    e-RAB-ID                            E-RAB-ID,
    s1-DL-GTPtunnelEndpoint             GTPtunnelEndpoint,
    dL-Forwarding-GTPtunnelEndpoint     GTPtunnelEndpoint                                                   OPTIONAL,
    uL-Forwarding-GTPtunnelEndpoint     GTPtunnelEndpoint                                                   OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-Admitted-ToBeAdded-ModAckItem-SCG-BearerExtIEs} }   OPTIONAL,
    ...
}

E-RABs-Admitted-ToBeAdded-ModAckItem-SCG-BearerExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-Admitted-ToBeAdded-ModAckItem-Split-Bearer ::= SEQUENCE {
    e-RAB-ID                        E-RAB-ID,
    seNB-GTPtunnelEndpoint          GTPtunnelEndpoint,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-Admitted-ToBeAdded-ModAckItem-Split-BearerExtIEs} } OPTIONAL,
    ...
}

E-RABs-Admitted-ToBeAdded-ModAckItem-Split-BearerExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}
E-RABs-Admitted-ToBeModified-ModAckList ::= SEQUENCE (SIZE (1..maxnoofBearers)) OF ProtocolIE-Single-Container { {E-RABs-Admitted-ToBeModified-
ModAckItemIEs} }

E-RABs-Admitted-ToBeModified-ModAckItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-Admitted-ToBeModified-ModAckItem     CRITICALITY ignore  TYPE E-RABs-Admitted-ToBeModified-ModAckItem  PRESENCE mandatory}
}

E-RABs-Admitted-ToBeModified-ModAckItem ::= CHOICE {
    sCG-Bearer      E-RABs-Admitted-ToBeModified-ModAckItem-SCG-Bearer,
    split-Bearer    E-RABs-Admitted-ToBeModified-ModAckItem-Split-Bearer,
    ...
}

E-RABs-Admitted-ToBeModified-ModAckItem-SCG-Bearer ::= SEQUENCE {
    e-RAB-ID                        E-RAB-ID,
    s1-DL-GTPtunnelEndpoint         GTPtunnelEndpoint                                                   OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-Admitted-ToBeModified-ModAckItem-SCG-BearerExtIEs} } OPTIONAL,
    ...
}

E-RABs-Admitted-ToBeModified-ModAckItem-SCG-BearerExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-Admitted-ToBeModified-ModAckItem-Split-Bearer ::= SEQUENCE {
    e-RAB-ID                        E-RAB-ID,
```

```
    seNB-GTPtunnelEndpoint          GTPtunnelEndpoint                                                   OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-Admitted-ToBeModified-ModAckItem-Split-BearerExtIEs} } OPTIONAL,
    ...
}

E-RABs-Admitted-ToBeModified-ModAckItem-Split-BearerExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-Admitted-ToBeReleased-ModAckList ::= SEQUENCE (SIZE (1..maxnoofBearers)) OF ProtocolIE-Single-Container { {E-RABs-Admitted-ToBeReleased-
ModAckItemIEs} }

E-RABs-Admitted-ToBeReleased-ModAckItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-Admitted-ToBeReleased-ModAckItem     CRITICALITY ignore  TYPE E-RABs-Admitted-ToReleased-ModAckItem    PRESENCE mandatory}
}

E-RABs-Admitted-ToReleased-ModAckItem ::= CHOICE {
    sCG-Bearer      E-RABs-Admitted-ToBeReleased-ModAckItem-SCG-Bearer,
    split-Bearer    E-RABs-Admitted-ToBeReleased-ModAckItem-Split-Bearer,
    ...
}

E-RABs-Admitted-ToBeReleased-ModAckItem-SCG-Bearer ::= SEQUENCE {
    e-RAB-ID                    E-RAB-ID,
    iE-Extensions               ProtocolExtensionContainer { {E-RABs-Admitted-ToBeReleased-ModAckItem-SCG-BearerExtIEs} }OPTIONAL,
    ...
}

E-RABs-Admitted-ToBeReleased-ModAckItem-SCG-BearerExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-Admitted-ToBeReleased-ModAckItem-Split-Bearer ::= SEQUENCE {
    e-RAB-ID                    E-RAB-ID,
    iE-Extensions               ProtocolExtensionContainer { {E-RABs-Admitted-ToBeReleased-ModAckItem-Split-BearerExtIEs} } OPTIONAL,
    ...
}

E-RABs-Admitted-ToBeReleased-ModAckItem-Split-BearerExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

-- **************************************************************
--
-- SENB MODIFICATION REQUEST REJECT
--
-- **************************************************************

SeNBModificationRequestReject ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{SeNBModificationRequestReject-IEs}},
    ...
}

SeNBModificationRequestReject-IEs X2AP-PROTOCOL-IES ::= {
```

```
    { ID id-MeNB-UE-X2AP-ID                    CRITICALITY ignore  TYPE UE-X2AP-ID              PRESENCE mandatory}|
    { ID id-SeNB-UE-X2AP-ID                    CRITICALITY ignore  TYPE UE-X2AP-ID              PRESENCE mandatory}|
    { ID id-Cause                              CRITICALITY ignore  TYPE Cause                   PRESENCE mandatory}|
    { ID id-CriticalityDiagnostics             CRITICALITY ignore  TYPE CriticalityDiagnostics  PRESENCE optional}|
    { ID id-MeNB-UE-X2AP-ID-Extension          CRITICALITY ignore  TYPE UE-X2AP-ID-Extension    PRESENCE optional}|
    { ID id-SeNB-UE-X2AP-ID-Extension          CRITICALITY ignore  TYPE UE-X2AP-ID-Extension    PRESENCE optional},
    ...
}

-- **************************************************************
--
-- SENB MODIFICATION REQUIRED
--
-- **************************************************************

SeNBModificationRequired ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container        {{SeNBModificationRequired-IEs}},
    ...
}

SeNBModificationRequired-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                    CRITICALITY reject  TYPE UE-X2AP-ID                    PRESENCE mandatory}|
    { ID id-SeNB-UE-X2AP-ID                    CRITICALITY reject  TYPE UE-X2AP-ID                    PRESENCE mandatory}|
    { ID id-Cause                              CRITICALITY ignore  TYPE Cause                         PRESENCE mandatory}|
    { ID id-SCGChangeIndication                CRITICALITY ignore  TYPE SCGChangeIndication           PRESENCE optional}|
    { ID id-E-RABs-ToBeReleased-ModReqd        CRITICALITY ignore  TYPE E-RABs-ToBeReleased-ModReqd   PRESENCE optional}|
    { ID id-SeNBtoMeNBContainer                CRITICALITY ignore  TYPE SeNBtoMeNBContainer           PRESENCE optional}|
    { ID id-MeNB-UE-X2AP-ID-Extension          CRITICALITY reject  TYPE UE-X2AP-ID-Extension          PRESENCE optional}|
    { ID id-SeNB-UE-X2AP-ID-Extension          CRITICALITY reject  TYPE UE-X2AP-ID-Extension          PRESENCE optional},
    ...
}


E-RABs-ToBeReleased-ModReqd ::= SEQUENCE (SIZE (1..maxnoofBearers)) OF ProtocolIE-Single-Container { {E-RABs-ToBeReleased-ModReqdItemIEs} }

E-RABs-ToBeReleased-ModReqdItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-ToBeReleased-ModReqdItem  CRITICALITY ignore     TYPE E-RABs-ToBeReleased-ModReqdItem   PRESENCE mandatory },
    ...
}

E-RABs-ToBeReleased-ModReqdItem ::= SEQUENCE {
    e-RAB-ID                        E-RAB-ID,
    cause                           Cause,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeReleased-ModReqdItemExtIEs} } OPTIONAL,
    ...
}

E-RABs-ToBeReleased-ModReqdItemExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

-- **************************************************************
--
-- SENB MODIFICATION CONFIRM
```

```
--
-- **************************************************************

SeNBModificationConfirm ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{SeNBModificationConfirm-IEs}},
    ...
}

SeNBModificationConfirm-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                     CRITICALITY ignore  TYPE UE-X2AP-ID                PRESENCE mandatory}|
    { ID id-SeNB-UE-X2AP-ID                     CRITICALITY ignore  TYPE UE-X2AP-ID                PRESENCE mandatory}|
    { ID id-MeNBtoSeNBContainer                 CRITICALITY ignore  TYPE MeNBtoSeNBContainer       PRESENCE optional}|
    { ID id-CriticalityDiagnostics              CRITICALITY ignore  TYPE CriticalityDiagnostics    PRESENCE optional}|
    { ID id-MeNB-UE-X2AP-ID-Extension           CRITICALITY ignore  TYPE UE-X2AP-ID-Extension      PRESENCE optional}|
    { ID id-SeNB-UE-X2AP-ID-Extension           CRITICALITY ignore  TYPE UE-X2AP-ID-Extension      PRESENCE optional},
    ...
}

-- **************************************************************
--
-- SENB MODIFICATION REFUSE
--
-- **************************************************************

SeNBModificationRefuse ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container        {{SeNBModificationRefuse-IEs}},
    ...
}

SeNBModificationRefuse-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                     CRITICALITY ignore  TYPE UE-X2AP-ID                PRESENCE mandatory}|
    { ID id-SeNB-UE-X2AP-ID                     CRITICALITY ignore  TYPE UE-X2AP-ID                PRESENCE mandatory}|
    { ID id-Cause                               CRITICALITY ignore  TYPE Cause                     PRESENCE mandatory}|
    { ID id-MeNBtoSeNBContainer                 CRITICALITY ignore  TYPE MeNBtoSeNBContainer       PRESENCE optional}|
    { ID id-CriticalityDiagnostics              CRITICALITY ignore  TYPE CriticalityDiagnostics    PRESENCE optional}|
    { ID id-MeNB-UE-X2AP-ID-Extension           CRITICALITY ignore  TYPE UE-X2AP-ID-Extension      PRESENCE optional}|
    { ID id-SeNB-UE-X2AP-ID-Extension           CRITICALITY ignore  TYPE UE-X2AP-ID-Extension      PRESENCE optional},
    ...
}

-- **************************************************************
--
-- SENB RELEASE REQUEST
--
-- **************************************************************

SeNBReleaseRequest ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container        {{SeNBReleaseRequest-IEs}},
    ...
}

SeNBReleaseRequest-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                     CRITICALITY reject  TYPE UE-X2AP-ID                        PRESENCE mandatory}|
    { ID id-SeNB-UE-X2AP-ID                     CRITICALITY reject  TYPE UE-X2AP-ID                        PRESENCE optional}|
```

```
    { ID id-Cause                               CRITICALITY ignore  TYPE Cause                               PRESENCE optional}|
    { ID id-E-RABs-ToBeReleased-List-RelReq     CRITICALITY ignore  TYPE E-RABs-ToBeReleased-List-RelReq     PRESENCE optional}|
    { ID id-UE-ContextKeptIndicator             CRITICALITY ignore  TYPE UE-ContextKeptIndicator             PRESENCE optional}|
    { ID id-MeNB-UE-X2AP-ID-Extension           CRITICALITY reject  TYPE UE-X2AP-ID-Extension               PRESENCE optional}|
    { ID id-SeNB-UE-X2AP-ID-Extension           CRITICALITY reject  TYPE UE-X2AP-ID-Extension               PRESENCE optional}|
    { ID id-MakeBeforeBreakIndicator            CRITICALITY ignore  TYPE MakeBeforeBreakIndicator            PRESENCE optional},
    ...
}
E-RABs-ToBeReleased-List-RelReq ::= SEQUENCE (SIZE(1..maxnoofBearers)) OF ProtocolIE-Single-Container { {E-RABs-ToBeReleased-RelReqItemIEs} }

E-RABs-ToBeReleased-RelReqItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-ToBeReleased-RelReqItem      CRITICALITY ignore  TYPE E-RABs-ToBeReleased-RelReqItem    PRESENCE mandatory},
    ...
}

E-RABs-ToBeReleased-RelReqItem ::= CHOICE {
    sCG-Bearer      E-RABs-ToBeReleased-RelReqItem-SCG-Bearer,
    split-Bearer    E-RABs-ToBeReleased-RelReqItem-Split-Bearer,
    ...
}

E-RABs-ToBeReleased-RelReqItem-SCG-Bearer ::= SEQUENCE {
    e-RAB-ID                        E-RAB-ID,
    uL-Forwarding-GTPtunnelEndpoint         GTPtunnelEndpoint                                       OPTIONAL,
    dL-Forwarding-GTPtunnelEndpoint         GTPtunnelEndpoint                                       OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeReleased-RelReqItem-SCG-BearerExtIEs} } OPTIONAL,
    ...
}

E-RABs-ToBeReleased-RelReqItem-SCG-BearerExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-ToBeReleased-RelReqItem-Split-Bearer ::= SEQUENCE {
    e-RAB-ID                        E-RAB-ID,
    dL-Forwarding-GTPtunnelEndpoint         GTPtunnelEndpoint                                   OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeReleased-RelReqItem-Split-BearerExtIEs} } OPTIONAL,
    ...
}

E-RABs-ToBeReleased-RelReqItem-Split-BearerExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

-- **************************************************************
--
-- SENB RELEASE REQUIRED
--
-- **************************************************************

SeNBReleaseRequired ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{SeNBReleaseRequired-IEs}},
    ...
}
```

```
SeNBReleaseRequired-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                CRITICALITY reject  TYPE UE-X2AP-ID                PRESENCE mandatory}|
    { ID id-SeNB-UE-X2AP-ID                CRITICALITY reject  TYPE UE-X2AP-ID                PRESENCE mandatory}|
    { ID id-Cause                          CRITICALITY ignore  TYPE Cause                     PRESENCE mandatory}|
    { ID id-MeNB-UE-X2AP-ID-Extension      CRITICALITY reject  TYPE UE-X2AP-ID-Extension      PRESENCE optional}|
    { ID id-SeNB-UE-X2AP-ID-Extension      CRITICALITY reject  TYPE UE-X2AP-ID-Extension      PRESENCE optional},
    ...
}

-- **************************************************************
--
-- SENB RELEASE CONFIRM
--
-- **************************************************************

SeNBReleaseConfirm ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{SeNBReleaseConfirm-IEs}},
    ...
}

SeNBReleaseConfirm-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                        CRITICALITY ignore  TYPE UE-X2AP-ID                        PRESENCE mandatory}|
    { ID id-SeNB-UE-X2AP-ID                        CRITICALITY ignore  TYPE UE-X2AP-ID                        PRESENCE mandatory}|
    { ID id-E-RABs-ToBeReleased-List-RelConf       CRITICALITY ignore  TYPE E-RABs-ToBeReleased-List-RelConf   PRESENCE optional}|
    { ID id-CriticalityDiagnostics                 CRITICALITY ignore  TYPE CriticalityDiagnostics            PRESENCE optional}|
    { ID id-MeNB-UE-X2AP-ID-Extension              CRITICALITY ignore  TYPE UE-X2AP-ID-Extension              PRESENCE optional}|
    { ID id-SeNB-UE-X2AP-ID-Extension              CRITICALITY ignore  TYPE UE-X2AP-ID-Extension              PRESENCE optional},
    ...
}
E-RABs-ToBeReleased-List-RelConf ::= SEQUENCE (SIZE(1..maxnoofBearers)) OF ProtocolIE-Single-Container { {E-RABs-ToBeReleased-RelConfItemIEs} }

E-RABs-ToBeReleased-RelConfItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-ToBeReleased-RelConfItem     CRITICALITY ignore      TYPE E-RABs-ToBeReleased-RelConfItem    PRESENCE mandatory},
    ...
}

E-RABs-ToBeReleased-RelConfItem ::= CHOICE {
    sCG-Bearer      E-RABs-ToBeReleased-RelConfItem-SCG-Bearer,
    split-Bearer    E-RABs-ToBeReleased-RelConfItem-Split-Bearer,
    ...
}

E-RABs-ToBeReleased-RelConfItem-SCG-Bearer ::= SEQUENCE {
    e-RAB-ID                        E-RAB-ID,
    uL-Forwarding-GTPtunnelEndpoint         GTPtunnelEndpoint                                       OPTIONAL,
    dL-Forwarding-GTPtunnelEndpoint         GTPtunnelEndpoint                                       OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeReleased-RelConfItem-SCG-BearerExtIEs} } OPTIONAL,
    ...
}

E-RABs-ToBeReleased-RelConfItem-SCG-BearerExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}
```

```
E-RABs-ToBeReleased-RelConfItem-Split-Bearer ::= SEQUENCE {
    e-RAB-ID                        E-RAB-ID,
    dL-Forwarding-GTPtunnelEndpoint         GTPtunnelEndpoint                                       OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeReleased-RelConfItem-Split-BearerExtIEs} } OPTIONAL,
    ...
}

E-RABs-ToBeReleased-RelConfItem-Split-BearerExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

-- **************************************************************
--
-- SENB COUNTER CHECK REQUEST
--
-- **************************************************************

SeNBCounterCheckRequest ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{SeNBCounterCheckRequest-IEs}},
    ...
}

SeNBCounterCheckRequest-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                     CRITICALITY ignore  TYPE UE-X2AP-ID                         PRESENCE mandatory}|
    { ID id-SeNB-UE-X2AP-ID                     CRITICALITY ignore  TYPE UE-X2AP-ID                         PRESENCE mandatory}|
    { ID id-E-RABs-SubjectToCounterCheck-List   CRITICALITY ignore  TYPE E-RABs-SubjectToCounterCheck-List   PRESENCE mandatory}|
    { ID id-MeNB-UE-X2AP-ID-Extension           CRITICALITY ignore  TYPE UE-X2AP-ID-Extension               PRESENCE optional}|
    { ID id-SeNB-UE-X2AP-ID-Extension           CRITICALITY ignore  TYPE UE-X2AP-ID-Extension               PRESENCE optional},
    ...
}
E-RABs-SubjectToCounterCheck-List ::= SEQUENCE (SIZE(1..maxnoofBearers)) OF ProtocolIE-Single-Container { {E-RABs-SubjectToCounterCheckItemIEs} }

E-RABs-SubjectToCounterCheckItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-SubjectToCounterCheckItem    CRITICALITY ignore  TYPE E-RABs-SubjectToCounterCheckItem    PRESENCE mandatory},
    ...
}

E-RABs-SubjectToCounterCheckItem ::= SEQUENCE {
    e-RAB-ID                        E-RAB-ID,
    uL-Count                        INTEGER (0..4294967295),
    dL-Count                        INTEGER (0..4294967295),
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-SubjectToCounterCheckItemExtIEs} } OPTIONAL,
    ...
}

E-RABs-SubjectToCounterCheckItemExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

-- **************************************************************
--
-- X2 REMOVAL REQUEST
--
```

```
-- **************************************************************

X2RemovalRequest ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{X2RemovalRequest-IEs}},
    ...
}

X2RemovalRequest-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-GlobalENB-ID                CRITICALITY reject  TYPE GlobalENB-ID           PRESENCE mandatory}|
    { ID id-X2RemovalThreshold          CRITICALITY reject  TYPE X2BenefitValue         PRESENCE optional},
...
}



-- **************************************************************
--
-- X2 REMOVAL RESPONSE
--
-- **************************************************************

X2RemovalResponse ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{X2RemovalResponse-IEs}},
    ...
}

X2RemovalResponse-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-GlobalENB-ID                CRITICALITY reject  TYPE GlobalENB-ID               PRESENCE mandatory}|
    { ID id-CriticalityDiagnostics      CRITICALITY ignore  TYPE CriticalityDiagnostics     PRESENCE optional},
    ...
}



-- **************************************************************
--
-- X2 REMOVAL FAILURE
--
-- **************************************************************

X2RemovalFailure ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{X2RemovalFailure-IEs}},
    ...
}

X2RemovalFailure-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-Cause                       CRITICALITY ignore  TYPE Cause                          PRESENCE mandatory}|
    { ID id-CriticalityDiagnostics      CRITICALITY ignore  TYPE CriticalityDiagnostics         PRESENCE optional},
    ...
}


-- **************************************************************
--
```

```
-- RETRIEVE UE CONTEXT REQUEST
--
-- **************************************************************

RetrieveUEContextRequest ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{ RetrieveUEContextRequest-IEs}},
    ...
}

RetrieveUEContextRequest-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-New-eNB-UE-X2AP-ID                  CRITICALITY reject  TYPE UE-X2AP-ID             PRESENCE mandatory}|
    { ID id-SeNB-UE-X2AP-ID-Extension           CRITICALITY reject  TYPE UE-X2AP-ID-Extension   PRESENCE optional}|
    { ID id-resumeID                            CRITICALITY reject  TYPE ResumeID               PRESENCE mandatory}|
    { ID id-ShortMAC-I                          CRITICALITY reject  TYPE ShortMAC-I             PRESENCE mandatory}|
    { ID id-NewEUTRANCellIdentifier             CRITICALITY reject  TYPE EUTRANCellIdentifier   PRESENCE mandatory}|
    {ID id-FailureCellCRNTI                     CRITICALITY reject  TYPE CRNTI                  PRESENCE optional}|
    {ID id-FailureCellPCI                       CRITICALITY reject  TYPE PCI                    PRESENCE optional},
    ...
}

-- **************************************************************
--
-- RETRIEVE UE CONTEXT RESPONSE
--
-- **************************************************************

RetrieveUEContextResponse ::= SEQUENCE {
    protocolIEs         ProtocolIE-Container    {{ RetrieveUEContextResponse-IEs}},
    ...
}

RetrieveUEContextResponse-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-New-eNB-UE-X2AP-ID              CRITICALITY ignore  TYPE UE-X2AP-ID                     PRESENCE mandatory}|
    { ID id-New-eNB-UE-X2AP-ID-Extension    CRITICALITY ignore  TYPE UE-X2AP-ID-Extension           PRESENCE optional}|
    { ID id-Old-eNB-UE-X2AP-ID              CRITICALITY ignore  TYPE UE-X2AP-ID                     PRESENCE mandatory}|
    { ID id-Old-eNB-UE-X2AP-ID-Extension    CRITICALITY ignore  TYPE UE-X2AP-ID-Extension           PRESENCE optional}|
    { ID id-GUMMEI-ID                       CRITICALITY reject  TYPE GUMMEI                         PRESENCE mandatory}|
    { ID id-UE-ContextInformationRetrieve   CRITICALITY reject  TYPE UE-ContextInformationRetrieve  PRESENCE mandatory}|
    { ID id-TraceActivation                 CRITICALITY ignore  TYPE TraceActivation                PRESENCE optional}|
    { ID id-SRVCCOperationPossible          CRITICALITY ignore  TYPE SRVCCOperationPossible         PRESENCE optional}|
    { ID id-Masked-IMEISV                   CRITICALITY ignore  TYPE Masked-IMEISV                  PRESENCE optional}|
    { ID id-ExpectedUEBehaviour             CRITICALITY ignore  TYPE ExpectedUEBehaviour            PRESENCE optional}|
    { ID id-ProSeAuthorized                 CRITICALITY ignore  TYPE ProSeAuthorized                PRESENCE optional}|
    { ID id-CriticalityDiagnostics          CRITICALITY ignore  TYPE CriticalityDiagnostics         PRESENCE optional}|
    { ID id-V2XServicesAuthorized           CRITICALITY ignore  TYPE V2XServicesAuthorized          PRESENCE optional}|
    { ID id-AerialUEsubscriptionInformation CRITICALITY ignore  TYPE AerialUEsubscriptionInformation PRESENCE optional},
    ...
}

UE-ContextInformationRetrieve ::= SEQUENCE {
    mME-UE-S1AP-ID                      UE-S1AP-ID,
    uESecurityCapabilities              UESecurityCapabilities,
    aS-SecurityInformation              AS-SecurityInformation,
    uEaggregateMaximumBitRate           UEAggregateMaximumBitRate,
```

```
    subscriberProfileIDforRFP           SubscriberProfileIDforRFP       OPTIONAL,
    e-RABs-ToBeSetup-ListRetrieve       E-RABs-ToBeSetup-ListRetrieve,
    rRC-Context                         RRC-Context,
    handoverRestrictionList             HandoverRestrictionList         OPTIONAL,
    locationReportingInformation        LocationReportingInformation    OPTIONAL,
    managBasedMDTallowed                ManagementBasedMDTallowed       OPTIONAL,
    managBasedMDTPLMNList               MDTPLMNList                     OPTIONAL,
    iE-Extensions                       ProtocolExtensionContainer { {UE-ContextInformationRetrieve-ExtIEs} } OPTIONAL,
    ...
}

UE-ContextInformationRetrieve-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
{ ID id-UESidelinkAggregateMaximumBitRate   CRITICALITY ignore  EXTENSION UESidelinkAggregateMaximumBitRate     PRESENCE optional},
    ...
}

E-RABs-ToBeSetup-ListRetrieve ::= SEQUENCE (SIZE(1..maxnoofBearers)) OF ProtocolIE-Single-Container { {E-RABs-ToBeSetupRetrieve-ItemIEs} }

E-RABs-ToBeSetupRetrieve-ItemIEs    X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-ToBeSetupRetrieve-Item   CRITICALITY ignore  TYPE E-RABs-ToBeSetupRetrieve-Item   PRESENCE mandatory},
    ...
}

E-RABs-ToBeSetupRetrieve-Item ::= SEQUENCE {
    e-RAB-ID                        E-RAB-ID,
    e-RAB-Level-QoS-Parameters      E-RAB-Level-QoS-Parameters,
    bearerType                      BearerType  OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeSetupRetrieve-ItemExtIEs} } OPTIONAL,
    ...
}

E-RABs-ToBeSetupRetrieve-ItemExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    { ID id-uL-GTPtunnelEndpoint        CRITICALITY reject  EXTENSION GTPtunnelEndpoint     PRESENCE mandatory},
    ...
}

-- **************************************************************
--
-- RETRIEVE UE CONTEXT FAILURE
--
-- **************************************************************

RetrieveUEContextFailure ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{ RetrieveUEContextFailure-IEs}},
    ...
}

RetrieveUEContextFailure-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-New-eNB-UE-X2AP-ID              CRITICALITY ignore  TYPE UE-X2AP-ID                 PRESENCE mandatory}|
    { ID id-New-eNB-UE-X2AP-ID-Extension    CRITICALITY ignore  TYPE UE-X2AP-ID-Extension       PRESENCE optional}|
    { ID id-Cause                           CRITICALITY ignore  TYPE Cause                      PRESENCE mandatory}|
    { ID id-CriticalityDiagnostics          CRITICALITY ignore  TYPE CriticalityDiagnostics     PRESENCE optional},
    ...
}
```

```
-- **************************************************************
--
-- SGNB ADDITION REQUEST
--
-- **************************************************************

SgNBAdditionRequest ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container {{SgNBAdditionRequest-IEs}},
    ...
}

SgNBAdditionRequest-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                         CRITICALITY reject  TYPE UE-X2AP-ID                             PRESENCE mandatory}|
    { ID id-NRUESecurityCapabilities                    CRITICALITY reject  TYPE NRUESecurityCapabilities            PRESENCE mandatory}|
    { ID id-SgNBSecurityKey                         CRITICALITY reject  TYPE SgNBSecurityKey                     PRESENCE mandatory}|
    { ID id-SgNBUEAggregateMaximumBitRate           CRITICALITY reject  TYPE UEAggregateMaximumBitRate           PRESENCE mandatory}|
    { ID id-SelectedPLMN                                CRITICALITY ignore  TYPE PLMN-Identity                   PRESENCE optional}|
    { ID id-HandoverRestrictionList                 CRITICALITY ignore  TYPE HandoverRestrictionList             PRESENCE optional}|
    { ID id-E-RABs-ToBeAdded-SgNBAddReqList         CRITICALITY reject  TYPE E-RABs-ToBeAdded-SgNBAddReqList     PRESENCE mandatory}|
    { ID id-MeNBtoSgNBContainer                     CRITICALITY reject  TYPE MeNBtoSgNBContainer                 PRESENCE mandatory}|
    { ID id-SgNB-UE-X2AP-ID                         CRITICALITY reject  TYPE SgNB-UE-X2AP-ID                     PRESENCE optional}|
    { ID id-ExpectedUEBehaviour                     CRITICALITY ignore  TYPE ExpectedUEBehaviour                 PRESENCE optional}|
    { ID id-MeNB-UE-X2AP-ID-Extension               CRITICALITY reject  TYPE UE-X2AP-ID-Extension                PRESENCE optional}|
    { ID id-RequestedSplitSRBs                      CRITICALITY reject  TYPE SplitSRBs                           PRESENCE optional}|
    { ID id-MeNBResourceCoordinationInformation     CRITICALITY ignore  TYPE MeNBResourceCoordinationInformation PRESENCE optional}|
    { ID id-SGNB-Addition-Trigger-Ind                CRITICALITY reject  TYPE SGNB-Addition-Trigger-Ind           PRESENCE optional}|
    { ID id-SubscriberProfileIDforRFP               CRITICALITY ignore  TYPE SubscriberProfileIDforRFP           PRESENCE optional}|
    { ID id-MeNBCell-ID                             CRITICALITY reject  TYPE ECGI                                PRESENCE mandatory},
    ...
}

E-RABs-ToBeAdded-SgNBAddReqList ::= SEQUENCE (SIZE(1..maxnoofBearers)) OF ProtocolIE-Single-Container { {E-RABs-ToBeAdded-SgNBAddReq-ItemIEs} }

E-RABs-ToBeAdded-SgNBAddReq-ItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-ToBeAdded-SgNBAddReq-Item        CRITICALITY reject  TYPE E-RABs-ToBeAdded-SgNBAddReq-Item    PRESENCE mandatory},
    ...
}

E-RABs-ToBeAdded-SgNBAddReq-Item ::= SEQUENCE {
    e-RAB-ID                                E-RAB-ID,
    drb-ID                                  DRB-ID,
    en-DC-ResourceConfiguration             EN-DC-ResourceConfiguration,
    resource-configuration                  CHOICE {
        sgNBPDCPpresent                         E-RABs-ToBeAdded-SgNBAddReq-Item-SgNBPDCPpresent,
        sgNBPDCPnotpresent                      E-RABs-ToBeAdded-SgNBAddReq-Item-SgNBPDCPnotpresent,
        ...
    },
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeAdded-SgNBAddReq-ItemExtIEs} }   OPTIONAL,
    ...
}

E-RABs-ToBeAdded-SgNBAddReq-ItemExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
```

```
}

E-RABs-ToBeAdded-SgNBAddReq-Item-SgNBPDCPpresent ::= SEQUENCE {
    full-E-RAB-Level-QoS-Parameters             E-RAB-Level-QoS-Parameters,
    max-MCG-admit-E-RAB-Level-QoS-Parameters    GBR-QosInformation                                                  OPTIONAL,
-- This IE shall be present if MCG resource and SCG resources IEs in the the EN-DC Resource Configuration IE are set to “present” and GBR QoS
Information IE is present in  Full E-RAB Level QoS Parameters IE --
    dL-Forwarding                               DL-Forwarding                                                       OPTIONAL,
    meNB-DL-GTP-TEIDatMCG                       GTPtunnelEndpoint                                                   OPTIONAL,
-- This IE shall be present if MCG resource IE in the the EN-DC Resource Configuration IE is set to “present” --
    s1-UL-GTPtunnelEndpoint                     GTPtunnelEndpoint,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeAdded-SgNBAddReq-Item-SgNBPDCPpresentExtIEs} } OPTIONAL,
    ...
}

E-RABs-ToBeAdded-SgNBAddReq-Item-SgNBPDCPpresentExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-ToBeAdded-SgNBAddReq-Item-SgNBPDCPnotpresent ::= SEQUENCE {
    requested-SCG-E-RAB-Level-QoS-Parameters        E-RAB-Level-QoS-Parameters,
    meNB-UL-GTP-TEIDatPDCP                          GTPtunnelEndpoint,
    secondary-meNB-UL-GTP-TEIDatPDCP                GTPtunnelEndpoint   OPTIONAL,
    rlc-Mode                                        RLCMode,
    uL-Configuration                                ULConfiguration OPTIONAL,
-- This IE shall be present if MCG resource and SCG resources IEs in the the EN-DC Resource Configuration IE are set to “present” --
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeAdded-SgNBAddReq-Item-SgNBPDCPnotpresentExtIEs} }     OPTIONAL,
    ...
}

E-RABs-ToBeAdded-SgNBAddReq-Item-SgNBPDCPnotpresentExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

-- **************************************************************
--
-- SGNB ADDITION REQUEST ACKNOWLEDGE
--
-- **************************************************************

SgNBAdditionRequestAcknowledge ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{SgNBAdditionRequestAcknowledge-IEs}},
    ...
}

SgNBAdditionRequestAcknowledge-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                             CRITICALITY reject  TYPE UE-X2AP-ID                                     PRESENCE mandatory}|
    { ID id-SgNB-UE-X2AP-ID                             CRITICALITY reject  TYPE SgNB-UE-X2AP-ID                                   PRESENCE
mandatory}|
    { ID id-E-RABs-Admitted-ToBeAdded-SgNBAddReqAckList CRITICALITY ignore  TYPE E-RABs-Admitted-ToBeAdded-SgNBAddReqAckList      PRESENCE
mandatory}|
    { ID id-E-RABs-NotAdmitted-List                     CRITICALITY ignore  TYPE E-RAB-List                                     PRESENCE optional}|
    { ID id-SgNBtoMeNBContainer                         CRITICALITY reject  TYPE SgNBtoMeNBContainer                            PRESENCE mandatory}|
    { ID id-CriticalityDiagnostics                      CRITICALITY ignore  TYPE CriticalityDiagnostics                         PRESENCE optional}|
```

```
    { ID id-MeNB-UE-X2AP-ID-Extension                CRITICALITY reject  TYPE UE-X2AP-ID-Extension                          PRESENCE optional}|
    { ID id-AdmittedSplitSRBs                        CRITICALITY reject  TYPE SplitSRBs                                  PRESENCE optional}|
    { ID id-SgNBResourceCoordinationInformation      CRITICALITY ignore  TYPE SgNBResourceCoordinationInformation        PRESENCE optional}|
    { ID id-RRCConfigIndication                      CRITICALITY reject  TYPE RRC-Config-Ind                            PRESENCE optional},
    ...
}

E-RABs-Admitted-ToBeAdded-SgNBAddReqAckList ::= SEQUENCE (SIZE (1..maxnoofBearers)) OF ProtocolIE-Single-Container { {E-RABs-Admitted-ToBeAdded-
SgNBAddReqAck-ItemIEs} }

E-RABs-Admitted-ToBeAdded-SgNBAddReqAck-ItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-Admitted-ToBeAdded-SgNBAddReqAck-Item    CRITICALITY ignore  TYPE E-RABs-Admitted-ToBeAdded-SgNBAddReqAck-Item    PRESENCE
mandatory}
}

E-RABs-Admitted-ToBeAdded-SgNBAddReqAck-Item ::= SEQUENCE {
    e-RAB-ID                                E-RAB-ID,
    en-DC-ResourceConfiguration         EN-DC-ResourceConfiguration,
    resource-configuration              CHOICE {
        sgNBPDCPpresent                     E-RABs-Admitted-ToBeAdded-SgNBAddReqAck-Item-SgNBPDCPpresent,
        sgNBPDCPnotpresent                  E-RABs-Admitted-ToBeAdded-SgNBAddReqAck-Item-SgNBPDCPnotpresent,
        ...
    },
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeAdded-SgNBAddReqAck-ItemExtIEs} }   OPTIONAL,
    ...
}

E-RABs-ToBeAdded-SgNBAddReqAck-ItemExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-Admitted-ToBeAdded-SgNBAddReqAck-Item-SgNBPDCPpresent ::= SEQUENCE {
    s1-DL-GTPtunnelEndpoint                 GTPtunnelEndpoint,
    sgNB-UL-GTP-TEIDatPDCP                  GTPtunnelEndpoint                                                                   OPTIONAL,
-- This IE shall be present if MCG resource IE in the the EN-DC Resource Configuration IE is set to “present” --
    rlc-Mode                                RLCMode                                                                             OPTIONAL,
-- This IE shall be present if MCG resource IE in the the EN-DC Resource Configuration IE is set to “present” --
    dL-Forwarding-GTPtunnelEndpoint         GTPtunnelEndpoint                                                                   OPTIONAL,
    uL-Forwarding-GTPtunnelEndpoint         GTPtunnelEndpoint                                                                   OPTIONAL,
    mCG-E-RAB-Level-QoS-Parameters          E-RAB-Level-QoS-Parameters                                                          OPTIONAL,
-- This IE shall be present if MCG resource and SCG resource IEs in the the EN-DC Resource Configuration IE are set to “present” and the GBR QoS
Information IE is present in the Requested MCG E-RAB Level QoS Parameters IE --
    uL-Configuration                            ULConfiguration                                                                     OPTIONAL,
-- This IE shall be present if MCG resource and SCG resources IEs in the the EN-DC Resource Configuration IE are set to “present” --
    iE-Extensions                           ProtocolExtensionContainer { {E-RABs-Admitted-ToBeAdded-SgNBAddReqAck-Item-SgNBPDCPpresentExtIEs} }
        OPTIONAL,
    ...
}

E-RABs-Admitted-ToBeAdded-SgNBAddReqAck-Item-SgNBPDCPpresentExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-Admitted-ToBeAdded-SgNBAddReqAck-Item-SgNBPDCPnotpresent ::= SEQUENCE {
```

```
    sgNB-DL-GTP-TEIDatSCG               GTPtunnelEndpoint,
    secondary-sgNB-DL-GTP-TEIDatSCG     GTPtunnelEndpoint       OPTIONAL,
    iE-Extensions                       ProtocolExtensionContainer { {E-RABs-Admitted-ToBeAdded-SgNBAddReqAck-Item-SgNBPDCPnotpresentExtIEs} }
    OPTIONAL,
    ...
}

E-RABs-Admitted-ToBeAdded-SgNBAddReqAck-Item-SgNBPDCPnotpresentExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}



-- **************************************************************
--
-- SGNB ADDITION REQUEST REJECT
--
-- **************************************************************

SgNBAdditionRequestReject ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{SgNBAdditionRequestReject-IEs}},
    ...
}

SgNBAdditionRequestReject-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                 CRITICALITY reject  TYPE UE-X2AP-ID                 PRESENCE mandatory}|
    { ID id-SgNB-UE-X2AP-ID                 CRITICALITY reject  TYPE SgNB-UE-X2AP-ID            PRESENCE optional}|
    { ID id-Cause                           CRITICALITY ignore  TYPE Cause                      PRESENCE mandatory}|
    { ID id-CriticalityDiagnostics          CRITICALITY ignore  TYPE CriticalityDiagnostics     PRESENCE optional}|
    { ID id-MeNB-UE-X2AP-ID-Extension       CRITICALITY reject  TYPE UE-X2AP-ID-Extension       PRESENCE optional},
    ...
}


-- **************************************************************
--
-- SGNB RECONFIGURATION COMPLETE
--
-- **************************************************************

SgNBReconfigurationComplete ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{SgNBReconfigurationComplete-IEs}},
    ...
}

SgNBReconfigurationComplete-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                     CRITICALITY reject  TYPE UE-X2AP-ID                             PRESENCE mandatory}|
    { ID id-SgNB-UE-X2AP-ID                     CRITICALITY reject  TYPE SgNB-UE-X2AP-ID                        PRESENCE mandatory}|
    { ID id-ResponseInformationSgNBReconfComp   CRITICALITY ignore  TYPE ResponseInformationSgNBReconfComp      PRESENCE mandatory}|
    { ID id-MeNB-UE-X2AP-ID-Extension           CRITICALITY reject  TYPE UE-X2AP-ID-Extension                   PRESENCE optional},
    ...
}

ResponseInformationSgNBReconfComp ::= CHOICE {
```

```
    success-SgNBReconfComp              ResponseInformationSgNBReconfComp-SuccessItem,
    reject-by-MeNB-SgNBReconfComp       ResponseInformationSgNBReconfComp-RejectByMeNBItem,
    ...
}

ResponseInformationSgNBReconfComp-SuccessItem ::= SEQUENCE {
    meNBtoSgNBContainer             MeNBtoSgNBContainer                OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { {ResponseInformationSgNBReconfComp-SuccessItemExtIEs} } OPTIONAL,
    ...
}

ResponseInformationSgNBReconfComp-SuccessItemExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

ResponseInformationSgNBReconfComp-RejectByMeNBItem ::= SEQUENCE {
    cause                           Cause,
    iE-Extensions                   ProtocolExtensionContainer { {ResponseInformationSgNBReconfComp-RejectByMeNBItemExtIEs} }     OPTIONAL,
    ...
}

ResponseInformationSgNBReconfComp-RejectByMeNBItemExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}


-- **************************************************************
--
-- SGNB MODIFICATION REQUEST
--
-- **************************************************************

SgNBModificationRequest ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{ SgNBModificationRequest-IEs}},
    ...
}

SgNBModificationRequest-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                     CRITICALITY reject  TYPE UE-X2AP-ID                         PRESENCE mandatory}|
    { ID id-SgNB-UE-X2AP-ID                     CRITICALITY reject  TYPE SgNB-UE-X2AP-ID                    PRESENCE mandatory}|
    { ID id-Cause                               CRITICALITY ignore  TYPE Cause                              PRESENCE mandatory}|
    { ID id-SelectedPLMN                        CRITICALITY ignore  TYPE PLMN-Identity                      PRESENCE optional}|
    { ID id-HandoverRestrictionList             CRITICALITY ignore  TYPE HandoverRestrictionList            PRESENCE optional}|
    { ID    id-SCGConfigurationQuery            CRITICALITY ignore  TYPE SCGConfigurationQuery              PRESENCE optional}|
    { ID id-UE-ContextInformation-SgNBModReq    CRITICALITY reject  TYPE UE-ContextInformation-SgNBModReq    PRESENCE optional}|
    { ID id-MeNBtoSgNBContainer                 CRITICALITY ignore  TYPE MeNBtoSgNBContainer                PRESENCE optional}|
    { ID id-MeNB-UE-X2AP-ID-Extension           CRITICALITY reject  TYPE UE-X2AP-ID-Extension               PRESENCE optional}|
    { ID id-MeNBResourceCoordinationInformation CRITICALITY ignore  TYPE MeNBResourceCoordinationInformation PRESENCE optional}|
    { ID id-RequestedSplitSRBs                  CRITICALITY ignore  TYPE SplitSRBs                          PRESENCE optional}|
    { ID id-RequestedSplitSRBsrelease           CRITICALITY ignore  TYPE SplitSRBs                          PRESENCE optional},
    ...
}

UE-ContextInformation-SgNBModReq ::= SEQUENCE {
```

```
    nRUE-SecurityCapabilities       NRUESecurityCapabilities                                                OPTIONAL,
    sgNB-SecurityKey                SgNBSecurityKey                                                         OPTIONAL,
    sgNBUEAggregateMaximumBitRate   UEAggregateMaximumBitRate                                               OPTIONAL,
    e-RABs-ToBeAdded                E-RABs-ToBeAdded-SgNBModReq-List                                        OPTIONAL,
    e-RABs-ToBeModified             E-RABs-ToBeModified-SgNBModReq-List                                     OPTIONAL,
    e-RABs-ToBeReleased             E-RABs-ToBeReleased-SgNBModReq-List                                     OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { {UE-ContextInformationSgNBModReqExtIEs} }  OPTIONAL,
    ...
}

UE-ContextInformationSgNBModReqExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    {   ID id-SubscriberProfileIDforRFP                CRITICALITY ignore  EXTENSION SubscriberProfileIDforRFP                      PRESENCE
optional},
    ...
}

E-RABs-ToBeAdded-SgNBModReq-List ::= SEQUENCE (SIZE(1..maxnoofBearers)) OF ProtocolIE-Single-Container { {E-RABs-ToBeAdded-SgNBModReq-ItemIEs} }

E-RABs-ToBeAdded-SgNBModReq-ItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-ToBeAdded-SgNBModReq-Item        CRITICALITY ignore  TYPE E-RABs-ToBeAdded-SgNBModReq-Item    PRESENCE mandatory},
    ...
}

E-RABs-ToBeAdded-SgNBModReq-Item ::= SEQUENCE {
    e-RAB-ID                                E-RAB-ID,
    drb-ID                                  DRB-ID,
    en-DC-ResourceConfiguration             EN-DC-ResourceConfiguration,
    resource-configuration                  CHOICE {
        sgNBPDCPpresent                     E-RABs-ToBeAdded-SgNBModReq-Item-SgNBPDCPpresent,
        sgNBPDCPnotpresent                  E-RABs-ToBeAdded-SgNBModReq-Item-SgNBPDCPnotpresent,
        ...
    },
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeAdded-SgNBModReq-ItemExtIEs} }   OPTIONAL,
    ...
}

E-RABs-ToBeAdded-SgNBModReq-ItemExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-ToBeAdded-SgNBModReq-Item-SgNBPDCPpresent ::= SEQUENCE {
    full-E-RAB-Level-QoS-Parameters         E-RAB-Level-QoS-Parameters,
    max-MN-admit-E-RAB-Level-QoS-Parameters GBR-QosInformation                                              OPTIONAL,
-- This IE shall be present if MCG resource and SCG resources IEs in the the EN-DC Resource Configuration IE are set to “present” and GBR QoS
Information IE is present in  Full E-RAB Level QoS Parameters IE --
    dL-Forwarding                           DL-Forwarding                                                                   OPTIONAL,
    meNB-DL-GTP-TEIDatMCG                   GTPtunnelEndpoint                                                               OPTIONAL,
-- This IE shall be present if MCG resource IE in the the EN-DC Resource Configuration IE is set to “present” --
    s1-UL-GTPtunnelEndpoint                 GTPtunnelEndpoint,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeAdded-SgNBModReq-Item-SgNBPDCPpresentExtIEs} }    OPTIONAL,
    ...
}

E-RABs-ToBeAdded-SgNBModReq-Item-SgNBPDCPpresentExtIEs X2AP-PROTOCOL-EXTENSION ::= {
```

```
    ...
}

E-RABs-ToBeAdded-SgNBModReq-Item-SgNBPDCPnotpresent ::= SEQUENCE {
    requested-SCG-E-RAB-Level-QoS-Parameters        E-RAB-Level-QoS-Parameters,
    meNB-UL-GTP-TEIDatPDCP                          GTPtunnelEndpoint,
    secondary-meNB-UL-GTP-TEIDatPDCP                GTPtunnelEndpoint       OPTIONAL,
    rlc-Mode                                        RLCMode,
    uL-Configuration                                ULConfiguration                                         OPTIONAL,
-- This IE shall be present if MCG resource and SCG resources IEs in the the EN-DC Resource Configuration IE are set to “present” --
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeAdded-SgNBModReq-Item-SgNBPDCPnotpresentExtIEs} }    OPTIONAL,
    ...
}

E-RABs-ToBeAdded-SgNBModReq-Item-SgNBPDCPnotpresentExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}


E-RABs-ToBeModified-SgNBModReq-List ::= SEQUENCE (SIZE(1..maxnoofBearers)) OF ProtocolIE-Single-Container { {E-RABs-ToBeModified-SgNBModReq-
ItemIEs} }

E-RABs-ToBeModified-SgNBModReq-ItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-ToBeModified-SgNBModReq-Item CRITICALITY ignore  TYPE E-RABs-ToBeModified-SgNBModReq-Item     PRESENCE mandatory},
    ...
}


E-RABs-ToBeModified-SgNBModReq-Item ::= SEQUENCE {
    e-RAB-ID                            E-RAB-ID,
    en-DC-ResourceConfiguration         EN-DC-ResourceConfiguration,
    resource-configuration              CHOICE {
        sgNBPDCPpresent                     E-RABs-ToBeModified-SgNBModReq-Item-SgNBPDCPpresent,
        sgNBPDCPnotpresent                  E-RABs-ToBeModified-SgNBModReq-Item-SgNBPDCPnotpresent,
        ...
    },
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeModified-SgNBModReq-ItemExtIEs} }   OPTIONAL,
    ...
}

E-RABs-ToBeModified-SgNBModReq-ItemExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-ToBeModified-SgNBModReq-Item-SgNBPDCPpresent ::= SEQUENCE {
    full-E-RAB-Level-QoS-Parameters         E-RAB-Level-QoS-Parameters                                                  OPTIONAL,
    max-MN-admit-E-RAB-Level-QoS-Parameters E-RAB-Level-QoS-Parameters                                                  OPTIONAL,
    meNB-DL-GTP-TEIDatMCG                   GTPtunnelEndpoint                                                           OPTIONAL,
    s1-UL-GTPtunnelEndpoint                 GTPtunnelEndpoint                                                           OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeModified-SgNBModReq-Item-SgNBPDCPpresentExtIEs} } OPTIONAL,
    ...
}

E-RABs-ToBeModified-SgNBModReq-Item-SgNBPDCPpresentExtIEs X2AP-PROTOCOL-EXTENSION ::= {
```

```
    ...
}

E-RABs-ToBeModified-SgNBModReq-Item-SgNBPDCPnotpresent ::= SEQUENCE {
    requested-SCG-E-RAB-Level-QoS-Parameters        E-RAB-Level-QoS-Parameters                                                  OPTIONAL,
    meNB-UL-GTP-TEIDatPDCP                      GTPtunnelEndpoint                                                           OPTIONAL,
    uL-Configuration                                ULConfiguration                                                             OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeModified-SgNBModReq-Item-SgNBPDCPnotpresentExtIEs} } OPTIONAL,
    ...
}

E-RABs-ToBeModified-SgNBModReq-Item-SgNBPDCPnotpresentExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-ToBeReleased-SgNBModReq-List ::= SEQUENCE (SIZE(1..maxnoofBearers)) OF ProtocolIE-Single-Container { {E-RABs-ToBeReleased-SgNBModReq-
ItemIEs} }

E-RABs-ToBeReleased-SgNBModReq-ItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-ToBeReleased-SgNBModReq-Item CRITICALITY ignore  TYPE E-RABs-ToBeReleased-SgNBModReq-Item     PRESENCE mandatory},
    ...
}

E-RABs-ToBeReleased-SgNBModReq-Item ::= SEQUENCE {
    e-RAB-ID                            E-RAB-ID,
    en-DC-ResourceConfiguration         EN-DC-ResourceConfiguration,
    resource-configuration              CHOICE {
        sgNBPDCPpresent                     E-RABs-ToBeReleased-SgNBModReq-Item-SgNBPDCPpresent,
        sgNBPDCPnotpresent                  E-RABs-ToBeReleased-SgNBModReq-Item-SgNBPDCPnotpresent,
        ...
    },
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeReleased-SgNBModReq-ItemExtIEs} }   OPTIONAL,
    ...
}

E-RABs-ToBeReleased-SgNBModReq-ItemExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-ToBeReleased-SgNBModReq-Item-SgNBPDCPpresent ::= SEQUENCE {
    dL-GTPtunnelEndpoint            GTPtunnelEndpoint                                                               OPTIONAL,
    uL-GTPtunnelEndpoint            GTPtunnelEndpoint                                                               OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeReleased-SgNBModReq-Item-SgNBPDCPpresentExtIEs} } OPTIONAL,
    ...
}

E-RABs-ToBeReleased-SgNBModReq-Item-SgNBPDCPpresentExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-ToBeReleased-SgNBModReq-Item-SgNBPDCPnotpresent ::= SEQUENCE {
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeReleased-SgNBModReq-Item-SgNBPDCPnotpresentExtIEs} } OPTIONAL,
    ...
}
```

```
E-RABs-ToBeReleased-SgNBModReq-Item-SgNBPDCPnotpresentExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}



-- **************************************************************
--
-- SGNB MODIFICATION REQUEST ACKNOWLEDGE
--
-- **************************************************************

SgNBModificationRequestAcknowledge ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{SgNBModificationRequestAcknowledge-IEs}},
    ...
}

SgNBModificationRequestAcknowledge-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                          CRITICALITY ignore  TYPE UE-X2AP-ID                                    PRESENCE mandatory}|
    { ID id-SgNB-UE-X2AP-ID                          CRITICALITY ignore  TYPE SgNB-UE-X2AP-ID                                  PRESENCE
mandatory}|
    { ID id-E-RABs-Admitted-ToBeAdded-SgNBModAckList       CRITICALITY ignore  TYPE E-RABs-Admitted-ToBeAdded-SgNBModAckList       PRESENCE
optional}|
    { ID id-E-RABs-Admitted-ToBeModified-SgNBModAckList CRITICALITY ignore  TYPE E-RABs-Admitted-ToBeModified-SgNBModAckList   PRESENCE optional}|
    { ID id-E-RABs-Admitted-ToBeReleased-SgNBModAckList CRITICALITY ignore  TYPE E-RABs-Admitted-ToBeReleased-SgNBModAckList   PRESENCE optional}|
    { ID id-E-RABs-NotAdmitted-List                  CRITICALITY ignore  TYPE E-RAB-List                                     PRESENCE optional}|
    { ID id-SgNBtoMeNBContainer                      CRITICALITY ignore  TYPE SgNBtoMeNBContainer                            PRESENCE optional}|
    { ID id-CriticalityDiagnostics                   CRITICALITY ignore  TYPE CriticalityDiagnostics                         PRESENCE optional}|
    { ID id-MeNB-UE-X2AP-ID-Extension                CRITICALITY ignore  TYPE UE-X2AP-ID-Extension                           PRESENCE optional}|
    { ID id-SgNBResourceCoordinationInformation      CRITICALITY ignore  TYPE SgNBResourceCoordinationInformation            PRESENCE optional}|
    { ID id-AdmittedSplitSRBs                        CRITICALITY ignore  TYPE SplitSRBs                                      PRESENCE optional}|
    { ID id-AdmittedSplitSRBsrelease                     CRITICALITY ignore  TYPE SplitSRBs                                  PRESENCE
optional},
    ...
}

E-RABs-Admitted-ToBeAdded-SgNBModAckList ::= SEQUENCE (SIZE (1..maxnoofBearers)) OF ProtocolIE-Single-Container { {E-RABs-Admitted-ToBeAdded-
SgNBModAck-ItemIEs} }

E-RABs-Admitted-ToBeAdded-SgNBModAck-ItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-Admitted-ToBeAdded-SgNBModAck-Item   CRITICALITY ignore  TYPE E-RABs-Admitted-ToBeAdded-SgNBModAck-Item     PRESENCE mandatory}
}

E-RABs-Admitted-ToBeAdded-SgNBModAck-Item ::= SEQUENCE {
    e-RAB-ID                            E-RAB-ID,
    en-DC-ResourceConfiguration         EN-DC-ResourceConfiguration,
    resource-configuration              CHOICE {
        sgNBPDCPpresent                     E-RABs-Admitted-ToBeAdded-SgNBModAck-Item-SgNBPDCPpresent,
        sgNBPDCPnotpresent                  E-RABs-Admitted-ToBeAdded-SgNBModAck-Item-SgNBPDCPnotpresent,
        ...
    },
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-Admitted-ToBeAdded-SgNBModAck-ItemExtIEs} }   OPTIONAL,
    ...
```

```
}

E-RABs-Admitted-ToBeAdded-SgNBModAck-ItemExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-Admitted-ToBeAdded-SgNBModAck-Item-SgNBPDCPpresent ::= SEQUENCE {
    s1-DL-GTPtunnelEndpoint                GTPtunnelEndpoint,
    sgNB-UL-GTP-TEIDatPDCP                 GTPtunnelEndpoint                                                    OPTIONAL,
-- This IE shall be present if MCG resource IE in the the EN-DC Resource Configuration IE are set to “present” --
    rlc-Mode                                   RLCMode                                                          OPTIONAL,
-- This IE shall be present if MCG resource IE in the the EN-DC Resource Configuration IE are set to “present” --
    dL-Forwarding-GTPtunnelEndpoint        GTPtunnelEndpoint                                                    OPTIONAL,
    uL-Forwarding-GTPtunnelEndpoint        GTPtunnelEndpoint                                                    OPTIONAL,
    mCG-E-RAB-Level-QoS-Parameters         E-RAB-Level-QoS-Parameters                                           OPTIONAL,
-- This IE shall be present if MCG resource and SCG resource IEs in the the EN-DC Resource Configuration IE are set to “present” and the GBR QoS
Information IE is present in the Requested MCG E-RAB Level QoS Parameters IE --
    uL-Configuration                       ULConfiguration                                                      OPTIONAL,
-- This IE shall be present if MCG resource and SCG resources IEs in the the EN-DC Resource Configuration IE are set to “present” --
    iE-Extensions                  ProtocolExtensionContainer { {E-RABs-Admitted-ToBeAdded-SgNBModAck-Item-SgNBPDCPpresentExtIEs} }    OPTIONAL,
    ...
}

E-RABs-Admitted-ToBeAdded-SgNBModAck-Item-SgNBPDCPpresentExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-Admitted-ToBeAdded-SgNBModAck-Item-SgNBPDCPnotpresent ::= SEQUENCE {
    sgNB-DL-GTP-TEIDatSCG                  GTPtunnelEndpoint,
    secondary-sgNB-DL-GTP-TEIDatSCG        GTPtunnelEndpoint           OPTIONAL,
    iE-Extensions                  ProtocolExtensionContainer { {E-RABs-Admitted-ToBeAdded-SgNBModAck-Item-SgNBPDCPnotpresentExtIEs} } OPTIONAL,
    ...
}

E-RABs-Admitted-ToBeAdded-SgNBModAck-Item-SgNBPDCPnotpresentExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-Admitted-ToBeModified-SgNBModAckList ::= SEQUENCE (SIZE (1..maxnoofBearers)) OF ProtocolIE-Single-Container { {E-RABs-Admitted-ToBeModified-
SgNBModAck-ItemIEs} }

E-RABs-Admitted-ToBeModified-SgNBModAck-ItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-Admitted-ToBeModified-SgNBModAck-Item        CRITICALITY ignore  TYPE E-RABs-Admitted-ToBeModified-SgNBModAck-Item   PRESENCE
mandatory}
}

E-RABs-Admitted-ToBeModified-SgNBModAck-Item ::= SEQUENCE {
    e-RAB-ID                               E-RAB-ID,
    en-DC-ResourceConfiguration        EN-DC-ResourceConfiguration,
    resource-configuration             CHOICE {
        sgNBPDCPpresent                    E-RABs-Admitted-ToBeModified-SgNBModAck-Item-SgNBPDCPpresent,
        sgNBPDCPnotpresent                 E-RABs-Admitted-ToBeModified-SgNBModAck-Item-SgNBPDCPnotpresent,
        ...
    },
```

```
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeAdded-SgNBModAck-ItemExtIEs} }   OPTIONAL,
    ...
}

E-RABs-ToBeAdded-SgNBModAck-ItemExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-Admitted-ToBeModified-SgNBModAck-Item-SgNBPDCPpresent ::= SEQUENCE {
    s1-DL-GTPtunnelEndpoint                 GTPtunnelEndpoint                                                   OPTIONAL,
    sgNB-UL-GTP-TEIDatPDCP                  GTPtunnelEndpoint                                                   OPTIONAL,
    mCG-E-RAB-Level-QoS-Parameters          E-RAB-Level-QoS-Parameters                                          OPTIONAL,
    uL-Configuration                            ULConfiguration                                                   OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-Admitted-ToBeModified-SgNBModAck-Item-SgNBPDCPpresentExtIEs} } OPTIONAL,
    ...
}

E-RABs-Admitted-ToBeModified-SgNBModAck-Item-SgNBPDCPpresentExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-Admitted-ToBeModified-SgNBModAck-Item-SgNBPDCPnotpresent ::= SEQUENCE {
    sgNB-DL-GTP-TEIDatSCG                   GTPtunnelEndpoint
    OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-Admitted-ToBeModified-SgNBModAck-Item-SgNBPDCPnotpresentExtIEs} }
    OPTIONAL,
    ...
}

E-RABs-Admitted-ToBeModified-SgNBModAck-Item-SgNBPDCPnotpresentExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-Admitted-ToBeReleased-SgNBModAckList ::= SEQUENCE (SIZE (1..maxnoofBearers)) OF ProtocolIE-Single-Container { {E-RABs-Admitted-ToBeReleased-
SgNBModAck-ItemIEs} }

E-RABs-Admitted-ToBeReleased-SgNBModAck-ItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-Admitted-ToBeReleased-SgNBModAck-Item        CRITICALITY ignore  TYPE E-RABs-Admitted-ToReleased-SgNBModAck-Item     PRESENCE
mandatory}
}

E-RABs-Admitted-ToReleased-SgNBModAck-Item ::= SEQUENCE {
    e-RAB-ID                            E-RAB-ID,
    en-DC-ResourceConfiguration         EN-DC-ResourceConfiguration,
    resource-configuration              CHOICE {
        sgNBPDCPpresent                     E-RABs-Admitted-ToBeReleased-SgNBModAck-Item-SgNBPDCPpresent,
        sgNBPDCPnotpresent                  E-RABs-Admitted-ToBeReleased-SgNBModAck-Item-SgNBPDCPnotpresent,
        ...
    },
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeReleased-SgNBModAck-ItemExtIEs} }   OPTIONAL,
    ...
}

E-RABs-ToBeReleased-SgNBModAck-ItemExtIEs X2AP-PROTOCOL-EXTENSION ::= {
```

```
    ...
}

E-RABs-Admitted-ToBeReleased-SgNBModAck-Item-SgNBPDCPpresent ::= SEQUENCE {
    iE-Extensions               ProtocolExtensionContainer { {E-RABs-Admitted-ToBeReleased-SgNBModAck-Item-SgNBPDCPpresentExtIEs} }     OPTIONAL,
    ...
}

E-RABs-Admitted-ToBeReleased-SgNBModAck-Item-SgNBPDCPpresentExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-Admitted-ToBeReleased-SgNBModAck-Item-SgNBPDCPnotpresent ::= SEQUENCE {
    iE-Extensions               ProtocolExtensionContainer { {E-RABs-Admitted-ToBeReleased-SgNBModAck-Item-SgNBPDCPnotpresentExtIEs} } OPTIONAL,
    ...
}

E-RABs-Admitted-ToBeReleased-SgNBModAck-Item-SgNBPDCPnotpresentExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}


-- **************************************************************
--
-- SGNB MODIFICATION REQUEST REJECT
--
-- **************************************************************

SgNBModificationRequestReject ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{SgNBModificationRequestReject-IEs}},
    ...
}

SgNBModificationRequestReject-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                     CRITICALITY ignore  TYPE UE-X2AP-ID              PRESENCE mandatory}|
    { ID id-SgNB-UE-X2AP-ID                     CRITICALITY ignore  TYPE SgNB-UE-X2AP-ID            PRESENCE mandatory}|
    { ID id-Cause                               CRITICALITY ignore  TYPE Cause                   PRESENCE mandatory}|
    { ID id-CriticalityDiagnostics              CRITICALITY ignore  TYPE CriticalityDiagnostics  PRESENCE optional}|
    { ID id-MeNB-UE-X2AP-ID-Extension           CRITICALITY ignore  TYPE UE-X2AP-ID-Extension    PRESENCE optional},
    ...
}


-- **************************************************************
--
-- SGNB MODIFICATION REQUIRED
--
-- **************************************************************

SgNBModificationRequired ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container        {{SgNBModificationRequired-IEs}},
    ...
}
```

```
SgNBModificationRequired-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                          CRITICALITY reject  TYPE UE-X2AP-ID                            PRESENCE mandatory}|
    { ID id-SgNB-UE-X2AP-ID                          CRITICALITY reject  TYPE SgNB-UE-X2AP-ID                        PRESENCE mandatory}|
    { ID id-Cause                                    CRITICALITY ignore  TYPE Cause                               PRESENCE mandatory}|
    { ID id-PDCPChangeIndication                         CRITICALITY ignore  TYPE PDCPChangeIndication                   PRESENCE optional}|
    { ID id-E-RABs-ToBeReleased-SgNBModReqdList      CRITICALITY ignore  TYPE E-RABs-ToBeReleased-SgNBModReqdList  PRESENCE optional}|
    { ID id-SgNBtoMeNBContainer                      CRITICALITY ignore  TYPE SgNBtoMeNBContainer                 PRESENCE optional}|
    { ID id-MeNB-UE-X2AP-ID-Extension                CRITICALITY reject  TYPE UE-X2AP-ID-Extension                PRESENCE optional}|
    { ID id-E-RABs-ToBeModified-SgNBModReqdList      CRITICALITY ignore  TYPE E-RABs-ToBeModified-SgNBModReqdList  PRESENCE optional}|
    { ID id-SgNBResourceCoordinationInformation      CRITICALITY ignore  TYPE SgNBResourceCoordinationInformation  PRESENCE optional},
    ...
}


E-RABs-ToBeReleased-SgNBModReqdList ::= SEQUENCE (SIZE (1..maxnoofBearers)) OF ProtocolIE-Single-Container { {E-RABs-ToBeReleased-SgNBModReqd-
ItemIEs} }

E-RABs-ToBeReleased-SgNBModReqd-ItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-ToBeReleased-SgNBModReqd-Item     CRITICALITY ignore     TYPE E-RABs-ToBeReleased-SgNBModReqd-Item    PRESENCE mandatory },
    ...
}

E-RABs-ToBeReleased-SgNBModReqd-Item ::= SEQUENCE {
    e-RAB-ID                            E-RAB-ID,
    cause                           Cause,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeReleased-SgNBModReqd-ItemExtIEs} } OPTIONAL,
    ...
}

E-RABs-ToBeReleased-SgNBModReqd-ItemExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-ToBeModified-SgNBModReqdList ::= SEQUENCE (SIZE (1..maxnoofBearers)) OF ProtocolIE-Single-Container { {E-RABs-ToBeModified-SgNBModReqd-
ItemIEs} }

E-RABs-ToBeModified-SgNBModReqd-ItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-ToBeModified-SgNBModReqd-Item     CRITICALITY ignore     TYPE E-RABs-ToBeModified-SgNBModReqd-Item    PRESENCE mandatory },
    ...
}

E-RABs-ToBeModified-SgNBModReqd-Item ::= SEQUENCE {
    e-RAB-ID                                E-RAB-ID,
    en-DC-ResourceConfiguration         EN-DC-ResourceConfiguration,
    resource-configuration              CHOICE {
        sgNBPDCPpresent                     E-RABs-ToBeModified-SgNBModReqd-Item-SgNBPDCPpresent,
        sgNBPDCPnotpresent                  E-RABs-ToBeModified-SgNBModReqd-Item-SgNBPDCPnotpresent,
        ...
    },
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeModified-SgNBModReqd-ItemExtIEs} }  OPTIONAL,
    ...
}

E-RABs-ToBeModified-SgNBModReqd-ItemExtIEs X2AP-PROTOCOL-EXTENSION ::= {
```

```
    ...
}

E-RABs-ToBeModified-SgNBModReqd-Item-SgNBPDCPpresent ::= SEQUENCE {
    requested-MCG-E-RAB-Level-QoS-Parameters        E-RAB-Level-QoS-Parameters                                      OPTIONAL,
    uL-Configuration                                ULConfiguration                                                 OPTIONAL,
    sgNB-UL-GTP-TEIDatPDCP                      GTPtunnelEndpoint                                                 OPTIONAL,
    s1-DL-GTP-TEIDatSgNB                            GTPtunnelEndpoint                                               OPTIONAL,
    iE-Extensions               ProtocolExtensionContainer { {E-RABs-ToBeModified-SgNBModReqd-Item-SgNBPDCPpresentExtIEs} }    OPTIONAL,
    ...
}

E-RABs-ToBeModified-SgNBModReqd-Item-SgNBPDCPpresentExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-ToBeModified-SgNBModReqd-Item-SgNBPDCPnotpresent ::= SEQUENCE {
    sgNB-DL-GTP-TEIDatSCG               GTPtunnelEndpoint               OPTIONAL,
    secondary-sgNB-DL-GTP-TEIDatSCG     GTPtunnelEndpoint               OPTIONAL,
    iE-Extensions               ProtocolExtensionContainer { {E-RABs-ToBeModified-SgNBModReqd-Item-SgNBPDCPnotpresentExtIEs} }    OPTIONAL,
    ...
}

E-RABs-ToBeModified-SgNBModReqd-Item-SgNBPDCPnotpresentExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}


-- **************************************************************
--
-- SGNB MODIFICATION CONFIRM
--
-- **************************************************************

SgNBModificationConfirm ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{SgNBModificationConfirm-IEs}},
    ...
}

SgNBModificationConfirm-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                                 CRITICALITY ignore  TYPE UE-X2AP-ID                                 PRESENCE mandatory}|
    { ID id-SgNB-UE-X2AP-ID                                 CRITICALITY ignore  TYPE SgNB-UE-X2AP-ID                            PRESENCE mandatory}|
    { ID id-E-RABs-AdmittedToBeModified-SgNBModConfList     CRITICALITY ignore  TYPE E-RABs-AdmittedToBeModified-SgNBModConfList     PRESENCE
optional}|
    { ID id-MeNBtoSgNBContainer                             CRITICALITY ignore  TYPE MeNBtoSgNBContainer                        PRESENCE optional}|
    { ID id-CriticalityDiagnostics                          CRITICALITY ignore  TYPE CriticalityDiagnostics                     PRESENCE optional}|
    { ID id-MeNB-UE-X2AP-ID-Extension                       CRITICALITY ignore  TYPE UE-X2AP-ID-Extension                       PRESENCE optional}|
    { ID id-MeNBResourceCoordinationInformation             CRITICALITY ignore  TYPE MeNBResourceCoordinationInformation    PRESENCE optional},
    ...
}

E-RABs-AdmittedToBeModified-SgNBModConfList ::= SEQUENCE (SIZE (1..maxnoofBearers)) OF ProtocolIE-Single-Container
    { {E-RABs-AdmittedToBeModified-SgNBModConf-ItemIEs} }
```

```
E-RABs-AdmittedToBeModified-SgNBModConf-ItemIEs X2AP-PROTOCOL-IES ::= {
{ ID id-E-RABs-AdmittedToBeModified-SgNBModConf-Item     CRITICALITY ignore TYPE E-RABs-AdmittedToBeModified-SgNBModConf-Item   PRESENCE
mandatory },
    ...
}

E-RABs-AdmittedToBeModified-SgNBModConf-Item ::= SEQUENCE {
    e-RAB-ID                                E-RAB-ID,
    en-DC-ResourceConfiguration         EN-DC-ResourceConfiguration,
    resource-configuration              CHOICE {
        sgNBPDCPpresent                     E-RABs-AdmittedToBeModified-SgNBModConf-Item-SgNBPDCPpresent,
        sgNBPDCPnotpresent                  E-RABs-AdmittedToBeModified-SgNBModConf-Item-SgNBPDCPnotpresent,
        ...
    },
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-AdmittedToBeModified-SgNBModConf-ItemExtIEs} }   OPTIONAL,
    ...
}

E-RABs-AdmittedToBeModified-SgNBModConf-ItemExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-AdmittedToBeModified-SgNBModConf-Item-SgNBPDCPpresent ::= SEQUENCE {
    iE-Extensions               ProtocolExtensionContainer { {E-RABs-AdmittedToBeModified-SgNBModConf-Item-SgNBPDCPpresentExtIEs} }     OPTIONAL,
    ...
}

E-RABs-AdmittedToBeModified-SgNBModConf-Item-SgNBPDCPpresentExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-AdmittedToBeModified-SgNBModConf-Item-SgNBPDCPnotpresent ::= SEQUENCE {
    secondary-meNB-UL-GTP-TEIDatPDCP                GTPtunnelEndpoint               OPTIONAL,
    iE-Extensions               ProtocolExtensionContainer { {E-RABs-AdmittedToBeModified-SgNBModConf-Item-SgNBPDCPnotpresentExtIEs} }
    OPTIONAL,
    ...
}

E-RABs-AdmittedToBeModified-SgNBModConf-Item-SgNBPDCPnotpresentExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

-- **************************************************************
--
-- SGNB MODIFICATION REFUSE
--
-- **************************************************************

SgNBModificationRefuse ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container        {{SgNBModificationRefuse-IEs}},
    ...
}

SgNBModificationRefuse-IEs X2AP-PROTOCOL-IES ::= {
```

```
    { ID id-MeNB-UE-X2AP-ID                    CRITICALITY ignore  TYPE UE-X2AP-ID              PRESENCE mandatory}|
    { ID id-SgNB-UE-X2AP-ID                    CRITICALITY ignore  TYPE SgNB-UE-X2AP-ID              PRESENCE mandatory}|
    { ID id-Cause                              CRITICALITY ignore  TYPE Cause                   PRESENCE mandatory}|
    { ID id-MeNBtoSgNBContainer                CRITICALITY ignore  TYPE MeNBtoSgNBContainer        PRESENCE optional}|
    { ID id-CriticalityDiagnostics             CRITICALITY ignore  TYPE CriticalityDiagnostics   PRESENCE optional}|
    { ID id-MeNB-UE-X2AP-ID-Extension          CRITICALITY ignore  TYPE UE-X2AP-ID-Extension     PRESENCE optional},
    ...
}

-- **************************************************************
--
-- SGNB RELEASE REQUEST
--
-- **************************************************************

SgNBReleaseRequest ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container        {{SgNBReleaseRequest-IEs}},
    ...
}

SgNBReleaseRequest-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                        CRITICALITY reject  TYPE UE-X2AP-ID                            PRESENCE mandatory}|
    { ID id-SgNB-UE-X2AP-ID                        CRITICALITY reject  TYPE SgNB-UE-X2AP-ID                          PRESENCE optional}|
    { ID id-Cause                                  CRITICALITY ignore  TYPE Cause                                 PRESENCE mandatory}|
    { ID id-E-RABs-ToBeReleased-SgNBRelReqList     CRITICALITY ignore  TYPE E-RABs-ToBeReleased-SgNBRelReqList     PRESENCE optional}|
    { ID id-UE-ContextKeptIndicator                CRITICALITY ignore  TYPE UE-ContextKeptIndicator                PRESENCE optional}|
    { ID id-MeNB-UE-X2AP-ID-Extension              CRITICALITY reject  TYPE UE-X2AP-ID-Extension                   PRESENCE optional}|
    { ID id-MeNBtoSgNBContainer                    CRITICALITY reject  TYPE MeNBtoSgNBContainer                      PRESENCE optional},
    ...
}

E-RABs-ToBeReleased-SgNBRelReqList ::= SEQUENCE (SIZE(1..maxnoofBearers)) OF ProtocolIE-Single-Container { {E-RABs-ToBeReleased-SgNBRelReq-
ItemIEs} }

E-RABs-ToBeReleased-SgNBRelReq-ItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-ToBeReleased-SgNBRelReq-Item     CRITICALITY ignore  TYPE E-RABs-ToBeReleased-SgNBRelReq-Item   PRESENCE mandatory},
    ...
}

E-RABs-ToBeReleased-SgNBRelReq-Item ::= SEQUENCE {
    e-RAB-ID                            E-RAB-ID,
    en-DC-ResourceConfiguration         EN-DC-ResourceConfiguration,
    resource-configuration              CHOICE {
        sgNBPDCPpresent                     E-RABs-ToBeReleased-SgNBRelReq-Item-SgNBPDCPpresent,
        sgNBPDCPnotpresent                  E-RABs-ToBeReleased-SgNBRelReq-Item-SgNBPDCPnotpresent,
        ...
    },
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeReleased-SgNBRelReq-ItemExtIEs} }   OPTIONAL,
    ...
}

E-RABs-ToBeReleased-SgNBRelReq-ItemExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}
```

```
E-RABs-ToBeReleased-SgNBRelReq-Item-SgNBPDCPpresent ::= SEQUENCE {
    uL-GTPtunnelEndpoint            GTPtunnelEndpoint                                                   OPTIONAL,
    dL-GTPtunnelEndpoint            GTPtunnelEndpoint                                                       OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeReleased-SgNBRelReq-Item-SgNBPDCPpresentExtIEs} } OPTIONAL,
    ...
}

E-RABs-ToBeReleased-SgNBRelReq-Item-SgNBPDCPpresentExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-ToBeReleased-SgNBRelReq-Item-SgNBPDCPnotpresent ::= SEQUENCE {
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeReleased-SgNBRelReq-Item-SgNBPDCPnotpresentExtIEs} } OPTIONAL,
    ...
}

E-RABs-ToBeReleased-SgNBRelReq-Item-SgNBPDCPnotpresentExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

-- **************************************************************
--
-- SGNB RELEASE REQUEST ACKNOWLEDGE
--
-- **************************************************************

SgNBReleaseRequestAcknowledge ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container        {{SgNBReleaseRequestAcknowledge-IEs}},
    ...
}

SgNBReleaseRequestAcknowledge-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                     CRITICALITY reject  TYPE UE-X2AP-ID                         PRESENCE mandatory}|
    { ID id-SgNB-UE-X2AP-ID                     CRITICALITY reject  TYPE SgNB-UE-X2AP-ID                       PRESENCE mandatory}|
    { ID id-CriticalityDiagnostics              CRITICALITY ignore  TYPE CriticalityDiagnostics             PRESENCE optional}|
    { ID id-MeNB-UE-X2AP-ID-Extension           CRITICALITY reject  TYPE UE-X2AP-ID-Extension               PRESENCE optional},
    ...
}

-- **************************************************************
--
-- SGNB RELEASE REQUEST REJECT
--
-- **************************************************************

SgNBReleaseRequestReject ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container        {{SgNBReleaseRequestReject-IEs}},
    ...
}

SgNBReleaseRequestReject-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                     CRITICALITY reject  TYPE UE-X2AP-ID                         PRESENCE mandatory}|
```

```
    { ID id-SgNB-UE-X2AP-ID                     CRITICALITY reject  TYPE SgNB-UE-X2AP-ID                     PRESENCE mandatory}|
    { ID id-Cause                               CRITICALITY ignore  TYPE Cause                               PRESENCE mandatory}|
    { ID id-CriticalityDiagnostics              CRITICALITY ignore  TYPE CriticalityDiagnostics              PRESENCE optional}|
    { ID id-MeNB-UE-X2AP-ID-Extension           CRITICALITY reject  TYPE UE-X2AP-ID-Extension                PRESENCE optional},
    ...
}

-- **************************************************************
--
-- SGNB RELEASE REQUIRED
--
-- **************************************************************

SgNBReleaseRequired ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{SgNBReleaseRequired-IEs}},
    ...
}

SgNBReleaseRequired-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                 CRITICALITY reject  TYPE UE-X2AP-ID                 PRESENCE mandatory}|
    { ID id-SgNB-UE-X2AP-ID                 CRITICALITY reject  TYPE SgNB-UE-X2AP-ID              PRESENCE mandatory}|
    { ID id-Cause                           CRITICALITY ignore  TYPE Cause                      PRESENCE mandatory}|
    { ID id-MeNB-UE-X2AP-ID-Extension       CRITICALITY reject  TYPE UE-X2AP-ID-Extension       PRESENCE optional},
    ...
}

-- **************************************************************
--
-- SGNB RELEASE CONFIRM
--
-- **************************************************************

SgNBReleaseConfirm ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{SgNBReleaseConfirm-IEs}},
    ...
}

SgNBReleaseConfirm-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                         CRITICALITY ignore  TYPE UE-X2AP-ID                         PRESENCE mandatory}|
    { ID id-SgNB-UE-X2AP-ID                         CRITICALITY ignore  TYPE SgNB-UE-X2AP-ID                     PRESENCE mandatory}|
    { ID id-E-RABs-ToBeReleased-SgNBRelConfList     CRITICALITY ignore  TYPE E-RABs-ToBeReleased-SgNBRelConfList  PRESENCE optional}|
    { ID id-CriticalityDiagnostics                  CRITICALITY ignore  TYPE CriticalityDiagnostics              PRESENCE optional}|
    { ID id-MeNB-UE-X2AP-ID-Extension               CRITICALITY ignore  TYPE UE-X2AP-ID-Extension                PRESENCE optional},
    ...
}

E-RABs-ToBeReleased-SgNBRelConfList ::= SEQUENCE (SIZE(1..maxnoofBearers)) OF ProtocolIE-Single-Container { {E-RABs-ToBeReleased-SgNBRelConf-
ItemIEs} }

E-RABs-ToBeReleased-SgNBRelConf-ItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-ToBeReleased-SgNBRelConf-Item        CRITICALITY ignore      TYPE E-RABs-ToBeReleased-SgNBRelConf-Item    PRESENCE mandatory},
    ...
}
```

```
E-RABs-ToBeReleased-SgNBRelConf-Item ::= SEQUENCE {
    e-RAB-ID                            E-RAB-ID,
    en-DC-ResourceConfiguration         EN-DC-ResourceConfiguration,
    resource-configuration              CHOICE {
        sgNBPDCPpresent                     E-RABs-ToBeReleased-SgNBRelConf-Item-SgNBPDCPpresent,
        sgNBPDCPnotpresent                  E-RABs-ToBeReleased-SgNBRelConf-Item-SgNBPDCPnotpresent,
        ...
    },
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeReleased-SgNBRelConf-ItemExtIEs} }  OPTIONAL,
    ...
}

E-RABs-ToBeReleased-SgNBRelConf-ItemExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-ToBeReleased-SgNBRelConf-Item-SgNBPDCPpresent ::= SEQUENCE {
    uL-GTPtunnelEndpoint            GTPtunnelEndpoint                                                                   OPTIONAL,
    dL-GTPtunnelEndpoint            GTPtunnelEndpoint                                                                   OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeReleased-SgNBRelConf-Item-SgNBPDCPpresentExtIEs} } OPTIONAL,
    ...
}

E-RABs-ToBeReleased-SgNBRelConf-Item-SgNBPDCPpresentExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-ToBeReleased-SgNBRelConf-Item-SgNBPDCPnotpresent ::= SEQUENCE {
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeReleased-SgNBRelConf-Item-SgNBPDCPnotpresentExtIEs} }   OPTIONAL,
    ...
}

E-RABs-ToBeReleased-SgNBRelConf-Item-SgNBPDCPnotpresentExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}


-- **************************************************************
--
-- SGNB COUNTER CHECK REQUEST
--
-- **************************************************************

SgNBCounterCheckRequest ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{SgNBCounterCheckRequest-IEs}},
    ...
}

SgNBCounterCheckRequest-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                             CRITICALITY ignore  TYPE UE-X2AP-ID                             PRESENCE mandatory}|
    { ID id-SgNB-UE-X2AP-ID                             CRITICALITY ignore  TYPE SgNB-UE-X2AP-ID                           PRESENCE mandatory}|
    { ID id-E-RABs-SubjectToSgNBCounterCheck-List       CRITICALITY ignore  TYPE E-RABs-SubjectToSgNBCounterCheck-List   PRESENCE mandatory}|
    { ID id-MeNB-UE-X2AP-ID-Extension                   CRITICALITY ignore  TYPE UE-X2AP-ID-Extension                   PRESENCE optional},
    ...
```

```
}
E-RABs-SubjectToSgNBCounterCheck-List ::= SEQUENCE (SIZE(1..maxnoofBearers)) OF ProtocolIE-Single-Container { {E-RABs-SubjectToSgNBCounterCheck-
ItemIEs} }

E-RABs-SubjectToSgNBCounterCheck-ItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-SubjectToSgNBCounterCheck-Item       CRITICALITY ignore  TYPE E-RABs-SubjectToSgNBCounterCheck-Item    PRESENCE mandatory},
    ...
}

E-RABs-SubjectToSgNBCounterCheck-Item ::= SEQUENCE {
    e-RAB-ID                        E-RAB-ID,
    uL-Count                        INTEGER (0..4294967295),
    dL-Count                        INTEGER (0..4294967295),
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-SubjectToSgNBCounterCheck-ItemExtIEs} } OPTIONAL,
    ...
}

E-RABs-SubjectToSgNBCounterCheck-ItemExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

-- **************************************************************
--
-- SGNB CHANGE REQUIRED
--
-- **************************************************************

SgNBChangeRequired ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container        {{SgNBChangeRequired-IEs}},
    ...
}

SgNBChangeRequired-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                     CRITICALITY ignore  TYPE UE-X2AP-ID             PRESENCE mandatory}|
    { ID id-SgNB-UE-X2AP-ID                     CRITICALITY ignore  TYPE SgNB-UE-X2AP-ID           PRESENCE mandatory}|
    { ID id-Target-SgNB-ID                      CRITICALITY ignore  TYPE GNB-ID                 PRESENCE mandatory}|
    { ID id-Cause                               CRITICALITY ignore  TYPE Cause                  PRESENCE mandatory}|
    { ID id-SgNBtoMeNBContainer                 CRITICALITY ignore  TYPE SgNBtoMeNBContainer        PRESENCE optional}|
    { ID id-MeNB-UE-X2AP-ID-Extension           CRITICALITY reject  TYPE UE-X2AP-ID-Extension   PRESENCE optional},
    ...
}

-- **************************************************************
--
-- SGNB CHANGE CONFIRM
--
-- **************************************************************

SgNBChangeConfirm ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{SgNBChangeConfirm-IEs}},
    ...
}

SgNBChangeConfirm-IEs X2AP-PROTOCOL-IES ::= {
```

```
    { ID id-MeNB-UE-X2AP-ID                       CRITICALITY ignore  TYPE UE-X2AP-ID                            PRESENCE mandatory}|
    { ID id-SgNB-UE-X2AP-ID                       CRITICALITY ignore  TYPE SgNB-UE-X2AP-ID                        PRESENCE mandatory}|
    { ID id-E-RABs-ToBeReleased-SgNBChaConfList   CRITICALITY ignore  TYPE E-RABs-ToBeReleased-SgNBChaConfList  PRESENCE optional}|
    { ID id-CriticalityDiagnostics                CRITICALITY ignore  TYPE CriticalityDiagnostics              PRESENCE optional}|
    { ID id-MeNB-UE-X2AP-ID-Extension             CRITICALITY ignore  TYPE UE-X2AP-ID-Extension               PRESENCE optional},
    ...
}

E-RABs-ToBeReleased-SgNBChaConfList ::= SEQUENCE (SIZE(1..maxnoofBearers)) OF ProtocolIE-Single-Container { {E-RABs-ToBeReleased-SgNBChaConf-
ItemIEs} }

E-RABs-ToBeReleased-SgNBChaConf-ItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABs-ToBeReleased-SgNBChaConf-Item       CRITICALITY ignore      TYPE E-RABs-ToBeReleased-SgNBChaConf-Item   PRESENCE mandatory},
    ...
}

E-RABs-ToBeReleased-SgNBChaConf-Item ::= SEQUENCE {
    e-RAB-ID                            E-RAB-ID,
    en-DC-ResourceConfiguration         EN-DC-ResourceConfiguration,
    resource-configuration              CHOICE {
        sgNBPDCPpresent                     E-RABs-ToBeReleased-SgNBChaConf-Item-SgNBPDCPpresent,
        sgNBPDCPnotpresent                  E-RABs-ToBeReleased-SgNBChaConf-Item-SgNBPDCPnotpresent,
        ...
    },
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeReleased-SgNBChaConf-ItemExtIEs} } OPTIONAL,
    ...
}

E-RABs-ToBeReleased-SgNBChaConf-ItemExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-ToBeReleased-SgNBChaConf-Item-SgNBPDCPpresent ::= SEQUENCE {
    uL-GTPtunnelEndpoint            GTPtunnelEndpoint                                                                   OPTIONAL,
    dL-GTPtunnelEndpoint            GTPtunnelEndpoint                                                                   OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeReleased-SgNBChaConf-Item-SgNBPDCPpresentExtIEs} } OPTIONAL,
    ...
}

E-RABs-ToBeReleased-SgNBChaConf-Item-SgNBPDCPpresentExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABs-ToBeReleased-SgNBChaConf-Item-SgNBPDCPnotpresent ::= SEQUENCE {
    iE-Extensions                   ProtocolExtensionContainer { {E-RABs-ToBeReleased-SgNBChaConf-Item-SgNBPDCPnotpresentExtIEs} }   OPTIONAL,
    ...
}

E-RABs-ToBeReleased-SgNBChaConf-Item-SgNBPDCPnotpresentExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

-- **************************************************************
--
```

```
-- RRC Transfer
--
-- ************************************************************

RRCTransfer ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container        {{RRCTransfer-IEs}},
    ...
}

RRCTransfer-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                     CRITICALITY reject  TYPE UE-X2AP-ID              PRESENCE mandatory}|
    { ID id-SgNB-UE-X2AP-ID                     CRITICALITY reject  TYPE SgNB-UE-X2AP-ID           PRESENCE mandatory}|
    { ID id-SplitSRB                                CRITICALITY reject  TYPE SplitSRB              PRESENCE optional}|
    { ID id-UENRMeasurement                     CRITICALITY reject  TYPE UENRMeasurement           PRESENCE optional}|
    { ID id-MeNB-UE-X2AP-ID-Extension           CRITICALITY reject  TYPE UE-X2AP-ID-Extension     PRESENCE optional},
    ...
}

-- ************************************************************
--
-- SGNB CHANGE REFUSE
--
-- ************************************************************

SgNBChangeRefuse ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container        {{SgNBChangeRefuse-IEs}},
    ...
}

SgNBChangeRefuse-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                     CRITICALITY ignore  TYPE UE-X2AP-ID              PRESENCE mandatory}|
    { ID id-SgNB-UE-X2AP-ID                     CRITICALITY ignore  TYPE SgNB-UE-X2AP-ID           PRESENCE mandatory}|
    { ID id-Cause                               CRITICALITY ignore  TYPE Cause                     PRESENCE mandatory}|
    { ID id-CriticalityDiagnostics              CRITICALITY ignore  TYPE CriticalityDiagnostics    PRESENCE optional}|
    { ID id-MeNB-UE-X2AP-ID-Extension           CRITICALITY reject  TYPE UE-X2AP-ID-Extension     PRESENCE optional},
    ...
}

-- ************************************************************
--
-- EN-DC X2 SETUP REQUEST
--
-- ************************************************************

ENDCX2SetupRequest ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{ENDCX2SetupRequest-IEs}},
    ...
}

ENDCX2SetupRequest-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-InitiatingNodeType-EndcX2Setup          CRITICALITY reject  TYPE InitiatingNodeType-EndcX2Setup     PRESENCE mandatory},
    ...
}
```

```
InitiatingNodeType-EndcX2Setup ::= CHOICE {
    init-eNB               ProtocolIE-Container    {{ENB-ENDCX2SetupReqIEs}},
    init-en-gNB         ProtocolIE-Container    {{En-gNB-ENDCX2SetupReqIEs}},
    ...
}

ENB-ENDCX2SetupReqIEs X2AP-PROTOCOL-IES ::= {
    { ID id-GlobalENB-ID                              CRITICALITY reject  TYPE GlobalENB-ID                              PRESENCE mandatory}|
    { ID id-ServedEUTRAcellsENDCX2ManagementList      CRITICALITY reject  TYPE ServedEUTRAcellsENDCX2ManagementList    PRESENCE mandatory},
    ...
}

ServedEUTRAcellsENDCX2ManagementList ::= SEQUENCE (SIZE (1.. maxCellineNB)) OF SEQUENCE {
    servedEUTRACellInfo                ServedCell-Information,
    nrNeighbourInfo                    NRNeighbour-Information     OPTIONAL,
    iE-Extensions                      ProtocolExtensionContainer { { ServedEUTRAcellsENDCX2Management-ExtIEs} } OPTIONAL,
    ...
}

ServedEUTRAcellsENDCX2Management-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

En-gNB-ENDCX2SetupReqIEs X2AP-PROTOCOL-IES ::= {
    { ID id-Globalen-gNB-ID                         CRITICALITY reject  TYPE GlobalGNB-ID                            PRESENCE mandatory}|
    { ID id-ServedNRcellsENDCX2ManagementList       CRITICALITY reject  TYPE ServedNRcellsENDCX2ManagementList      PRESENCE mandatory},
    ...
}

ServedNRcellsENDCX2ManagementList ::= SEQUENCE (SIZE (1.. maxCellinengNB)) OF SEQUENCE {
    servedNRCellInfo                     ServedNRCell-Information,
    nRNeighbourInfo                    NRNeighbour-Information OPTIONAL,
    iE-Extensions                      ProtocolExtensionContainer { { En-gNBServedCells-ExtIEs} } OPTIONAL,
    ...
}

En-gNBServedCells-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

ServedNRCell-Information ::= SEQUENCE {
    nrpCI               NRPCI,
    nrCellID            NRCGI,
    fiveGS-TAC          FiveGS-TAC,
    configured-TAC      TAC         OPTIONAL,
    broadcastPLMNs      BroadcastPLMNs-Item,
    nrModeInfo          CHOICE {
        fdd     FDD-InfoServedNRCell-Information,
        tdd     TDD-InfoServedNRCell-Information,
        ...
    },
    measurementTimingConfiguration  OCTET STRING,
    iE-Extensions                      ProtocolExtensionContainer { { ServedNRCell-Information-ExtIEs} } OPTIONAL,
    ...
```

```
}

ServedNRCell-Information-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

FDD-InfoServedNRCell-Information ::= SEQUENCE {
    ul-NRFreqInfo               NRFreqInfo,
    dl-NRFreqInfo               NRFreqInfo,
    ul-NR-TxBW              NR-TxBW,
    dl-NR-TxBW              NR-TxBW,
    iE-Extensions           ProtocolExtensionContainer { { FDD-InfoServedNRCell-Information-ExtIEs } }    OPTIONAL,
    ...
}

FDD-InfoServedNRCell-Information-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

FDD-InfoNeighbourServedNRCell-Information ::= SEQUENCE {
    ul-NRFreqInfo           NRFreqInfo,
    dl-NRFreqInfo           NRFreqInfo,
    iE-Extensions           ProtocolExtensionContainer { { FDD-InfoNeighbourServedNRCell-Information-ExtIEs } }    OPTIONAL,
    ...
}

FDD-InfoNeighbourServedNRCell-Information-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

TDD-InfoServedNRCell-Information ::= SEQUENCE {
    nRFreqInfo              NRFreqInfo,
    nR-TxBW                 NR-TxBW,
    iE-Extensions           ProtocolExtensionContainer { { TDD-InfoServedNRCell-Information-ExtIEs } }    OPTIONAL,
    ...
}

TDD-InfoServedNRCell-Information-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

TDD-InfoNeighbourServedNRCell-Information ::= SEQUENCE {
    nRFreqInfo              NRFreqInfo,
    iE-Extensions           ProtocolExtensionContainer { { TDD-InfoNeighbourServedNRCell-Information-ExtIEs } }    OPTIONAL,
    ...
}

TDD-InfoNeighbourServedNRCell-Information-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

NRNeighbour-Information ::= SEQUENCE (SIZE (1.. maxofNRNeighbours))OF SEQUENCE {
    nrpCI               NRPCI,
    nrCellID                NRCGI,
```

```
    nrFreqInfo          NRFreqInfo,
    fiveGS-TAC          FiveGS-TAC,
    configured-TAC      TAC         OPTIONAL,
    measurementTimingConfiguration  OCTET STRING,
    nRNeighbourModeInfo         CHOICE {
        fdd     FDD-InfoNeighbourServedNRCell-Information,
        tdd     TDD-InfoNeighbourServedNRCell-Information,
        ...
    },
    iE-Extensions                       ProtocolExtensionContainer { { NRNeighbour-Information-ExtIEs} } OPTIONAL,
    ...
}

NRNeighbour-Information-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

CellAssistanceInformation ::= CHOICE {
    limited-list                Limited-list,
    full-list               ENUMERATED  {allServedNRcells, ...},
    ...
}


Limited-list    ::= SEQUENCE (SIZE (1..maxCellinengNB)) OF SEQUENCE {
    nrCellID            NRCGI,
        iE-Extensions                       ProtocolExtensionContainer { {Limited-list-ExtIEs} } OPTIONAL,
    ...
}

Limited-list-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

-- **************************************************************
--
-- EN-DC X2 SETUP RESPONSE
--
-- **************************************************************

ENDCX2SetupResponse ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{ENDCX2SetupResponse-IEs}},
    ...
}

ENDCX2SetupResponse-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-RespondingNodeType-EndcX2Setup      CRITICALITY reject  TYPE RespondingNodeType-EndcX2Setup    PRESENCE mandatory},
    ...
}

RespondingNodeType-EndcX2Setup ::= CHOICE {
    respond-eNB         ProtocolIE-Container    {{ENB-ENDCX2SetupReqAckIEs}},
    respond-en-gNB      ProtocolIE-Container    {{En-gNB-ENDCX2SetupReqAckIEs}},
    ...
```

```
}

ENB-ENDCX2SetupReqAckIEs X2AP-PROTOCOL-IES ::= {
    { ID id-GlobalENB-ID                            CRITICALITY reject  TYPE GlobalENB-ID                            PRESENCE mandatory}|
    { ID id-ServedEUTRAcellsENDCX2ManagementList    CRITICALITY reject  TYPE ServedEUTRAcellsENDCX2ManagementList    PRESENCE mandatory},
    ...
}


En-gNB-ENDCX2SetupReqAckIEs X2AP-PROTOCOL-IES ::= {
    { ID id-Globalen-gNB-ID                         CRITICALITY reject  TYPE GlobalGNB-ID                          PRESENCE mandatory}|
    { ID id-ServedNRcellsENDCX2ManagementList       CRITICALITY reject  TYPE ServedNRcellsENDCX2ManagementList    PRESENCE mandatory},
    ...
}

-- **************************************************************
--
-- EN-DC X2 SETUP FAILURE
--
-- **************************************************************

ENDCX2SetupFailure ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{ENDCX2SetupFailure-IEs}},
    ...
}

ENDCX2SetupFailure-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-Cause                   CRITICALITY ignore      TYPE Cause                          PRESENCE mandatory} |
    { ID id-CriticalityDiagnostics  CRITICALITY ignore      TYPE CriticalityDiagnostics         PRESENCE optional },
    ...
}

-- **************************************************************
--
-- EN-DC CONFIGURATION UPDATE
--
-- **************************************************************

ENDCConfigurationUpdate ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{ENDCConfigurationUpdate-IEs}},
    ...
}

ENDCConfigurationUpdate-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-InitiatingNodeType-EndcConfigUpdate         CRITICALITY reject  TYPE InitiatingNodeType-EndcConfigUpdate        PRESENCE mandatory},
    ...
}

InitiatingNodeType-EndcConfigUpdate::= CHOICE {
    init-eNB            ProtocolIE-Container    {{ENB-ENDCConfigUpdateIEs}},
    init-en-gNB         ProtocolIE-Container    {{En-gNB-ENDCConfigUpdateIEs}},
    ...
}
```

```
ENB-ENDCConfigUpdateIEs X2AP-PROTOCOL-IES ::= {
    { ID id-CellAssistanceInformation               CRITICALITY reject  TYPE CellAssistanceInformation                  PRESENCE optional }|
    { ID id-ServedEUTRAcellsENDCX2ManagementList        CRITICALITY reject  TYPE ServedEUTRAcellsENDCX2ManagementList      PRESENCE optional }|
    { ID id-ServedEUTRAcellsToModifyListENDCConfUpd CRITICALITY reject  TYPE ServedEUTRAcellsToModifyListENDCConfUpd    PRESENCE optional }|
    { ID id-ServedEUTRAcellsToDeleteListENDCConfUpd CRITICALITY reject  TYPE ServedEUTRAcellsToDeleteListENDCConfUpd    PRESENCE optional },
    ...
}

ServedEUTRAcellsToModifyListENDCConfUpd ::= SEQUENCE (SIZE (1.. maxCellineNB)) OF SEQUENCE {
    old-ECGI                                ECGI,
    servedEUTRACellInfo                 ServedCell-Information,
    nrNeighbourInfo                     NRNeighbour-Information     OPTIONAL,
    iE-Extensions                       ProtocolExtensionContainer { { ServedEUTRAcellsToModifyListENDCConfUpd-ExtIEs} } OPTIONAL,
    ...
}

ServedEUTRAcellsToModifyListENDCConfUpd-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

ServedEUTRAcellsToDeleteListENDCConfUpd ::= SEQUENCE (SIZE (1..maxCellineNB)) OF ECGI


En-gNB-ENDCConfigUpdateIEs X2AP-PROTOCOL-IES ::= {
    { ID id-ServedNRcellsENDCX2ManagementList       CRITICALITY reject  TYPE ServedNRcellsENDCX2ManagementList        PRESENCE optional }|
    { ID id-ServedNRcellsToModifyListENDCConfUpd        CRITICALITY reject  TYPE ServedNRcellsToModifyENDCConfUpdList    PRESENCE optional }|
    { ID id-ServedNRcellsToDeleteListENDCConfUpd        CRITICALITY reject  TYPE ServedNRcellsToDeleteENDCConfUpdList    PRESENCE optional },
    ...
}

ServedNRcellsToModifyENDCConfUpdList ::= SEQUENCE (SIZE (1..maxCellinengNB)) OF ServedNRCellsToModify-Item

ServedNRCellsToModify-Item::= SEQUENCE {
    old-nrcgi                       NRCGI,
    servedNRCellInformation         ServedNRCell-Information,
    nrNeighbourInformation          NRNeighbour-Information         OPTIONAL,
    nrDeactivationIndication            DeactivationIndication          OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { { ServedNRCellsToModify-Item-ExtIEs} } OPTIONAL,
    ...
}

ServedNRCellsToModify-Item-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

ServedNRcellsToDeleteENDCConfUpdList ::= SEQUENCE (SIZE (1..maxCellinengNB)) OF NRCGI

-- **************************************************************
--
-- EN-DC CONFIGURATION UPDATE ACKNOWLEDGE
--
-- **************************************************************

ENDCConfigurationUpdateAcknowledge ::= SEQUENCE {
```

```
    protocolIEs     ProtocolIE-Container    {{ENDCConfigurationUpdateAcknowledge-IEs}},
    ...
}

ENDCConfigurationUpdateAcknowledge-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-RespondingNodeType-EndcConfigUpdate         CRITICALITY reject  TYPE RespondingNodeType-EndcConfigUpdate        PRESENCE mandatory},
    ...
}


RespondingNodeType-EndcConfigUpdate::= CHOICE {
    respond-eNB         ProtocolIE-Container    {{ENB-ENDCConfigUpdateAckIEs}},
    respond-en-gNB      ProtocolIE-Container    {{En-gNB-ENDCConfigUpdateAckIEs}},
    ...
}


ENB-ENDCConfigUpdateAckIEs X2AP-PROTOCOL-IES ::= {
  ...
}

En-gNB-ENDCConfigUpdateAckIEs X2AP-PROTOCOL-IES ::= {
    { ID id-ServedNRcellsENDCX2ManagementList       CRITICALITY reject  TYPE ServedNRcellsENDCX2ManagementList     PRESENCE optional},
    ...
}


-- **************************************************************
--
-- EN-DC CONFIGURATION UPDATE FAILURE
--
-- **************************************************************

ENDCConfigurationUpdateFailure ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{ENDCConfigurationUpdateFailure-IEs}},
    ...
}

ENDCConfigurationUpdateFailure-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-Cause                       CRITICALITY ignore  TYPE Cause                      PRESENCE mandatory}|
    { ID id-CriticalityDiagnostics      CRITICALITY ignore  TYPE CriticalityDiagnostics     PRESENCE optional},
    ...
}


-- **************************************************************
--
-- EN-DC CELL ACTIVATION REQUEST
--
-- **************************************************************

ENDCCellActivationRequest ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{ENDCCellActivationRequest-IEs}},
    ...
```

```
}

ENDCCellActivationRequest-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-ServedNRCellsToActivate     CRITICALITY reject  TYPE ServedNRCellsToActivate         PRESENCE mandatory}|
    { ID id-ActivationID                CRITICALITY reject  TYPE ActivationID                   PRESENCE mandatory},
    ...
}

ServedNRCellsToActivate::= SEQUENCE (SIZE (1.. maxCellinengNB)) OF ServedNRCellsToActivate-Item

ServedNRCellsToActivate-Item::= SEQUENCE {
    nrCellID                        NRCGI,
    iE-Extensions                   ProtocolExtensionContainer { { ServedNRCellsToActivate-Item-ExtIEs} } OPTIONAL,
    ...
}

ServedNRCellsToActivate-Item-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

-- **************************************************************
--
-- EN-DC CELL ACTIVATION RESPONSE
--
-- **************************************************************

ENDCCellActivationResponse ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{ENDCCellActivationResponse-IEs}},
    ...
}

ENDCCellActivationResponse-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-ActivatedNRCellList     CRITICALITY ignore  TYPE ActivatedNRCellList                PRESENCE mandatory}|
    { ID id-ActivationID                CRITICALITY reject  TYPE ActivationID                   PRESENCE mandatory}|
    { ID id-CriticalityDiagnostics  CRITICALITY ignore  TYPE CriticalityDiagnostics         PRESENCE optional},
    ...
}

ActivatedNRCellList ::= SEQUENCE (SIZE (1.. maxCellinengNB)) OF ActivatedNRCellList-Item

ActivatedNRCellList-Item::= SEQUENCE {
    nrCellID                        NRCGI,
    iE-Extensions                       ProtocolExtensionContainer { { ActivatedNRCellList-Item-ExtIEs} } OPTIONAL,
    ...
}

ActivatedNRCellList-Item-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

--**************************************************************
--
-- EN-DC CELL ACTIVATION FAILURE
--
```

```
-- **************************************************************

ENDCCellActivationFailure ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{ENDCCellActivationFailure-IEs}},
    ...
}

ENDCCellActivationFailure-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-ActivationID                    CRITICALITY reject  TYPE ActivationID              PRESENCE mandatory }|
    { ID id-Cause                       CRITICALITY ignore  TYPE Cause                      PRESENCE mandatory }|
    { ID id-CriticalityDiagnostics      CRITICALITY ignore  TYPE CriticalityDiagnostics     PRESENCE optional },
    ...
}

-- **************************************************************
--
-- SECONDARY RAT DATA USAGE REPORT
--
-- **************************************************************

SecondaryRATDataUsageReport ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container        {{SecondaryRATDataUsageReport-IEs}},
    ...
}

SecondaryRATDataUsageReport-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                 CRITICALITY reject  TYPE UE-X2AP-ID                     PRESENCE mandatory}|
    { ID id-SgNB-UE-X2AP-ID                 CRITICALITY reject  TYPE SgNB-UE-X2AP-ID                    PRESENCE mandatory}|
    { ID id-SecondaryRATUsageReportList     CRITICALITY reject  TYPE SecondaryRATUsageReportList    PRESENCE mandatory}|
    { ID id-MeNB-UE-X2AP-ID-Extension       CRITICALITY reject  TYPE UE-X2AP-ID-Extension            PRESENCE optional},
    ...
}

SgNBActivityNotification ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container        {{SgNBActivityNotification-IEs}},
    ...
}

SgNBActivityNotification-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-MeNB-UE-X2AP-ID                 CRITICALITY reject  TYPE UE-X2AP-ID                     PRESENCE mandatory}|
    { ID id-SgNB-UE-X2AP-ID                 CRITICALITY reject  TYPE SgNB-UE-X2AP-ID                    PRESENCE mandatory}|
    { ID id-UEContextLevelUserPlaneActivity CRITICALITY reject  TYPE UserPlaneTrafficActivityReport PRESENCE mandatory}|
    { ID id-ERABActivityNotifyItemList      CRITICALITY reject  TYPE ERABActivityNotifyItemList      PRESENCE mandatory}|
    { ID id-MeNB-UE-X2AP-ID-Extension       CRITICALITY reject  TYPE UE-X2AP-ID-Extension            PRESENCE optional},
    ...
}

-- **************************************************************
--
-- EN-DC PARTIAL RESET REQUIRED
--
-- **************************************************************

ENDCPartialResetRequired ::= SEQUENCE {
```

```
    protocolIEs     ProtocolIE-Container    {{ENDCPartialResetRequired-IEs}},
    ...
}

ENDCPartialResetRequired-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-UEs-ToBeReset               CRITICALITY reject  TYPE UEsToBeResetList               PRESENCE mandatory}|
    { ID id-Cause                       CRITICALITY ignore  TYPE Cause                        PRESENCE mandatory },
    ...
}

-- **************************************************************
--
-- EN-DC PARTIAL RESET CONFIRM
--
-- **************************************************************

ENDCPartialResetConfirm ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{ENDCPartialResetConfirm-IEs}},
    ...
}

ENDCPartialResetConfirm-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-UEs-Admitted-ToBeReset              CRITICALITY reject  TYPE UEsToBeResetList           PRESENCE mandatory},
    ...
}

-- **************************************************************
--
-- E-UTRA - NR CELL RESOURCE COORDINATION REQUEST
--
-- **************************************************************

EUTRANRCellResourceCoordinationRequest ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container        {{EUTRANRCellResourceCoordinationRequest-IEs}},
    ...
}

EUTRANRCellResourceCoordinationRequest-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-InitiatingNodeType-EutranrCellResourceCoordination      CRITICALITY reject  TYPE InitiatingNodeType-EutranrCellResourceCoordination
        PRESENCE mandatory},
    ...
}

InitiatingNodeType-EutranrCellResourceCoordination ::= CHOICE {
    initiate-eNB            ProtocolIE-Container    {{ENB-EUTRA-NRCellResourceCoordinationReqIEs}},
    initiate-en-gNB         ProtocolIE-Container    {{En-gNB-EUTRA-NRCellResourceCoordinationReqIEs}},
    ...
}


ENB-EUTRA-NRCellResourceCoordinationReqIEs X2AP-PROTOCOL-IES ::= {
    { ID id-DataTrafficResourceIndication   CRITICALITY reject  TYPE   DataTrafficResourceIndication PRESENCE mandatory}|
    { ID id-SpectrumSharingGroupID CRITICALITY reject TYPE SpectrumSharingGroupID PRESENCE mandatory}|
    { ID id-ListofEUTRACellsinEUTRACoordinationReq  CRITICALITY reject  TYPE ListofEUTRACellsinEUTRACoordinationReq PRESENCE mandatory },
```

```
    ...
}


En-gNB-EUTRA-NRCellResourceCoordinationReqIEs X2AP-PROTOCOL-IES ::= {
    { ID id-DataTrafficResourceIndication   CRITICALITY reject  TYPE   DataTrafficResourceIndication PRESENCE mandatory}|
    { ID id-ListofEUTRACellsinNRCoordinationReq CRITICALITY reject  TYPE ListofEUTRACellsinNRCoordinationReq  PRESENCE mandatory }|
    { ID id-SpectrumSharingGroupID CRITICALITY reject TYPE SpectrumSharingGroupID PRESENCE mandatory}|
    { ID id-ListofNRCellsinNRCoordinationReq CRITICALITY reject TYPE ListofNRCellsinNRCoordinationReq PRESENCE mandatory },
    ...
}


ListofEUTRACellsinEUTRACoordinationReq ::= SEQUENCE (SIZE (0..maxCellineNB)) OF ECGI
ListofEUTRACellsinNRCoordinationReq ::= SEQUENCE (SIZE (1..maxCellineNB)) OF ECGI
ListofNRCellsinNRCoordinationReq ::= SEQUENCE (SIZE (0..maxnoNRcellsSpectrumSharingWithE-UTRA)) OF NRCGI

-- **************************************************************
--
-- E-UTRA - NR CELL RESOURCE COORDINATION RESPONSE
--
-- **************************************************************

EUTRANRCellResourceCoordinationResponse ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container        {{EUTRANRCellResourceCoordinationResponse-IEs}},
    ...
}

EUTRANRCellResourceCoordinationResponse-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-RespondingNodeType-EutranrCellResourceCoordination      CRITICALITY reject  TYPE RespondingNodeType-EutranrCellResourceCoordination
        PRESENCE mandatory},
    ...
}

RespondingNodeType-EutranrCellResourceCoordination ::= CHOICE {
    respond-eNB         ProtocolIE-Container    {{ENB-EUTRA-NRCellResourceCoordinationReqAckIEs}},
    respond-en-gNB      ProtocolIE-Container    {{En-gNB-EUTRA-NRCellResourceCoordinationReqAckIEs}},
    ...
}


ENB-EUTRA-NRCellResourceCoordinationReqAckIEs X2AP-PROTOCOL-IES ::= {
    { ID id-DataTrafficResourceIndication   CRITICALITY reject  TYPE   DataTrafficResourceIndication PRESENCE mandatory}|
    { ID id-SpectrumSharingGroupID CRITICALITY reject TYPE SpectrumSharingGroupID PRESENCE mandatory}|
    { ID id-ListofEUTRACellsinEUTRACoordinationResp     CRITICALITY reject  TYPE ListofEUTRACellsinEUTRACoordinationResp PRESENCE mandatory },
    ...
}


En-gNB-EUTRA-NRCellResourceCoordinationReqAckIEs X2AP-PROTOCOL-IES ::= {
    { ID id-DataTrafficResourceIndication   CRITICALITY reject  TYPE   DataTrafficResourceIndication PRESENCE mandatory}|
    { ID id-SpectrumSharingGroupID CRITICALITY reject TYPE SpectrumSharingGroupID PRESENCE mandatory}|
    { ID id-ListofNRCellsinNRCoordinationResp       CRITICALITY reject  TYPE ListofNRCellsinNRCoordinationResp  PRESENCE mandatory },
```

```
    ...
}

ListofEUTRACellsinEUTRACoordinationResp ::= SEQUENCE (SIZE (1..maxCellineNB)) OF ECGI
ListofNRCellsinNRCoordinationResp ::= SEQUENCE (SIZE (1..maxnoNRcellsSpectrumSharingWithE-UTRA)) OF NRCGI

-- **************************************************************
--
-- EN-DC X2 REMOVAL REQUEST
--
-- **************************************************************

ENDCX2RemovalRequest ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{ENDCX2RemovalRequest-IEs}},
    ...
}

ENDCX2RemovalRequest-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-InitiatingNodeType-EndcX2Removal           CRITICALITY reject  TYPE InitiatingNodeType-EndcX2Removal     PRESENCE mandatory},
    ...
}

InitiatingNodeType-EndcX2Removal ::= CHOICE {
    init-eNB               ProtocolIE-Container    {{ENB-ENDCX2RemovalReqIEs}},
    init-en-gNB         ProtocolIE-Container    {{En-gNB-ENDCX2RemovalReqIEs}},
    ...
}

ENB-ENDCX2RemovalReqIEs X2AP-PROTOCOL-IES ::= {
    { ID id-GlobalENB-ID                           CRITICALITY reject  TYPE GlobalENB-ID                          PRESENCE mandatory},
    ...
}

En-gNB-ENDCX2RemovalReqIEs X2AP-PROTOCOL-IES ::= {
    { ID id-Globalen-gNB-ID                        CRITICALITY reject  TYPE GlobalGNB-ID                          PRESENCE mandatory},
    ...
}

-- **************************************************************
--
-- EN-DC X2 REMOVAL RESPONSE
--
-- **************************************************************

ENDCX2RemovalResponse ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{ENDCX2RemovalResponse-IEs}},
    ...
}

ENDCX2RemovalResponse-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-RespondingNodeType-EndcX2Removal       CRITICALITY reject  TYPE RespondingNodeType-EndcX2Removal   PRESENCE mandatory},
    ...
}
```

```
RespondingNodeType-EndcX2Removal ::= CHOICE {
    respond-eNB         ProtocolIE-Container    {{ENB-ENDCX2RemovalReqAckIEs}},
    respond-en-gNB      ProtocolIE-Container    {{En-gNB-ENDCX2RemovalReqAckIEs}},
    ...
}

ENB-ENDCX2RemovalReqAckIEs X2AP-PROTOCOL-IES ::= {
    { ID id-GlobalENB-ID                            CRITICALITY reject  TYPE GlobalENB-ID                          PRESENCE mandatory},
    ...
}

En-gNB-ENDCX2RemovalReqAckIEs X2AP-PROTOCOL-IES ::= {
    { ID id-Globalen-gNB-ID                       CRITICALITY reject  TYPE GlobalGNB-ID                          PRESENCE mandatory},
    ...
}

-- **************************************************************
--
-- EN-DC X2 REMOVAL FAILURE
--
-- **************************************************************

ENDCX2RemovalFailure ::= SEQUENCE {
    protocolIEs     ProtocolIE-Container    {{ENDCX2RemovalFailure-IEs}},
    ...
}

ENDCX2RemovalFailure-IEs X2AP-PROTOCOL-IES ::= {
    { ID id-Cause                   CRITICALITY ignore      TYPE Cause                          PRESENCE mandatory} |
    { ID id-CriticalityDiagnostics  CRITICALITY ignore      TYPE CriticalityDiagnostics         PRESENCE optional },
    ...
}

END
```

9.3.5 Information Element definitions

```
-- **************************************************************
--
-- Information Element Definitions
--
-- **************************************************************

X2AP-IEs {
itu-t (0) identified-organization (4) etsi (0) mobileDomain (0)
eps-Access (21) modules (3) x2ap (2) version1 (1) x2ap-IEs (2) }

DEFINITIONS AUTOMATIC TAGS ::=

BEGIN

IMPORTS
```

```
    id-E-RAB-Item,
    id-Number-of-Antennaports,
    id-MBSFN-Subframe-Info,
    id-PRACH-Configuration,
    id-CSG-Id,
    id-MDTConfiguration,
    id-SignallingBasedMDTPLMNList,
    id-MultibandInfoList,
    id-FreqBandIndicatorPriority,
    id-NeighbourTAC,
    id-Time-UE-StayedInCell-EnhancedGranularity,
    id-MBMS-Service-Area-List,
    id-HO-cause,
    id-eARFCNExtension,
    id-DL-EARFCNExtension,
    id-UL-EARFCNExtension,
    id-M3Configuration,
    id-M4Configuration,
    id-M5Configuration,
    id-MDT-Location-Info,
    id-NRrestriction,
    id-AdditionalSpecialSubframe-Info,
    id-UEID,
    id-enhancedRNTP,
    id-ProSeUEtoNetworkRelaying,
    id-M6Configuration,
    id-M7Configuration,
    id-OffsetOfNbiotChannelNumberToDL-EARFCN,
    id-OffsetOfNbiotChannelNumberToUL-EARFCN,
    id-AdditionalSpecialSubframeExtension-Info,
    id-BandwidthReducedSI,
    id-extended-e-RAB-MaximumBitrateDL,
    id-extended-e-RAB-MaximumBitrateUL,
    id-extended-e-RAB-GuaranteedBitrateDL,
    id-extended-e-RAB-GuaranteedBitrateUL,
    id-extended-uEaggregateMaximumBitRateDownlink,
    id-extended-uEaggregateMaximumBitRateUplink,
    id-E-RABUsageReport-Item,
    id-SecondaryRATUsageReport-Item,
    id-UEAppLayerMeasConfig,
    id-DL-scheduling-PDCCH-CCE-usage,
    id-UL-scheduling-PDCCH-CCE-usage,
    id-DownlinkPacketLossRate,
    id-UplinkPacketLossRate,
    id-serviceType,
    id-ProtectedEUTRAResourceIndication,
    id-NRS-NSSS-PowerOffset,
    id-NSSS-NumOccasionDifferentPrecoder,


    maxnoofBearers,
    maxCellineNB,
    maxEARFCN,
```

```
    maxEARFCNPlusOne,
    newmaxEARFCN,
    maxInterfaces,

    maxnoofBands,
    maxnoofBPLMNs,
    maxnoofCells,
    maxnoofEPLMNs,
    maxnoofEPLMNsPlusOne,
    maxnoofForbLACs,
    maxnoofForbTACs,
    maxnoofNeighbours,
    maxnoofPRBs,
    maxNrOfErrors,
    maxPools,
    maxnoofMBSFN,
    maxnoofTAforMDT,
    maxnoofCellIDforMDT,
    maxnoofMBMSServiceAreaIdentities,
    maxnoofMDTPLMNs,
    maxnoofCoMPHypothesisSet,
    maxnoofCoMPCells,
    maxUEReport,
    maxCellReport,
    maxnoofPA,
    maxCSIProcess,
    maxCSIReport,
    maxSubband,
    maxnooftimeperiods,
    maxnoofCellIDforQMC,
    maxnoofTAforQMC,
    maxnoofPLMNforQMC,
    maxUEsinengNBDU,
    maxnoofProtectedResourcePatterns,
    maxnoNRcellsSpectrumSharingWithE-UTRA,
    maxnoofNrCellBands

FROM X2AP-Constants

    Criticality,
    ProcedureCode,
    ProtocolIE-ID,
    TriggeringMessage
FROM X2AP-CommonDataTypes

    ProtocolExtensionContainer{},
    ProtocolIE-Single-Container{},

    X2AP-PROTOCOL-EXTENSION,
    X2AP-PROTOCOL-IES
FROM X2AP-Containers;

-- A
```

```
ABSInformation ::= CHOICE {
    fdd                 ABSInformationFDD,
    tdd                 ABSInformationTDD,
    abs-inactive        NULL,
    ...
}

ABSInformationFDD ::= SEQUENCE {
    abs-pattern-info                    BIT STRING (SIZE(40)),
    numberOfCellSpecificAntennaPorts    ENUMERATED {one, two, four, ...},
    measurement-subset                  BIT STRING (SIZE(40)),
    iE-Extensions                       ProtocolExtensionContainer { { ABSInformationFDD-ExtIEs} } OPTIONAL,
    ...
}

ABSInformationFDD-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

ABSInformationTDD ::= SEQUENCE {
    abs-pattern-info                    BIT STRING (SIZE(1..70, ...)),
    numberOfCellSpecificAntennaPorts    ENUMERATED {one, two, four, ...},
    measurement-subset                  BIT STRING (SIZE(1..70, ...)),
    iE-Extensions                       ProtocolExtensionContainer { { ABSInformationTDD-ExtIEs} } OPTIONAL,
    ...
}

ABSInformationTDD-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

ABS-Status ::= SEQUENCE {
    dL-ABS-status                           DL-ABS-status,
    usableABSInformation                    UsableABSInformation,
    iE-Extensions                           ProtocolExtensionContainer { {ABS-Status-ExtIEs} } OPTIONAL,
    ...
}

ABS-Status-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

ActivationID ::= INTEGER (0..255)

AdditionalSpecialSubframe-Info ::=      SEQUENCE {
    additionalspecialSubframePatterns       AdditionalSpecialSubframePatterns,
    cyclicPrefixDL                          CyclicPrefixDL,
    cyclicPrefixUL                          CyclicPrefixUL,
    iE-Extensions                           ProtocolExtensionContainer { { AdditionalSpecialSubframe-Info-ExtIEs} } OPTIONAL,
    ...
}

AdditionalSpecialSubframe-Info-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
```

```
}

AdditionalSpecialSubframePatterns ::= ENUMERATED {
    ssp0,
    ssp1,
    ssp2,
    ssp3,
    ssp4,
    ssp5,
    ssp6,
    ssp7,
    ssp8,
    ssp9,
    ...
}

AdditionalSpecialSubframeExtension-Info ::=     SEQUENCE {
    additionalspecialSubframePatternsExtension  AdditionalSpecialSubframePatternsExtension,
    cyclicPrefixDL                              CyclicPrefixDL,
    cyclicPrefixUL                              CyclicPrefixUL,
    iE-Extensions                               ProtocolExtensionContainer { { AdditionalSpecialSubframeExtension-Info-ExtIEs} } OPTIONAL,
    ...
}

AdditionalSpecialSubframeExtension-Info-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

AdditionalSpecialSubframePatternsExtension ::= ENUMERATED {
    ssp10,
    ...
}

AerialUEsubscriptionInformation ::= ENUMERATED {
    allowed,
    not-allowed,
    ...
}

AllocationAndRetentionPriority ::= SEQUENCE {
    priorityLevel               PriorityLevel,
    pre-emptionCapability       Pre-emptionCapability,
    pre-emptionVulnerability    Pre-emptionVulnerability,
    iE-Extensions               ProtocolExtensionContainer { {AllocationAndRetentionPriority-ExtIEs} } OPTIONAL,
    ...
}

AllocationAndRetentionPriority-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

AreaScopeOfMDT ::= CHOICE {
    cellBased                   CellBasedMDT,
    tABased                     TABasedMDT,
```

```
    pLMNWide                    NULL,
    ...,
    tAIBased                    TAIBasedMDT
}

AreaScopeOfQMC ::= CHOICE {
    cellBased                   CellBasedQMC,
    tABased                     TABasedQMC,
    tAIBased                    TAIBasedQMC,
    pLMNAreaBased               PLMNAreaBasedQMC,
    ...
}

AS-SecurityInformation ::= SEQUENCE {
    key-eNodeB-star     Key-eNodeB-Star,
    nextHopChainingCount            NextHopChainingCount,
    iE-Extensions                       ProtocolExtensionContainer { { AS-SecurityInformation-ExtIEs} } OPTIONAL,
    ...
}

AS-SecurityInformation-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}


-- B

BandwidthReducedSI::= ENUMERATED {
    scheduled,
    ...
}

BearerType ::= ENUMERATED {
    non-IP,
    ...
}

BenefitMetric ::= INTEGER (-101..100, ...)

BitRate ::= INTEGER (0..10000000000)
BroadcastPLMNs-Item ::= SEQUENCE (SIZE(1..maxnoofBPLMNs)) OF PLMN-Identity


-- C

CapacityValue ::= INTEGER (0..100)

Cause ::= CHOICE {
    radioNetwork        CauseRadioNetwork,
    transport           CauseTransport,
    protocol            CauseProtocol,
    misc                CauseMisc,
    ...
}
```

```
CauseMisc ::= ENUMERATED {
    control-processing-overload,
    hardware-failure,
    om-intervention,
    not-enough-user-plane-processing-resources,
    unspecified,
    ...
}

CauseProtocol ::= ENUMERATED {
    transfer-syntax-error,
    abstract-syntax-error-reject,
    abstract-syntax-error-ignore-and-notify,
    message-not-compatible-with-receiver-state,
    semantic-error,
    unspecified,
    abstract-syntax-error-falsely-constructed-message,
    ...
}

CauseRadioNetwork ::= ENUMERATED {
    handover-desirable-for-radio-reasons,
    time-critical-handover,
    resource-optimisation-handover,
    reduce-load-in-serving-cell,
    partial-handover,
    unknown-new-eNB-UE-X2AP-ID,
    unknown-old-eNB-UE-X2AP-ID,
    unknown-pair-of-UE-X2AP-ID,
    ho-target-not-allowed,
    tx2relocoverall-expiry,
    trelocprep-expiry,
    cell-not-available,
    no-radio-resources-available-in-target-cell,
    invalid-MME-GroupID,
    unknown-MME-Code,
    encryption-and-or-integrity-protection-algorithms-not-supported,
    reportCharacteristicsEmpty,
    noReportPeriodicity,
    existingMeasurementID,
    unknown-eNB-Measurement-ID,
    measurement-temporarily-not-available,
    unspecified,
    ...,
    load-balancing,
    handover-optimisation,
    value-out-of-allowed-range,
    multiple-E-RAB-ID-instances,
    switch-off-ongoing,
    not-supported-QCI-value,
    measurement-not-supported-for-the-object,
    tDCoverall-expiry,
    tDCprep-expiry,
```

```
    action-desirable-for-radio-reasons,
    reduce-load,
    resource-optimisation,
    time-critical-action,
    target-not-allowed,
    no-radio-resources-available,
    invalid-QoS-combination,
    encryption-algorithms-not-aupported,
    procedure-cancelled,
    rRM-purpose,
    improve-user-bit-rate,
    user-inactivity,
    radio-connection-with-UE-lost,
    failure-in-the-radio-interface-procedure,
    bearer-option-not-supported,
    mCG-Mobility,
    sCG-Mobility,
    count-reaches-max-value,
    unknown-old-en-gNB-UE-X2AP-ID,
    pDCP-Overload

}

CauseTransport ::= ENUMERATED {
    transport-resource-unavailable,
    unspecified,
    ...
}

CellBasedMDT::= SEQUENCE {
    cellIdListforMDT    CellIdListforMDT,
    iE-Extensions       ProtocolExtensionContainer { {CellBasedMDT-ExtIEs} } OPTIONAL,
    ...
}

CellBasedMDT-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

CellBasedQMC::= SEQUENCE {
    cellIdListforQMC        CellIdListforQMC,
    iE-Extensions       ProtocolExtensionContainer { {CellBasedQMC-ExtIEs} } OPTIONAL,
    ...
}

CellBasedQMC-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

CellCapacityClassValue ::= INTEGER (1..100, ...)

CellDeploymentStatusIndicator ::= ENUMERATED {pre-change-notification, ...}

CellIdListforMDT ::= SEQUENCE (SIZE(1..maxnoofCellIDforMDT)) OF ECGI
```

```
CellIdListforQMC ::= SEQUENCE (SIZE(1..maxnoofCellIDforQMC)) OF ECGI

CellReplacingInfo ::= SEQUENCE {
    replacingCellsList              ReplacingCellsList,
    iE-Extensions                   ProtocolExtensionContainer { { CellReplacingInfo-ExtIEs}}   OPTIONAL,
    ...
}

CellReplacingInfo-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

CellReportingIndicator ::= ENUMERATED {stop-request, ... }

Cell-Size ::= ENUMERATED {verysmall, small, medium, large, ... }


CellType ::= SEQUENCE {
    cell-Size                       Cell-Size,
    iE-Extensions                   ProtocolExtensionContainer { { CellType-ExtIEs}}    OPTIONAL,
    ...
}

CellType-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

CoMPHypothesisSet ::= SEQUENCE (SIZE(1..maxnoofCoMPCells)) OF CoMPHypothesisSetItem

CoMPHypothesisSetItem ::= SEQUENCE {
    coMPCellID                      ECGI,
    coMPHypothesis                  BIT STRING (SIZE(6..4400, ...)),
    iE-Extensions                   ProtocolExtensionContainer { { CoMPHypothesisSetItem-ExtIEs} } OPTIONAL,
    ...
}

CoMPHypothesisSetItem-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

CoMPInformation ::= SEQUENCE {
    coMPInformationItem                 CoMPInformationItem,
    coMPInformationStartTime            CoMPInformationStartTime,
    iE-Extensions                       ProtocolExtensionContainer { { CoMPInformation-ExtIEs} } OPTIONAL,
    ...
}

CoMPInformation-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

CoMPInformationItem ::= SEQUENCE (SIZE(1..maxnoofCoMPHypothesisSet)) OF
    SEQUENCE {
```

```
        coMPHypothesisSet                   CoMPHypothesisSet,
        benefitMetric                       BenefitMetric,
        iE-Extensions                       ProtocolExtensionContainer { { CoMPInformationItem-ExtIEs} } OPTIONAL,
        ...
    }

CoMPInformationItem-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

CoMPInformationStartTime ::= SEQUENCE (SIZE(0..1)) OF
    SEQUENCE {
        startSFN                            INTEGER (0..1023, ...),
        startSubframeNumber                 INTEGER (0..9, ...),
        iE-Extensions                       ProtocolExtensionContainer { { CoMPInformationStartTime-ExtIEs} } OPTIONAL,
        ...
    }

CoMPInformationStartTime-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

CompositeAvailableCapacity ::= SEQUENCE {
    cellCapacityClassValue                          CellCapacityClassValue              OPTIONAL,
    capacityValue                                   CapacityValue,
    iE-Extensions                                   ProtocolExtensionContainer { { CompositeAvailableCapacity-ExtIEs} } OPTIONAL,
    ...
}

CompositeAvailableCapacity-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

CompositeAvailableCapacityGroup ::= SEQUENCE {
    dL-CompositeAvailableCapacity               CompositeAvailableCapacity,
    uL-CompositeAvailableCapacity               CompositeAvailableCapacity,
    iE-Extensions                               ProtocolExtensionContainer { { CompositeAvailableCapacityGroup-ExtIEs} } OPTIONAL,
    ...
}

CompositeAvailableCapacityGroup-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

Correlation-ID ::= OCTET STRING (SIZE (4))

COUNTvalue ::= SEQUENCE {
    pDCP-SN                 PDCP-SN,
    hFN                     HFN,
    iE-Extensions           ProtocolExtensionContainer { { COUNTvalue-ExtIEs} } OPTIONAL,
    ...
}

COUNTvalue-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
```

```
    ...
}

COUNTValueExtended ::= SEQUENCE {
    pDCP-SNExtended         PDCP-SNExtended,
    hFNModified             HFNModified,
    iE-Extensions           ProtocolExtensionContainer { { COUNTValueExtended-ExtIEs} } OPTIONAL,
    ...
}

COUNTValueExtended-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

COUNTvaluePDCP-SNlength18 ::= SEQUENCE {
    pDCP-SNlength18         PDCP-SNlength18,
    hFNforPDCP-SNlength18   HFNforPDCP-SNlength18,
    iE-Extensions           ProtocolExtensionContainer { { COUNTvaluePDCP-SNlength18-ExtIEs} } OPTIONAL,
    ...
}

COUNTvaluePDCP-SNlength18-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

CoverageModificationList ::= SEQUENCE (SIZE (1..maxCellineNB)) OF CoverageModification-Item

CoverageModification-Item ::= SEQUENCE {
    eCGI                        ECGI,
    coverageState               INTEGER (0..15, ...),
    cellDeploymentStatusIndicator   CellDeploymentStatusIndicator           OPTIONAL,
    cellReplacingInfo           CellReplacingInfo                   OPTIONAL,
-- Included in case the Cell Deployment Status Indicator IE is present
    ...
}

CriticalityDiagnostics ::= SEQUENCE {
    procedureCode               ProcedureCode               OPTIONAL,
    triggeringMessage           TriggeringMessage           OPTIONAL,
    procedureCriticality        Criticality                 OPTIONAL,
    iEsCriticalityDiagnostics   CriticalityDiagnostics-IE-List  OPTIONAL,
    iE-Extensions               ProtocolExtensionContainer { {CriticalityDiagnostics-ExtIEs} }   OPTIONAL,
    ...
}


CriticalityDiagnostics-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

CriticalityDiagnostics-IE-List ::= SEQUENCE (SIZE (1..maxNrOfErrors)) OF
    SEQUENCE {
        iECriticality           Criticality,
        iE-ID                   ProtocolIE-ID,
```

```
        typeOfError             TypeOfError,
        iE-Extensions           ProtocolExtensionContainer { {CriticalityDiagnostics-IE-List-ExtIEs} } OPTIONAL,
        ...
}

CriticalityDiagnostics-IE-List-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

CRNTI ::= BIT STRING (SIZE (16))

CSGMembershipStatus ::= ENUMERATED {
    member,
    not-member
}

CSG-Id ::= BIT STRING (SIZE (27))

CSIReportList ::= SEQUENCE (SIZE(1..maxUEReport)) OF
    SEQUENCE {
        uEID                            UEID,
        cSIReportPerCSIProcess          CSIReportPerCSIProcess,
        iE-Extensions                   ProtocolExtensionContainer { { CSIReportList-ExtIEs} } OPTIONAL,
        ...
    }

CSIReportList-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

CSIReportPerCSIProcess ::= SEQUENCE (SIZE(1.. maxCSIProcess)) OF
    SEQUENCE {
        cSIProcessConfigurationIndex    INTEGER (1..7, ...),
        cSIReportPerCSIProcessItem      CSIReportPerCSIProcessItem,
        iE-Extensions                   ProtocolExtensionContainer { { CSIReportPerCSIProcess-ExtIEs} } OPTIONAL,
        ...
    }

CSIReportPerCSIProcess-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

CSIReportPerCSIProcessItem ::= SEQUENCE (SIZE(1.. maxCSIReport)) OF
    SEQUENCE {
        rI                              INTEGER (1..8, ...),
        widebandCQI                     WidebandCQI,
        subbandSize                     SubbandSize,
        subbandCQIList                  SubbandCQIList  OPTIONAL,
        iE-Extensions                   ProtocolExtensionContainer { { CSIReportPerCSIProcessItem-ExtIEs} } OPTIONAL,
        ...
    }

CSIReportPerCSIProcessItem-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
```

```
}

CyclicPrefixDL ::= ENUMERATED {
    normal,
    extended,
    ...
}

CyclicPrefixUL ::= ENUMERATED {
    normal,
    extended,
    ...
}


-- D


DataTrafficResources ::= BIT STRING (SIZE(12..8800))

DataTrafficResourceIndication ::= SEQUENCE {
    activationSFN                   INTEGER (0..1023),
    sharedResourceType              SharedResourceType,
    reservedSubframePattern         ReservedSubframePattern OPTIONAL,
...
}

DeactivationIndication::= ENUMERATED {
    deactivated,
    ...
}

DeliveryStatus ::= SEQUENCE {
    highestSuccessDeliveredPDCPSN       INTEGER (0..4095),
    iE-Extensions       ProtocolExtensionContainer { {DeliveryStatus-ExtIEs} } OPTIONAL,
    ...
}

DeliveryStatus-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}


DL-ABS-status::= INTEGER (0..100)

DL-Forwarding ::= ENUMERATED {
    dL-forwardingProposed,
    ...
}

DL-GBR-PRB-usage::= INTEGER (0..100)

DL-non-GBR-PRB-usage::= INTEGER (0..100)
```

```
DLResourceBitmapULandDLSharing ::=   DataTrafficResources

DLResourcesULandDLSharing ::= CHOICE {
unchanged           NULL,
    changed             DLResourceBitmapULandDLSharing,
    ...
}

DL-scheduling-PDCCH-CCE-usage::= INTEGER (0..100)

DL-Total-PRB-usage::= INTEGER (0..100)

DRB-ID ::= INTEGER (1..32)

DynamicDLTransmissionInformation ::= CHOICE {
    naics-active            DynamicNAICSInformation,
    naics-inactive          NULL,
    ...
}

DynamicNAICSInformation ::= SEQUENCE {
    transmissionModes                   BIT STRING (SIZE(8))                                                OPTIONAL,
    pB-information                      INTEGER(0..3)                                                       OPTIONAL,
    pA-list                             SEQUENCE (SIZE(0..maxnoofPA)) OF PA-Values,
    iE-Extensions                       ProtocolExtensionContainer { {DynamicNAICSInformation-ExtIEs} } OPTIONAL,
    ...
}

DynamicNAICSInformation-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

-- E

EARFCN ::= INTEGER (0..maxEARFCN)

EARFCNExtension ::= INTEGER(maxEARFCNPlusOne..newmaxEARFCN, ...)

ECGI ::= SEQUENCE {
    pLMN-Identity               PLMN-Identity,
    eUTRANcellIdentifier        EUTRANCellIdentifier,
    iE-Extensions               ProtocolExtensionContainer { {ECGI-ExtIEs} } OPTIONAL,
    ...
}

ECGI-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

EnhancedRNTP ::= SEQUENCE {
    enhancedRNTPBitmap          BIT STRING (SIZE(12..8800, ...)),
    rNTP-High-Power-Threshold   RNTP-Threshold,
    enhancedRNTPStartTime       EnhancedRNTPStartTime  OPTIONAL,
    iE-Extensions               ProtocolExtensionContainer { { EnhancedRNTP-ExtIEs} } OPTIONAL,
```

```
    ...
}

EnhancedRNTP-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

EnhancedRNTPStartTime ::= SEQUENCE {
        startSFN                INTEGER (0..1023, ...),
        startSubframeNumber     INTEGER (0..9, ...),
        iE-Extensions           ProtocolExtensionContainer { { EnhancedRNTPStartTime-ExtIEs} } OPTIONAL,
        ...
    }

EnhancedRNTPStartTime-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

ENB-ID ::= CHOICE {
    macro-eNB-ID    BIT STRING (SIZE (20)),
    home-eNB-ID     BIT STRING (SIZE (28)),
    ... ,
    short-Macro-eNB-ID      BIT STRING (SIZE(18)),
    long-Macro-eNB-ID       BIT STRING (SIZE(21))
}

EncryptionAlgorithms ::= BIT STRING (SIZE (16, ...))

EN-DC-ResourceConfiguration ::= SEQUENCE {
    pDCPatSgNB      ENUMERATED {present, not-present, ...},
    mCGresources    ENUMERATED {present, not-present, ...},
    sCGresources    ENUMERATED {present, not-present, ...},
    iE-Extensions                   ProtocolExtensionContainer { { EN-DC-ResourceConfigurationExtIEs} } OPTIONAL,
    ...
}

EN-DC-ResourceConfigurationExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}


EPLMNs ::= SEQUENCE (SIZE(1..maxnoofEPLMNs)) OF PLMN-Identity

ERABActivityNotifyItemList ::= SEQUENCE (SIZE (1..maxnoofBearers)) OF ERABActivityNotifyItem

ERABActivityNotifyItem ::= SEQUENCE {
    e-RAB-ID                        E-RAB-ID,
    activityReport                  UserPlaneTrafficActivityReport,
    iE-Extensions                   ProtocolExtensionContainer { {ERABActivityNotifyItem-ExtIEs} }   OPTIONAL,
    ...
}

ERABActivityNotifyItem-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
```

```
}

E-RAB-ID ::= INTEGER (0..15, ...)

E-RAB-Level-QoS-Parameters ::= SEQUENCE {
    qCI                             QCI,
    allocationAndRetentionPriority  AllocationAndRetentionPriority,
    gbrQosInformation               GBR-QosInformation                                          OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { { E-RAB-Level-QoS-Parameters-ExtIEs} } OPTIONAL,
    ...
}

E-RAB-Level-QoS-Parameters-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
-- Extended for introduction of downlink and uplink packet loss rate for enhanced Voice performance –
    { ID id-DownlinkPacketLossRate          CRITICALITY ignore  EXTENSION Packet-LossRate       PRESENCE optional}|
    { ID id-UplinkPacketLossRate            CRITICALITY ignore  EXTENSION Packet-LossRate       PRESENCE optional},
    ...
}

E-RAB-List ::= SEQUENCE (SIZE(1.. maxnoofBearers)) OF ProtocolIE-Single-Container { {E-RAB-ItemIEs} }

E-RAB-ItemIEs   X2AP-PROTOCOL-IES ::= {
    { ID id-E-RAB-Item   CRITICALITY ignore     TYPE E-RAB-Item     PRESENCE mandatory },
    ...
}

E-RAB-Item ::= SEQUENCE {
    e-RAB-ID                E-RAB-ID,
    cause                       Cause,
    iE-Extensions               ProtocolExtensionContainer { {E-RAB-Item-ExtIEs} } OPTIONAL,
    ...
}

E-RAB-Item-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

E-RABUsageReportList ::= SEQUENCE (SIZE(1..maxnooftimeperiods)) OF ProtocolIE-Single-Container { {E-RABUsageReport-ItemIEs} }

E-RABUsageReport-ItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-E-RABUsageReport-Item    CRITICALITY ignore     TYPE E-RABUsageReport-Item  PRESENCE mandatory },
    ...
}

E-RABUsageReport-Item ::= SEQUENCE {
    startTimeStamp              OCTET STRING (SIZE(4)),
    endTimeStamp                    OCTET STRING (SIZE(4)),
    usageCountUL                    INTEGER (0..18446744073709551615),
    usageCountDL                    INTEGER (0..18446744073709551615),
    iE-Extensions               ProtocolExtensionContainer { { E-RABUsageReport-Item-ExtIEs} } OPTIONAL,
...
}

E-RABUsageReport-Item-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
```

```
    ...
}

EUTRA-Mode-Info ::= CHOICE {
    fDD     FDD-Info,
    tDD     TDD-Info,
    ...
}

EUTRANCellIdentifier ::= BIT STRING (SIZE (28))

EUTRANTraceID       ::= OCTET STRING (SIZE (8))

EventType ::= ENUMERATED{
    change-of-serving-cell,
    ...
}

ExpectedUEBehaviour ::= SEQUENCE {
    expectedActivity        ExpectedUEActivityBehaviour OPTIONAL,
    expectedHOInterval      ExpectedHOInterval          OPTIONAL,
    iE-Extensions           ProtocolExtensionContainer { { ExpectedUEBehaviour-ExtIEs} } OPTIONAL,
    ...
}

ExpectedUEBehaviour-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

ExpectedUEActivityBehaviour ::= SEQUENCE {
    expectedActivityPeriod                  ExpectedActivityPeriod                  OPTIONAL,
    expectedIdlePeriod                      ExpectedIdlePeriod                      OPTIONAL,
    sourceofUEActivityBehaviourInformation  SourceOfUEActivityBehaviourInformation  OPTIONAL,
    iE-Extensions       ProtocolExtensionContainer { { ExpectedUEActivityBehaviour-ExtIEs} } OPTIONAL,
    ...
}

ExpectedUEActivityBehaviour-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

ExpectedActivityPeriod ::= INTEGER (1..30|40|50|60|80|100|120|150|180|181,...)

ExpectedIdlePeriod ::= INTEGER (1..30|40|50|60|80|100|120|150|180|181,...)

ExpectedHOInterval ::= ENUMERATED {
    sec15, sec30, sec60, sec90, sec120, sec180, long-time,
    ...
}

ExtendedULInterferenceOverloadInfo ::= SEQUENCE {
    associatedSubframes                         BIT STRING (SIZE (5)),
    extended-ul-InterferenceOverloadIndication  UL-InterferenceOverloadIndication,
    iE-Extensions                               ProtocolExtensionContainer { { ExtendedULInterferenceOverloadInfo-ExtIEs} } OPTIONAL,
```

```
    ...
}

ExtendedULInterferenceOverloadInfo-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

ExtendedBitRate ::= INTEGER (10000000001..4000000000000,...)

-- F

FDD-Info ::= SEQUENCE {
    uL-EARFCN                       EARFCN,
    dL-EARFCN                       EARFCN,
    uL-Transmission-Bandwidth       Transmission-Bandwidth,
    dL-Transmission-Bandwidth       Transmission-Bandwidth,
    iE-Extensions               ProtocolExtensionContainer { {FDD-Info-ExtIEs} } OPTIONAL,
    ...
}

FDD-Info-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    { ID id-UL-EARFCNExtension                      CRITICALITY reject  EXTENSION EARFCNExtension                       PRESENCE optional}|
    { ID id-DL-EARFCNExtension                      CRITICALITY reject  EXTENSION EARFCNExtension                       PRESENCE optional}|
    { ID id-OffsetOfNbiotChannelNumberToDL-EARFCN   CRITICALITY reject  EXTENSION OffsetOfNbiotChannelNumberToEARFCN    PRESENCE optional}|
    { ID id-OffsetOfNbiotChannelNumberToUL-EARFCN   CRITICALITY reject  EXTENSION OffsetOfNbiotChannelNumberToEARFCN    PRESENCE optional}|
    { ID id-NRS-NSSS-PowerOffset                    CRITICALITY ignore  EXTENSION NRS-NSSS-PowerOffset                  PRESENCE optional}|
    { ID id-NSSS-NumOccasionDifferentPrecoder       CRITICALITY ignore  EXTENSION NSSS-NumOccasionDifferentPrecoder     PRESENCE optional},
    ...
}

ForbiddenInterRATs ::= ENUMERATED {
    all,
    geran,
    utran,
    cdma2000,
    ...,
    geranandutran,
    cdma2000andutran

}

ForbiddenTAs ::= SEQUENCE (SIZE(1.. maxnoofEPLMNsPlusOne)) OF ForbiddenTAs-Item

ForbiddenTAs-Item ::= SEQUENCE {
    pLMN-Identity       PLMN-Identity,
    forbiddenTACs       ForbiddenTACs,
    iE-Extensions       ProtocolExtensionContainer { {ForbiddenTAs-Item-ExtIEs} } OPTIONAL,
    ...
}

ForbiddenTAs-Item-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}
```

```
ForbiddenTACs ::= SEQUENCE (SIZE(1..maxnoofForbTACs)) OF TAC

ForbiddenLAs ::= SEQUENCE (SIZE(1..maxnoofEPLMNsPlusOne)) OF ForbiddenLAs-Item

ForbiddenLAs-Item ::= SEQUENCE {
    pLMN-Identity       PLMN-Identity,
    forbiddenLACs       ForbiddenLACs,
    iE-Extensions       ProtocolExtensionContainer { {ForbiddenLAs-Item-ExtIEs} } OPTIONAL,
    ...
}

ForbiddenLAs-Item-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

ForbiddenLACs ::= SEQUENCE (SIZE(1..maxnoofForbLACs)) OF LAC

Fourframes ::= BIT STRING (SIZE (24))

FreqBandIndicator ::= INTEGER (1..256, ...)

FreqBandIndicatorPriority ::= ENUMERATED {
    not-broadcasted,
    broadcasted,
    ...
}


FreqBandNrItem ::= SEQUENCE {
    freqBandIndicatorNr             INTEGER (1..1024,...),
    supportedSULBandList    SEQUENCE (SIZE(0..maxnoofNrCellBands)) OF SupportedSULFreqBandItem,
    iE-Extensions               ProtocolExtensionContainer { {FreqBandNrItem-ExtIEs} } OPTIONAL,
    ...
}

FreqBandNrItem-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

-- G

GBR-QosInformation ::= SEQUENCE {
    e-RAB-MaximumBitrateDL          BitRate,
    e-RAB-MaximumBitrateUL          BitRate,
    e-RAB-GuaranteedBitrateDL       BitRate,
    e-RAB-GuaranteedBitrateUL       BitRate,
    iE-Extensions                   ProtocolExtensionContainer { { GBR-QosInformation-ExtIEs} } OPTIONAL,
    ...
}

GBR-QosInformation-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
-- Extension for maximum bitrate > 10Gbps --
    { ID id-extended-e-RAB-MaximumBitrateDL     CRITICALITY ignore  EXTENSION ExtendedBitRate   PRESENCE optional}|
    { ID id-extended-e-RAB-MaximumBitrateUL     CRITICALITY ignore  EXTENSION ExtendedBitRate   PRESENCE optional}|
```

```
    { ID id-extended-e-RAB-GuaranteedBitrateDL  CRITICALITY ignore  EXTENSION ExtendedBitRate   PRESENCE optional}|
    { ID id-extended-e-RAB-GuaranteedBitrateUL  CRITICALITY ignore  EXTENSION ExtendedBitRate   PRESENCE optional},
    ...
}

GlobalENB-ID ::= SEQUENCE {
    pLMN-Identity           PLMN-Identity,
    eNB-ID                  ENB-ID,
    iE-Extensions           ProtocolExtensionContainer { {GlobalENB-ID-ExtIEs} } OPTIONAL,
    ...
}

GlobalENB-ID-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

GlobalGNB-ID ::= SEQUENCE {
    pLMN-Identity           PLMN-Identity,
    gNB-ID                  GNB-ID,
    iE-Extensions           ProtocolExtensionContainer { {GlobalGNB-ID-ExtIEs} } OPTIONAL,
    ...
}

GlobalGNB-ID-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

GTPtunnelEndpoint ::= SEQUENCE {
    transportLayerAddress           TransportLayerAddress,
    gTP-TEID                        GTP-TEI,
    iE-Extensions                   ProtocolExtensionContainer { {GTPtunnelEndpoint-ExtIEs} } OPTIONAL,
    ...
}

GTPtunnelEndpoint-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

GTP-TEI                 ::= OCTET STRING (SIZE (4))

GUGroupIDList       ::= SEQUENCE (SIZE (1..maxPools)) OF GU-Group-ID


GU-Group-ID         ::= SEQUENCE {
    pLMN-Identity       PLMN-Identity,
    mME-Group-ID        MME-Group-ID,
    iE-Extensions       ProtocolExtensionContainer { {GU-Group-ID-ExtIEs} } OPTIONAL,
    ...
}

GU-Group-ID-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}
```

```
GUMMEI          ::= SEQUENCE {

    gU-Group-ID     GU-Group-ID,
    mME-Code            MME-Code,
    iE-Extensions                   ProtocolExtensionContainer { {GUMMEI-ExtIEs} } OPTIONAL,
    ...
}

GUMMEI-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

GNB-ID ::= CHOICE {
    gNB-ID  BIT STRING (SIZE (22..32)),
    ...
}

-- H

HandoverReportType ::= ENUMERATED {
    hoTooEarly,
    hoToWrongCell,
    ...,
    interRATpingpong
}

HandoverRestrictionList ::= SEQUENCE {
    servingPLMN                 PLMN-Identity,
    equivalentPLMNs             EPLMNs                  OPTIONAL,
    forbiddenTAs                ForbiddenTAs            OPTIONAL,
    forbiddenLAs                ForbiddenLAs            OPTIONAL,
    forbiddenInterRATs          ForbiddenInterRATs      OPTIONAL,
    iE-Extensions               ProtocolExtensionContainer { {HandoverRestrictionList-ExtIEs} } OPTIONAL,
    ...
}

HandoverRestrictionList-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    { ID id-NRrestriction       CRITICALITY ignore  EXTENSION NRrestriction PRESENCE optional},
    ...
}

HFN ::= INTEGER (0..1048575)

HFNModified ::= INTEGER (0..131071)

HFNforPDCP-SNlength18 ::= INTEGER (0..16383)

HWLoadIndicator ::= SEQUENCE {
    dLHWLoadIndicator           LoadIndicator,
    uLHWLoadIndicator           LoadIndicator,
    iE-Extensions               ProtocolExtensionContainer { { HWLoadIndicator-ExtIEs} } OPTIONAL,
    ...
}
```

```
HWLoadIndicator-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}


-- I

IntegrityProtectionAlgorithms ::= BIT STRING (SIZE (16, ...))

InterfacesToTrace ::= BIT STRING (SIZE (8))

InvokeIndication ::= ENUMERATED{
    abs-information,
    ...,
    naics-information-start,
    naics-information-stop
}

-- J
-- K

Key-eNodeB-Star ::= BIT STRING (SIZE(256))

-- L

LAC                ::= OCTET STRING (SIZE (2)) --(EXCEPT ('0000'H|'FFFE'H))

LastVisitedCell-Item ::= CHOICE {
    e-UTRAN-Cell                    LastVisitedEUTRANCellInformation,
    uTRAN-Cell                      LastVisitedUTRANCellInformation,
    gERAN-Cell                      LastVisitedGERANCellInformation,
    ...
}

LastVisitedEUTRANCellInformation ::= SEQUENCE {
    global-Cell-ID                  ECGI,
    cellType                        CellType,
    time-UE-StayedInCell            Time-UE-StayedInCell,
    iE-Extensions                   ProtocolExtensionContainer { { LastVisitedEUTRANCellInformation-ExtIEs} } OPTIONAL,
    ...
}

LastVisitedEUTRANCellInformation-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
-- Extension for Rel-11 to support enhanced granularity for time UE stayed in cell --
    { ID id-Time-UE-StayedInCell-EnhancedGranularity    CRITICALITY ignore  EXTENSION Time-UE-StayedInCell-EnhancedGranularity PRESENCE optional}|
    { ID id-HO-cause                                    CRITICALITY ignore  EXTENSION Cause                                    PRESENCE optional},
    ...
}

LastVisitedGERANCellInformation ::= CHOICE {
    undefined                       NULL,
    ...
}
```

```
LastVisitedUTRANCellInformation ::= OCTET STRING

LHN-ID ::=  OCTET STRING(SIZE (32..256))

Links-to-log ::= ENUMERATED {uplink, downlink, both-uplink-and-downlink, ...}

LoadIndicator ::= ENUMERATED {
    lowLoad,
    mediumLoad,
    highLoad,
    overLoad,
    ...
}

LocationReportingInformation ::= SEQUENCE {
    eventType       EventType,
    reportArea      ReportArea,
    iE-Extensions       ProtocolExtensionContainer { {LocationReportingInformation-ExtIEs} } OPTIONAL,
    ...
}

LocationReportingInformation-ExtIEs X2AP-PROTOCOL-EXTENSION ::={
    ...
}

-- M

M1PeriodicReporting ::= SEQUENCE {
    reportInterval              ReportIntervalMDT,
    reportAmount                ReportAmountMDT,
    iE-Extensions               ProtocolExtensionContainer { { M1PeriodicReporting-ExtIEs} } OPTIONAL,
    ...
}

M1PeriodicReporting-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

M1ReportingTrigger::= ENUMERATED{
    periodic,
    a2eventtriggered,
    ...,
    a2eventtriggered-periodic
}

M1ThresholdEventA2 ::= SEQUENCE {
    measurementThreshold        MeasurementThresholdA2,
    iE-Extensions               ProtocolExtensionContainer { { M1ThresholdEventA2-ExtIEs} } OPTIONAL,
    ...
}

M1ThresholdEventA2-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
```

```
}

M3Configuration ::= SEQUENCE {
    m3period            M3period,
    iE-Extensions       ProtocolExtensionContainer { { M3Configuration-ExtIEs} } OPTIONAL,
    ...
}

M3Configuration-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

M3period ::= ENUMERATED {ms100, ms1000, ms10000, ... }

M4Configuration ::= SEQUENCE {
    m4period            M4period,
    m4-links-to-log     Links-to-log,
    iE-Extensions       ProtocolExtensionContainer { { M4Configuration-ExtIEs} } OPTIONAL,
    ...
}

M4Configuration-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

M4period ::= ENUMERATED {ms1024, ms2048, ms5120, ms10240, min1, ... }


M5Configuration ::= SEQUENCE {
    m5period            M5period,
    m5-links-to-log     Links-to-log,
    iE-Extensions       ProtocolExtensionContainer { { M5Configuration-ExtIEs} } OPTIONAL,
    ...
}

M5Configuration-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

M5period ::= ENUMERATED {ms1024, ms2048, ms5120, ms10240, min1, ... }

M6Configuration ::= SEQUENCE {
    m6report-interval   M6report-interval,
    m6delay-threshold   M6delay-threshold   OPTIONAL,
-- This IE shall be present if the M6 Links to log IE is set to “uplink” or to “both-uplink-and-downlink” --
    m6-links-to-log     Links-to-log,
    iE-Extensions       ProtocolExtensionContainer { { M6Configuration-ExtIEs} } OPTIONAL,
    ...
}

M6Configuration-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}
```

```
M6report-interval ::= ENUMERATED { ms1024, ms2048, ms5120, ms10240, ... }

M6delay-threshold ::= ENUMERATED { ms30, ms40, ms50, ms60, ms70, ms80, ms90, ms100, ms150, ms300, ms500, ms750, ... }

M7Configuration ::= SEQUENCE {
    m7period            M7period,
    m7-links-to-log     Links-to-log,
    iE-Extensions       ProtocolExtensionContainer { { M7Configuration-ExtIEs} } OPTIONAL,
    ...
}

M7Configuration-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

M7period ::= INTEGER(1..60, ...)

MakeBeforeBreakIndicator::= ENUMERATED {true, ...}

ManagementBasedMDTallowed ::= ENUMERATED {allowed, ...}

Masked-IMEISV ::= BIT STRING (SIZE (64))

MDT-Activation      ::= ENUMERATED {
    immediate-MDT-only,
    immediate-MDT-and-Trace,
    ...
}

MDT-Configuration ::= SEQUENCE {
    mdt-Activation              MDT-Activation,
    areaScopeOfMDT              AreaScopeOfMDT,
    measurementsToActivate      MeasurementsToActivate,
    m1reportingTrigger          M1ReportingTrigger,
    m1thresholdeventA2          M1ThresholdEventA2          OPTIONAL,
-- Included in case of event-triggered, or event-triggered periodic reporting for measurement M1
    m1periodicReporting         M1PeriodicReporting         OPTIONAL,
-- Included in case of periodic, or event-triggered periodic reporting for measurement M1
    iE-Extensions               ProtocolExtensionContainer { { MDT-Configuration-ExtIEs} } OPTIONAL,
    ...
}

MDT-Configuration-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    {ID id-M3Configuration              CRITICALITY ignore  EXTENSION M3Configuration       PRESENCE conditional}|
    {ID id-M4Configuration              CRITICALITY ignore  EXTENSION M4Configuration       PRESENCE conditional}|
    {ID id-M5Configuration              CRITICALITY ignore  EXTENSION M5Configuration       PRESENCE conditional}|
    {ID id-MDT-Location-Info            CRITICALITY ignore  EXTENSION MDT-Location-Info     PRESENCE optional}|
    {ID id-SignallingBasedMDTPLMNList   CRITICALITY ignore  EXTENSION MDTPLMNList           PRESENCE optional}|
    {ID id-M6Configuration              CRITICALITY ignore  EXTENSION M6Configuration       PRESENCE conditional}|
    {ID id-M7Configuration              CRITICALITY ignore  EXTENSION M7Configuration       PRESENCE conditional},
    ...
}

MDTPLMNList ::= SEQUENCE (SIZE(1..maxnoofMDTPLMNs)) OF PLMN-Identity
```

```
MDT-Location-Info ::= BIT STRING (SIZE (8))

Measurement-ID  ::= INTEGER (1..4095, ...)

MeasurementsToActivate::= BIT STRING (SIZE (8))

MeasurementThresholdA2 ::= CHOICE {
    threshold-RSRP              Threshold-RSRP,
    threshold-RSRQ              Threshold-RSRQ,
    ...
}

MeNBResourceCoordinationInformation ::= SEQUENCE {
    eUTRA-Cell-ID                   ECGI,
    uLCoordinationInformation       BIT STRING (SIZE(6..4400, ...)),
    dLCoordinationInformation       BIT STRING (SIZE(6..4400, ...))     OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { { MeNBResourceCoordinationInformationExtIEs} }     OPTIONAL,
    ...
}

MeNBResourceCoordinationInformationExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

MeNBtoSeNBContainer  ::= OCTET STRING

MME-Group-ID    ::= OCTET STRING (SIZE (2))

MME-Code        ::= OCTET STRING (SIZE (1))

MBMS-Service-Area-Identity-List ::= SEQUENCE (SIZE(1.. maxnoofMBMSServiceAreaIdentities)) OF MBMS-Service-Area-Identity

MBMS-Service-Area-Identity ::= OCTET STRING (SIZE (2))

MBSFN-Subframe-Infolist::= SEQUENCE (SIZE(1.. maxnoofMBSFN)) OF MBSFN-Subframe-Info

MBSFN-Subframe-Info ::= SEQUENCE {
    radioframeAllocationPeriod      RadioframeAllocationPeriod,
    radioframeAllocationOffset      RadioframeAllocationOffset,
    subframeAllocation              SubframeAllocation,
    iE-Extensions                   ProtocolExtensionContainer { { MBSFN-Subframe-Info-ExtIEs } }    OPTIONAL,
    ...
}

MBSFN-Subframe-Info-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

MobilityParametersModificationRange ::= SEQUENCE {
    handoverTriggerChangeLowerLimit     INTEGER (-20..20),
    handoverTriggerChangeUpperLimit     INTEGER (-20..20),
    ...
}
```

```
MobilityParametersInformation ::= SEQUENCE {
    handoverTriggerChange           INTEGER (-20..20),
    ...
}

MultibandInfoList ::= SEQUENCE (SIZE(1..maxnoofBands)) OF BandInfo


BandInfo    ::= SEQUENCE {
    freqBandIndicator       FreqBandIndicator,
    iE-Extensions           ProtocolExtensionContainer { { BandInfo-ExtIEs } }  OPTIONAL,
    ...
}

BandInfo-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

MeNBtoSgNBContainer ::= OCTET STRING

SplitSRBs ::= ENUMERATED {srb1, srb2, srb1and2, ...}

SplitSRB ::= SEQUENCE {
    rrcContainer                RRCContainer            OPTIONAL,
    srbType                     SRBType,
    deliveryStatus              DeliveryStatus          OPTIONAL,
    iE-Extensions               ProtocolExtensionContainer { {SplitSRB-ExtIEs} } OPTIONAL,
    ...
}

SplitSRB-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

UENRMeasurement ::= SEQUENCE {
    uENRMeasurements            RRCContainer,
    iE-Extensions           ProtocolExtensionContainer { {UENRMeasurement-ExtIEs} } OPTIONAL,
    ...
}

UENRMeasurement-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

-- N

Neighbour-Information ::= SEQUENCE (SIZE (0..maxnoofNeighbours)) OF SEQUENCE {
    eCGI                        ECGI,
    pCI                         PCI,
    eARFCN                      EARFCN,
    iE-Extensions               ProtocolExtensionContainer { {Neighbour-Information-ExtIEs} } OPTIONAL,
    ...
}
```

```
Neighbour-Information-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    { ID id-NeighbourTAC        CRITICALITY ignore  EXTENSION TAC              PRESENCE optional}|
    { ID id-eARFCNExtension     CRITICALITY reject  EXTENSION EARFCNExtension   PRESENCE optional},
    ...
}

NextHopChainingCount ::= INTEGER (0..7)

Number-of-Antennaports ::= ENUMERATED {
        an1,
        an2,
        an4,
        ...
}

NRFreqInfo ::= SEQUENCE{
    nRARFCN         INTEGER (0.. 3279165),
    nRARFCN-SUL     INTEGER (0.. 3279165)       OPTIONAL,
    freqBandListNr  SEQUENCE (SIZE(1..maxnoofNrCellBands)) OF FreqBandNrItem,
    sULInformation  SULInformation      OPTIONAL,
    iE-Extensions   ProtocolExtensionContainer { {NRFreqInfo-ExtIEs} } OPTIONAL,

    ...
}

NRFreqInfo-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

NRCellIdentifier ::= BIT STRING (SIZE (36))

NRCGI ::= SEQUENCE {
    pLMN-Identity               PLMN-Identity,
    nRcellIdentifier                NRCellIdentifier,
    iE-Extensions               ProtocolExtensionContainer { {NRCGI-ExtIEs} } OPTIONAL,
    ...
}

NRCGI-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

NRPCI ::= INTEGER (0..1007)

NRrestriction ::= ENUMERATED {
    nRrestricted,
    ...
}

NRencryptionAlgorithms ::= BIT STRING (SIZE (16,...))
NRintegrityProtectionAlgorithms ::= BIT STRING (SIZE (16,...))

NR-TxBW ::= SEQUENCE {
```

```
    nRSCS   NRSCS,
    nRNRB   NRNRB,
    iE-Extensions               ProtocolExtensionContainer { { NR-TxBW-ExtIEs} } OPTIONAL,
    ...
}

NR-TxBW-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

NRNRB ::= ENUMERATED { nrb11, nrb18, nrb24, nrb25, nrb31, nrb32, nrb38, nrb51, nrb52, nrb65, nrb66, nrb78, nrb79, nrb93, nrb106, nrb107, nrb121,
nrb132, nrb133, nrb135, nrb160, nrb162, nrb189, nrb216, nrb217, nrb245, nrb264, nrb270, nrb273, ...}

NRSCS ::= ENUMERATED { scs15, scs30, scs60, scs120, ...}

NRS-NSSS-PowerOffset ::= ENUMERATED { minusThree, zero, three, ...}

FiveGS-TAC ::= OCTET STRING (SIZE (3))

NRUESecurityCapabilities ::= SEQUENCE {
    nRencryptionAlgorithms              NRencryptionAlgorithms,
    nRintegrityProtectionAlgorithms     NRintegrityProtectionAlgorithms,
    iE-Extensions                       ProtocolExtensionContainer { { NRUESecurityCapabilities-ExtIEs} }  OPTIONAL,
...
}

NRUESecurityCapabilities-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

NSSS-NumOccasionDifferentPrecoder ::= ENUMERATED { two, four, eight, ...}

-- O

OffsetOfNbiotChannelNumberToEARFCN ::= ENUMERATED {
        minusTen,
        minusNine,
        minusEight,
        minusSeven,
        minusSix,
        minusFive,
        minusFour,
        minusThree,
        minusTwo,
        minusOne,
        minusZeroDotFive,
        zero,
        one,
        two,
        three,
        four,
        five,
        six,
        seven,
```

```
        eight,
        nine,
        ...
}

Oneframe ::= BIT STRING (SIZE (6))

-- P

Packet-LossRate ::= INTEGER(0..1000)

PA-Values ::= ENUMERATED {
    dB-6,
    dB-4dot77,
    dB-3,
    dB-1dot77,
    dB0,
    dB1,
    dB2,
    dB3,
    ...
}

PDCPChangeIndication ::= ENUMERATED {s-KgNB-update-required, pDCP-data-recovery-required,...}

PDCP-SN ::= INTEGER (0..4095)

PDCP-SNExtended ::= INTEGER (0..32767)

PDCP-SNlength18 ::= INTEGER (0..262143)

PCI ::= INTEGER (0..503, ...)

PLMN-Identity ::= OCTET STRING (SIZE(3))

Port-Number ::= OCTET STRING (SIZE (2))

PRACH-Configuration ::= SEQUENCE {
    rootSequenceIndex                   INTEGER (0..837),
    zeroCorrelationIndex                INTEGER (0..15),
    highSpeedFlag                       BOOLEAN,
    prach-FreqOffset                    INTEGER (0..94),
    prach-ConfigIndex                   INTEGER (0..63)     OPTIONAL,  -- present for TDD --
    iE-Extensions                       ProtocolExtensionContainer { {PRACH-Configuration-ExtIEs} } OPTIONAL,
    ...
}

PLMNAreaBasedQMC ::= SEQUENCE {
    plmnListforQMC      PLMNListforQMC,
    iE-Extensions       ProtocolExtensionContainer { {PLMNAreaBasedQMC-ExtIEs} } OPTIONAL,
    ...
}

PLMNAreaBasedQMC-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
```

```
    ...
}

PLMNListforQMC ::= SEQUENCE (SIZE(1..maxnoofPLMNforQMC)) OF PLMN-Identity


PRACH-Configuration-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

Pre-emptionCapability ::= ENUMERATED {
    shall-not-trigger-pre-emption,
    may-trigger-pre-emption
}

Pre-emptionVulnerability ::= ENUMERATED {
    not-pre-emptable,
    pre-emptable
}

PriorityLevel               ::= INTEGER { spare (0), highest (1), lowest (14), no-priority (15) } (0..15)

ProSeAuthorized ::= SEQUENCE {
    proSeDirectDiscovery        ProSeDirectDiscovery            OPTIONAL,
    proSeDirectCommunication    ProSeDirectCommunication        OPTIONAL,
    iE-Extensions               ProtocolExtensionContainer { {ProSeAuthorized-ExtIEs} } OPTIONAL,
    ...
}

ProSeAuthorized-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    { ID id-ProSeUEtoNetworkRelaying    CRITICALITY ignore  EXTENSION ProSeUEtoNetworkRelaying    PRESENCE optional},
    ...
}

ProSeDirectDiscovery ::= ENUMERATED {
    authorized,
    not-authorized,
    ...
}

ProSeDirectCommunication ::= ENUMERATED {
    authorized,
    not-authorized,
    ...
}

ProSeUEtoNetworkRelaying ::= ENUMERATED {
    authorized,
    not-authorized,
    ...
}

ProtectedEUTRAResourceIndication::= SEQUENCE {
    activationSFN                           INTEGER (0..1023),
```

```
    protectedResourceList                   ProtectedResourceList,
    mBSFNControlRegionLength                INTEGER (0..3) OPTIONAL,
    pDCCHRegionLength                       INTEGER (1..3) OPTIONAL,
    ...
}


ProtectedFootprintTimePattern ::= SEQUENCE {
    protectedFootprintTimePeriodicity               INTEGER (1..80, ...),
    protectedFootprintStartTime                     INTEGER (1..20, ...),
    ...
}

ProtectedResourceList ::= SEQUENCE (SIZE(1.. maxnoofProtectedResourcePatterns)) OF ProtectedResourceList-Item

ProtectedResourceList-Item ::= SEQUENCE {
    resourceType                    ResourceType,
    intraPRBProtectedResourceFootprint      BIT STRING (SIZE(84, ...)),
    protectedFootprintFrequencyPattern      BIT STRING (SIZE(6..110, ...)),
    protectedFootprintTimePattern           ProtectedFootprintTimePattern,
    ...
}

-- Q

QCI ::= INTEGER (0..255)

-- R

RadioframeAllocationOffset ::= INTEGER (0..7, ...)

RadioframeAllocationPeriod ::= ENUMERATED{
    n1,
    n2,
    n4,
    n8,
    n16,
    n32,
    ...
}


RadioResourceStatus ::= SEQUENCE {
    dL-GBR-PRB-usage                            DL-GBR-PRB-usage,
    uL-GBR-PRB-usage                            UL-GBR-PRB-usage,
    dL-non-GBR-PRB-usage                        DL-non-GBR-PRB-usage,
    uL-non-GBR-PRB-usage                        UL-non-GBR-PRB-usage,
    dL-Total-PRB-usage                          DL-Total-PRB-usage,
    uL-Total-PRB-usage                          UL-Total-PRB-usage,
    iE-Extensions                               ProtocolExtensionContainer { {RadioResourceStatus-ExtIEs} } OPTIONAL,
    ...
}

RadioResourceStatus-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
```

```
    {ID id-DL-scheduling-PDCCH-CCE-usage       CRITICALITY ignore  EXTENSION DL-scheduling-PDCCH-CCE-usage     PRESENCE optional}|

    {ID id-UL-scheduling-PDCCH-CCE-usage       CRITICALITY ignore  EXTENSION UL-scheduling-PDCCH-CCE-usage     PRESENCE optional},
    ...
}

ReceiveStatusofULPDCPSDUs ::= BIT STRING (SIZE(4096))

ReceiveStatusOfULPDCPSDUsExtended ::= BIT STRING (SIZE(1..16384))

ReceiveStatusOfULPDCPSDUsPDCP-SNlength18 ::= BIT STRING (SIZE(1..131072))

Registration-Request    ::= ENUMERATED {
    start,
    stop,
    ...,
    partial-stop,
    add
}

RelativeNarrowbandTxPower ::= SEQUENCE {

    rNTP-PerPRB                         BIT STRING (SIZE(6..110, ...)),
    rNTP-Threshold                      RNTP-Threshold,
    numberOfCellSpecificAntennaPorts    ENUMERATED {one, two, four, ...},
    p-B                                 INTEGER (0..3,...),
    pDCCH-InterferenceImpact            INTEGER (0..4,...),
    iE-Extensions                       ProtocolExtensionContainer { { RelativeNarrowbandTxPower-ExtIEs} } OPTIONAL,
    ...
}

RelativeNarrowbandTxPower-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    { ID id-enhancedRNTP    CRITICALITY ignore  EXTENSION EnhancedRNTP      PRESENCE optional },
    ...
}

ReplacingCellsList ::= SEQUENCE (SIZE(0.. maxCellineNB)) OF ReplacingCellsList-Item

ReplacingCellsList-Item ::= SEQUENCE {
    eCGI            ECGI,
    ...
}

ReportAmountMDT ::= ENUMERATED{r1, r2, r4, r8, r16, r32, r64, rinfinity}

ReportArea ::= ENUMERATED{
    ecgi,
    ...
}

ReportCharacteristics   ::= BIT STRING (SIZE (32))

ReportingPeriodicityCSIR ::= ENUMERATED {
    ms5,
```

```
    ms10,
    ms20,
    ms40,
    ms80,
...
}

ReportingPeriodicityRSRPMR ::= ENUMERATED {
    one-hundred-20-ms,
    two-hundred-40-ms,
    four-hundred-80-ms,
    six-hundred-40-ms,
...
}

ReportIntervalMDT ::= ENUMERATED {ms120, ms240, ms480, ms640, ms1024, ms2048, ms5120, ms10240, min1, min6, min12, min30, min60}

ReservedSubframePattern ::= SEQUENCE{
    subframeType                    SubframeType,
    reservedSubframePattern         BIT STRING (SIZE(10..40)),
    mBSFNControlRegionLength        INTEGER (0..3),
    ...
}

ResourceType ::= ENUMERATED {
    downlinknonCRS,
    cRS,
    uplink,
    ...
}

ResumeID    ::= CHOICE {
    non-truncated   BIT STRING(SIZE(40)),
    truncated       BIT STRING(SIZE(24)),
    ...
}

RLCMode ::= ENUMERATED {
    rlc-am,
    rlc-um
}

RNTP-Threshold ::= ENUMERATED {
    minusInfinity,
    minusEleven,
    minusTen,
    minusNine,
    minusEight,
    minusSeven,
    minusSix,
    minusFive,
    minusFour,
    minusThree,
    minusTwo,
```

```
    minusOne,
    zero,
    one,
    two,
    three,
    ...
}

RRC-Config-Ind ::= ENUMERATED {
    full-config,
    delta-config,
    ...
}

RRC-Context ::= OCTET STRING

RRCConnReestabIndicator ::= ENUMERATED {
    reconfigurationFailure, handoverFailure, otherFailure, ...
}
-- The values correspond to the values of ReestablishmentCause reported from the UE in the RRCConnectionReestablishmentRequest, as defined in TS
36.331 [9]

RRCConnSetupIndicator::= ENUMERATED {
    rrcConnSetup,
    ...
}

RSRPMeasurementResult ::= SEQUENCE (SIZE(1..maxCellReport)) OF
    SEQUENCE {
        rSRPCellID                      ECGI,
        rSRPMeasured                    INTEGER (0..97, ...),
        iE-Extensions                   ProtocolExtensionContainer { { RSRPMeasurementResult-ExtIEs} } OPTIONAL,
        ...
    }

RSRPMeasurementResult-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

RSRPMRList ::= SEQUENCE (SIZE(1..maxUEReport)) OF
    SEQUENCE {
        rSRPMeasurementResult           RSRPMeasurementResult,
        iE-Extensions                   ProtocolExtensionContainer { { RSRPMRList-ExtIEs} } OPTIONAL,
        ...
    }

RSRPMRList-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    { ID id-UEID    CRITICALITY ignore  EXTENSION UEID      PRESENCE optional},
    ...
}

RRCContainer ::= OCTET STRING

-- S
```

```
S1TNLLoadIndicator ::= SEQUENCE {
    dLS1TNLLoadIndicator            LoadIndicator,
    uLS1TNLLoadIndicator            LoadIndicator,
    iE-Extensions                   ProtocolExtensionContainer { { S1TNLLoadIndicator-ExtIEs} } OPTIONAL,
    ...
}

S1TNLLoadIndicator-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

SCGChangeIndication ::= ENUMERATED {pDCPCountWrapAround, pSCellChange, other, ...}

SecondaryRATUsageReportList ::= SEQUENCE (SIZE(1..maxnoofBearers)) OF ProtocolIE-Single-Container {{SecondaryRATUsageReport-ItemIEs}}

SecondaryRATUsageReport-ItemIEs X2AP-PROTOCOL-IES ::= {
    { ID id-SecondaryRATUsageReport-Item        CRITICALITY reject  TYPE SecondaryRATUsageReport-Item     PRESENCE mandatory},
    ...
}

SecondaryRATUsageReport-Item ::= SEQUENCE {
    e-RAB-ID                        E-RAB-ID,
    secondaryRATType                ENUMERATED {nr, ...},
    e-RABUsageReportList            E-RABUsageReportList,
    iE-Extensions               ProtocolExtensionContainer { { SecondaryRATUsageReport-Item-ExtIEs} } OPTIONAL,
...
}

SecondaryRATUsageReport-Item-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

SeNBSecurityKey ::= BIT STRING (SIZE(256))

SeNBtoMeNBContainer ::= OCTET STRING


ServedCells ::= SEQUENCE (SIZE (1.. maxCellineNB)) OF SEQUENCE {
    servedCellInfo                  ServedCell-Information,
    neighbour-Info                  Neighbour-Information          OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { {ServedCell-ExtIEs} } OPTIONAL,
    ...
}

ServedCell-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

ServedCell-Information ::= SEQUENCE {
    pCI                 PCI,
    cellId              ECGI,
    tAC                 TAC,
    broadcastPLMNs      BroadcastPLMNs-Item,
```

```
    eUTRA-Mode-Info     EUTRA-Mode-Info,
    iE-Extensions       ProtocolExtensionContainer { {ServedCell-Information-ExtIEs} } OPTIONAL,
    ...
}

ServedCell-Information-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    { ID id-Number-of-Antennaports              CRITICALITY ignore  EXTENSION Number-of-Antennaports            PRESENCE optional}|
    { ID id-PRACH-Configuration                 CRITICALITY ignore  EXTENSION PRACH-Configuration               PRESENCE optional}|
    { ID id-MBSFN-Subframe-Info                 CRITICALITY ignore  EXTENSION MBSFN-Subframe-Infolist           PRESENCE optional}|
    { ID id-CSG-Id                              CRITICALITY ignore  EXTENSION CSG-Id                            PRESENCE optional}|
    { ID id-MBMS-Service-Area-List              CRITICALITY ignore  EXTENSION MBMS-Service-Area-Identity-List   PRESENCE optional}|
    { ID id-MultibandInfoList                   CRITICALITY ignore  EXTENSION MultibandInfoList                 PRESENCE optional}|
    { ID id-FreqBandIndicatorPriority           CRITICALITY ignore  EXTENSION FreqBandIndicatorPriority         PRESENCE optional}|
    { ID id-BandwidthReducedSI                  CRITICALITY ignore  EXTENSION BandwidthReducedSI                PRESENCE optional}|
    { ID id-ProtectedEUTRAResourceIndication    CRITICALITY ignore  EXTENSION ProtectedEUTRAResourceIndication  PRESENCE optional},
    ...
}

ServiceType ::= ENUMERATED{
    qMC-for-streaming-service,
    qMC-for-MTSI-service,
    ...
}

SgNBResourceCoordinationInformation ::= SEQUENCE {
    nR-CGI                          NRCGI,
    uLCoordinationInformation       BIT STRING (SIZE(6..4400, ...)),
    dLCoordinationInformation       BIT STRING (SIZE(6..4400, ...)) OPTIONAL,
    iE-Extensions                   ProtocolExtensionContainer { { SgNBResourceCoordinationInformationExtIEs} }     OPTIONAL,
    ...
}

SgNBResourceCoordinationInformationExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

SgNB-UE-X2AP-ID ::= INTEGER (0..4294967295)

SIPTOBearerDeactivationIndication ::= ENUMERATED {
    true,
    ...
}

SharedResourceType ::= CHOICE{
    uLOnlySharing       ULOnlySharing,
    uLandDLSharing      ULandDLSharing,
    ...
}

ShortMAC-I ::= BIT STRING (SIZE(16))


SGNB-Addition-Trigger-Ind    ::= ENUMERATED {
    sn-change,
```

```
    inter-eNB-HO,
    intra-eNB-HO,
    ...
}

SourceOfUEActivityBehaviourInformation ::= ENUMERATED {
    subscription-information,
    statistics,
    ...
}

SpecialSubframe-Info ::= SEQUENCE {
    specialSubframePatterns     SpecialSubframePatterns,
    cyclicPrefixDL              CyclicPrefixDL,
    cyclicPrefixUL              CyclicPrefixUL,
    iE-Extensions               ProtocolExtensionContainer { { SpecialSubframe-Info-ExtIEs} } OPTIONAL,
    ...
}

SpecialSubframe-Info-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

SpecialSubframePatterns ::= ENUMERATED {
    ssp0,
    ssp1,
    ssp2,
    ssp3,
    ssp4,
    ssp5,
    ssp6,
    ssp7,
    ssp8,
    ...
}

SpectrumSharingGroupID ::= INTEGER (1..maxCellineNB)

SubbandCQI ::= SEQUENCE {
    subbandCQICodeword0         SubbandCQICodeword0,
    subbandCQICodeword1         SubbandCQICodeword1     OPTIONAL,
    iE-Extensions               ProtocolExtensionContainer { { SubbandCQI-ExtIEs} } OPTIONAL,
    ...
}

SRVCCOperationPossible ::= ENUMERATED {
    possible,
    ...
}

SubbandCQI-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}
```

```
SubbandCQICodeword0 ::= CHOICE {
    four-bitCQI                     INTEGER (0..15, ...),
    two-bitSubbandDifferentialCQI   INTEGER (0..3, ...),
    two-bitDifferentialCQI          INTEGER (0..3, ...),
    ...
}
SubbandCQICodeword1 ::= CHOICE {
    four-bitCQI                         INTEGER (0..15, ...),
    three-bitSpatialDifferentialCQI     INTEGER (0..7, ...),
    two-bitSubbandDifferentialCQI       INTEGER (0..3, ...),
    two-bitDifferentialCQI              INTEGER (0..3, ...),
    ...
}

SubbandCQIList ::= SEQUENCE (SIZE(1.. maxSubband)) OF SubbandCQIItem

SubbandCQIItem ::= SEQUENCE {
    subbandCQI          SubbandCQI,
    subbandIndex        INTEGER (0..27,...),
    iE-Extensions       ProtocolExtensionContainer { { SubbandCQIItem-ExtIEs} } OPTIONAL,
    ...
}

SubbandCQIItem-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

SubbandSize ::= ENUMERATED {
    size2,
    size3,
    size4,
    size6,
    size8,
    ...
}

SubscriberProfileIDforRFP ::= INTEGER (1..256)

SubframeAllocation ::= CHOICE {
    oneframe                        Oneframe,
    fourframes                      Fourframes,
    ...
}

SubframeAssignment ::= ENUMERATED {
    sa0,
    sa1,
    sa2,
    sa3,
    sa4,
    sa5,
    sa6,
    ...
}
```

```
SubframeType ::= ENUMERATED{mbsfn,nonmbsfn,...}

SgNBSecurityKey ::= BIT STRING (SIZE(256))

SgNBtoMeNBContainer ::= OCTET STRING

SRBType ::= ENUMERATED {srb1, srb2, ...}
SCGConfigurationQuery ::= ENUMERATED {true,...}

SULInformation ::= SEQUENCE {
    sUL-ARFCN               INTEGER (0.. 3279165),
    sUL-TxBW                NR-TxBW,
    iE-Extensions           ProtocolExtensionContainer { { SULInformation-ExtIEs } }        OPTIONAL,
    ...
}


SupportedSULFreqBandItem ::= SEQUENCE {
    freqBandIndicatorNr             INTEGER (1..1024,...),
    ...
}

SupportedSULFreqBandItem-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

SULInformation-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

-- T

TABasedMDT::= SEQUENCE {
    tAListforMDT        TAListforMDT,
    iE-Extensions       ProtocolExtensionContainer { {TABasedMDT-ExtIEs} } OPTIONAL,
    ...
}

TABasedMDT-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

TAC ::= OCTET STRING (SIZE (2))

TAIBasedMDT ::= SEQUENCE {
    tAIListforMDT           TAIListforMDT,
    iE-Extensions           ProtocolExtensionContainer { {TAIBasedMDT-ExtIEs} } OPTIONAL,
    ...
}

TAIBasedMDT-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}
```

```
TAIListforMDT ::= SEQUENCE (SIZE(1..maxnoofTAforMDT)) OF TAI-Item

TAI-Item ::= SEQUENCE {
    tAC                 TAC,
    pLMN-Identity       PLMN-Identity,
    iE-Extensions       ProtocolExtensionContainer { { TAI-Item-ExtIEs} } OPTIONAL,
    ...
}

TAI-Item-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

TAListforMDT ::= SEQUENCE (SIZE(1..maxnoofTAforMDT)) OF TAC

TABasedQMC ::= SEQUENCE {
    tAListforQMC        TAListforQMC,
    iE-Extensions       ProtocolExtensionContainer { {TABasedQMC-ExtIEs} } OPTIONAL,
    ...
}

TABasedQMC-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

TAListforQMC ::= SEQUENCE (SIZE(1..maxnoofTAforQMC)) OF TAC

TAIBasedQMC ::= SEQUENCE {
    tAIListforQMC       TAIListforQMC,
    iE-Extensions       ProtocolExtensionContainer { {TAIBasedQMC-ExtIEs} } OPTIONAL,
    ...
}

TAIBasedQMC-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

TAIListforQMC ::= SEQUENCE (SIZE(1..maxnoofTAforQMC)) OF TAI-Item

TargetCellInUTRAN ::= OCTET STRING -- This IE is to be encoded according to the UTRAN Cell ID in the Last Visited UTRAN Cell Information IE in TS
25.413 [24]

TargeteNBtoSource-eNBTransparentContainer   ::= OCTET STRING

TDD-Info ::= SEQUENCE {
    eARFCN                      EARFCN,
    transmission-Bandwidth      Transmission-Bandwidth,
    subframeAssignment          SubframeAssignment,
    specialSubframe-Info        SpecialSubframe-Info,
    iE-Extensions               ProtocolExtensionContainer { {TDD-Info-ExtIEs} } OPTIONAL,
    ...
}
TDD-Info-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
```

```
    { ID id-AdditionalSpecialSubframe-Info  CRITICALITY ignore  EXTENSION AdditionalSpecialSubframe-Info   PRESENCE optional}|
    { ID id-eARFCNExtension                 CRITICALITY reject  EXTENSION EARFCNExtension                  PRESENCE optional}|
    { ID id-AdditionalSpecialSubframeExtension-Info CRITICALITY ignore  EXTENSION AdditionalSpecialSubframeExtension-Info PRESENCE optional},
    ...
}

Threshold-RSRP ::= INTEGER(0..97)

Threshold-RSRQ ::= INTEGER(0..34)

TimeToWait ::= ENUMERATED {
    v1s,
    v2s,
    v5s,
    v10s,
    v20s,
    v60s,
    ...
}

Time-UE-StayedInCell ::= INTEGER (0..4095)

Time-UE-StayedInCell-EnhancedGranularity ::= INTEGER (0..40950)

TraceActivation ::= SEQUENCE {
    eUTRANTraceID                   EUTRANTraceID,
    interfacesToTrace               InterfacesToTrace,
traceDepth                          TraceDepth,
traceCollectionEntityIPAddress      TraceCollectionEntityIPAddress,
    iE-Extensions                   ProtocolExtensionContainer { {TraceActivation-ExtIEs} } OPTIONAL,
    ...
}

TraceActivation-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    { ID id-MDTConfiguration            CRITICALITY ignore  EXTENSION MDT-Configuration         PRESENCE optional}|
    { ID id-UEAppLayerMeasConfig        CRITICALITY ignore  EXTENSION UEAppLayerMeasConfig      PRESENCE optional},
    ...
}

TraceCollectionEntityIPAddress ::= BIT STRING (SIZE(1..160, ...))

TraceDepth      ::= ENUMERATED {
    minimum,
    medium,
    maximum,
    minimumWithoutVendorSpecificExtension,
    mediumWithoutVendorSpecificExtension,
    maximumWithoutVendorSpecificExtension,
    ...
}

Transmission-Bandwidth ::= ENUMERATED {
        bw6,
        bw15,
```

```
        bw25,
        bw50,
        bw75,
        bw100,
        ...,
        bw1
}

TransportLayerAddress           ::= BIT STRING (SIZE(1..160, ...))

TunnelInformation ::= SEQUENCE {
    transportLayerAddress   TransportLayerAddress,
    uDP-Port-Number         Port-Number         OPTIONAL,
    iE-Extensions           ProtocolExtensionContainer { {Tunnel-Information-ExtIEs} } OPTIONAL,
    ...
}

Tunnel-Information-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

TypeOfError ::= ENUMERATED {
    not-understood,
    missing,
    ...
}


-- U

UEAggregateMaximumBitRate ::= SEQUENCE {
    uEaggregateMaximumBitRateDownlink   BitRate,
    uEaggregateMaximumBitRateUplink     BitRate,
    iE-Extensions                       ProtocolExtensionContainer { {UEAggregate-MaximumBitrate-ExtIEs} } OPTIONAL,
    ...
}

UEAggregate-MaximumBitrate-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    { ID id-extended-uEaggregateMaximumBitRateDownlink  CRITICALITY ignore  EXTENSION ExtendedBitRate   PRESENCE optional}|
    { ID id-extended-uEaggregateMaximumBitRateUplink    CRITICALITY ignore  EXTENSION ExtendedBitRate   PRESENCE optional},
    ...
}

UEAppLayerMeasConfig ::= SEQUENCE {
    containerForAppLayerMeasConfig          OCTET STRING (SIZE(1..1000)),
    areaScopeOfQMC      AreaScopeOfQMC,
    iE-Extensions       ProtocolExtensionContainer { {UEAppLayerMeasConfig-ExtIEs} } OPTIONAL,
    ...
}

UEAppLayerMeasConfig-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    {ID id-serviceType  CRITICALITY ignore  EXTENSION ServiceType   PRESENCE optional},
    ...
}
```

```
UE-ContextKeptIndicator ::= ENUMERATED {
    true,
    ...
}

UEID ::= BIT STRING (SIZE (16))

UE-HistoryInformation ::= SEQUENCE (SIZE(1..maxnoofCells)) OF LastVisitedCell-Item

UE-HistoryInformationFromTheUE ::= OCTET STRING
-- This IE is a transparent container and shall be encoded as the VisitedCellInfoList field contained in the UEInformationResponse message as
defined in TS 36.331 [9]

UE-S1AP-ID ::= INTEGER (0.. 4294967295)

UE-X2AP-ID ::= INTEGER (0..4095)

UE-X2AP-ID-Extension ::= INTEGER (0..4095, ...)

UE-RLF-Report-Container::= OCTET STRING
-- This IE is a transparent container and shall be encoded as the RLF-Report-r9 field contained in the UEInformationResponse message as defined in
TS 36.331 [9]

UE-RLF-Report-Container-for-extended-bands ::= OCTET STRING
-- This IE is a transparent container and shall be encoded as the RLF-Report-v9e0 field contained in the UEInformationResponse message as defined
in TS 36.331 [9]

UESecurityCapabilities ::= SEQUENCE {
    encryptionAlgorithms                EncryptionAlgorithms,
    integrityProtectionAlgorithms       IntegrityProtectionAlgorithms,
    iE-Extensions                       ProtocolExtensionContainer { { UESecurityCapabilities-ExtIEs} }    OPTIONAL,
...
}

UESecurityCapabilities-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

UESidelinkAggregateMaximumBitRate ::= SEQUENCE {
    uESidelinkAggregateMaximumBitRate       BitRate,
    iE-Extensions                   ProtocolExtensionContainer { {UE-Sidelink-Aggregate-MaximumBitRate-ExtIEs} } OPTIONAL,
    ...
}

UE-Sidelink-Aggregate-MaximumBitRate-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

UEsToBeResetList ::= SEQUENCE (SIZE (1.. maxUEsinengNBDU)) OF UEsToBeResetList-Item

UEsToBeResetList-Item::= SEQUENCE {
    meNB-ID                 UE-X2AP-ID,
    meNB-ID-ext             UE-X2AP-ID-Extension                                        OPTIONAL,
```

```
    sgNB-ID                 SgNB-UE-X2AP-ID                                                 OPTIONAL,
    iE-Extensions           ProtocolExtensionContainer { { UEsToBeResetList-Item-ExtIEs} }  OPTIONAL,
    ...
}

UEsToBeResetList-Item-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

ULandDLSharing ::= SEQUENCE{
    uLResourcesULandDLSharing               ULResourcesULandDLSharing,
    dLResourcesULandDLSharing               DLResourcesULandDLSharing,
    ...
}

ULConfiguration::= SEQUENCE {
    uL-PDCP         UL-UE-Configuration,
    iE-Extensions                   ProtocolExtensionContainer { { ULConfiguration-ExtIEs} } OPTIONAL,
    ...
}

ULConfiguration-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

UL-UE-Configuration::= ENUMERATED { no-data, shared, only, ... }

UL-GBR-PRB-usage::= INTEGER (0..100)

UL-HighInterferenceIndicationInfo ::= SEQUENCE (SIZE(1..maxCellineNB)) OF UL-HighInterferenceIndicationInfo-Item

UL-HighInterferenceIndicationInfo-Item ::= SEQUENCE {
    target-Cell-ID                  ECGI,
    ul-interferenceindication       UL-HighInterferenceIndication,
    iE-Extensions                   ProtocolExtensionContainer { { UL-HighInterferenceIndicationInfo-Item-ExtIEs} } OPTIONAL,
    ...
}

UL-HighInterferenceIndicationInfo-Item-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

UL-HighInterferenceIndication ::= BIT STRING (SIZE(1..110, ...))

UL-InterferenceOverloadIndication ::= SEQUENCE (SIZE(1..maxnoofPRBs)) OF UL-InterferenceOverloadIndication-Item

UL-InterferenceOverloadIndication-Item ::= ENUMERATED {
    high-interference,
    medium-interference,
    low-interference,
    ...
}

UL-non-GBR-PRB-usage::= INTEGER (0..100)
```

```
ULOnlySharing ::= SEQUENCE{
    uLResourceBitmapULOnlySharing   DataTrafficResources,
    ...
}

ULResourceBitmapULandDLSharing ::=  DataTrafficResources


ULResourcesULandDLSharing ::= CHOICE {
    unchanged           NULL,
    changed             ULResourceBitmapULandDLSharing,
    ...
}

UL-scheduling-PDCCH-CCE-usage::= INTEGER (0..100)

UL-Total-PRB-usage::= INTEGER (0..100)

UsableABSInformation ::= CHOICE {
    fdd                 UsableABSInformationFDD,
    tdd                 UsableABSInformationTDD,
    ...
}

UsableABSInformationFDD ::= SEQUENCE {
    usable-abs-pattern-info             BIT STRING (SIZE(40)),
    iE-Extensions                       ProtocolExtensionContainer { { UsableABSInformationFDD-ExtIEs} } OPTIONAL,
    ...
}

UsableABSInformationFDD-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

UsableABSInformationTDD ::= SEQUENCE {
    usaable-abs-pattern-info            BIT STRING (SIZE(1..70, ...)),
    iE-Extensions                       ProtocolExtensionContainer { { UsableABSInformationTDD-ExtIEs} } OPTIONAL,
    ...
}

UsableABSInformationTDD-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}


UserPlaneTrafficActivityReport ::= ENUMERATED {inactive, re-activated, ...}

-- V

V2XServicesAuthorized ::= SEQUENCE {
    vehicleUE           VehicleUE                                                   OPTIONAL,
pedestrianUE            PedestrianUE                                                OPTIONAL,
    iE-Extensions       ProtocolExtensionContainer { {V2XServicesAuthorized-ExtIEs} }   OPTIONAL,
```

```
    ...
}

V2XServicesAuthorized-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

VehicleUE ::= ENUMERATED {
    authorized,
    not-authorized,
    ...
}

PedestrianUE ::= ENUMERATED {
    authorized,
    not-authorized,
    ...
}

-- W

WidebandCQI ::= SEQUENCE {
    widebandCQICodeword0        INTEGER (0..15, ...),
    widebandCQICodeword1        WidebandCQICodeword1        OPTIONAL,
    iE-Extensions               ProtocolExtensionContainer { { WidebandCQI-ExtIEs} } OPTIONAL,
    ...
}

WidebandCQI-ExtIEs X2AP-PROTOCOL-EXTENSION ::= {
    ...
}

WidebandCQICodeword1::= CHOICE {
    four-bitCQI                         INTEGER (0..15, ...),
    three-bitSpatialDifferentialCQI     INTEGER (0..7, ...),
    ...
}

WTID ::= CHOICE {
    wTID-Type1          WTID-Type1,
    wTID-Type2          WTID-Long-Type2,
    ...
}

WTID-Type1 ::= SEQUENCE {
    pLMN-Identity               PLMN-Identity,
    shortWTID                   BIT STRING (SIZE(24)),
    ...
}

WTID-Long-Type2 ::= BIT STRING (SIZE(48))

WT-UE-XwAP-ID ::= OCTET STRING (SIZE (3))
```

```
-- X

X2BenefitValue ::= INTEGER (1..8, ...)

-- Y
-- Z

END
```

9.3.6 Common definitions

```
-- **************************************************************
--
-- Common definitions
--
-- **************************************************************

X2AP-CommonDataTypes {
itu-t (0) identified-organization (4) etsi (0) mobileDomain (0)
eps-Access (21) modules (3) x2ap (2) version1 (1) x2ap-CommonDataTypes (3) }

DEFINITIONS AUTOMATIC TAGS ::=

BEGIN

-- **************************************************************
--
-- Extension constants
--
-- **************************************************************

maxPrivateIEs                                   INTEGER ::= 65535
maxProtocolExtensions                           INTEGER ::= 65535
maxProtocolIEs                                  INTEGER ::= 65535

-- **************************************************************
--
-- Common Data Types
--
-- **************************************************************

Criticality     ::= ENUMERATED { reject, ignore, notify }

Presence        ::= ENUMERATED { optional, conditional, mandatory }

PrivateIE-ID    ::= CHOICE {
    local               INTEGER (0.. maxPrivateIEs),
    global              OBJECT IDENTIFIER
}

ProcedureCode       ::= INTEGER (0..255)
```

```
ProtocolIE-ID       ::= INTEGER (0..maxProtocolIEs)


TriggeringMessage   ::= ENUMERATED { initiating-message, successful-outcome, unsuccessful-outcome}

END
```

9.3.7 Constant definitions

```
-- **************************************************************
--
-- Constant definitions
--
-- **************************************************************

X2AP-Constants {
itu-t (0) identified-organization (4) etsi (0) mobileDomain (0)
eps-Access (21) modules (3) x2ap (2) version1 (1) x2ap-Constants (4) }

DEFINITIONS AUTOMATIC TAGS ::=

BEGIN

IMPORTS
    ProcedureCode,
    ProtocolIE-ID
FROM X2AP-CommonDataTypes;

-- **************************************************************
--
-- Elementary Procedures
--
-- **************************************************************

id-handoverPreparation                                  ProcedureCode ::= 0
id-handoverCancel                                       ProcedureCode ::= 1
id-loadIndication                                       ProcedureCode ::= 2
id-errorIndication                                      ProcedureCode ::= 3
id-snStatusTransfer                                     ProcedureCode ::= 4
id-uEContextRelease                                     ProcedureCode ::= 5
id-x2Setup                                              ProcedureCode ::= 6
id-reset                                                ProcedureCode ::= 7
id-eNBConfigurationUpdate                               ProcedureCode ::= 8
id-resourceStatusReportingInitiation                    ProcedureCode ::= 9
id-resourceStatusReporting                              ProcedureCode ::= 10
id-privateMessage                                       ProcedureCode ::= 11
id-mobilitySettingsChange                               ProcedureCode ::= 12
id-rLFIndication                                        ProcedureCode ::= 13
id-handoverReport                                       ProcedureCode ::= 14
id-cellActivation                                       ProcedureCode ::= 15
id-x2Release                                            ProcedureCode ::= 16
id-x2APMessageTransfer                                  ProcedureCode ::= 17
id-x2Removal                                            ProcedureCode ::= 18
```

```
id-seNBAdditionPreparation                                  ProcedureCode ::= 19
id-seNBReconfigurationCompletion                            ProcedureCode ::= 20
id-meNBinitiatedSeNBModificationPreparation                 ProcedureCode ::= 21
id-seNBinitiatedSeNBModification                            ProcedureCode ::= 22
id-meNBinitiatedSeNBRelease                                 ProcedureCode ::= 23
id-seNBinitiatedSeNBRelease                                 ProcedureCode ::= 24
id-seNBCounterCheck                                         ProcedureCode ::= 25
id-retrieveUEContext                                        ProcedureCode ::= 26
id-sgNBAdditionPreparation                                  ProcedureCode ::= 27
id-sgNBReconfigurationCompletion                                ProcedureCode ::= 28
id-meNBinitiatedSgNBModificationPreparation                 ProcedureCode ::= 29
id-sgNBinitiatedSgNBModification                                ProcedureCode ::= 30
id-meNBinitiatedSgNBRelease                                 ProcedureCode ::= 31
id-sgNBinitiatedSgNBRelease                                 ProcedureCode ::= 32
id-sgNBCounterCheck                                         ProcedureCode ::= 33
id-sgNBChange                                               ProcedureCode ::= 34
id-rRCTransfer                                              ProcedureCode ::= 35
id-endcX2Setup                                              ProcedureCode ::= 36
id-endcConfigurationUpdate                                  ProcedureCode ::= 37
id-secondaryRATDataUsageReport                              ProcedureCode ::= 38
id-endcCellActivation                                       ProcedureCode ::= 39
id-endcPartialReset                                         ProcedureCode ::= 40
id-eUTRANRCellResourceCoordination                          ProcedureCode ::= 41
id-SgNBActivityNotification                                 ProcedureCode ::= 42
id-endcX2Removal                                            ProcedureCode ::= 43

-- ************************************************************
--
-- Lists
--
-- ************************************************************

maxEARFCN                                   INTEGER ::= 65535
maxEARFCNPlusOne                            INTEGER ::= 65536
newmaxEARFCN                                INTEGER ::= 262143
maxInterfaces                               INTEGER ::= 16
maxCellineNB                                INTEGER ::= 256
maxnoofBands                                INTEGER ::= 16
maxnoofBearers                              INTEGER ::= 256
maxNrOfErrors                               INTEGER ::= 256
maxnoofPDCP-SN                              INTEGER ::= 16
maxnoofEPLMNs                               INTEGER ::= 15
maxnoofEPLMNsPlusOne                        INTEGER ::= 16
maxnoofForbLACs                             INTEGER ::= 4096
maxnoofForbTACs                             INTEGER ::= 4096
maxnoofBPLMNs                               INTEGER ::= 6
maxnoofNeighbours                           INTEGER ::= 512
maxnoofPRBs                                 INTEGER ::= 110
maxPools                                    INTEGER ::= 16
maxnoofCells                                INTEGER ::= 16
maxnoofMBSFN                                INTEGER ::= 8
maxFailedMeasObjects                        INTEGER ::= 32
maxnoofCellIDforMDT                         INTEGER ::= 32
maxnoofTAforMDT                             INTEGER ::= 8
```

```
maxnoofMBMSServiceAreaIdentities            INTEGER ::= 256
maxnoofMDTPLMNs                             INTEGER ::= 16
maxnoofCoMPHypothesisSet                    INTEGER ::= 256
maxnoofCoMPCells                            INTEGER ::= 32
maxUEReport                                 INTEGER ::= 128
maxCellReport                               INTEGER ::= 9
maxnoofPA                                   INTEGER ::= 3
maxCSIProcess                               INTEGER ::= 4
maxCSIReport                                INTEGER ::= 2
maxSubband                                  INTEGER ::= 14
maxofNRNeighbours                           INTEGER ::= 1024
maxCellinengNB                              INTEGER ::= 16384
--  maxnoofNRCarriers                       INTEGER ::= 32
maxnooftimeperiods                          INTEGER ::= 2
maxnoofCellIDforQMC                         INTEGER ::= 32
maxnoofTAforQMC                             INTEGER ::= 8
maxnoofPLMNforQMC                           INTEGER ::= 16
maxUEsinengNBDU                             INTEGER ::= 8192
maxnoofProtectedResourcePatterns            INTEGER ::= 16
maxnoNRcellsSpectrumSharingWithE-UTRA       INTEGER ::= 64
maxnoofNrCellBands                          INTEGER ::= 32

-- ************************************************************
--
-- IEs
--
-- ************************************************************

id-E-RABs-Admitted-Item                                         ProtocolIE-ID ::= 0
id-E-RABs-Admitted-List                                         ProtocolIE-ID ::= 1
id-E-RAB-Item                                                   ProtocolIE-ID ::= 2
id-E-RABs-NotAdmitted-List                                      ProtocolIE-ID ::= 3
id-E-RABs-ToBeSetup-Item                                        ProtocolIE-ID ::= 4
id-Cause                                                        ProtocolIE-ID ::= 5
id-CellInformation                                              ProtocolIE-ID ::= 6
id-CellInformation-Item                                         ProtocolIE-ID ::= 7
id-New-eNB-UE-X2AP-ID                                           ProtocolIE-ID ::= 9
id-Old-eNB-UE-X2AP-ID                                           ProtocolIE-ID ::= 10
id-TargetCell-ID                                                ProtocolIE-ID ::= 11
id-TargeteNBtoSource-eNBTransparentContainer                    ProtocolIE-ID ::= 12
id-TraceActivation                                              ProtocolIE-ID ::= 13
id-UE-ContextInformation                                        ProtocolIE-ID ::= 14
id-UE-HistoryInformation                                        ProtocolIE-ID ::= 15
id-UE-X2AP-ID                                                   ProtocolIE-ID ::= 16
id-CriticalityDiagnostics                                       ProtocolIE-ID ::= 17
id-E-RABs-SubjectToStatusTransfer-List                          ProtocolIE-ID ::= 18
id-E-RABs-SubjectToStatusTransfer-Item                          ProtocolIE-ID ::= 19
id-ServedCells                                                  ProtocolIE-ID ::= 20
id-GlobalENB-ID                                                 ProtocolIE-ID ::= 21
id-TimeToWait                                                   ProtocolIE-ID ::= 22
id-GUMMEI-ID                                                    ProtocolIE-ID ::= 23
id-GUGroupIDList                                                ProtocolIE-ID ::= 24
id-ServedCellsToAdd                                             ProtocolIE-ID ::= 25
id-ServedCellsToModify                                          ProtocolIE-ID ::= 26
```

```
id-ServedCellsToDelete                                  ProtocolIE-ID ::= 27
id-Registration-Request                                 ProtocolIE-ID ::= 28
id-CellToReport                                         ProtocolIE-ID ::= 29
id-ReportingPeriodicity                                 ProtocolIE-ID ::= 30
id-CellToReport-Item                                    ProtocolIE-ID ::= 31
id-CellMeasurementResult                                ProtocolIE-ID ::= 32
id-CellMeasurementResult-Item                           ProtocolIE-ID ::= 33
id-GUGroupIDToAddList                                   ProtocolIE-ID ::= 34
id-GUGroupIDToDeleteList                                ProtocolIE-ID ::= 35
id-SRVCCOperationPossible                               ProtocolIE-ID ::= 36
id-Measurement-ID                                       ProtocolIE-ID ::= 37
id-ReportCharacteristics                                ProtocolIE-ID ::= 38
id-ENB1-Measurement-ID                                  ProtocolIE-ID ::= 39
id-ENB2-Measurement-ID                                  ProtocolIE-ID ::= 40
id-Number-of-Antennaports                               ProtocolIE-ID ::= 41
id-CompositeAvailableCapacityGroup                      ProtocolIE-ID ::= 42
id-ENB1-Cell-ID                                         ProtocolIE-ID ::= 43
id-ENB2-Cell-ID                                         ProtocolIE-ID ::= 44
id-ENB2-Proposed-Mobility-Parameters                    ProtocolIE-ID ::= 45
id-ENB1-Mobility-Parameters                             ProtocolIE-ID ::= 46
id-ENB2-Mobility-Parameters-Modification-Range          ProtocolIE-ID ::= 47
id-FailureCellPCI                                       ProtocolIE-ID ::= 48
id-Re-establishmentCellECGI                             ProtocolIE-ID ::= 49
id-FailureCellCRNTI                                     ProtocolIE-ID ::= 50
id-ShortMAC-I                                           ProtocolIE-ID ::= 51
id-SourceCellECGI                                       ProtocolIE-ID ::= 52
id-FailureCellECGI                                      ProtocolIE-ID ::= 53
id-HandoverReportType                                   ProtocolIE-ID ::= 54
id-PRACH-Configuration                                  ProtocolIE-ID ::= 55
id-MBSFN-Subframe-Info                                  ProtocolIE-ID ::= 56
id-ServedCellsToActivate                                ProtocolIE-ID ::= 57
id-ActivatedCellList                                    ProtocolIE-ID ::= 58
id-DeactivationIndication                               ProtocolIE-ID ::= 59
id-UE-RLF-Report-Container                              ProtocolIE-ID ::= 60
id-ABSInformation                                       ProtocolIE-ID ::= 61
id-InvokeIndication                                     ProtocolIE-ID ::= 62
id-ABS-Status                                           ProtocolIE-ID ::= 63
id-PartialSuccessIndicator                              ProtocolIE-ID ::= 64
id-MeasurementInitiationResult-List                     ProtocolIE-ID ::= 65
id-MeasurementInitiationResult-Item                     ProtocolIE-ID ::= 66
id-MeasurementFailureCause-Item                         ProtocolIE-ID ::= 67
id-CompleteFailureCauseInformation-List                 ProtocolIE-ID ::= 68
id-CompleteFailureCauseInformation-Item                 ProtocolIE-ID ::= 69
id-CSG-Id                                               ProtocolIE-ID ::= 70
id-CSGMembershipStatus                                  ProtocolIE-ID ::= 71
id-MDTConfiguration                                     ProtocolIE-ID ::= 72
id-ManagementBasedMDTallowed                            ProtocolIE-ID ::= 74
id-RRCConnSetupIndicator                                ProtocolIE-ID ::= 75
id-NeighbourTAC                                         ProtocolIE-ID ::= 76
id-Time-UE-StayedInCell-EnhancedGranularity             ProtocolIE-ID ::= 77
id-RRCConnReestabIndicator                              ProtocolIE-ID ::= 78
id-MBMS-Service-Area-List                               ProtocolIE-ID ::= 79
id-HO-cause                                             ProtocolIE-ID ::= 80
id-TargetCellInUTRAN                                    ProtocolIE-ID ::= 81
```

```
id-MobilityInformation                                  ProtocolIE-ID ::= 82
id-SourceCellCRNTI                                      ProtocolIE-ID ::= 83
id-MultibandInfoList                                    ProtocolIE-ID ::= 84
id-M3Configuration                                      ProtocolIE-ID ::= 85
id-M4Configuration                                      ProtocolIE-ID ::= 86
id-M5Configuration                                      ProtocolIE-ID ::= 87
id-MDT-Location-Info                                    ProtocolIE-ID ::= 88
id-ManagementBasedMDTPLMNList                           ProtocolIE-ID ::= 89
id-SignallingBasedMDTPLMNList                           ProtocolIE-ID ::= 90
id-ReceiveStatusOfULPDCPSDUsExtended                    ProtocolIE-ID ::= 91
id-ULCOUNTValueExtended                                 ProtocolIE-ID ::= 92
id-DLCOUNTValueExtended                                 ProtocolIE-ID ::= 93
id-eARFCNExtension                                      ProtocolIE-ID ::= 94
id-UL-EARFCNExtension                                   ProtocolIE-ID ::= 95
id-DL-EARFCNExtension                                   ProtocolIE-ID ::= 96
id-AdditionalSpecialSubframe-Info                       ProtocolIE-ID ::= 97
id-Masked-IMEISV                                        ProtocolIE-ID ::= 98
id-IntendedULDLConfiguration                            ProtocolIE-ID ::= 99
id-ExtendedULInterferenceOverloadInfo                   ProtocolIE-ID ::= 100
id-RNL-Header                                           ProtocolIE-ID ::= 101
id-x2APMessage                                          ProtocolIE-ID ::= 102
id-ProSeAuthorized                                      ProtocolIE-ID ::= 103
id-ExpectedUEBehaviour                                  ProtocolIE-ID ::= 104
id-UE-HistoryInformationFromTheUE                       ProtocolIE-ID ::= 105
id-DynamicDLTransmissionInformation                     ProtocolIE-ID ::= 106
id-UE-RLF-Report-Container-for-extended-bands           ProtocolIE-ID ::= 107
id-CoMPInformation                                      ProtocolIE-ID ::= 108
id-ReportingPeriodicityRSRPMR                           ProtocolIE-ID ::= 109
id-RSRPMRList                                           ProtocolIE-ID ::= 110
id-MeNB-UE-X2AP-ID                                      ProtocolIE-ID ::= 111
id-SeNB-UE-X2AP-ID                                      ProtocolIE-ID ::= 112
id-UE-SecurityCapabilities                              ProtocolIE-ID ::= 113
id-SeNBSecurityKey                                      ProtocolIE-ID ::= 114
id-SeNBUEAggregateMaximumBitRate                        ProtocolIE-ID ::= 115
id-ServingPLMN                                          ProtocolIE-ID ::= 116
id-E-RABs-ToBeAdded-List                                ProtocolIE-ID ::= 117
id-E-RABs-ToBeAdded-Item                                ProtocolIE-ID ::= 118
id-MeNBtoSeNBContainer                                  ProtocolIE-ID ::= 119
id-E-RABs-Admitted-ToBeAdded-List                       ProtocolIE-ID ::= 120
id-E-RABs-Admitted-ToBeAdded-Item                       ProtocolIE-ID ::= 121
id-SeNBtoMeNBContainer                                  ProtocolIE-ID ::= 122
id-ResponseInformationSeNBReconfComp                    ProtocolIE-ID ::= 123
id-UE-ContextInformationSeNBModReq                      ProtocolIE-ID ::= 124
id-E-RABs-ToBeAdded-ModReqItem                          ProtocolIE-ID ::= 125
id-E-RABs-ToBeModified-ModReqItem                       ProtocolIE-ID ::= 126
id-E-RABs-ToBeReleased-ModReqItem                       ProtocolIE-ID ::= 127
id-E-RABs-Admitted-ToBeAdded-ModAckList                 ProtocolIE-ID ::= 128
id-E-RABs-Admitted-ToBeModified-ModAckList              ProtocolIE-ID ::= 129
id-E-RABs-Admitted-ToBeReleased-ModAckList              ProtocolIE-ID ::= 130
id-E-RABs-Admitted-ToBeAdded-ModAckItem                 ProtocolIE-ID ::= 131
id-E-RABs-Admitted-ToBeModified-ModAckItem              ProtocolIE-ID ::= 132
id-E-RABs-Admitted-ToBeReleased-ModAckItem              ProtocolIE-ID ::= 133
id-E-RABs-ToBeReleased-ModReqd                          ProtocolIE-ID ::= 134
id-E-RABs-ToBeReleased-ModReqdItem                      ProtocolIE-ID ::= 135
```

```
id-SCGChangeIndication                                  ProtocolIE-ID ::= 136
id-E-RABs-ToBeReleased-List-RelReq                      ProtocolIE-ID ::= 137
id-E-RABs-ToBeReleased-RelReqItem                       ProtocolIE-ID ::= 138
id-E-RABs-ToBeReleased-List-RelConf                     ProtocolIE-ID ::= 139
id-E-RABs-ToBeReleased-RelConfItem                      ProtocolIE-ID ::= 140
id-E-RABs-SubjectToCounterCheck-List                    ProtocolIE-ID ::= 141
id-E-RABs-SubjectToCounterCheckItem                     ProtocolIE-ID ::= 142
id-CoverageModificationList                             ProtocolIE-ID ::= 143
id-ReportingPeriodicityCSIR                             ProtocolIE-ID ::= 145
id-CSIReportList                                        ProtocolIE-ID ::= 146
id-UEID                                                 ProtocolIE-ID ::= 147
id-enhancedRNTP                                         ProtocolIE-ID ::= 148
id-ProSeUEtoNetworkRelaying                             ProtocolIE-ID ::= 149
id-ReceiveStatusOfULPDCPSDUsPDCP-SNlength18             ProtocolIE-ID ::= 150
id-ULCOUNTValuePDCP-SNlength18                          ProtocolIE-ID ::= 151
id-DLCOUNTValuePDCP-SNlength18                          ProtocolIE-ID ::= 152
id-UE-ContextReferenceAtSeNB                            ProtocolIE-ID ::= 153
id-UE-ContextKeptIndicator                              ProtocolIE-ID ::= 154
id-New-eNB-UE-X2AP-ID-Extension                         ProtocolIE-ID ::= 155
id-Old-eNB-UE-X2AP-ID-Extension                         ProtocolIE-ID ::= 156
id-MeNB-UE-X2AP-ID-Extension                            ProtocolIE-ID ::= 157
id-SeNB-UE-X2AP-ID-Extension                            ProtocolIE-ID ::= 158
id-LHN-ID                                               ProtocolIE-ID ::= 159
id-FreqBandIndicatorPriority                            ProtocolIE-ID ::= 160
id-M6Configuration                                      ProtocolIE-ID ::= 161
id-M7Configuration                                      ProtocolIE-ID ::= 162
id-Tunnel-Information-for-BBF                           ProtocolIE-ID ::= 163
id-SIPTO-BearerDeactivationIndication                   ProtocolIE-ID ::= 164
id-GW-TransportLayerAddress                             ProtocolIE-ID ::= 165
id-Correlation-ID                                       ProtocolIE-ID ::= 166
id-SIPTO-Correlation-ID                                 ProtocolIE-ID ::= 167
id-SIPTO-L-GW-TransportLayerAddress                     ProtocolIE-ID ::= 168
id-X2RemovalThreshold                                   ProtocolIE-ID ::= 169
id-CellReportingIndicator                               ProtocolIE-ID ::= 170
id-BearerType                                           ProtocolIE-ID ::= 171
id-resumeID                                             ProtocolIE-ID ::= 172
id-UE-ContextInformationRetrieve                        ProtocolIE-ID ::= 173
id-E-RABs-ToBeSetupRetrieve-Item                        ProtocolIE-ID ::= 174
id-NewEUTRANCellIdentifier                              ProtocolIE-ID ::= 175
id-V2XServicesAuthorized                                ProtocolIE-ID ::= 176
id-OffsetOfNbiotChannelNumberToDL-EARFCN                ProtocolIE-ID ::= 177
id-OffsetOfNbiotChannelNumberToUL-EARFCN                ProtocolIE-ID ::= 178
id-AdditionalSpecialSubframeExtension-Info              ProtocolIE-ID ::= 179
id-BandwidthReducedSI                                   ProtocolIE-ID ::= 180
id-MakeBeforeBreakIndicator                             ProtocolIE-ID ::= 181
id-UE-ContextReferenceAtWT                              ProtocolIE-ID ::= 182
id-WT-UE-ContextKeptIndicator                           ProtocolIE-ID ::= 183
id-UESidelinkAggregateMaximumBitRate                    ProtocolIE-ID ::= 184
id-uL-GTPtunnelEndpoint                                 ProtocolIE-ID ::= 185
id-DL-scheduling-PDCCH-CCE-usage                        ProtocolIE-ID ::= 193
id-UL-scheduling-PDCCH-CCE-usage                        ProtocolIE-ID ::= 194
id-UEAppLayerMeasConfig                                 ProtocolIE-ID ::= 195
id-extended-e-RAB-MaximumBitrateDL                      ProtocolIE-ID ::= 196
id-extended-e-RAB-MaximumBitrateUL                      ProtocolIE-ID ::= 197
```

```
id-extended-e-RAB-GuaranteedBitrateDL                    ProtocolIE-ID ::= 198
id-extended-e-RAB-GuaranteedBitrateUL                    ProtocolIE-ID ::= 199
id-extended-uEaggregateMaximumBitRateDownlink            ProtocolIE-ID ::= 200
id-extended-uEaggregateMaximumBitRateUplink              ProtocolIE-ID ::= 201
id-NRrestriction                                             ProtocolIE-ID ::= 202
id-SgNBSecurityKey                                       ProtocolIE-ID ::= 203
id-SgNBUEAggregateMaximumBitRate                             ProtocolIE-ID ::= 204
id-E-RABs-ToBeAdded-SgNBAddReqList                       ProtocolIE-ID ::= 205
id-MeNBtoSgNBContainer                                   ProtocolIE-ID ::= 206
id-SgNB-UE-X2AP-ID                                       ProtocolIE-ID ::= 207
id-RequestedSplitSRBs                                    ProtocolIE-ID ::= 208
id-E-RABs-ToBeAdded-SgNBAddReq-Item                      ProtocolIE-ID ::= 209
id-E-RABs-Admitted-ToBeAdded-SgNBAddReqAckList           ProtocolIE-ID ::= 210
id-SgNBtoMeNBContainer                                   ProtocolIE-ID ::= 211
id-AdmittedSplitSRBs                                         ProtocolIE-ID ::= 212
id-E-RABs-Admitted-ToBeAdded-SgNBAddReqAck-Item          ProtocolIE-ID ::= 213
id-ResponseInformationSgNBReconfComp                         ProtocolIE-ID ::= 214
id-UE-ContextInformation-SgNBModReq                      ProtocolIE-ID ::= 215
id-E-RABs-ToBeAdded-SgNBModReq-Item                      ProtocolIE-ID ::= 216
id-E-RABs-ToBeModified-SgNBModReq-Item                   ProtocolIE-ID ::= 217
id-E-RABs-ToBeReleased-SgNBModReq-Item                   ProtocolIE-ID ::= 218
id-E-RABs-Admitted-ToBeAdded-SgNBModAckList              ProtocolIE-ID ::= 219
id-E-RABs-Admitted-ToBeModified-SgNBModAckList           ProtocolIE-ID ::= 220
id-E-RABs-Admitted-ToBeReleased-SgNBModAckList           ProtocolIE-ID ::= 221
id-E-RABs-Admitted-ToBeAdded-SgNBModAck-Item                 ProtocolIE-ID ::= 222
id-E-RABs-Admitted-ToBeModified-SgNBModAck-Item          ProtocolIE-ID ::= 223
id-E-RABs-Admitted-ToBeReleased-SgNBModAck-Item          ProtocolIE-ID ::= 224
id-E-RABs-ToBeReleased-SgNBModReqdList                   ProtocolIE-ID ::= 225
id-E-RABs-ToBeModified-SgNBModReqdList                   ProtocolIE-ID ::= 226
id-E-RABs-ToBeReleased-SgNBModReqd-Item                  ProtocolIE-ID ::= 227
id-E-RABs-ToBeModified-SgNBModReqd-Item                  ProtocolIE-ID ::= 228
id-E-RABs-ToBeReleased-SgNBChaConfList                   ProtocolIE-ID ::= 229
id-E-RABs-ToBeReleased-SgNBChaConf-Item                  ProtocolIE-ID ::= 230
id-E-RABs-ToBeReleased-SgNBRelReqList                    ProtocolIE-ID ::= 231
id-E-RABs-ToBeReleased-SgNBRelReq-Item                   ProtocolIE-ID ::= 232
id-E-RABs-ToBeReleased-SgNBRelConfList                   ProtocolIE-ID ::= 233
id-E-RABs-ToBeReleased-SgNBRelConf-Item                  ProtocolIE-ID ::= 234
id-E-RABs-SubjectToSgNBCounterCheck-List                     ProtocolIE-ID ::= 235
id-E-RABs-SubjectToSgNBCounterCheck-Item                     ProtocolIE-ID ::= 236
id-RRCContainer                                          ProtocolIE-ID ::= 237
id-SRBType                                               ProtocolIE-ID ::= 238
id-Target-SgNB-ID                                        ProtocolIE-ID ::= 239
id-HandoverRestrictionList                               ProtocolIE-ID ::= 240
id-SCGConfigurationQuery                                     ProtocolIE-ID ::= 241
id-SplitSRB                                              ProtocolIE-ID ::= 242
id-UENRMeasurement                                       ProtocolIE-ID ::= 243
id-InitiatingNodeType-EndcX2Setup                        ProtocolIE-ID ::= 244
id-InitiatingNodeType-EndcConfigUpdate                   ProtocolIE-ID ::= 245
id-RespondingNodeType-EndcX2Setup                        ProtocolIE-ID ::= 246
id-RespondingNodeType-EndcConfigUpdate                   ProtocolIE-ID ::= 247
id-NRUESecurityCapabilities                              ProtocolIE-ID ::= 248
id-PDCPChangeIndication                                  ProtocolIE-ID ::= 249
id-ServedEUTRAcellsENDCX2ManagementList                  ProtocolIE-ID ::= 250
id-CellAssistanceInformation                                 ProtocolIE-ID ::= 251
```

```
id-Globalen-gNB-ID                                                  ProtocolIE-ID ::= 252
id-ServedNRcellsENDCX2ManagementList                                    ProtocolIE-ID ::= 253
id-UE-ContextReferenceAtSgNB                                            ProtocolIE-ID ::= 254
id-SecondaryRATUsageReport                                          ProtocolIE-ID ::= 255
id-ActivationID                                                     ProtocolIE-ID ::= 256
id-MeNBResourceCoordinationInformation                              ProtocolIE-ID ::= 257
id-SgNBResourceCoordinationInformation                              ProtocolIE-ID ::= 258
id-ServedEUTRAcellsToModifyListENDCConfUpd                          ProtocolIE-ID ::= 259
id-ServedEUTRAcellsToDeleteListENDCConfUpd                          ProtocolIE-ID ::= 260
id-ServedNRcellsToModifyListENDCConfUpd                             ProtocolIE-ID ::= 261
id-ServedNRcellsToDeleteListENDCConfUpd                             ProtocolIE-ID ::= 262
id-E-RABUsageReport-Item                                                ProtocolIE-ID ::= 263
id-Old-SgNB-UE-X2AP-ID                                              ProtocolIE-ID ::= 264
id-SecondaryRATUsageReportList                                      ProtocolIE-ID ::= 265
id-SecondaryRATUsageReport-Item                                     ProtocolIE-ID ::= 266
id-ServedNRCellsToActivate                                          ProtocolIE-ID ::= 267
id-ActivatedNRCellList                                              ProtocolIE-ID ::= 268
id-SelectedPLMN                                                     ProtocolIE-ID ::= 269
id-UEs-ToBeReset                                                    ProtocolIE-ID ::= 270
id-UEs-Admitted-ToBeReset                                           ProtocolIE-ID ::= 271
id-RRCConfigIndication                                              ProtocolIE-ID ::= 272
id-DownlinkPacketLossRate                                           ProtocolIE-ID ::= 273
id-UplinkPacketLossRate                                             ProtocolIE-ID ::= 274
id-SubscriberProfileIDforRFP                                        ProtocolIE-ID ::= 275
id-serviceType                                                      ProtocolIE-ID ::= 276
id-AerialUEsubscriptionInformation                                  ProtocolIE-ID ::= 277
id-SGNB-Addition-Trigger-Ind                                        ProtocolIE-ID ::= 278
id-MeNBCell-ID                                                      ProtocolIE-ID ::= 279
id-RequestedSplitSRBsrelease                                        ProtocolIE-ID ::= 280
id-AdmittedSplitSRBsrelease                                         ProtocolIE-ID ::= 281
id-NRS-NSSS-PowerOffset                                             ProtocolIE-ID ::= 282
id-NSSS-NumOccasionDifferentPrecoder                                ProtocolIE-ID ::= 283
id-ProtectedEUTRAResourceIndication                                 ProtocolIE-ID ::= 284
id-InitiatingNodeType-EutranrCellResourceCoordination               ProtocolIE-ID ::= 285
id-RespondingNodeType-EutranrCellResourceCoordination               ProtocolIE-ID ::= 286
id-DataTrafficResourceIndication                                    ProtocolIE-ID ::= 287
id-SpectrumSharingGroupID                                           ProtocolIE-ID ::= 288
id-ListofEUTRACellsinEUTRACoordinationReq                           ProtocolIE-ID ::= 289
id-ListofEUTRACellsinEUTRACoordinationResp                          ProtocolIE-ID ::= 290
id-ListofEUTRACellsinNRCoordinationReq                              ProtocolIE-ID ::= 291
id-ListofNRCellsinNRCoordinationReq                                 ProtocolIE-ID ::= 292
id-ListofNRCellsinNRCoordinationResp                                ProtocolIE-ID ::= 293
id-E-RABs-AdmittedToBeModified-SgNBModConfList                      ProtocolIE-ID ::= 294
id-E-RABs-AdmittedToBeModified-SgNBModConf-Item                     ProtocolIE-ID ::= 295
id-UEContextLevelUserPlaneActivity                                  ProtocolIE-ID ::= 296
id-ERABActivityNotifyItemList                                       ProtocolIE-ID ::= 297
id-InitiatingNodeType-EndcX2Removal                                 ProtocolIE-ID ::= 298
id-RespondingNodeType-EndcX2Removal                                 ProtocolIE-ID ::= 299

END
```

9.3.8 Container definitions

```
-- **************************************************************
--
-- Container definitions
--
-- **************************************************************

X2AP-Containers {
itu-t (0) identified-organization (4) etsi (0) mobileDomain (0)
eps-Access (21) modules (3) x2ap (2) version1 (1) x2ap-Containers (5) }

DEFINITIONS AUTOMATIC TAGS ::=

BEGIN

-- **************************************************************
--
-- IE parameter types from other modules.
--
-- **************************************************************

IMPORTS
    maxPrivateIEs,
    maxProtocolExtensions,
    maxProtocolIEs,
    Criticality,
    Presence,
    PrivateIE-ID,
    ProtocolIE-ID
FROM X2AP-CommonDataTypes;

-- **************************************************************
--
-- Class Definition for Protocol IEs
--
-- **************************************************************

X2AP-PROTOCOL-IES ::= CLASS {
    &id             ProtocolIE-ID           UNIQUE,
    &criticality    Criticality,
    &Value,
    &presence       Presence
}
WITH SYNTAX {
    ID              &id
    CRITICALITY     &criticality
    TYPE            &Value
    PRESENCE        &presence
}

-- **************************************************************
--
```

```
-- Class Definition for Protocol IEs
--
-- ************************************************************

X2AP-PROTOCOL-IES-PAIR ::= CLASS {
    &id                     ProtocolIE-ID       UNIQUE,
    &firstCriticality       Criticality,
    &FirstValue,
    &secondCriticality      Criticality,
    &SecondValue,
    &presence               Presence
}
WITH SYNTAX {
    ID                      &id
    FIRST CRITICALITY       &firstCriticality
    FIRST TYPE              &FirstValue
    SECOND CRITICALITY      &secondCriticality
    SECOND TYPE             &SecondValue
    PRESENCE                &presence
}

-- ************************************************************
--
-- Class Definition for Protocol Extensions
--
-- ************************************************************

X2AP-PROTOCOL-EXTENSION ::= CLASS {
    &id                 ProtocolIE-ID       UNIQUE,
    &criticality        Criticality,
    &Extension,
    &presence           Presence
}
WITH SYNTAX {
    ID                  &id
    CRITICALITY         &criticality
    EXTENSION           &Extension
    PRESENCE            &presence
}

-- ************************************************************
--
-- Class Definition for Private IEs
--
-- ************************************************************

X2AP-PRIVATE-IES ::= CLASS {
    &id                 PrivateIE-ID,
    &criticality        Criticality,
    &Value,
    &presence           Presence
}
WITH SYNTAX {
    ID                  &id
```

```
    CRITICALITY         &criticality
    TYPE                &Value
    PRESENCE            &presence
}

-- **************************************************************
--
-- Container for Protocol IEs
--
-- **************************************************************

ProtocolIE-Container {X2AP-PROTOCOL-IES : IEsSetParam} ::=
    SEQUENCE (SIZE (0..maxProtocolIEs)) OF
    ProtocolIE-Field {{IEsSetParam}}

ProtocolIE-Single-Container {X2AP-PROTOCOL-IES : IEsSetParam} ::=
    ProtocolIE-Field {{IEsSetParam}}

ProtocolIE-Field {X2AP-PROTOCOL-IES : IEsSetParam} ::= SEQUENCE {
    id              X2AP-PROTOCOL-IES.&id                   ({IEsSetParam}),
    criticality     X2AP-PROTOCOL-IES.&criticality          ({IEsSetParam}{@id}),
    value           X2AP-PROTOCOL-IES.&Value                ({IEsSetParam}{@id})
}

-- **************************************************************
--
-- Container for Protocol IE Pairs
--
-- **************************************************************

ProtocolIE-ContainerPair {X2AP-PROTOCOL-IES-PAIR : IEsSetParam} ::=
    SEQUENCE (SIZE (0..maxProtocolIEs)) OF
    ProtocolIE-FieldPair {{IEsSetParam}}

ProtocolIE-FieldPair {X2AP-PROTOCOL-IES-PAIR : IEsSetParam} ::= SEQUENCE {
    id                  X2AP-PROTOCOL-IES-PAIR.&id                  ({IEsSetParam}),
    firstCriticality    X2AP-PROTOCOL-IES-PAIR.&firstCriticality    ({IEsSetParam}{@id}),
    firstValue          X2AP-PROTOCOL-IES-PAIR.&FirstValue          ({IEsSetParam}{@id}),
    secondCriticality   X2AP-PROTOCOL-IES-PAIR.&secondCriticality   ({IEsSetParam}{@id}),
    secondValue         X2AP-PROTOCOL-IES-PAIR.&SecondValue         ({IEsSetParam}{@id})
}

-- **************************************************************
--
-- Container Lists for Protocol IE Containers
--
-- **************************************************************

ProtocolIE-ContainerList {INTEGER : lowerBound, INTEGER : upperBound, X2AP-PROTOCOL-IES : IEsSetParam} ::=
    SEQUENCE (SIZE (lowerBound..upperBound)) OF
    ProtocolIE-Container {{IEsSetParam}}

ProtocolIE-ContainerPairList {INTEGER : lowerBound, INTEGER : upperBound, X2AP-PROTOCOL-IES-PAIR : IEsSetParam} ::=
    SEQUENCE (SIZE (lowerBound..upperBound)) OF
```

```
    ProtocolIE-ContainerPair {{IEsSetParam}}

-- **************************************************************
--
-- Container for Protocol Extensions
--
-- **************************************************************

ProtocolExtensionContainer {X2AP-PROTOCOL-EXTENSION : ExtensionSetParam} ::=
    SEQUENCE (SIZE (1..maxProtocolExtensions)) OF
    ProtocolExtensionField {{ExtensionSetParam}}

ProtocolExtensionField {X2AP-PROTOCOL-EXTENSION : ExtensionSetParam} ::= SEQUENCE {
    id                  X2AP-PROTOCOL-EXTENSION.&id             ({ExtensionSetParam}),
    criticality         X2AP-PROTOCOL-EXTENSION.&criticality    ({ExtensionSetParam}{@id}),
    extensionValue      X2AP-PROTOCOL-EXTENSION.&Extension      ({ExtensionSetParam}{@id})
}

-- **************************************************************
--
-- Container for Private IEs
--
-- **************************************************************

PrivateIE-Container {X2AP-PRIVATE-IES : IEsSetParam} ::=
    SEQUENCE (SIZE (1..maxPrivateIEs)) OF
    PrivateIE-Field {{IEsSetParam}}

PrivateIE-Field {X2AP-PRIVATE-IES : IEsSetParam} ::= SEQUENCE {
    id              X2AP-PRIVATE-IES.&id            ({IEsSetParam}),
    criticality     X2AP-PRIVATE-IES.&criticality   ({IEsSetParam}{@id}),
    value           X2AP-PRIVATE-IES.&Value         ({IEsSetParam}{@id})
}

END
```

9.4 Message transfer syntax

X2AP shall use the ASN.1 Basic Packed Encoding Rules (BASIC-PER) Aligned Variant as transfer syntax, as specified in ITU-T Rec. X.691 [5].

9.5 Timers

$T_{RELOCprep}$

- Specifies the maximum time for the Handover Preparation procedure in the source eNB.

$TX2_{RELOCoverall}$

- Specifies the maximum time for the protection of the overall handover procedure in the source eNB.

T_{DCprep}

- Specifies the maximum time for the SeNB Addition Preparation, MeNB initiated SeNB Modification Preparation, SgNB Addition Preparation, or MeNB initiated SgNB Modification Preparation procedure in the MeNB.

$T_{DCoverall}$

- Specifies the maximum time in the SeNB for either the SeNB initiated SeNB Modification procedure or the protection of the E-UTRAN actions necessary to configure UE resources at SeNB Addition or MeNB initiated SeNB Modification. Or specifies the maximum time in the SgNB for either the SgNB initiated SgNB Modification procedure or the protection of the E-UTRAN actions necessary to configure UE resources at SgNB Addition or MeNB initiated SgNB Modification.

10 Handling of unknown, unforeseen and erroneous protocol data

Section 10 of TS 36.413 [4] is applicable for the purposes of the present document.

Annex A (informative): Change history

TSG #	TSG Doc.	CR	Rev	Subject/Comment	New
09/2009				Rel-9 version is created based on v.8.7.0	9.0.0
45	RP-090787	0296	1	Handling of Emergency Calls in Limited Service Mode	9.0.0
45	RP-090787	0297	1	Emergency Calls Mobility Handling	9.0.0
46	RP-091192	0307		Introduction of signalling support for Composite Available Capacity with relative units	9.1.0
46	RP-091192	0308	2	Configuration adaptation for MLB on X2	9.1.0
46	RP-091183	0310	1	Clarification on operational use of updated configuration data	9.1.0
46	RP-091192	0317	2	Automatic PRACH information exchange over X2 for SON	9.1.0
46	RP-091192	0333	1	Introduction of Radio Link Failure Indication procedure	9.1.0
46	RP-091192	0334	1	Introduction of Handover Report procedure	9.1.0
46	RP-091192	0335		Introduction of signalling support for Composite Available Capacity with relative units	9.1.0
47	RP-100213	0337		Correction to the Resource Status Reporting Initiation procedure	9.2.0
47	RP-100229	0341	2	Addition of MBSFN information on X2 interface	9.2.0
47	RP-100228	0344	4	Cell pair identification for Mobility Settings Change procedure	9.2.0
47	RP-100213	0352		Addition of cause value for not admitted E-RAB	9.2.0
47	RP-100229	0355	1	Rapporteur's update of X2AP protocol	9.2.0
47	RP-100230	0356	3	RNL-based energy saving solution	9.2.0
47	RP-100228	0358	1	Inclusion of UE RLF Report in RLF INDICATION message	9.2.0
48	RP-100599	0363	1	Correction of RLF INDICATION message	9.3.0
48	RP-100599	0364	1	Missing error cause for Not supported QCI on Handover	9.3.0
48	RP-100599	0370	1	Introduction of PLMN-related abnormal conditions during X2 handover in network sharing scenarios.	9.3.0
48	RP-100599	0372	1	Outcome of RAN3#68 review of X2AP	9.3.0
48	RP-100599	0373	1	Correction of forbidden inter-RAT	9.3.0
49	RP-100908	0376	1	Explicit PLMN coding in Trace IEs	9.4.0
49	RP-100906	0380	2	The corrections for Last Visited Cell Information	9.4.0
49	RP-100906	0383	1	Handover Restriction List	9.4.0
49	RP-100908	0384	1	Complete list of served cells to be provided in X2 SETUP and eNB Configuration Update messages	9.4.0
50	RP-101271	0385		Clarification on Handover Restriction List	9.5.0
50	RP-101270	0403	3	Correction of semantics description	9.5.0
12/2010				Rel-10 version created based in v. 9.5.0	10.0.0
50	RP-101304	0393	2	Introduction of partial failure in Resource Status Reporting Initiation procedure including detailed reporting of failure cause	10.0.0
50	RP-101279	0407	4	X2 handover support	10.0.0
SP-49	SP-100629			Clarification on the use of References (TS 21.801 CR#0030)	10.1.0
51	RP-110231	0408		Conditions for Enhanced X2 mobility	10.1.0
51	RP-110237	0409		Introduction of X2 signalling support for eICIC	10.1.0
51	RP-110222	0411	1	Correction of the usage of optional ShortMAC-I IE in RLF INDICATION message	10.1.0
51	RP-110230	0413	2	Support for MDT	10.1.0
51	RP-110226	0419	2	Clarification on TEID value range for X2AP	10.1.0
51	RP-110231	0420		Clarify X2 Handover Scenarios	10.1.0
51	RP-110237	0427	1	Enabling reporting of ABS resource status for eICIC purposes	10.1.0
52	RP-110695	0435	1	MDT correction for TAI	10.2.0
52	RP-110698	0436	1	Clarification on Radio Resource Status	10.2.0
52	RP-110700	0443	4	X2 support of RLF Report extension for SON MRO defined in R10	10.2.0
52	RP-110695	0447	3	Support for MDT user consent	10.2.0
52	RP-110686	0451	2	Rapporteur's proposal following review of TS 36.423	10.2.0
52	RP-110689	0452	1	Correction of the partial success mechanism in Resource Status Reporting	10.2.0
52	RP-110695	0453	2	MDT amendments	10.2.0
52	RP-110685	0454		Reference review outcome in TS 36.423	10.2.0
52	RP-110695	0456		Correction of trace function and trace session	10.2.0
53	RP-111196	0464	2	Clarification of procedures defined for MLB purposes	10.3.0
53	RP-111196	0469	1	ASN.1 definition conforms to ITU-T Recommendations	10.3.0
53	RP-111194	0476	2	Updates of reported quantities for eICIC	10.3.0
53	RP-111195	0478	1	Definition of value of bit in Measurements to Activate	10.3.0
53	RP-111197	0479		Clarification on PLMN Identity	10.3.0
54	RP-111648	0480	2	Correction on ABS Information	10.4.0
55	RP-120234	0491	1	Correct of reset	10.5.0
03/2012				Rel-11 version created based in v. 10.5.0	11.0.0

55	RP-120236	0487	1	Addition of TAC to the neighbour information of a served cell for X2 setup and eNB update procedures	11.0.0
56	RP-120751	0496	-	Introduction of the Security Algorithm (ZUC)	11.1.0
56	RP-120751	0498	2	Clarification on TAC in X2 Setup	11.1.0
56	RP-120751	0501	3	Adding RRC re-establishment cause to RLF indication	11.1.0
56	RP-120752	0513	1	Correction on Emergency ARP Value	11.1.0
56	RP-120752	0516	1	Improved granularity for the time UE stayed in cell	11.1.0
57	RP-121137	0520	2	Support of MBMS Service Continuity	11.2.0
57	RP-121140	0527	3	Multiband support per cell	11.2.0
57	RP-121135	0540	1	Enhancement of HO REPORT to enable inter-RAT ping-pong detection and addition of HO cause value to the UE history information	11.2.0
57	RP-121139	0546		Support for new special subframe configurations	11.2.0
58	RP-121731	0548		Addition of Mobility Information	11.3.0
58	RP-121730	0549	3	Introduction of new MDT measurements	11.3.0
58	RP-121732	0550	1	HeNB Mobility enhancement when target is hybrid HeNB	11.3.0
58	RP-121730	0552	2	Multi-PLMN MDT	11.3.0
58	RP-121731	0564		Clarification on successful handover for HO report procedure	11.3.0
58	RP-121737	0569	2	X2AP Rapporteur Update	11.3.0
59	RP-130208	0572	3	Correction on the Special Subframe Pattern	11.4.0
59	RP-130208	0580	2	Support for Downlink-Only Bands	11.4.0
59	RP-130207	0581		Correction on use of Mobility Information	11.4.0
59	RP-130207	0582	1	Correction on MRO procedures	11.4.0
59	RP-130237	0583	2	Extending maxEARFCN	11.4.0
59	RP-130237	0584	1	Extending Maximum Frequency Band Index	11.4.0
59	RP-130211	0585	1	Rapporteur correction of X2AP	11.4.0
59	RP-130207	0586		Clarification on Signalling Based MDT PLMN List	11.4.0
59	RP-130210	0587	1	X2AP modification for PDCP SN extension	11.4.0
60	RP-130643	0588		Correction on the Definition of Direct Neighbours	11.5.0
60	RP-130641	0589	1	Correction for the MDT Location Information IE	11.5.0
60	RP-130640	0590	5	Correction on RLF INDICATION procedure	11.5.0
60	RP-130643	0592	1	Security key generation in case of MFBI	11.5.0
60	RP-130643	0593	2	Correction on the Multiple Frequency Band Indicators	11.5.0
61	RP-131181	0598	1	Correction on Handover Report procedure	11.6.0
61	RP-131179	0602	2	Correction on ABS Information	11.6.0
61	RP-131183	0606	1	Correction of terminology concerning the mobility restriction function	11.6.0
62	RP-131902	0609	3	Correction of Handover Restriction List	11.7.0
62	RP-131902	0611	1	Correction for Load Balancing Related cause value CR for 36423	11.7.0
62	RP-131902	0623	2	Correction for Load Balancing Related IE	12.0.0
62	RP-131909	0607	3	Handling SIPTO@LN during UE Context Release procedure	12.0.0
63	RP-140294	0634		Correction to tabular of Served Cell Information IE	12.1.0
64	RP-140901	0629	4	TDD eIMTA support on X2AP	12.2.0
64	RP-140906	0630	4	Provide IMEISV to eNB to identify UE characteristics	12.2.0
64	RP-140905	0661	1	Correction of SN STATUS TRANSFER	12.2.0
64	RP-140905	0676		Clarification of DL ABS status	12.2.0
64	RP-140897	0641	4	Introduce X2GW procedures in Stage-3	12.2.0
65	RP-141520	0663	3	Introduction of the UE history reported from the UE	12.3.0
65	RP-141518	0690	2	Introduction of an indication of the expected UE behaviour	12.3.0
66	RP-142089	0691	8	Introduction of Dual Connectivity	12.4.0
66	RP-142090	0692	10	Introduction of inter-eNB CoMP signalling	12.4.0
66	RP-142092	0748	5	X2 support for Network Assisted Interference Cancellation	12,4.0
66	RP-142094	0754	2	X2AP Rapporteur Update	12.4.0
66	RP-142094	0759	2	Correction on RLF Report Container	12.4.0
66	RP-142094	0776	2	Setting of Re-establishment Cell ID in RLF Indication message	12.4.0
66	RP-142094	0777	3	X2 Removal Signaling	12.4.0
12/2014				History table corrected	12.4.1
12/2014				ASN.1 correction to make it compilable	12.4.2
67	RP-150353	0693	5	ProSe authorized indication	12.5.0
67	RP-150351	0782	1	Corrections on the usage of SeNB UE AMBR in dual connectivity	12.5.0
67	RP-150351	0790	1	Corrections of Dual Connectivity in general	12.5.0
67	RP-150356	0797	1	Correction on DC stage3	12.5.0
67	RP-150348	0801	1	Correction of the Usage of the MultibandInfoList IE	12.5.0
67	RP-150351	0802	1	Introduction of Cause values for Dual Connectivity	12.5.0
67	RP-150356	0803	1	ASN.1 Corrections for X2AP	12.5.0
67	RP-150351	0804	2	Corrections for Dual Connectivity	12.5.0

67	RP-150356	0805		Miscellaneous Editorials for X2AP	12.5.0
67	RP-150351	0806	1	Correction on SeNB behaviour for distinguishing uplink PDCP PDUs	12.5.0
68	RP-150943	0807	1	Correction on the definition of SeNB Reconfiguration Complete	12.6.0
68	RP-150943	0827	1	Introduction of a new DC cause for not supported configurations	12.6.0
68	RP-150943	0831		Clarification on UE-AMBR for split bearer	12.6.0
06/2015				Rel-13 version created based in v. 12.6.0	13.0.0
68	RP-150945	0808	8	Addition of Intra-LTE notifications of AAS-based reconfigurations	13.0.0
69	RP-151455	0788	11	Introduction of enhanced inter-eNB CoMP signalling	13.1.0
69	RP-151451	0854	1	Correction on GBR parameters for dual connectivity	13.1.0
69	RP-151450	0877	1	Handling of Unknown or Erroneous AP IDs in Dual Connectivity	13.1.0
70	RP-152100	0850	5	UE-to-Network Relay authorization	13.2.0
70	RP-152099	0892	2	Extension of PDCP SN	13.2.0
70	RP-152102	0901	4	Adding CSG support to DC	13.2.0
70	RP-152086	0907		Correction on inter eNB CoMP	13.2.0
70	RP-152102	0910	5	Support of SIPTO stand-alone architecture in dual connectivity	13.2.0
70	RP-152102	0911	2	Support of SIPTO and LIPA in dual connectivity	13.2.0
70	RP-152102	0912	6	Support of handover without SeNB change	13.2.0
70	RP-152102	0916	2	Handling of User Inactivity in the SeNB	13.2.0
70	RP-152086	0918		Correction of Subband Index	13.2.0
70	RP-152085	0924	4	Correction of intra cell handovers in multiband deployments	13.2.0
70	RP-152102	0927	2	Extension of UE X2AP ID	13.2.0
70	RP-152102	0929	2	SIPTO@LN and LIPA bearer deactivation for DC	13.2.0
70	RP-152103	0932	3	Introduction of feMDT	13.2.0
70	RP-152108	0936	2	Addition of the Cell Deployment Status Indicator and replacing cell information	13.2.0
70	RP-152102	0939	1	Tunnel Information of BBAI in Dual Connectivity	13.2.0
71	RP-160449	0937	3	Addition of X2 Removal Threshold to the X2 Removal Request message	13.3.0
71	RP-160449	0949	2	Modification of an ongoing resource reporting procedure	13.3.0
71	RP-160448	0950	1	Correction on SeNB Addition Preparation concerning inter-MeNB handover without SeNB change	13.3.0
71	RP-160448	0953	1	Correction on usage of extended eNB UE X2AP ID	13.3.0
71	RP-160448	0954		Correction for SeNB Addition behaviour Abnormal	13.3.0
71	RP-160451	0959		Clarification on the abnormal condition for DC SIPTO@LN	13.3.0
71	RP-160449	0962	1	Rapporteur's Update	13.3.0
71	RP-160448	0963	3	Correction on Old/New eNB UE X2AP ID	13.3.0
72	RP-161042	0965	7	Introduction of the inter-eNB UE Context Resume function	13.4.0
72	RP-161043	0968	1	Correction on the DC function description	13.4.0
72	RP-161043	0969	3	Correction on eNB UE X2AP ID Extension	13.4.0
72	RP-161043	0972	2	Indication of Bearer Type for cIOT	13.4.0
72	RP-161047	0978		Correction of RSRP Measurement Report List	13.4.0
73	RP-161551	0989	1	Correction on NB-IoT inter node RRC container	13.5.0
73	RP-161550	0998	2	Correction on Security Related Information in UE Context Retrieval Request	13.5.0
09/2016				Rel-14 version created based in v. 13.5.0	14.0.0
73	RP-161552	0975	5	Vehicular Authorization Signaling over X2	14.0.0
74	RP-162337	1007		Clarification on V2X Services Authorized IE	14.1.0
74	RP-162340	1008	3	Target cell selection for low complexity UEs and UEs in enhanced coverage	14.1.0
74	RP-162340	1011	-	Correction to Served Cell Information for NB-IoT	14.1.0

Change history							
Date	Meeting	TDoc	CR	Rev	Cat	Subject/Comment	New version
03/2017	RP-75	RP-170535	1023		B	X2AP Support for Inter-eNB Mobility without WT Change	14.2.0
03/2017	RP-75	RP-170537	1005	3	B	Introduction of a new special subframe configuration	14.2.0
03/2017	RP-75	RP-170538	1025		B	Support of V2X over X2	14.2.0
03/2017	RP-75	RP-170542	1026		B	Introduction of New types of eNB ID	14.2.0
03/2017	RP-75	RP-170536	1024	1	B	Introduction of eMOB Stage3	14.2.0
06/2017	RP-75	RP-171329	1033	1	A	Introduction of UL TNL address in CIoT UP Solution	14.3.0
09/2017	RP-77	RP-171974	1035	1	F	Correction on NB-IoT UP mobility	14.4.0
09/2017	RP-77	RP-171974	1037	1	F	Correction of SeNB Release Confirm	14.4.0
12/2017	RP-78	RP-172673	1044	2	F	Introduction of new IEs in X2 for high performing load balance	14.5.0
12/2017	RP-78	RP-172715	1046	-	F	Correction of mismatched tabular and ASN.1	14.5.0
12/2017	RP-78	RP-172672	1041	6	B	Baseline CR to TS 36.423 covering agreements of RAN3 #98	15.0.0
12/2017	RP-78	RP-172674	1045	1	B	Introduction of QoE Measurement Collection for LTE	15.0.0
03/2018	RP-79	RP-180468	1050	-	B	X2AP corrections for agreed EN-DC BL CR	15.1.0
03/2018	RP-79	RP-180468	1051	1	F	Essential corrections for EN-DC	15.1.0
03/2018	RP-79	RP-180468	1052	1	F	Clarification on HRL for EN-DC	15.1.0
03/2018	RP-79	RP-180468	1053	-	F	Correction of counter Check procedure for EN-DC	15.1.0
03/2018	RP-79	RP-180468	1054	-	B	Support for supplementary UL carrier	15.1.0
03/2018	RP-79	RP-180468	1056	-	F	Correction on SgNB initiated SgNB Modification procedure	15.1.0
03/2018	RP-79	RP-180468	1061	1	F	Correction of mandatory/optional/Conditional IEs in 36.423	15.1.0
03/2018	RP-79	RP-180468	1067	2		Support for S-RLF	15.1.0
03/2018	RP-79	RP-180468	1071	2	F	Update of EN-DC X2 Setup and EN-DC Configuration Update	15.1.0
03/2018	RP-79	RP-180468	1073	-	F	Removal of wrong abnormal behaviour that does not exist in EN-DC	15.1.0
03/2018	RP-79	RP-180468	1078	1		CR for addition of cause	15.1.0
03/2018	RP-79	RP-180468	1079	2	F	Clarification and correction on X2 for EN-DC	15.1.0
03/2018	RP-79	RP-180468	1081	1	F	Corrections for EN-DC	15.1.0
03/2018	RP-79	RP-180468	1082	1	F	Resolve the remaining issues over X2 for EN-DC	15.1.0
03/2018	RP-79	RP-180468	1083	1	F	Introduction of DRB ID for EN-DC	15.1.0
03/2018	RP-79	RP-180314	1087	1	F	Removing data forwarding from the corresponding node for EN-DC	15.1.0
03/2018	RP-79	RP-180472	1092	1	F	Rapporteur correction of 36.423 before NSA ASN.1 freeze	15.1.0
03/2018	RP-79	RP-180473	1093	-	A	Correction on Offset of NB-IoT Channel Number to EARFCN	15.1.0
03/2018	RP-79	RP-180468	1094	-	F	Correction of TAC for NG-RAN cells before NSA ASN.1 freeze	15.1.0
03/2018	RP-79	RP-180468	1095	-	F	Remove PDCP change indication in SN modification request message	15.1.0
03/2018	RP-79	RP-180468	1096	-	F	Change the presence of container in SgNB reconfiguration complete procedure	15.1.0
03/2018	RP-79	RP-180468	1097	-	F	Addition of Measurement Timing Configuration information	15.1.0
06/2018	RP-80	RP-181241	1047	6	B	Support of Enhanced VoLTE Performance	15.2.0
06/2018	RP-80	RP-181239	1065	4	F	X2 partial reset for EN-DC	15.2.0
06/2018	RP-80	RP-181238	1068	1	F	Clarification of the interactions with the UE Context Release	15.2.0
06/2018	RP-80	RP-181241	1086	3	C	Introduction of QMC for MTSI in EUTRAN	15.2.0
06/2018	RP-80	RP-181237	1090	9	B	Baseline CR for E-UTRA - NR Cell Resource Coordination for TS 36.423 covering agreements of RAN3#100	15.2.0
06/2018	RP-80	RP-181238	1104	-	F	Correction of UL link configuration in TS36.423	15.2.0
06/2018	RP-80	RP-181410	1107	4	F	Addition of the full config indicator	15.2.0
06/2018	RP-80	RP-181239	1116	1	F	Correction of the SeNB Reconfiguration Completion procedure	15.2.0
06/2018	RP-80	RP-181239	1117	2	F	Correction of abnormal conditions for EN-DC security algorithm selection	15.2.0
06/2018	RP-80	RP-181238	1121	1	F	Correction of reference in RRC Container	15.2.0
06/2018	RP-80	RP-181238	1122	-	F	Correction of condition presence of E-RAB Level QoS Parameters related	15.2.0
06/2018	RP-80	RP-181238	1123	1	F	Support of TEID change at SN	15.2.0
06/2018	RP-80	RP-181237	1125	4	B	X2AP CR for support of NR Multiple frequency band in EN-DC	15.2.0
06/2018	RP-80	RP-181238	1130	-	F	Correction of max NR ARFCN value	15.2.0
06/2018	RP-80	RP-181243	1132	3	B	Baseline CR: Introduction of the Aerial Usage Indication	15.2.0
06/2018	RP-80	RP-181238	1133	1	F	Use of SPID for EN-DC	15.2.0
06/2018	RP-80	RP-181238	1134	1	F	Correction of references to RRC containers for EN-DC	15.2.0
06/2018	RP-80	RP-181238	1135	-	F	Corrections on Tabular indentation and ASN.1 criticality	15.2.0
06/2018	RP-80	RP-181239	1138	-	F	Adding missing relation for the TEID	15.2.0
06/2018	RP-80	RP-181241	1142	3	B	Retrieve UE Context at UE Re-establishment	15.2.0
06/2018	RP-80	RP-181241	1143	-	D	Rapporteur's corrections on the specification	15.2.0
06/2018	RP-80	RP-181239	1145	-	F	Correction on the same terminology of "Split SRB" in TS36.423	15.2.0
06/2018	RP-80	RP-181239	1146	2	F	Correction of Split SRB configuration in TS36.423	15.2.0
06/2018	RP-80	RP-181239	1149	3	F	CR for Clarification on resource coordination	15.2.0
06/2018	RP-80	RP-181239	1152	-	F	Correction for PDCP Duplication	15.2.0
06/2018	RP-80	RP-181239	1153	-	F	Coordination of Inactivity for EN-DC	15.2.0
06/2018	RP-80	RP-181239	1155	-	C	Introduction of CN type restriction	15.2.0
06/2018	RP-80	RP-181239	1158	-	F	User Inactivity handling over X2 EN-DC	15.2.0
06/2018	RP-80	RP-181239	1160	1	F	Addition of Cause Value	15.2.0
06/2018	RP-80	RP-181239	1161	2	F	Addition of MeNB cell ID to solve the PCI confusion	15.2.0

06/2018	RP-80	RP-181239	1164	-	F	Corrections on misalignment between tabular and ASN.1	15.2.0
06/2018	RP-80	RP-181239	1165	1	F	Introduction of EN-DC X2 removal procedure	15.2.0
06/2018	RP-80	RP-181239	1167	-	F	Support of DL TEID change over S1 at SN	15.2.0
06/2018	RP-80	RP-181242	1174	2	B	Support of NB-IoT measurement enhancement and TDD Config	15.2.0
06/2018	RP-80	RP-181239	1175	-	F	ASN.1 correction for EN-DC support in TS 36.423	15.2.0
06/2018	RP-80	RP-181239	1176	1	F	Introduction of a Configured TAC into the NR Neighbour Information IE and the Served NR Cell Information IE	15.2.0
06/2018	RP-80	RP-181239	1178	-	F	Correction of the Limited List IE encoding to enable extensibility	15.2.0

History

Document history		
V15.2.0	July 2018	Publication

EXHIBIT M

ETSI TS 138 212 V15.2.0 (2018-07)

5G;
NR;
Multiplexing and channel coding
(3GPP TS 38.212 version 15.2.0 Release 15)

Reference
DTS/TSGR-0138212vf20

Keywords
5G

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Important notice

The present document can be downloaded from:
http://www.etsi.org/standards-search

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the only prevailing document is the print of the Portable Document Format (PDF) version kept on a specific network drive within ETSI Secretariat.

Users of the present document should be aware that the document may be subject to revision or change of status.
Information on the current status of this and other ETSI documents is available at
https://portal.etsi.org/TB/ETSIDeliverableStatus.aspx

If you find errors in the present document, please send your comment to one of the following services:
https://portal.etsi.org/People/CommiteeSupportStaff.aspx

Copyright Notification

No part may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm except as authorized by written permission of ETSI.
The content of the PDF version shall not be modified without the written authorization of ETSI.
The copyright and the foregoing restriction extend to reproduction in all media.

© ETSI 2018.
All rights reserved.

DECTTM, **PLUGTESTS**TM, **UMTS**TM and the ETSI logo are trademarks of ETSI registered for the benefit of its Members.
3GPPTM and **LTE**TM are trademarks of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners.
oneM2M logo is protected for the benefit of its Members.
GSM® and the GSM logo are trademarks registered and owned by the GSM Association.

Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (https://ipr.etsi.org/).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

Foreword

This Technical Specification (TS) has been produced by ETSI 3rd Generation Partnership Project (3GPP).

The present document may refer to technical specifications or reports using their 3GPP identities, UMTS identities or GSM identities. These should be interpreted as being references to the corresponding ETSI deliverables.

The cross reference between GSM, UMTS, 3GPP and ETSI identities can be found under http://webapp.etsi.org/key/queryform.asp.

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

Contents

Intellectual Property Rights 2
Foreword 2
Modal verbs terminology 2
Foreword 6
1 Scope 7
2 References 7
3 Definitions, symbols and abbreviations 7
3.1 Definitions 7
3.2 Symbols 7
3.3 Abbreviations 7
4 Mapping to physical channels 8
4.1 Uplink 8
4.2 Downlink 9
5 General procedures 9
5.1 CRC calculation 9
5.2 Code block segmentation and code block CRC attachment 10
5.2.1 Polar coding 10
5.2.2 Low density parity check coding 10
5.3 Channel coding 12
5.3.1 Polar coding 13
5.3.1.1 Interleaving 13
5.3.1.2 Polar encoding 14
5.3.2 Low density parity check coding 18
5.3.3 Channel coding of small block lengths 25
5.3.3.1 Encoding of 1-bit information 25
5.3.3.2 Encoding of 2-bit information 25
5.3.3.3 Encoding of other small block lengths 25
5.4 Rate matching 26
5.4.1 Rate matching for Polar code 26
5.4.1.1 Sub-block interleaving 26
5.4.1.2 Bit selection 27
5.4.1.3 Interleaving of coded bits 28
5.4.2 Rate matching for LDPC code 29
5.4.2.1 Bit selection 29
5.4.2.2 Bit interleaving 31
5.4.3 Rate matching for channel coding of small block lengths 31
5.5 Code block concatenation 32
6 Uplink transport channels and control information 32
6.1 Random access channel 32
6.2 Uplink shared channel 32
6.2.1 Transport block CRC attachment 32
6.2.2 LDPC base graph selection 33
6.2.3 Code block segmentation and code block CRC attachment 33
6.2.4 Channel coding of UL-SCH 33
6.2.5 Rate matching 33
6.2.6 Code block concatenation 33
6.2.7 Data and control multiplexing 33
6.3 Uplink control information 43
6.3.1 Uplink control information on PUCCH 43
6.3.1.1 UCI bit sequence generation 43
6.3.1.1.1 HARQ-ACK/SR only 43
6.3.1.1.2 CSI only 44
6.3.1.1.3 HARQ-ACK/SR and CSI 50

6.3.1.2 Code block segmentation and CRC attachment 51
6.3.1.2.1 UCI encoded by Polar code 51
6.3.1.2.2 UCI encoded by channel coding of small block lengths 51
6.3.1.3 Channel coding of UCI 52
6.3.1.3.1 UCI encoded by Polar code 52
6.3.1.3.2 UCI encoded by channel coding of small block lengths 52
6.3.1.4 Rate matching 52
6.3.1.4.1 UCI encoded by Polar code 52
6.3.1.4.2 UCI encoded by channel coding of small block lengths 53
6.3.1.5 Code block concatenation 54
6.3.1.6 Multiplexing of coded UCI bits to PUCCH 54
6.3.2 Uplink control information on PUSCH 56
6.3.2.1 UCI bit sequence generation 56
6.3.2.1.1 HARQ-ACK 56
6.3.2.1.2 CSI 57
6.3.2.2 Code block segmentation and CRC attachment 59
6.3.2.2.1 UCI encoded by Polar code 59
6.3.2.2.2 UCI encoded by channel coding of small block lengths 59
6.3.2.3 Channel coding of UCI 60
6.3.2.3.1 UCI encoded by Polar code 60
6.3.2.3.2 UCI encoded by channel coding of small block lengths 60
6.3.2.4 Rate matching 60
6.3.2.4.1 UCI encoded by Polar code 60
6.3.2.4.1.1 HARQ-ACK 60
6.3.2.4.1.2 CSI part 1 62
6.3.2.4.1.3 CSI part 2 64
6.3.2.4.2 UCI encoded by channel coding of small block lengths 66
6.3.2.4.2.1 HARQ-ACK 66
6.3.2.4.2.2 CSI part 1 66
6.3.2.4.2.3 CSI part 2 66
6.3.2.5 Code block concatenation 67
6.3.2.6 Multiplexing of coded UCI bits to PUSCH 67

7 Downlink transport channels and control information 67
7.1 Broadcast channel 67
7.1.1 PBCH payload generation 67
7.1.2 Scrambling 68
7.1.3 Transport block CRC attachment 69
7.1.4 Channel coding 69
7.1.5 Rate matching 69
7.2 Downlink shared channel and paging channel 69
7.2.1 Transport block CRC attachment 69
7.2.2 LDPC base graph selection 70
7.2.3 Code block segmentation and code block CRC attachment 70
7.2.4 Channel coding 70
7.2.5 Rate matching 70
7.2.6 Code block concatenation 70
7.3 Downlink control information 71
7.3.1 DCI formats 71
7.3.1.1 DCI formats for scheduling of PUSCH 71
7.3.1.1.1 Format 0_0 71
7.3.1.1.2 Format 0_1 74
7.3.1.2 DCI formats for scheduling of PDSCH 86
7.3.1.2.1 Format 1_0 86
7.3.1.2.2 Format 1_1 89
7.3.1.3 DCI formats for other purposes 96
7.3.1.3.1 Format 2_0 96
7.3.1.3.2 Format 2_1 96
7.3.1.3.3 Format 2_2 96
7.3.1.3.4 Format 2_3 96
7.3.2 CRC attachment 97
7.3.3 Channel coding 97

7.3.4 Rate matching 98

Annex <A> (informative): Change history 99

History 100

Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

- x the first digit:
  - 1 presented to TSG for information;
  - 2 presented to TSG for approval;
  - 3 or greater indicates TSG approved document under change control.
- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The present document specifies the coding, multiplexing and mapping to physical channels for 5G NR.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 38.201: "NR; Physical Layer – General Description"

[3] 3GPP TS 38.202: "NR; Services provided by the physical layer"

[4] 3GPP TS 38.211: "NR; Physical channels and modulation"

[5] 3GPP TS 38.213: "NR; Physical layer procedures for control"

[6] 3GPP TS 38.214: "NR; Physical layer procedures for data"

[7] 3GPP TS 38.215: "NR; Physical layer measurements"

[8] 3GPP TS 38.321: "NR; Medium Access Control (MAC) protocol specification"

[9] 3GPP TS 38.331: "NR; Radio Resource Control (RRC) protocol specification"

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

3.2 Symbols

For the purposes of the present document, the following symbols apply:

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

BCH	Broadcast channel
CBG	Code block group
CBGTI	Code block group transmission information
CORESET	Control resource set
CQI	Channel quality indicator

CRC	Cyclic redundancy check
CRI	CSI-RS resource indicator
CSI	Channel state information
CSI-RS	CSI reference signal
DAI	Downlink assignment index
DCI	Downlink control information
DL	Downlink
DL-SCH	Downlink shared channel
DMRS	Dedicated demodulation reference signal
HARQ	Hybrid automatic repeat request
HARQ-ACK	Hybrid automatic repeat request acknowledgement
LDPC	Low density parity check
LI	Layer indicator
MCS	Modulation and coding scheme
OFDM	Orthogonal frequency division multiplex
PBCH	Physical broadcast channel
PCH	Paging channel
PDCCH	Physical downlink control channel
PDSCH	Physical downlink shared channel
PMI	Precoding matrix indicator
PRB	Physical resource block
PRACH	Physical random access channel
PTRS	Phase-tracking reference signal
PUCCH	Physical uplink control channel
PUSCH	Physical uplink shared channel
RACH	Random access channel
RI	Rank indicator
RSRP	Reference signal received power
SFN	System frame number
SR	Scheduling request
SRS	Sounding reference signal
SS	Synchronisation signal
SUL	Supplementary uplink
TPC	Transmit power control
TrCH	Transport channel
UCI	Uplink control information
UE	User equipment
UL	Uplink
UL-SCH	Uplink shared channel
VRB	Virtual resource block
ZP CSI-RS	Zero power CSI-RS

4 Mapping to physical channels

4.1 Uplink

Table 4.1-1 specifies the mapping of the uplink transport channels to their corresponding physical channels. Table 4.1-2 specifies the mapping of the uplink control channel information to its corresponding physical channel.

Table 4.1-1

TrCH	Physical Channel
UL-SCH	PUSCH
RACH	PRACH

Table 4.1-2

Control information	Physical Channel
UCI	PUCCH, PUSCH

4.2 Downlink

Table 4.2-1 specifies the mapping of the downlink transport channels to their corresponding physical channels. Table 4.2-2 specifies the mapping of the downlink control channel information to its corresponding physical channel.

Table 4.2-1

TrCH	Physical Channel
DL-SCH	PDSCH
BCH	PBCH
PCH	PDSCH

Table 4.2-2

Control information	Physical Channel
DCI	PDCCH

5 General procedures

Data and control streams from/to MAC layer are encoded /decoded to offer transport and control services over the radio transmission link. Channel coding scheme is a combination of error detection, error correcting, rate matching, interleaving and transport channel or control information mapping onto/splitting from physical channels.

5.1 CRC calculation

Denote the input bits to the CRC computation by $a_0, a_1, a_2, a_3, ..., a_{A-1}$, and the parity bits by $p_0, p_1, p_2, p_3, ..., p_{L-1}$, where A is the size of the input sequence and L is the number of parity bits. The parity bits are generated by one of the following cyclic generator polynomials:

- $g_{\text{CRC24A}}(D) = [D^{24} + D^{23} + D^{18} + D^{17} + D^{14} + D^{11} + D^{10} + D^7 + D^6 + D^5 + D^4 + D^3 + D + 1]$ for a CRC length $L = 24$;
- $g_{\text{CRC24B}}(D) = [D^{24} + D^{23} + D^6 + D^5 + D + 1]$ for a CRC length $L = 24$;
- $g_{\text{CRC24C}}(D) = [D^{24} + D^{23} + D^{21} + D^{20} + D^{17} + D^{15} + D^{13} + D^{12} + D^8 + D^4 + D^2 + D + 1]$ for a CRC length $L = 24$;
- $g_{\text{CRC16}}(D) = [D^{16} + D^{12} + D^5 + 1]$ for a CRC length $L = 16$;
- $g_{\text{CRC11}}(D) = [D^{11} + D^{10} + D^9 + D^5 + 1]$ for a CRC length $L = 11$;
- $g_{\text{CRC6}}(D) = [D^6 + D^5 + 1]$ for a CRC length $L = 6$.

The encoding is performed in a systematic form, which means that in GF(2), the polynomial:

$$a_0 D^{A+L-1} + a_1 D^{A+L-2} + ... + a_{A-1} D^L + p_0 D^{L-1} + p_1 D^{L-2} + ... + p_{L-2} D^1 + p_{L-1}$$

yields a remainder equal to 0 when divided by the corresponding CRC generator polynomial.

The bits after CRC attachment are denoted by $b_0, b_1, b_2, b_3, ..., b_{B-1}$, where $B = A + L$. The relation between a_k and b_k is:

$b_k = a_k$ for $k = 0,1,2,...,A-1$

$b_k = p_{k-A}$ for $k = A, A+1, A+2, ..., A+L-1$.

5.2 Code block segmentation and code block CRC attachment

5.2.1 Polar coding

The input bit sequence to the code block segmentation is denoted by $a_0, a_1, a_2, a_3, ..., a_{A-1}$, where $A > 0$.

if $I_{seg} = 1$

Number of code blocks: $C = 2$;

else

Number of code blocks: $C = 1$

end if

$A' = \lceil A/C \rceil \cdot C$;

for $i = 0$ to $A'-A-1$

$a'_i = 0$;

end for

for $i = A'-A$ to $A'-1$

$a'_i = a_{i-(A'-A)}$;

end for

$s = 0$;

for $r = 0$ to $C-1$

for $k = 0$ to $A'/C-1$

$c_{rk} = a'_s$;

$s = s+1$;

end for

The sequence $c_{r0}, c_{r1}, c_{r2}, c_{r3}, ..., c_{r(A'/C-1)}$ is used to calculate the CRC parity bits $p_{r0}, p_{r1}, p_{r2}, ..., p_{r(L-1)}$ according to Subclause 5.1 with a generator polynomial of length L.

for $k = A'/C$ to $A'/C+L-1$

$c_{rk} = p_{r(k-A'/C)}$;

end for

end for

The value of A is no larger than 1706.

5.2.2 Low density parity check coding

The input bit sequence to the code block segmentation is denoted by $b_0, b_1, b_2, b_3, ..., b_{B-1}$, where $B > 0$. If B is larger than the maximum code block size K_{cb}, segmentation of the input bit sequence is performed and an additional CRC sequence of $L = 24$ bits is attached to each code block.

For LDPC base graph 1, the maximum code block size is:

- $K_{cb} = 8448$.

For LDPC base graph 2, the maximum code block size is:

- $K_{cb} = 3840$.

Total number of code blocks C is determined by:

if $B \le K_{cb}$

$L = 0$

Number of code blocks: $C = 1$

$B' = B$

else

$L = 24$

Number of code blocks: $C = \lceil B/(K_{cb} - L) \rceil$.

$B' = B + C \cdot L$

end if

The bits output from code block segmentation are denoted by $c_{r0}, c_{r1}, c_{r2}, c_{r3}, ..., c_{r(K_r-1)}$, where $0 \le r < C$ is the code block number, and $K_r = K$ is the number of bits for the code block number r.

The number of bits K in each code block is calculated as:

$K' = B'/C$;

For LDPC base graph 1,

$K_b = 22$.

For LDPC base graph 2,

if $B > 640$

$K_b = 10$;

elseif $B > 560$

$K_b = 9$;

elseif $B > 192$

$K_b = 8$;

else

$K_b = 6$;

end if

find the minimum value of Z in all sets of lifting sizes in Table 5.3.2-1, denoted as Z_c, such that $K_b \cdot Z_c \ge K'$, and set $K = 22Z_c$ for LDPC base graph 1 and $K = 10Z_c$ for LDPC base graph 2;

The bit sequence c_{rk} is calculated as:

$s = 0$;

for $r = 0$ to $C - 1$

for $k = 0$ to $K' - L - 1$

$c_{rk} = b_s$;

$s = s + 1$;

end for

if $C > 1$

The sequence $c_{r0}, c_{r1}, c_{r2}, c_{r3}, ..., c_{r(K'-L-1)}$ is used to calculate the CRC parity bits $p_{r0}, p_{r1}, p_{r2}, ..., p_{r(L-1)}$ according to Subclause 5.1 with the generator polynomial $g_{\text{CRC24B}}(D)$.

for $k = K' - L$ to $K' - 1$

$c_{rk} = p_{r(k+L-K')}$;

end for

end if

for $k = K'$ to $K - 1$ -- Insertion of filler bits

$c_{rk} = < NULL >$;

end for

end for

5.3 Channel coding

Usage of coding scheme for the different types of TrCH is shown in table 5.3-1. Usage of coding scheme for the different control information types is shown in table 5.3-2.

Table 5.3-1: Usage of channel coding scheme for TrCHs

TrCH	Coding scheme
UL-SCH	LDPC
DL-SCH	
PCH	
BCH	Polar code

Table 5.3-2: Usage of channel coding scheme for control information

Control Information	Coding scheme
DCI	Polar code
UCI	Block code
	Polar code

5.3.1 Polar coding

The bit sequence input for a given code block to channel coding is denoted by $c_0, c_1, c_2, c_3, ..., c_{K-1}$, where K is the number of bits to encode. After encoding the bits are denoted by $d_0, d_1, d_2, ..., d_{N-1}$, where $N = 2^n$ and the value of n is determined by the following:

Denote by E the rate matching output sequence length as given in Subclause 5.4.1;

If $E \le (9/8) \cdot 2^{(\lceil \log_2 E \rceil - 1)}$ and $K/E < 9/16$

$n_1 = \lceil \log_2 E \rceil - 1$;

else

$n_1 = \lceil \log_2 E \rceil$;

end if

$R_{\min} = 1/8$;

$n_2 = \lceil \log_2 (K / R_{\min}) \rceil$;

$n = \max\{\min\{n_1, n_2, n_{\max}\}, n_{\min}\}$

where $n_{\min} = 5$.

UE is not expected to be configured with $K + n_{PC} > E$, where n_{PC} is the number of parity check bits defined in Subclause 5.3.1.2.

5.3.1.1 Interleaving

The bit sequence $c_0, c_1, c_2, c_3, ..., c_{K-1}$ is interleaved into bit sequence $c'_0, c'_1, c'_2, c'_3, ..., c'_{K-1}$ as follows:

$c'_k = c_{\Pi(k)}$, $k = 0, 1, ..., K-1$

where the interleaving pattern $\Pi(k)$ is given by the following:

if $I_{IL} = 0$

$\Pi(k) = k$, $k = 0, 1, ..., K-1$

else

$k = 0$;

for $m = 0$ to $K_{IL}^{\max} - 1$

if $\Pi_{IL}^{\max}(m) \ge K_{IL}^{\max} - K$

$\Pi(k) = \Pi_{IL}^{\max}(m) - (K_{IL}^{\max} - K)$;

$k = k + 1$;

end if

end for

end if

where $\Pi_{IL}^{\max}(m)$ is given by Table 5.3.1.1-1 and $K_{IL}^{\max} = 164$.

Table 5.3.1.1-1: Interleaving pattern $\Pi_{IL}^{\max}(m)$

m	$\Pi_{IL}^{\max}(m)$	m	$\Pi_{IL}^{\max}(m)$	m	$\Pi_{IL}^{\max}(m)$	m	$\Pi_{IL}^{\max}(m)$	m	$\Pi_{IL}^{\max}(m)$	m	$\Pi_{IL}^{\max}(m)$
0	0	28	67	56	122	84	68	112	33	140	38
1	2	29	69	57	123	85	73	113	36	141	144
2	4	30	70	58	126	86	78	114	44	142	39
3	7	31	71	59	127	87	84	115	47	143	145
4	9	32	72	60	129	88	90	116	64	144	40
5	14	33	76	61	132	89	92	117	74	145	146
6	19	34	77	62	134	90	94	118	79	146	41
7	20	35	81	63	138	91	96	119	85	147	147
8	24	36	82	64	139	92	99	120	97	148	148
9	25	37	83	65	140	93	102	121	100	149	149
10	26	38	87	66	1	94	105	122	103	150	150
11	28	39	88	67	3	95	107	123	117	151	151
12	31	40	89	68	5	96	109	124	125	152	152
13	34	41	91	69	8	97	112	125	131	153	153
14	42	42	93	70	10	98	114	126	136	154	154
15	45	43	95	71	15	99	116	127	142	155	155
16	49	44	98	72	21	100	121	128	12	156	156
17	50	45	101	73	27	101	124	129	17	157	157
18	51	46	104	74	29	102	128	130	23	158	158
19	53	47	106	75	32	103	130	131	37	159	159
20	54	48	108	76	35	104	133	132	48	160	160
21	56	49	110	77	43	105	135	133	75	161	161
22	58	50	111	78	46	106	141	134	80	162	162
23	59	51	113	79	52	107	6	135	86	163	163
24	61	52	115	80	55	108	11	136	137		
25	62	53	118	81	57	109	16	137	143		
26	65	54	119	82	60	110	22	138	13		
27	66	55	120	83	63	111	30	139	18		

5.3.1.2 Polar encoding

The Polar sequence $\mathbf{Q}_0^{N_{\max}-1} = \{Q_0^{N_{\max}}, Q_1^{N_{\max}}, ..., Q_{N_{\max}-1}^{N_{\max}}\}$ is given by Table 5.3.1.2-1, where $0 \le Q_i^{N_{\max}} \le N_{\max} - 1$ denotes a bit index before Polar encoding for $i = 0,1,..., N_{\max} - 1$ and $N_{\max} = 1024$. The Polar sequence $\mathbf{Q}_0^{N_{\max}-1}$ is in ascending order of reliability $W(Q_0^{N_{\max}}) < W(Q_1^{N_{\max}}) < ... < W(Q_{N_{\max}-1}^{N_{\max}})$, where $W(Q_i^{N_{\max}})$ denotes the reliability of bit index $Q_i^{N_{\max}}$.

For any code block encoded to N bits, a same Polar sequence $\mathbf{Q}_0^{N-1} = \{Q_0^N, Q_1^N, Q_2^N, ..., Q_{N-1}^N\}$ is used. The Polar sequence $\mathbf{Q}_0^{N-1}$ is a subset of Polar sequence $\mathbf{Q}_0^{N_{\max}-1}$ with all elements $Q_i^{N_{\max}}$ of values less than N, ordered in ascending order of reliability $W(Q_0^N) < W(Q_1^N) < W(Q_2^N) < ... < W(Q_{N-1}^N)$.

Denote $\overline{\mathbf{Q}}_I^N$ as a set of bit indices in Polar sequence $\mathbf{Q}_0^{N-1}$, and $\overline{\mathbf{Q}}_F^N$ as the set of other bit indices in Polar sequence $\mathbf{Q}_0^{N-1}$, where $\overline{\mathbf{Q}}_I^N$ and $\overline{\mathbf{Q}}_F^N$ are given in Subclause 5.4.1.1, $|\overline{\mathbf{Q}}_I^N| = K + n_{PC}$, $|\overline{\mathbf{Q}}_F^N| = N - |\overline{\mathbf{Q}}_I^N|$, and n_{PC} is the number of parity check bits.

Denote $\mathbf{G}_N = (\mathbf{G}_2)^{\otimes n}$ as the n-th Kronecker power of matrix $\mathbf{G}_2$, where $\mathbf{G}_2 = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix}$.

For a bit index j with $j = 0,1,..., N-1$, denote $\mathbf{g}_j$ as the j-th row of $\mathbf{G}_N$ and $w(\mathbf{g}_j)$ as the row weight of $\mathbf{g}_j$, where $w(\mathbf{g}_j)$ is the number of ones in $\mathbf{g}_j$. Denote the set of bit indices for parity check bits as $\mathbf{Q}_{PC}^N$, where $|\mathbf{Q}_{PC}^N| = n_{PC}$. A number of $(n_{PC} - n_{PC}^{wm})$ parity check bits are placed in the $(n_{PC} - n_{PC}^{wm})$ least reliable bit indices in $\overline{\mathbf{Q}}_I^N$. A number of n_{PC}^{wm} other parity check bits are placed in the bit indices of minimum row weight in $\tilde{\mathbf{Q}}_I^N$, where $\tilde{\mathbf{Q}}_I^N$ denotes the $(|\overline{\mathbf{Q}}_I^N| - n_{PC})$ most reliable bit indices in $\overline{\mathbf{Q}}_I^N$; if there are more than n_{PC}^{wm} bit indices of the same minimum row weight in $\tilde{\mathbf{Q}}_I^N$, the n_{PC}^{wm} other parity check bits are placed in the n_{PC}^{wm} bit indices of the highest reliability and the minimum row weight in $\tilde{\mathbf{Q}}_I^N$.

Generate $\mathbf{u} = [u_0\ u_1\ u_2\ ...\ u_{N-1}]$ according to the following:

$k = 0$;

if $n_{PC} > 0$

$y_0 = 0;\ y_1 = 0;\ y_2 = 0;\ y_3 = 0;\ y_4 = 0;$

for $n = 0$ to $N-1$

$y_t = y_0;\ y_0 = y_1;\ y_1 = y_2;\ y_2 = y_3;\ y_3 = y_4;\ y_4 = y_t;$

if $n \in \overline{\mathbf{Q}}_I^N$

if $n \in \mathbf{Q}_{PC}^N$

$u_n = y_0;$

else

$u_n = c_k^{'};$

$k = k + 1;$

$y_0 = y_0 \oplus u_n;$

end if

else

$u_n = 0;$

end if

end for

else

for $n = 0$ to $N-1$

if $n \in \overline{\mathbf{Q}}_I^N$

$u_n = c_k^{'};$

$k = k + 1;$

else

$u_n = 0;$

end if

end for

end if

The output after encoding $\mathbf{d} = [d_0\ d_1\ d_2\ \ldots\ d_{N-1}]$ is obtained by $\mathbf{d} = \mathbf{u}\mathbf{G}_N$. The encoding is performed in GF(2).

Table 5.3.1.2-1: Polar sequence $\mathbf{Q}_0^{N_{\max}-1}$ and its corresponding reliability $W\left(Q_i^{N_{\max}}\right)$

$W(Q_i^{N_{max}})$	$Q_i^{N_{max}}$	$W(Q_i^{N_{max}})$	$Q_i^{N_{max}}$	$W(Q_i^{N_{max}})$	$Q_i^{N_{max}}$	$W(Q_i^{N_{max}})$	$Q_i^{N_{max}}$	$W(Q_i^{N_{max}})$	$Q_i^{N_{max}}$	$W(Q_i^{N_{max}})$	$Q_i^{N_{max}}$	$W(Q_i^{N_{max}})$	$Q_i^{N_{max}}$	$W(Q_i^{N_{max}})$	$Q_i^{N_{max}}$
0	0	128	518	256	94	384	214	512	364	640	414	768	819	896	966
1	1	129	54	257	204	385	309	513	654	641	223	769	814	897	755
2	2	130	83	258	298	386	188	514	659	642	663	770	439	898	859
3	4	131	57	259	400	387	449	515	335	643	692	771	929	899	940
4	8	132	521	260	608	388	217	516	480	644	835	772	490	900	830
5	16	133	112	261	352	389	408	517	315	645	619	773	623	901	911
6	32	134	135	262	325	390	609	518	221	646	472	774	671	902	871
7	3	135	78	263	533	391	596	519	370	647	455	775	739	903	639
8	5	136	289	264	155	392	551	520	613	648	796	776	916	904	888
9	64	137	194	265	210	393	650	521	422	649	809	777	463	905	479
10	9	138	85	266	305	394	229	522	425	650	714	778	843	906	946
11	6	139	276	267	547	395	159	523	451	651	721	779	381	907	750
12	17	140	522	268	300	396	420	524	614	652	837	780	497	908	969
13	10	141	58	269	109	397	310	525	543	653	716	781	930	909	508
14	18	142	168	270	184	398	541	526	235	654	864	782	821	910	861
15	128	143	139	271	534	399	773	527	412	655	810	783	726	911	757
16	12	144	99	272	537	400	610	528	343	656	606	784	961	912	970
17	33	145	86	273	115	401	657	529	372	657	912	785	872	913	919
18	65	146	60	274	167	402	333	530	775	658	722	786	492	914	875
19	20	147	280	275	225	403	119	531	317	659	696	787	631	915	862
20	256	148	89	276	326	404	600	532	222	660	377	788	729	916	758
21	34	149	290	277	306	405	339	533	426	661	435	789	700	917	948
22	24	150	529	278	772	406	218	534	453	662	817	790	443	918	977
23	36	151	524	279	157	407	368	535	237	663	319	791	741	919	923
24	7	152	196	280	656	408	652	536	559	664	621	792	845	920	972
25	129	153	141	281	329	409	230	537	833	665	812	793	920	921	761
26	66	154	101	282	110	410	391	538	804	666	484	794	382	922	877
27	512	155	147	283	117	411	313	539	712	667	430	795	822	923	952
28	11	156	176	284	212	412	450	540	834	668	838	796	851	924	495
29	40	157	142	285	171	413	542	541	661	669	667	797	730	925	703
30	68	158	530	286	776	414	334	542	808	670	488	798	498	926	935
31	130	159	321	287	330	415	233	543	779	671	239	799	880	927	978
32	19	160	31	288	226	416	555	544	617	672	378	800	742	928	883
33	13	161	200	289	549	417	774	545	604	673	459	801	445	929	762
34	48	162	90	290	538	418	175	546	433	674	622	802	471	930	503
35	14	163	545	291	387	419	123	547	720	675	627	803	635	931	925
36	72	164	292	292	308	420	658	548	816	676	437	804	932	932	878
37	257	165	322	293	216	421	612	549	836	677	380	805	687	933	735
38	21	166	532	294	416	422	341	550	347	678	818	806	903	934	993
39	132	167	263	295	271	423	777	551	897	679	461	807	825	935	885
40	35	168	149	296	279	424	220	552	243	680	496	808	500	936	939
41	258	169	102	297	158	425	314	553	662	681	669	809	846	937	994
42	26	170	105	298	337	426	424	554	454	682	679	810	745	938	980
43	513	171	304	299	550	427	395	555	318	683	724	811	826	939	926
44	80	172	296	300	672	428	673	556	675	684	841	812	732	940	764
45	37	173	163	301	118	429	583	557	618	685	629	813	446	941	941
46	25	174	92	302	332	430	355	558	898	686	351	814	962	942	967
47	22	175	47	303	579	431	287	559	781	687	467	815	936	943	886
48	136	176	267	304	540	432	183	560	376	688	438	816	475	944	831
49	260	177	385	305	389	433	234	561	428	689	737	817	853	945	947
50	264	178	546	306	173	434	125	562	665	690	251	818	867	946	507
51	38	179	324	307	121	435	557	563	736	691	462	819	637	947	889
52	514	180	208	308	553	436	660	564	567	692	442	820	907	948	984
53	96	181	386	309	199	437	616	565	840	693	441	821	487	949	751
54	67	182	150	310	784	438	342	566	625	694	469	822	695	950	942
55	41	183	153	311	179	439	316	567	238	695	247	823	746	951	996
56	144	184	165	312	228	440	241	568	359	696	683	824	828	952	971
57	28	185	106	313	338	441	778	569	457	697	842	825	753	953	890
58	69	186	55	314	312	442	563	570	399	698	738	826	854	954	509
59	42	187	328	315	704	443	345	571	787	699	899	827	857	955	949
60	516	188	536	316	390	444	452	572	591	700	670	828	504	956	973
61	49	189	577	317	174	445	397	573	678	701	783	829	799	957	1000
62	74	190	548	318	554	446	403	574	434	702	849	830	255	958	892
63	272	191	113	319	581	447	207	575	677	703	820	831	964	959	950
64	160	192	154	320	393	448	674	576	349	704	728	832	909	960	863
65	520	193	79	321	283	449	558	577	245	705	928	833	719	961	759
66	288	194	269	322	122	450	785	578	458	706	791	834	477	962	1008
67	528	195	108	323	448	451	432	579	666	707	367	835	915	963	510
68	192	196	578	324	353	452	357	580	620	708	901	836	638	964	979
69	544	197	224	325	561	453	187	581	363	709	630	837	748	965	953
70	70	198	166	326	203	454	236	582	127	710	685	838	944	966	763
71	44	199	519	327	63	455	664	583	191	711	844	839	869	967	974
72	131	200	552	328	340	456	624	584	782	712	633	840	491	968	954
73	81	201	195	329	394	457	587	585	407	713	711	841	699	969	879
74	50	202	270	330	527	458	780	586	436	714	253	842	754	970	981
75	73	203	641	331	582	459	705	587	626	715	691	843	858	971	982
76	15	204	523	332	556	460	126	588	571	716	824	844	478	972	927
77	320	205	275	333	181	461	242	589	465	717	902	845	968	973	995
78	133	206	580	334	295	462	565	590	681	718	686	846	383	974	765
79	52	207	291	335	285	463	398	591	246	719	740	847	910	975	956
80	23	208	59	336	232	464	346	592	707	720	850	848	815	976	887
81	134	209	169	337	124	465	456	593	350	721	375	849	976	977	985
82	384	210	560	338	205	466	358	594	599	722	444	850	870	978	997
83	76	211	114	339	182	467	405	595	668	723	470	851	917	979	986
84	137	212	277	340	643	468	303	596	790	724	483	852	727	980	943
85	82	213	156	341	562	469	569	597	460	725	415	853	493	981	891
86	56	214	87	342	286	470	244	598	249	726	485	854	873	982	998
87	27	215	197	343	585	471	595	599	682	727	905	855	701	983	766

88	97	216	116	344	299	472	189	600	573	728	795	856	931	984	511
89	39	217	170	345	354	473	566	601	411	729	473	857	756	985	988
90	259	218	61	346	211	474	676	602	803	730	634	858	860	986	1001
91	84	219	531	347	401	475	361	603	789	731	744	859	499	987	951
92	138	220	525	348	185	476	706	604	709	732	852	860	731	988	1002
93	145	221	642	349	396	477	589	605	365	733	960	861	823	989	893
94	261	222	281	350	344	478	215	606	440	734	865	862	922	990	975
95	29	223	278	351	586	479	786	607	628	735	693	863	874	991	894
96	43	224	526	352	645	480	647	608	689	736	797	864	918	992	1009
97	98	225	177	353	593	481	348	609	374	737	906	865	502	993	955
98	515	226	293	354	535	482	419	610	423	738	715	866	933	994	1004
99	88	227	388	355	240	483	406	611	466	739	807	867	743	995	1010
100	140	228	91	356	206	484	464	612	793	740	474	868	760	996	957
101	30	229	584	357	95	485	680	613	250	741	636	869	881	997	983
102	146	230	769	358	327	486	801	614	371	742	694	870	494	998	958
103	71	231	198	359	564	487	362	615	481	743	254	871	702	999	987
104	262	232	172	360	800	488	590	616	574	744	717	872	921	1000	1012
105	265	233	120	361	402	489	409	617	413	745	575	873	501	1001	999
106	161	234	201	362	356	490	570	618	603	746	913	874	876	1002	1016
107	576	235	336	363	307	491	788	619	366	747	798	875	847	1003	767
108	45	236	62	364	301	492	597	620	468	748	811	876	992	1004	989
109	100	237	282	365	417	493	572	621	655	749	379	877	447	1005	1003
110	640	238	143	366	213	494	219	622	900	750	697	878	733	1006	990
111	51	239	103	367	568	495	311	623	805	751	431	879	827	1007	1005
112	148	240	178	368	832	496	708	624	615	752	607	880	934	1008	959
113	46	241	294	369	588	497	598	625	684	753	489	881	882	1009	1011
114	75	242	93	370	186	498	601	626	710	754	866	882	937	1010	1013
115	266	243	644	371	646	499	651	627	429	755	723	883	963	1011	895
116	273	244	202	372	404	500	421	628	794	756	486	884	747	1012	1006
117	517	245	592	373	227	501	792	629	252	757	908	885	505	1013	1014
118	104	246	323	374	896	502	802	630	373	758	718	886	855	1014	1017
119	162	247	392	375	594	503	611	631	605	759	813	887	924	1015	1018
120	53	248	297	376	418	504	602	632	848	760	476	888	734	1016	991
121	193	249	770	377	302	505	410	633	690	761	856	889	829	1017	1020
122	152	250	107	378	649	506	231	634	713	762	839	890	965	1018	1007
123	77	251	180	379	771	507	688	635	632	763	725	891	938	1019	1015
124	164	252	151	380	360	508	653	636	482	764	698	892	884	1020	1019
125	768	253	209	381	539	509	248	637	806	765	914	893	506	1021	1021
126	268	254	284	382	111	510	369	638	427	766	752	894	749	1022	1022
127	274	255	648	383	331	511	190	639	904	767	868	895	945	1023	1023

5.3.2 Low density parity check coding

The bit sequence input for a given code block to channel coding is denoted by $c_0, c_1, c_2, c_3, ..., c_{K-1}$, where K is the number of bits to encode as defined in Subclause 5.2.2. After encoding the bits are denoted by $d_0, d_1, d_2, ..., d_{N-1}$, where $N = 66Z_c$ for LDPC base graph 1 and $N = 50Z_c$ for LDPC base graph 2, and the value of Z_c is given in Subclause 5.2.2.

For a code block encoded by LDPC, the following encoding procedure applies:

1) Find the set with index i_{LS} in Table 5.3.2-1 which contains Z_c.

2) for $k = 2Z_c$ to $K-1$

   if $c_k \neq <NULL>$

   $d_{k-2Z_c} = c_k$;

   else

   $c_k = 0$;

   $d_{k-2Z_c} = <NULL>$;

   end if

end for

3) Generate $N + 2Z_c - K$ parity bits $\mathbf{w} = [w_0, w_1, w_2, ..., w_{N+2Z_c-K-1}]^T$ such that $\mathbf{H} \times \begin{bmatrix} \mathbf{c} \\ \mathbf{w} \end{bmatrix} = \mathbf{0}$, where $\mathbf{c} = [c_0, c_1, c_2, ..., c_{K-1}]^T$; $\mathbf{0}$ is a column vector of all elements equal to 0. The encoding is performed in GF(2).

For LDPC base graph 1, a matrix of $\mathbf{H}_{\mathrm{BG}}$ has 46 rows with row indices $i = 0,1,2,...,45$ and 68 columns with column indices $j = 0,1,2,...,67$. For LDPC base graph 2, a matrix of $\mathbf{H}_{\mathrm{BG}}$ has 42 rows with row indices $i = 0,1,2,...,41$ and 52 columns with column indices $j = 0,1,2,...,51$. The elements in $\mathbf{H}_{\mathrm{BG}}$ with row and column indices given in Table 5.3.2-2 (for LDPC base graph 1) and Table 5.3.2-3 (for LDPC base graph 2) are of value 1, and all other elements in $\mathbf{H}_{\mathrm{BG}}$ are of value 0.

The matrix $\mathbf{H}$ is obtained by replacing each element of $\mathbf{H}_{\mathrm{BG}}$ with a $Z_c \times Z_c$ matrix, according to the following:

- Each element of value 0 in $\mathbf{H}_{\mathrm{BG}}$ is replaced by an all zero matrix $\mathbf{0}$ of size $Z_c \times Z_c$;
- Each element of value 1 in $\mathbf{H}_{\mathrm{BG}}$ is replaced by a circular permutation matrix $\mathbf{I}(P_{i,j})$ of size $Z_c \times Z_c$, where i and j are the row and column indices of the element, and $\mathbf{I}(P_{i,j})$ is obtained by circularly shifting the identity matrix $\mathbf{I}$ of size $Z_c \times Z_c$ to the right $P_{i,j}$ times. The value of $P_{i,j}$ is given by $P_{i,j} = \mathrm{mod}(V_{i,j}, Z_c)$. The value of $V_{i,j}$ is given by Tables 5.3.2-2 and 5.3.2-3 according to the set index i_{LS} and LDPC base graph.

4) for $k = K$ to $N + 2Z_c - 1$

$d_{k-2Z_c} = w_{k-K}$;

end for

Table 5.3.2-1: Sets of LDPC lifting size Z

Set index (i_{LS})	*Set of lifting sizes (Z)*
0	{2, 4, 8, 16, 32, 64, 128, 256}
1	{3, 6, 12, 24, 48, 96, 192, 384}
2	{5, 10, 20, 40, 80, 160, 320}
3	{7, 14, 28, 56, 112, 224}
4	{9, 18, 36, 72, 144, 288}
5	{11, 22, 44, 88, 176, 352}
6	{13, 26, 52, 104, 208}
7	{15, 30, 60, 120, 240}

Table 5.3.2-2: LDPC base graph 1 ($\mathbf{H}_{\mathrm{BG}}$) and its parity check matrices ($V_{i,j}$)

$\mathbf{H}_{BG}$		$V_{i,j}$							
Row index i	Column index j	Set index i_{LS}							
		0	1	2	3	4	5	6	7
0	0	250	307	73	223	211	294	0	135
	1	69	19	15	16	198	118	0	227
	2	226	50	103	94	188	167	0	126
	3	159	369	49	91	186	330	0	134
	5	100	181	240	74	219	207	0	84
	6	10	216	39	10	4	165	0	83
	9	59	317	15	0	29	243	0	53
	10	229	288	162	205	144	250	0	225
	11	110	109	215	216	116	1	0	205
	12	191	17	164	21	216	339	0	128
	13	9	357	133	215	115	201	0	75
	15	195	215	298	14	233	53	0	135
	16	23	106	110	70	144	347	0	217
	18	190	242	113	141	95	304	0	220
	19	35	180	16	198	216	167	0	90
	20	239	330	189	104	73	47	0	105
	21	31	346	32	81	261	188	0	137
	22	1	1	1	1	1	1	0	1
	23	0	0	0	0	0	0	0	0
1	0	2	76	303	141	179	77	22	96
	2	239	76	294	45	162	225	11	236
	3	117	73	27	151	223	96	124	136
	4	124	288	261	46	256	338	0	221
	5	71	144	161	119	160	268	10	128
	7	222	331	133	157	76	112	0	92
	8	104	331	4	133	202	302	0	172
	9	173	178	80	87	117	50	2	56
	11	220	295	129	206	109	167	16	11
	12	102	342	300	93	15	253	60	189
	14	109	217	76	79	72	334	0	95
	15	132	99	266	9	152	242	6	85
	16	142	354	72	118	158	257	30	153
	17	155	114	83	194	147	133	0	87
	19	255	331	260	31	156	9	168	163
	21	28	112	301	187	119	302	31	216
	22	0	0	0	0	0	0	105	0
	23	0	0	0	0	0	0	0	0
	24	0	0	0	0	0	0	0	0
2	0	106	205	68	207	258	226	132	189
	1	111	250	7	203	167	35	37	4
	2	185	328	80	31	220	213	21	225
	4	63	332	280	176	133	302	180	151
	5	117	256	38	180	243	111	4	236
	6	93	161	227	186	202	265	149	117
	7	229	267	202	95	218	128	48	179
	8	177	160	200	153	63	237	38	92
	9	95	63	71	177	0	294	122	24
	10	39	129	106	70	3	127	195	68
	13	142	200	295	77	74	110	155	6
	14	225	88	283	214	229	286	28	101
	15	225	53	301	77	0	125	85	33
	17	245	131	184	198	216	131	47	96
	18	205	240	246	117	269	163	179	125
	19	251	205	230	223	200	210	42	67
	20	117	13	276	90	234	7	66	230
	24	0	0	0	0	0	0	0	0
	25	0	0	0	0	0	0	0	0
3	0	121	276	220	201	187	97	4	128
	1	89	87	208	18	145	94	6	23
	3	84	0	30	165	166	49	33	162
	4	20	275	197	5	108	279	113	220
	6	150	199	61	45	82	139	49	43
	7	131	153	175	142	132	166	21	186
	8	243	56	79	16	197	91	6	96
	10	136	132	281	34	41	106	151	1
	11	86	305	303	155	162	246	83	216
	12	246	231	253	213	57	345	154	22
	13	219	341	164	147	36	269	87	24
	14	211	212	53	69	115	185	5	167
	16	240	304	44	96	242	249	92	200
	17	76	300	28	74	165	215	173	32
	18	244	271	77	99	0	143	120	235
	20	144	39	319	30	113	121	2	172
	21	12	357	68	158	108	121	142	219
	22	1	1	1	1	1	1	0	1
	25	0	0	0	0	0	0	0	0
4	0	157	332	233	170	246	42	24	64
	1	102	181	205	10	235	256	204	211
	26	0	0	0	0	0	0	0	0
5	0	205	195	83	164	261	219	185	2
	1	236	14	292	59	181	130	100	171
	3	194	115	50	86	72	251	24	47
	12	231	166	318	80	283	322	65	143
	16	28	241	201	182	254	295	207	210

$\mathbf{H}_{BG}$		$V_{i,j}$							
Row index i	Column index j	Set index i_{LS}							
		0	1	2	3	4	5	6	7
15	1	96	2	290	120	0	348	6	138
	10	65	210	60	131	183	15	81	220
	13	63	318	130	209	108	81	182	173
	18	75	55	184	209	68	176	53	142
	25	179	269	51	81	64	113	46	49
	37	0	0	0	0	0	0	0	0
16	1	64	13	69	154	270	190	88	78
	3	49	338	140	164	13	293	198	152
	11	49	57	45	43	99	332	160	84
	20	51	289	115	189	54	331	122	5
	22	154	57	300	101	0	114	182	205
	38	0	0	0	0	0	0	0	0
17	0	7	260	257	56	153	110	91	183
	14	164	303	147	110	137	228	184	112
	16	59	81	128	200	0	247	30	106
	17	1	358	51	63	0	116	3	219
	21	144	375	228	4	162	190	155	129
	39	0	0	0	0	0	0	0	0
18	1	42	130	260	199	161	47	1	183
	12	233	163	294	110	151	286	41	215
	13	8	280	291	200	0	246	167	180
	18	155	132	141	143	241	181	68	143
	19	147	4	295	186	144	73	148	14
	40	0	0	0	0	0	0	0	0
19	0	60	145	64	8	0	87	12	179
	1	73	213	181	6	0	110	6	108
	7	72	344	101	103	118	147	166	159
	8	127	242	270	198	144	258	184	138
	10	224	197	41	8	0	204	191	196
	41	0	0	0	0	0	0	0	0
20	0	151	187	301	105	265	89	6	77
	3	186	206	162	210	81	65	12	187
	9	217	264	40	121	90	155	15	203
	11	47	341	130	214	144	244	5	167
	22	160	59	10	183	228	30	30	130
	42	0	0	0	0	0	0	0	0
21	1	249	205	79	192	64	162	6	197
	5	121	102	175	131	46	264	86	122
	16	109	328	132	220	266	346	96	215
	20	131	213	283	50	9	143	42	65
	21	171	97	103	106	18	109	199	216
	43	0	0	0	0	0	0	0	0
22	0	64	30	177	53	72	280	44	25
	12	142	11	20	0	189	157	58	47
	13	188	233	55	3	72	236	130	126
	17	158	22	316	148	257	113	131	178
	44	0	0	0	0	0	0	0	0
23	1	156	24	249	88	180	18	45	185
	2	147	89	50	203	0	6	18	127
	10	170	61	133	168	0	181	132	117
	18	152	27	105	122	165	304	100	199
	45	0	0	0	0	0	0	0	0
24	0	112	298	289	49	236	38	9	32
	3	86	158	280	157	199	170	125	178
	4	236	235	110	64	0	249	191	2
	11	116	339	187	193	266	288	28	156
	22	222	234	281	124	0	194	6	58
	46	0	0	0	0	0	0	0	0
25	1	23	72	172	1	205	279	4	27
	6	136	17	295	166	0	255	74	141
	7	116	383	96	65	0	111	16	11
	14	182	312	46	81	183	54	28	181
	47	0	0	0	0	0	0	0	0
26	0	195	71	270	107	0	325	21	163
	2	243	81	110	176	0	326	142	131
	4	215	76	318	212	0	226	192	169
	15	61	136	67	127	277	99	197	98
	48	0	0	0	0	0	0	0	0
27	1	25	194	210	208	45	91	98	165
	6	104	194	29	141	36	326	140	232
	8	194	101	304	174	72	268	22	9
	49	0	0	0	0	0	0	0	0
28	0	128	222	11	146	275	102	4	32
	4	165	19	293	153	0	1	1	43
	19	181	244	50	217	155	40	40	200
	21	63	274	234	114	62	167	93	205
	50	0	0	0	0	0	0	0	0
29	1	86	252	27	150	0	273	92	232
	14	236	5	308	11	180	104	136	32
	18	84	147	117	53	0	243	106	118
	25	6	78	29	68	42	107	6	103
	51	0	0	0	0	0	0	0	0
30	0	216	159	91	34	0	171	2	170
	10	73	229	23	130	90	16	88	199

	21	123	51	267	130	79	258	161	180		13	120	260	105	210	252	95	112	26
	22	115	157	279	153	144	283	72	180		24	9	90	135	123	173	212	20	105
	27	0	0	0	0	0	0	0	0		52	0	0	0	0	0	0	0	0
6	0	183	278	289	158	80	294	6	199	31	1	95	100	222	175	144	101	4	73
	6	22	257	21	119	144	73	27	22		7	177	215	308	49	144	297	49	149
	10	28	1	293	113	169	330	163	23		22	172	258	66	177	166	279	125	175
	11	67	351	13	21	90	99	50	100		25	61	256	162	128	19	222	194	108
	13	244	92	232	63	59	172	48	92		53	0	0	0	0	0	0	0	0
	17	11	253	302	51	177	150	24	207	32	0	221	102	210	192	0	351	6	103
	18	157	18	138	136	151	284	38	52		12	112	201	22	209	211	265	126	110
	20	211	225	235	116	108	305	91	13		14	199	175	271	58	36	338	63	151
	28	0	0	0	0	0	0	0	0		24	121	287	217	30	162	83	20	211
7	0	220	9	12	17	169	3	145	77		54	0	0	0	0	0	0	0	0
	1	44	62	88	76	189	103	88	146	33	1	2	323	170	114	0	56	10	199
	4	159	316	207	104	154	224	112	209		2	187	8	20	49	0	304	30	132
	7	31	333	50	100	184	297	153	32		11	41	361	140	161	76	141	6	172
	8	167	290	25	150	104	215	159	166		21	211	105	33	137	18	101	92	65
	14	104	114	76	158	164	39	76	18		55	0	0	0	0	0	0	0	0
	29	0	0	0	0	0	0	0	0	34	0	127	230	187	82	197	60	4	161
8	0	112	307	295	33	54	348	172	181		7	167	148	296	186	0	320	153	237
	1	4	179	133	95	0	75	2	105		15	164	202	5	68	108	112	197	142
	3	7	165	130	4	252	22	131	141		17	159	312	44	150	0	54	155	180
	12	211	18	231	217	41	312	141	223		56	0	0	0	0	0	0	0	0
	16	102	39	296	204	98	224	96	177	35	1	161	320	207	192	199	100	4	231
	19	164	224	110	39	46	17	99	145		6	197	335	158	173	278	210	45	174
	21	109	368	269	58	15	59	101	199		12	207	2	55	26	0	195	168	145
	22	241	67	245	44	230	314	35	153		22	103	266	285	187	205	268	185	100
	24	90	170	154	201	54	244	116	38		57	0	0	0	0	0	0	0	0
	30	0	0	0	0	0	0	0	0	36	0	37	210	259	222	216	135	6	11
9	0	103	366	189	9	162	156	6	169		14	105	313	179	157	16	15	200	207
	1	182	232	244	37	159	88	10	12		15	51	297	178	0	0	35	177	42
	10	109	321	36	213	93	293	145	206		18	120	21	160	6	0	188	43	100
	11	21	133	286	105	134	111	53	221		58	0	0	0	0	0	0	0	0
	13	142	57	151	89	45	92	201	17	37	1	198	269	298	81	72	319	82	59
	17	14	303	267	185	132	152	4	212		13	220	82	15	195	144	236	2	204
	18	61	63	135	109	76	23	164	92		23	122	115	115	138	0	85	135	161
	20	216	82	209	218	209	337	173	205		59	0	0	0	0	0	0	0	0
	31	0	0	0	0	0	0	0	0	38	0	167	185	151	123	190	164	91	121
10	1	98	101	14	82	178	175	126	116		9	151	177	179	90	0	196	64	90
	2	149	339	80	165	1	253	77	151		10	157	289	64	73	0	209	198	26
	4	167	274	211	174	28	27	156	70		12	163	214	181	10	0	246	100	140
	7	160	111	75	19	267	231	16	230		60	0	0	0	0	0	0	0	0
	8	49	383	161	194	234	49	12	115	39	1	173	258	102	12	153	236	4	115
	14	58	354	311	103	201	267	70	84		3	139	93	77	77	0	264	28	188
	32	0	0	0	0	0	0	0	0		7	149	346	192	49	165	37	109	168
11	0	77	48	16	52	55	25	184	45		19	0	297	208	114	117	272	188	52
	1	41	102	147	11	23	322	194	115		61	0	0	0	0	0	0	0	0
	12	83	8	290	2	274	200	123	134	40	0	157	175	32	67	216	304	10	4
	16	182	47	289	35	181	351	16	1		8	137	37	80	45	144	237	84	103
	21	78	188	177	32	273	166	104	152		17	149	312	197	96	2	135	12	30
	22	252	334	43	84	39	338	109	165		62	0	0	0	0	0	0	0	0
	23	22	115	280	201	26	192	124	107	41	1	167	52	154	23	0	123	2	53
	33	0	0	0	0	0	0	0	0		3	173	314	47	215	0	77	75	189
12	0	160	77	229	142	225	123	6	186		9	139	139	124	60	0	25	142	215
	1	42	186	235	175	162	217	20	215		18	151	288	207	167	183	272	128	24
	10	21	174	169	136	244	142	203	124		63	0	0	0	0	0	0	0	0
	11	32	232	48	3	151	110	153	180	42	0	149	113	226	114	27	288	163	222
	13	234	50	105	28	238	176	104	98		4	157	14	65	91	0	83	10	170
	18	7	74	52	182	243	76	207	80		24	137	218	126	78	35	17	162	71
	34	0	0	0	0	0	0	0	0		64	0	0	0	0	0	0	0	0
13	0	177	313	39	81	231	311	52	220	43	1	151	113	228	206	52	210	1	22
	3	248	177	302	56	0	251	147	185		16	163	132	69	22	243	3	163	127
	7	151	266	303	72	216	265	1	154		18	173	114	176	134	0	53	99	49
	20	185	115	160	217	47	94	16	178		25	139	168	102	161	270	167	98	125
	23	62	370	37	78	36	81	46	150		65	0	0	0	0	0	0	0	0
	35	0	0	0	0	0	0	0	0	44	0	139	80	234	84	18	79	4	191
14	0	206	142	78	14	0	22	1	124		7	157	78	227	4	0	244	6	211
	12	55	248	299	175	186	322	202	144		9	163	163	259	9	0	293	142	187
	15	206	137	54	211	253	277	118	182		22	173	274	260	12	57	272	3	148
	16	127	89	61	191	16	156	130	95		66	0	0	0	0	0	0	0	0
	17	16	347	179	51	0	66	1	72	45	1	149	135	101	184	168	82	181	177
	21	229	12	258	43	79	78	2	76		6	151	149	228	121	0	67	45	114
	36	0	0	0	0	0	0	0	0		10	167	15	126	29	144	235	153	93
15	0	40	241	229	90	170	176	173	39		67	0	0	0	0	0	0	0	0

Table 5.3.2-3: LDPC base graph 2 ($\mathbf{H}_{\mathrm{BG}}$) and its parity check matrices ($V_{i,j}$)

$\mathbf{H}_{BG}$		$V_{i,j}$							
Row index	Column index	Set index i_{LS}							
i	j	0	1	2	3	4	5	6	7
0	0	9	174	0	72	3	156	143	145
	1	117	97	0	110	26	143	19	131
	2	204	166	0	23	53	14	176	71
	3	26	66	0	181	35	3	165	21
	6	189	71	0	95	115	40	196	23
	9	205	172	0	8	127	123	13	112
	10	0	0	0	1	0	0	0	1
	11	0	0	0	0	0	0	0	0
1	0	167	27	137	53	19	17	18	142
	3	166	36	124	156	94	65	27	174
	4	253	48	0	115	104	63	3	183
	5	125	92	0	156	66	1	102	27
	6	226	31	88	115	84	55	185	96
	7	156	187	0	200	98	37	17	23
	8	224	185	0	29	69	171	14	9
	9	252	3	55	31	50	133	180	167
	11	0	0	0	0	0	0	0	0
	12	0	0	0	0	0	0	0	0
2	0	81	25	20	152	95	98	126	74
	1	114	114	94	131	106	168	163	31
	3	44	117	99	46	92	107	47	3
	4	52	110	9	191	110	82	183	53
	8	240	114	108	91	111	142	132	155
	10	1	1	1	0	1	1	1	0
	12	0	0	0	0	0	0	0	0
	13	0	0	0	0	0	0	0	0
3	1	8	136	38	185	120	53	36	239
	2	58	175	15	6	121	174	48	171
	4	158	113	102	36	22	174	18	95
	5	104	72	146	124	4	127	111	110
	6	209	123	12	124	73	17	203	159
	7	54	118	57	110	49	89	3	199
	8	18	28	53	156	128	17	191	43
	9	128	186	46	133	79	105	160	75
	10	0	0	0	1	0	0	0	1
	13	0	0	0	0	0	0	0	0
4	0	179	72	0	200	42	86	43	29
	1	214	74	136	16	24	67	27	140
	11	71	29	157	101	51	83	117	180
	14	0	0	0	0	0	0	0	0
5	0	231	10	0	185	40	79	136	121
	1	41	44	131	138	140	84	49	41
	5	194	121	142	170	84	35	36	169
	7	159	80	141	219	137	103	132	88
	11	103	48	64	193	71	60	62	207
	15	0	0	0	0	0	0	0	0
6	0	155	129	0	123	109	47	7	137
	5	228	92	124	55	87	154	34	72
	7	45	100	99	31	107	10	198	172
	9	28	49	45	222	133	155	168	124
	11	158	184	148	209	139	29	12	56
	16	0	0	0	0	0	0	0	0
7	1	129	80	0	103	97	48	163	86
	5	147	186	45	13	135	125	78	186
	7	140	16	148	105	35	24	143	87
	11	3	102	96	150	108	47	107	172
	13	116	143	78	181	65	55	58	154
	17	0	0	0	0	0	0	0	0
8	0	142	118	0	147	70	53	101	176
	1	94	70	65	43	69	31	177	169
	12	230	152	87	152	88	161	22	225
	18	0	0	0	0	0	0	0	0
9	1	203	28	0	2	97	104	186	167
	8	205	132	97	30	40	142	27	238
	10	61	185	51	184	24	99	205	48
	11	247	178	85	83	49	64	81	68
	19	0	0	0	0	0	0	0	0
10	0	11	59	0	174	46	111	125	38
	1	185	104	17	150	41	25	60	217
	6	0	22	156	8	101	174	177	208
	7	117	52	20	56	96	23	51	232
	20	0	0	0	0	0	0	0	0
11	0	11	32	0	99	28	91	39	178
	7	236	92	7	138	30	175	29	214
	9	210	174	4	110	116	24	35	168
	13	56	154	2	99	64	141	8	51
	21	0	0	0	0	0	0	0	0
12	1	63	39	0	46	33	122	18	124
	3	111	93	113	217	122	11	155	122
	11	14	11	48	109	131	4	49	72
	22	0	0	0	0	0	0	0	0
13	0	83	49	0	37	76	29	32	48
	1	2	125	112	113	37	91	53	57
	8	38	35	102	143	62	27	95	167

$\mathbf{H}_{BG}$		$V_{i,j}$							
Row index	Column index	Set index i_{LS}							
i	j	0	1	2	3	4	5	6	7
16	26	0	0	0	0	0	0	0	0
17	1	254	158	0	48	120	134	57	196
	5	124	23	24	132	43	23	201	173
	11	114	9	109	206	65	62	142	195
	12	64	6	18	2	42	163	35	218
	27	0	0	0	0	0	0	0	0
18	0	220	186	0	68	17	173	129	128
	6	194	6	18	16	106	31	203	211
	7	50	46	86	156	142	22	140	210
	28	0	0	0	0	0	0	0	0
19	0	87	58	0	35	79	13	110	39
	1	20	42	158	138	28	135	124	84
	10	185	156	154	86	41	145	52	88
	29	0	0	0	0	0	0	0	0
20	1	26	76	0	6	2	128	196	117
	4	105	61	148	20	103	52	35	227
	11	29	153	104	141	78	173	114	6
	30	0	0	0	0	0	0	0	0
21	0	76	157	0	80	91	156	10	238
	8	42	175	17	43	75	166	122	13
	13	210	67	33	81	81	40	23	11
	31	0	0	0	0	0	0	0	0
22	1	222	20	0	49	54	18	202	195
	2	63	52	4	1	132	163	126	44
	32	0	0	0	0	0	0	0	0
23	0	23	106	0	156	68	110	52	5
	3	235	86	75	54	115	132	170	94
	5	238	95	158	134	56	150	13	111
	33	0	0	0	0	0	0	0	0
24	1	46	182	0	153	30	113	113	81
	2	139	153	69	88	42	108	161	19
	9	8	64	87	63	101	61	88	130
	34	0	0	0	0	0	0	0	0
25	0	228	45	0	211	128	72	197	66
	5	156	21	65	94	63	136	194	95
	35	0	0	0	0	0	0	0	0
26	2	29	67	0	90	142	36	164	146
	7	143	137	100	6	28	38	172	66
	12	160	55	13	221	100	53	49	190
	13	122	85	7	6	133	145	161	86
	36	0	0	0	0	0	0	0	0
27	0	8	103	0	27	13	42	168	64
	6	151	50	32	118	10	104	193	181
	37	0	0	0	0	0	0	0	0
28	1	98	70	0	216	106	64	14	7
	2	101	111	126	212	77	24	186	144
	5	135	168	110	193	43	149	46	16
	38	0	0	0	0	0	0	0	0
29	0	18	110	0	108	133	139	50	25
	4	28	17	154	61	25	161	27	57
	39	0	0	0	0	0	0	0	0
30	2	71	120	0	106	87	84	70	37
	5	240	154	35	44	56	173	17	139
	7	9	52	51	185	104	93	50	221
	9	84	56	134	176	70	29	6	17
	40	0	0	0	0	0	0	0	0
31	1	106	3	0	147	80	117	115	201
	13	1	170	20	182	139	148	189	46
	41	0	0	0	0	0	0	0	0
32	0	242	84	0	108	32	116	110	179
	5	44	8	20	21	89	73	0	14
	12	166	17	122	110	71	142	163	116
	42	0	0	0	0	0	0	0	0
33	2	132	165	0	71	135	105	163	46
	7	164	179	88	12	6	137	173	2
	10	235	124	13	109	2	29	179	106
	43	0	0	0	0	0	0	0	0
34	0	147	173	0	29	37	11	197	184
	12	85	177	19	201	25	41	191	135
	13	36	12	78	69	114	162	193	141
	44	0	0	0	0	0	0	0	0
35	1	57	77	0	91	60	126	157	85
	5	40	184	157	165	137	152	167	225
	11	63	18	6	55	93	172	181	175
	45	0	0	0	0	0	0	0	0
36	0	140	25	0	1	121	73	197	178
	2	38	151	63	175	129	154	167	112
	7	154	170	82	83	26	129	179	106
	46	0	0	0	0	0	0	0	0
37	10	219	37	0	40	97	167	181	154
	13	151	31	144	12	56	38	193	114
	47	0	0	0	0	0	0	0	0
38	1	31	84	0	37	1	112	157	42
	5	66	151	93	97	70	7	173	41

	13	222	166	26	140	47	127	186	219		11	38	190	19	46	1	19	191	105
	23	0	0	0	0	0	0	0	0		48	0	0	0	0	0	0	0	0
14	1	115	19	0	36	143	11	91	82	39	0	239	93	0	106	119	109	181	167
	6	145	118	138	95	51	145	20	232		7	172	132	24	181	32	6	157	45
	11	3	21	57	40	130	8	52	204		12	34	57	138	154	142	105	173	189
	13	232	163	27	116	97	166	109	162		49	0	0	0	0	0	0	0	0
	24	0	0	0	0	0	0	0	0	40	2	0	103	0	98	6	160	193	78
15	0	51	68	0	116	139	137	174	38		10	75	107	36	35	73	156	163	67
	10	175	63	73	200	96	103	108	217		13	120	163	143	36	102	82	179	180
	11	213	81	99	110	128	40	102	157		50	0	0	0	0	0	0	0	0
	25	0	0	0	0	0	0	0	0	41	1	129	147	0	120	48	132	191	53
16	1	203	87	0	75	48	78	125	170		5	229	7	2	101	47	6	197	215
	9	142	177	79	158	9	158	31	23		11	118	60	55	81	19	8	167	230
	11	8	135	111	134	28	17	54	175		51	0	0	0	0	0	0	0	0
	12	242	64	143	97	8	165	176	202										

5.3.3 Channel coding of small block lengths

The bit sequence input for a given code block to channel coding is denoted by $c_0, c_1, c_2, c_3, ..., c_{K-1}$, where K is the number of bits to encode. After encoding the bits are denoted by $d_0, d_1, d_2, ..., d_{N-1}$.

5.3.3.1 Encoding of 1-bit information

For $K = 1$, the code block is encoded according to Table 5.3.3.1-1, where $N = Q_m$ and Q_m is the modulation order for the code block.

Table 5.3.3.1-1: Encoding of 1-bit information

Q_m	**Encoded bits** $d_0, d_1, d_2, ..., d_{N-1}$
1	$[c_0]$
2	$[c_0$ y$]$
4	$[c_0$ y x x$]$
6	$[c_0$ y x x x x $]$
8	$[c_0$ y x x x x x x $]$

The "x" and "y" in Table 5.3.3.1-1 are placeholders for Subclause 6.3.1.1 of [4, TS 38.211] to scramble the information bits in a way that maximizes the Euclidean distance of the modulation symbols carrying the information bits.

5.3.3.2 Encoding of 2-bit information

For $K = 2$, the code block is encoded according to Table 5.3.3-2, where $c_2 = (c_0 + c_1) \bmod 2$, $N = 3Q_m$, and Q_m is the modulation order for the code block.

Table 5.3.3.2-1: Encoding of 2-bit information

Q_m	**Encoded bits** $d_0, d_1, d_2, ..., d_{N-1}$
1	$[c_0\ c_1\ c_2]$
2	$[c_0\ c_1\ c_2\ c_0\ c_1\ c_2]$
4	$[c_0\ c_1$ x x $c_2\ c_0$ x x $c_1\ c_2$ x x$]$
6	$[c_0\ c_1$ x x x x $c_2\ c_0$ x x x x $c_1\ c_2$ x x x x$]$
8	$[c_0\ c_1$ x x x x x x $c_2\ c_0$ x x x x x x $c_1\ c_2$ x x x x x x$]$

The "x" in Table 5.3.3.2-1 are placeholders for Subclause 6.3.1.1 of [4, TS 38.211] to scramble the information bits in a way that maximizes the Euclidean distance of the modulation symbols carrying the information bits.

5.3.3.3 Encoding of other small block lengths

For $3 \le K \le 11$, the code block is encoded by $d_i = \left(\sum_{k=0}^{K-1} c_k \cdot M_{i,k} \right) \bmod 2$, where $i = 0, 1, \cdots, N-1$, $N = 32$, and $M_{i,k}$ represents the basis sequences as defined in Table 5.3.3.3-1.

Table 5.3.3.3-1: Basis sequences for (32, K) code

i	$M_{i,0}$	$M_{i,1}$	$M_{i,2}$	$M_{i,3}$	$M_{i,4}$	$M_{i,5}$	$M_{i,6}$	$M_{i,7}$	$M_{i,8}$	$M_{i,9}$	$M_{i,10}$
0	1	1	0	0	0	0	0	0	0	0	1
1	1	1	1	0	0	0	0	0	0	1	1
2	1	0	0	1	0	0	1	0	1	1	1
3	1	0	1	1	0	0	0	0	1	0	1
4	1	1	1	1	0	0	0	1	0	0	1
5	1	1	0	0	1	0	1	1	1	0	1
6	1	0	1	0	1	0	1	0	1	1	1
7	1	0	0	1	1	0	0	1	1	0	1
8	1	1	0	1	1	0	0	1	0	1	1
9	1	0	1	1	1	0	1	0	0	1	1
10	1	0	1	0	0	1	1	1	0	1	1
11	1	1	1	0	0	1	1	0	1	0	1
12	1	0	0	1	0	1	0	1	1	1	1
13	1	1	0	1	0	1	0	1	0	1	1
14	1	0	0	0	1	1	0	1	0	0	1
15	1	1	0	0	1	1	1	1	0	1	1
16	1	1	1	0	1	1	1	0	0	1	0
17	1	0	0	1	1	1	0	0	1	0	0
18	1	1	0	1	1	1	1	1	0	0	0
19	1	0	0	0	0	1	1	0	0	0	0
20	1	0	1	0	0	0	1	0	0	0	1
21	1	1	0	1	0	0	0	0	0	1	1
22	1	0	0	0	1	0	0	1	1	0	1
23	1	1	1	0	1	0	0	0	1	1	1
24	1	1	1	1	1	0	1	1	1	1	0
25	1	1	0	0	0	1	1	1	0	0	1
26	1	0	1	1	0	1	0	0	1	1	0
27	1	1	1	1	0	1	0	1	1	1	0
28	1	0	1	0	1	1	1	0	1	0	0
29	1	0	1	1	1	1	1	1	1	0	0
30	1	1	1	1	1	1	1	1	1	1	1
31	1	0	0	0	0	0	0	0	0	0	0

5.4 Rate matching

5.4.1 Rate matching for Polar code

The rate matching for Polar code is defined per coded block and consists of sub-block interleaving, bit collection, and bit interleaving. The input bit sequence to rate matching is $d_0, d_1, d_2, ..., d_{N-1}$. The output bit sequence after rate matching is denoted as $f_0, f_1, f_2, ..., f_{E-1}$.

5.4.1.1 Sub-block interleaving

The bits input to the sub-block interleaver are the coded bits $d_0, d_1, d_2, ..., d_{N-1}$. The coded bits $d_0, d_1, d_2, ..., d_{N-1}$ are divided into 32 sub-blocks. The bits output from the sub-block interleaver are denoted as $y_0, y_1, y_2, ..., y_{N-1}$, generated as follows:

for $n = 0$ to $N - 1$

$i = \lfloor 32n / N \rfloor$;

$J(n) = P(i) \times (N / 32) + \mathrm{mod}(n, N / 32)$;

$y_n = d_{J(n)}$;

end for

where the sub-block interleaver pattern $P(i)$ is given by Table 5.4.1.1-1.

Table 5.4.1.1-1: Sub-block interleaver pattern $P(i)$

i	$P(i)$	i	$P(i)$	i	$P(i)$	i	$P(i)$	i	$P(i)$	i	$P(i)$	i	$P(i)$	i	$P(i)$
0	0	4	3	8	8	12	10	16	12	20	14	24	24	28	27
1	1	5	5	9	16	13	18	17	20	21	22	25	25	29	29
2	2	6	6	10	9	14	11	18	13	22	15	26	26	30	30
3	4	7	7	11	17	15	19	19	21	23	23	27	28	31	31

The sets of bit indices $\overline{\mathbf{Q}}_I^N$ and $\overline{\mathbf{Q}}_F^N$ are determined as follows, where K, n_{PC}, and $\mathbf{Q}_0^{N-1}$ are defined in Subclause 5.3.1

$\overline{\mathbf{Q}}_{F,tmp}^N = \varnothing$

if $E < N$

if $K/E \le 7/16$ -- puncturing

for $n = 0$ to $N - E - 1$

$\overline{\mathbf{Q}}_{F,tmp}^N = \overline{\mathbf{Q}}_{F,tmp}^N \cup \{J(n)\}$;

end for

if $E \ge 3N/4$

$\overline{\mathbf{Q}}_{F,tmp}^N = \overline{\mathbf{Q}}_{F,tmp}^N \cup \{0,1,\ldots,\lceil 3N/4 - E/2 \rceil - 1\}$;

else

$\overline{\mathbf{Q}}_{F,tmp}^N = \overline{\mathbf{Q}}_{F,tmp}^N \cup \{0,1,\ldots,\lceil 9N/16 - E/4 \rceil - 1\}$;

end if

else -- shortening

for $n = E$ to $N - 1$

$\overline{\mathbf{Q}}_{F,tmp}^N = \overline{\mathbf{Q}}_{F,tmp}^N \cup \{J(n)\}$;

end for

end if

end if

$\overline{\mathbf{Q}}_{I,tmp}^N = \mathbf{Q}_0^{N-1} \setminus \overline{\mathbf{Q}}_{F,tmp}^N$;

$\overline{\mathbf{Q}}_I^N$ comprises $(K + n_{PC})$ most reliable bit indices in $\overline{\mathbf{Q}}_{I,tmp}^N$;

$\overline{\mathbf{Q}}_F^N = \mathbf{Q}_0^{N-1} \setminus \overline{\mathbf{Q}}_I^N$;

5.4.1.2 Bit selection

The bit sequence after the sub-block interleaver $y_0, y_1, y_2, \ldots, y_{N-1}$ from Subclause 5.4.1.1 is written into a circular buffer of length N.

Denoting by E the rate matching output sequence length, the bit selection output bit sequence e_k, $k = 0,1,2,\ldots,E-1$, is generated as follows:

if $E \geq N$ -- repetition

for $k = 0$ to $E - 1$

$e_k = y_{\mathrm{mod}(k,N)}$;

end for

else

if $K / E \leq 7/16$ -- puncturing

for $k = 0$ to $E - 1$

$e_k = y_{k+N-E}$;

end for

else -- shortening

for $k = 0$ to $E - 1$

$e_k = y_k$;

end for

end if

end if

5.4.1.3 Interleaving of coded bits

The bit sequence $e_0, e_1, e_2, ..., e_{E-1}$ is interleaved into bit sequence $f_0, f_1, f_2, ..., f_{E-1}$, as follows:

If $I_{BIL} = 1$

Denote T as the smallest integer such that $T(T+1)/2 \geq E$;

$k = 0$;

for $i = 0$ to $T - 1$

for $j = 0$ to $T - 1 - i$

if $k < E$

$v_{i,j} = e_k$;

else

$v_{i,j} =< NULL >$;

end if

$k = k + 1$;

end for

end for

$k = 0$;

for $j = 0$ to $T - 1$

for $i = 0$ to $T - 1 - j$

if $v_{i,j} \neq < NULL >$

$f_k = v_{i,j}$;

$k = k + 1$

end if

end for

end for

else

for $i = 0$ to $E - 1$

$f_i = e_i$;

end for

end if

The value of E is no larger than 8192.

5.4.2 Rate matching for LDPC code

The rate matching for LDPC code is defined per coded block and consists of bit selection and bit interleaving. The input bit sequence to rate matching is $d_0, d_1, d_2, ..., d_{N-1}$. The output bit sequence after rate matching is denoted as $f_0, f_1, f_2, ..., f_{E-1}$.

5.4.2.1 Bit selection

The bit sequence after encoding $d_0, d_1, d_2, ..., d_{N-1}$ from Subclause 5.3.2 is written into a circular buffer of length N_{cb} for the r -th coded block, where N is defined in Subclause 5.3.2.

For the r -th code block, let $N_{cb} = N$ if $I_{LBRM} = 0$ and $N_{cb} = \min(N, N_{ref})$ otherwise, where $N_{ref} = \left\lfloor \frac{TBS_{\text{LBRM}}}{C \cdot R_{\text{LBRM}}} \right\rfloor$, $R_{\text{LBRM}} = 2/3$, TBS_{LBRM} is determined according to Subclause 6.1.4.2 in [6, TS 38.214] for UL-SCH and Subclause 5.1.3.2 in [6, TS 38.214] for DL-SCH/PCH, assuming the following:

- maximum number of layers for one TB supported by the UE for the serving cell, which for UL-SCH is according to higher layer parameter *ULmaxRank* if the parameter is configured;
- maximum modulation order configured for the serving cell, if configured by higher layers; otherwise a maximum modulation order $Q_m = 6$ is assumed for DL-SCH ;
- maximum coding rate of 948/1024;
- $n_{PRB} = n_{PRB,LBRM}$ is given by Table 5.4.2.1-1, where the value of $n_{PRB,LBRM}$ for DL-SCH is determined according to the initial bandwidth part if there is no other bandwidth part configured to the UE;
- $N_{RE} = 156 \cdot n_{PRB}$;
- C is the number of code blocks of the transport block determined according to Subclause 5.2.2.

Table 5.4.2.1-1: Value of $n_{PRB,LBRM}$

Maximum number of PRBs across all configured BWPs of a carrier	$n_{PRB,LBRM}$
Less than 33	32
33 to 66	66
67 to 107	107
108 to 135	135
136 to 162	162
163 to 217	217
Larger than 217	273

Denoting by E_r the rate matching output sequence length for the r -th coded block, where the value of E_r is determined as follows:

Set $j = 0$

for $r = 0$ to $C - 1$

if the r -th coded block is not scheduled for transmission as indicated by CBGTI according to Subclause 5.1.7.2 for DL-SCH and 6.1.5.2 for UL-SCH in [6, TS 38.214]

$E_r = 0$;

else

if $j \le C' - \mathrm{mod}(G/(N_L \cdot Q_m), C') - 1$

$$E_r = N_L \cdot Q_m \cdot \left\lfloor \frac{G}{N_L \cdot Q_m \cdot C'} \right\rfloor;$$

else

$$E_r = N_L \cdot Q_m \cdot \left\lceil \frac{G}{N_L \cdot Q_m \cdot C'} \right\rceil;$$

end if

$j = j + 1$;

end if

end for

where

- N_L is the number of transmission layers that the transport block is mapped onto;
- Q_m is the modulation order;
- G is the total number of coded bits available for transmission of the transport block;
- $C' = C$ if CBGTI is not present in the DCI scheduling the transport block and C' is the number of scheduled code blocks of the transport block if CBGTI is present in the DCI scheduling the transport block.

Denote by rv_{id} the redundancy version number for this transmission (rv_{id} = 0, 1, 2 or 3), the rate matching output bit sequence e_k, $k = 0,1,2,\ldots,E-1$, is generated as follows, where k_0 is given by Table 5.4.2.1-2 according to the value of rv_{id} and LDPC base graph:

$k = 0$;

$j = 0$;

while $k < E$

if $d_{(k_0+j) \bmod N_{cb}} \neq <NULL>$

$e_k = d_{(k_0+j) \bmod N_{cb}}$;

$k = k + 1$;

end if

$j = j + 1$;

end while

Table 5.4.2.1-2: Starting position of different redundancy versions, k_0

rv_{id}	k_0	
	LDPC base graph 1	LDPC base graph 2
0	0	0
1	$\left\lfloor \frac{17N_{cb}}{66Z_c} \right\rfloor Z_c$	$\left\lfloor \frac{13N_{cb}}{50Z_c} \right\rfloor Z_c$
2	$\left\lfloor \frac{33N_{cb}}{66Z_c} \right\rfloor Z_c$	$\left\lfloor \frac{25N_{cb}}{50Z_c} \right\rfloor Z_c$
3	$\left\lfloor \frac{56N_{cb}}{66Z_c} \right\rfloor Z_c$	$\left\lfloor \frac{43N_{cb}}{50Z_c} \right\rfloor Z_c$

5.4.2.2 Bit interleaving

The bit sequence $e_0, e_1, e_2, ..., e_{E-1}$ is interleaved to bit sequence $f_0, f_1, f_2, ..., f_{E-1}$, according to the following, where the value of Q_m is the modulation order.

for $j = 0$ to $E / Q_m - 1$

for $i = 0$ to $Q_m - 1$

$f_{i+j \cdot Q_m} = e_{i \cdot E / Q_m + j}$;

end for

end for

5.4.3 Rate matching for channel coding of small block lengths

The input bit sequence to rate matching is $d_0, d_1, d_2, ..., d_{N-1}$. The output bit sequence after rate matching is denoted as $f_0, f_1, f_2, ..., f_{E-1}$, where E is the rate matching output sequence length. The bit sequence $f_0, f_1, f_2, ..., f_{E-1}$ is obtained by the following:

for $k = 0$ to $E - 1$

$f_k = d_{k \bmod N}$;

end for

5.5 Code block concatenation

The input bit sequence for the code block concatenation block are the sequences f_{rk}, for $r = 0,..., C-1$ and $k = 0,..., E_r - 1$, where E_r is the number of rate matched bits for the r-th code block. The output bit sequence from the code block concatenation block is the sequence g_k for $k = 0,...,G-1$.

The code block concatenation consists of sequentially concatenating the rate matching outputs for the different code blocks. Therefore,

Set $k = 0$ and $r = 0$

while $r < C$

Set $j = 0$

while $j < E_r$

$g_k = f_{rj}$

$k = k + 1$

$j = j + 1$

end while

$r = r + 1$

end while

6 Uplink transport channels and control information

6.1 Random access channel

The sequence index for the random access channel is received from higher layers and is processed according to [4, TS 38.211].

6.2 Uplink shared channel

6.2.1 Transport block CRC attachment

Error detection is provided on each UL-SCH transport block through a Cyclic Redundancy Check (CRC).

The entire transport block is used to calculate the CRC parity bits. Denote the bits in a transport block delivered to layer 1 by $a_0, a_1, a_2, a_3,..., a_{A-1}$, and the parity bits by $p_0, p_1, p_2, p_3,..., p_{L-1}$, where A is the payload size and L is the number of parity bits. The lowest order information bit a_0 is mapped to the most significant bit of the transport block as defined in Subclause 6.1.1 of [TS38.321].

The parity bits are computed and attached to the UL-SCH transport block according to Subclause 5.1, by setting L to 24 bits and using the generator polynomial $g_{\text{CRC24A}}(D)$ if $A > 3824$; and by setting L to 16 bits and using the generator polynomial $g_{\text{CRC16}}(D)$ otherwise.

The bits after CRC attachment are denoted by $b_0, b_1, b_2, b_3,..., b_{B-1}$, where $B = A + L$.

6.2.2 LDPC base graph selection

For initial transmission of a transport block with coding rate R indicated by the MCS index according to Subclause 6.1.4.1 in [6, TS 38.214] and subsequent re-transmission of the same transport block, each code block of the transport block is encoded with either LDPC base graph 1 or 2 according to the following:

- if $A \leq 292$, or if $A \leq 3824$ and $R \leq 0.67$, or if $R \leq 0.25$, LDPC base graph 2 is used;
- otherwise, LDPC base graph 1 is used,

where A is the payload size as described in Subclause 6.2.1.

6.2.3 Code block segmentation and code block CRC attachment

The bits input to the code block segmentation are denoted by $b_0, b_1, b_2, b_3, ..., b_{B-1}$ where B is the number of bits in the transport block (including CRC).

Code block segmentation and code block CRC attachment are performed according to Subclause 5.2.2.

The bits after code block segmentation are denoted by $c_{r0}, c_{r1}, c_{r2}, c_{r3}, ..., c_{r(K_r-1)}$, where r is the code block number and K_r is the number of bits for code block number r according to Subclause 5.2.2.

6.2.4 Channel coding of UL-SCH

Code blocks are delivered to the channel coding block. The bits in a code block are denoted by $c_{r0}, c_{r1}, c_{r2}, c_{r3}, ..., c_{r(K_r-1)}$, where r is the code block number, and K_r is the number of bits in code block number r. The total number of code blocks is denoted by C and each code block is individually LDPC encoded according to Subclause 5.3.2.

After encoding the bits are denoted by $d_{r0}, d_{r1}, d_{r2}, d_{r3}, ..., d_{r(N_r-1)}$, where the values of N_r is given in Subclause 5.3.2.

6.2.5 Rate matching

Coded bits for each code block, denoted as $d_{r0}, d_{r1}, d_{r2}, d_{r3}, ..., d_{r(N_r-1)}$, are delivered to the rate match block, where r is the code block number, and N_r is the number of encoded bits in code block number r. The total number of code blocks is denoted by C and each code block is individually rate matched according to Subclause 5.4.2 by setting $I_{LBRM} = 1$ if higher layer parameter *rateMatching* is set to *limitedBufferRM* and by setting $I_{LBRM} = 0$ otherwise.

After rate matching, the bits are denoted by $f_{r0}, f_{r1}, f_{r2}, f_{r3}, ..., f_{r(E_r-1)}$, where E_r is the number of rate matched bits for code block number r.

6.2.6 Code block concatenation

The input bit sequence for the code block concatenation block are the sequences $f_{r0}, f_{r1}, f_{r2}, f_{r3}, ..., f_{r(E_r-1)}$, for $r = 0, ..., C-1$ and where E_r is the number of rate matched bits for the r-th code block.

Code block concatenation is performed according to Subclause 5.5.

The bits after code block concatenation are denoted by $g_0, g_1, g_2, g_3, ..., g_{G-1}$, where G is the total number of coded bits for transmission.

6.2.7 Data and control multiplexing

Denote the coded bits for UL-SCH as $g_0^{\text{UL-SCH}}, g_1^{\text{UL-SCH}}, g_2^{\text{UL-SCH}}, g_3^{\text{UL-SCH}}, ..., g_{G^{\text{UL-SCH}}-1}^{\text{UL-SCH}}$.

Denote the coded bits for HARQ-ACK, if any, as $g_0^{\text{ACK}}, g_1^{\text{ACK}}, g_2^{\text{ACK}}, g_3^{\text{ACK}}, ..., g_{G^{\text{ACK}}-1}^{\text{ACK}}$.

Denote the coded bits for CSI part 1, if any, as $g_0^{\text{CSI-part1}}, g_1^{\text{CSI-part1}}, g_2^{\text{CSI-part1}}, g_3^{\text{CSI-part1}}, ..., g_{G^{\text{CSI-part1}}-1}^{\text{CSI-part1}}$.

Denote the coded bits for CSI part 2, if any, as $g_0^{\text{CSI-part2}}, g_1^{\text{CSI-part2}}, g_2^{\text{CSI-part2}}, g_3^{\text{CSI-part2}}, ..., g_{G^{\text{CSI-part2}}-1}^{\text{CSI-part2}}$.

Denote the multiplexed data and control coded bit sequence as $g_0, g_1, g_2, g_3, ..., g_{G-1}$.

Denote l as the OFDM symbol index of the scheduled PUSCH, starting from 0 to $N_{\text{symb,all}}^{\text{PUSCH}} - 1$, where $N_{\text{symb,all}}^{\text{PUSCH}}$ is the total number of OFDM symbols of the PUSCH, including all OFDM symbols used for DMRS.

Denote k as the subcarrier index of the scheduled PUSCH, starting from 0 to $M_{\text{sc}}^{\text{PUSCH}} - 1$, where $M_{\text{sc}}^{\text{PUSCH}}$ is expressed as a number of subcarriers.

Denote $\Phi_l^{\text{UL-SCH}}$ as the set of resource elements, in ascending order of indices k, available for transmission of data in OFDM symbol l, for $l = 0, 1, 2, ..., N_{\text{symb,all}}^{\text{PUSCH}} - 1$.

Denote $M_{\text{sc}}^{\text{UL-SCH}}(l) = \left|\Phi_l^{\text{UL-SCH}}\right|$ as the number of elements in set $\Phi_l^{\text{UL-SCH}}$. Denote $\Phi_l^{\text{UL-SCH}}(j)$ as the j-th element in $\Phi_l^{\text{UL-SCH}}$.

Denote Φ_l^{UCI} as the set of resource elements, in ascending order of indices k, available for transmission of UCI in OFDM symbol l, for $l = 0, 1, 2, ..., N_{\text{symb,all}}^{\text{PUSCH}} - 1$. Denote $M_{\text{sc}}^{\text{UCI}}(l) = \left|\Phi_l^{\text{UCI}}\right|$ as the number of elements in set Φ_l^{UCI}. Denote $\Phi_l^{\text{UCI}}(j)$ as the j-th element in Φ_l^{UCI}. For any OFDM symbol that carriers DMRS of the PUSCH, $\Phi_l^{\text{UCI}} = \varnothing$. For any OFDM symbol that does not carry DMRS of the PUSCH, $\Phi_l^{\text{UCI}} = \Phi_l^{\text{UL-SCH}}$.

If frequency hopping is configured for the PUSCH,

- denote $l^{(1)}$ as the OFDM symbol index of the first OFDM symbol after the first set of consecutive OFDM symbol(s) carrying DMRS in the first hop;
- denote $l^{(2)}$ as the OFDM symbol index of the first OFDM symbol after the first set of consecutive OFDM symbol(s) carrying DMRS in the second hop.
- denote $l_{\text{CSI}}^{(1)}$ as the OFDM symbol index of the first OFDM symbol that does not carry DMRS in the first hop;
- denote $l_{\text{CSI}}^{(2)}$ as the OFDM symbol index of the first OFDM symbol that does not carry DMRS in the second hop;
- if HARQ-ACK is present for transmission on the PUSCH with UL-SCH, let
  - $G^{\text{ACK}}(1) = N_L \cdot Q_m \cdot \left\lfloor G^{\text{ACK}} / (2 \cdot N_L \cdot Q_m) \right\rfloor$ and $G^{\text{ACK}}(2) = N_L \cdot Q_m \cdot \left\lceil G^{\text{ACK}} / (2 \cdot N_L \cdot Q_m) \right\rceil$;
- if CSI is present for transmission on the PUSCH with UL-SCH, let
  - $G^{\text{CSI-part1}}(1) = N_L \cdot Q_m \cdot \left\lfloor G^{\text{CSI-part1}} / (2 \cdot N_L \cdot Q_m) \right\rfloor$;
  - $G^{\text{CSI-part1}}(2) = N_L \cdot Q_m \cdot \left\lceil G^{\text{CSI-part1}} / (2 \cdot N_L \cdot Q_m) \right\rceil$;
  - $G^{\text{CSI-part2}}(1) = N_L \cdot Q_m \cdot \left\lfloor G^{\text{CSI-part2}} / (2 \cdot N_L \cdot Q_m) \right\rfloor$; and
  - $G^{\text{CSI-part2}}(2) = N_L \cdot Q_m \cdot \left\lceil G^{\text{CSI-part2}} / (2 \cdot N_L \cdot Q_m) \right\rceil$;
- if only HARQ-ACK and CSI part 1 are present for transmission on the PUSCH without UL-SCH, let
  - $G^{\text{ACK}}(1) = \min\left(N_L \cdot Q_m \cdot \left\lfloor G^{\text{ACK}} / (2 \cdot N_L \cdot Q_m) \right\rfloor, M_3 \cdot N_L \cdot Q_m\right)$;

- $G^{\text{ACK}}(2) = G^{\text{ACK}} - G^{\text{ACK}}(1)$;
- $G^{\text{CSI-part1}}(1) = M_1 \cdot N_L \cdot Q_m - G^{\text{ACK}}(1)$; and
- $G^{\text{CSI-part1}}(2) = G^{\text{CSI-part1}} - G^{\text{CSI-part1}}(1)$;

- if HARQ-ACK, CSI part 1 and CSI part 2 are present for transmission on the PUSCH without UL-SCH, let
  - $G^{\text{ACK}}(1) = \min\left(N_L \cdot Q_m \cdot \left\lfloor G^{\text{ACK}} / \left(2 \cdot N_L \cdot Q_m\right)\right\rfloor , M_3 \cdot N_L \cdot Q_m\right)$;
  - $G^{\text{ACK}}(2) = G^{\text{ACK}} - G^{\text{ACK}}(1)$;
  - $G^{\text{CSI-part1}}(1) = \min\left(N_L \cdot Q_m \cdot \left\lfloor G^{\text{CSI-part1}} / \left(2 \cdot N_L \cdot Q_m\right)\right\rfloor, M_1 \cdot N_L \cdot Q_m - G^{\text{ACK}}(1)\right)$;
  - $G^{\text{CSI-part1}}(2) = G^{\text{CSI-part1}} - G^{\text{CSI-part1}}(1)$;
  - $G^{\text{CSI-part2}}(1) = M_1 \cdot N_L \cdot Q_m - G^{\text{CSI-part1}}(1)$ if the number of HARQ-ACK information bits is no more than 2, and $G^{\text{CSI-part2}}(1) = M_1 \cdot N_L \cdot Q_m - G^{\text{ACK}}(1) - G^{\text{CSI-part1}}(1)$ otherwise; and
  - $G^{\text{CSI-part2}}(2) = M_2 \cdot N_L \cdot Q_m - G^{\text{CSI-part1}}(2)$ if the number of HARQ-ACK information bits is no more than 2, and $G^{\text{CSI-part2}}(2) = M_2 \cdot N_L \cdot Q_m - G^{\text{ACK}}(2) - G^{\text{CSI-part1}}(2)$ otherwise;

- let $N_{\text{hop}}^{\text{PUSCH}} = 2$, and denote $N_{\text{symb,hop}}^{\text{PUSCH}}(1)$, $N_{\text{symb,hop}}^{\text{PUSCH}}(2)$ as the number of OFDM symbols of the PUSCH in the first and second hop, respectively;
- N_L is the number of transmission layers of the PUSCH;
- Q_m is the modulation order of the PUSCH;
- $M_1 = \sum_{l=0}^{N_{\text{symb,hop}}^{\text{PUSCH}}(1)-1} M_{\text{SC}}^{\text{UCI}}(l)$;
- $M_2 = \sum_{l=N_{\text{symb,hop}}^{\text{PUSCH}}(1)}^{N_{\text{symb,hop}}^{\text{PUSCH}}(1)+N_{\text{symb,hop}}^{\text{PUSCH}}(2)-1} M_{\text{SC}}^{\text{UCI}}(l)$
- $M_3 = \sum_{l=l^{(1)}}^{N_{\text{symb,hop}}^{\text{PUSCH}}(1)-1} M_{\text{SC}}^{\text{UCI}}(l)$.

If frequency hopping is not configured for the PUSCH,

- denote $l^{(1)}$ as the OFDM symbol index of the first OFDM symbol after the first set of consecutive OFDM symbol(s) carrying DMRS;
- denote $l_{\text{CSI}}^{(1)}$ as the OFDM symbol index of the first OFDM symbol that does not carry DMRS;
- if HARQ-ACK is present for transmission on the PUSCH, let $G^{\text{ACK}}(1) = G^{\text{ACK}}$;
- if CSI is present for transmission on the PUSCH, let $G^{\text{CSI-part1}}(1) = G^{\text{CSI-part1}}$ and $G^{\text{CSI-part2}}(1) = G^{\text{CSI-part2}}$;
- let $N_{\text{hop}}^{\text{PUSCH}} = 1$ and $N_{\text{symb,hop}}^{\text{PUSCH}}(1) = N_{\text{symb,all}}^{\text{PUSCH}}$.

The multiplexed data and control coded bit sequence $g_0, g_1, g_2, g_3, \ldots, g_{G-1}$ is obtained according to the following:

Step 1:

Set $\bar{\Phi}_l^{\text{UL-SCH}} = \Phi_l^{\text{UL-SCH}}$ for $l = 0, 1, 2, ..., N_{\text{symb,all}}^{\text{PUSCH}} - 1$;

Set $\bar{M}_{\text{sc}}^{\text{UL-SCH}}(l) = \left|\bar{\Phi}_l^{\text{UL-SCH}}\right|$ for $l = 0, 1, 2, ..., N_{\text{symb,all}}^{\text{PUSCH}} - 1$;

Set $\bar{\Phi}_l^{\text{UCI}} = \Phi_l^{\text{UCI}}$ for $l = 0, 1, 2, ..., N_{\text{symb,all}}^{\text{PUSCH}} - 1$;

Set $\bar{M}_{\text{sc}}^{\text{UCI}}(l) = \left|\bar{\Phi}_l^{\text{UCI}}\right|$ for $l = 0, 1, 2, ..., N_{\text{symb,all}}^{\text{PUSCH}} - 1$;

if the number of HARQ-ACK information bits to be transmitted on PUSCH is 0, 1 or 2 bits

the number of reserved resource elements for potential HARQ-ACK transmission is calculated according to Subclause 6.3.2.4.1.1, by setting $O_{\text{ACK}} = 2$;

denote $G_{\text{rvd}}^{\text{ACK}}$ as the number of coded bits for potential HARQ-ACK transmission using the reserved resource elements;

if frequency hopping is configured for the PUSCH, let $G_{\text{rvd}}^{\text{ACK}}(1) = N_L \cdot Q_m \cdot \left\lfloor G_{\text{rvd}}^{\text{ACK}} / (2 \cdot N_L \cdot Q_m) \right\rfloor$ and $G_{\text{rvd}}^{\text{ACK}}(2) = N_L \cdot Q_m \cdot \left\lceil G_{\text{rvd}}^{\text{ACK}} / (2 \cdot N_L \cdot Q_m) \right\rceil$;

if frequency hopping is not configured for the PUSCH, let $G_{\text{rvd}}^{\text{ACK}}(1) = G_{\text{rvd}}^{\text{ACK}}$;

denote $\bar{\Phi}_l^{\text{rvd}}$ as the set of reserved resource elements for potential HARQ-ACK transmission, in OFDM symbol l, for $l = 0, 1, 2, ..., N_{\text{symb,all}}^{\text{PUSCH}} - 1$;

Set $m_{\text{count}}^{\text{ACK}}(1) = 0$;

Set $m_{\text{count}}^{\text{ACK}}(2) = 0$;

$\bar{\Phi}_l^{\text{rvd}} = \varnothing$ for $l = 0, 1, 2, ..., N_{\text{symb,all}}^{\text{PUSCH}} - 1$;

for $i = 1$ to $N_{\text{hop}}^{\text{PUSCH}}$

$l = l^{(i)}$;

while $m_{\text{count}}^{\text{ACK}}(i) < G_{\text{rvd}}^{\text{ACK}}(i)$

if $\bar{M}_{\text{sc}}^{\text{UCI}}(l) > 0$

if $G_{\text{rvd}}^{\text{ACK}}(i) - m_{\text{count}}^{\text{ACK}}(i) \geq \bar{M}_{\text{sc}}^{\text{UCI}}(l) \cdot N_L \cdot Q_m$

$d = 1$;

$m_{\text{count}}^{\text{RE}} = \bar{M}_{\text{sc}}^{\text{UL-SCH}}(l)$;

end if

if $G_{\text{rvd}}^{\text{ACK}}(i) - m_{\text{count}}^{\text{ACK}}(i) < \bar{M}_{\text{sc}}^{\text{UCI}}(l) \cdot N_L \cdot Q_m$

$d = \left\lfloor \bar{M}_{\text{sc}}^{\text{UCI}}(l) \cdot N_L \cdot Q_m \Big/ \left(G_{\text{rvd}}^{\text{ACK}}(i) - m_{\text{count}}^{\text{ACK}}(i)\right) \right\rfloor$;

$m_{\text{count}}^{\text{RE}} = \left\lceil \left(G_{\text{rvd}}^{\text{ACK}}(i) - m_{\text{count}}^{\text{ACK}}(i)\right) / \left(N_L \cdot Q_m\right) \right\rceil$;

end if

for $j = 0$ to $m_{\text{count}}^{\text{RE}} - 1$

$\bar{\Phi}_l^{\text{rvd}} = \bar{\Phi}_l^{\text{rvd}} \cup \{\bar{\Phi}_l^{\text{UL-SCH}}(j \cdot d)\}$

$m_{\text{count}}^{\text{ACK}}(i) = m_{\text{count}}^{\text{ACK}}(i) + N_L \cdot Q_m$;

end for

end if

$l = l + 1$;

end while

end for

else

$\bar{\Phi}_l^{\text{rvd}} = \varnothing$ for $l = 0, 1, 2, ..., N_{\text{symb,all}}^{\text{PUSCH}} - 1$;

end if

Denote $\bar{M}_{\text{sc, rvd}}^{\bar{\Phi}}(l) = \left|\bar{\Phi}_l^{\text{rvd}}\right|$ as the number of elements in $\bar{\Phi}_l^{\text{rvd}}$.

Step 2:

if HARQ-ACK is present for transmission on the PUSCH and the number of HARQ-ACK information bits is more than 2,

Set $m_{\text{count}}^{\text{ACK}}(1) = 0$;

Set $m_{\text{count}}^{\text{ACK}}(2) = 0$;

Set $m_{\text{count,all}}^{\text{ACK}} = 0$;

for $i = 1$ to $N_{\text{hop}}^{\text{PUSCH}}$

$l = l^{(i)}$;

while $m_{\text{count}}^{\text{ACK}}(i) < G^{\text{ACK}}(i)$

if $\bar{M}_{\text{sc}}^{\text{UCI}}(l) > 0$

if $G^{\text{ACK}}(i) - m_{\text{count}}^{\text{ACK}}(i) \geq \bar{M}_{\text{sc}}^{\text{UCI}}(l) \cdot N_L \cdot Q_m$

$d = 1$;

$m_{\text{count}}^{\text{RE}} = \bar{M}_{\text{sc}}^{\text{UCI}}(l)$;

end if

if $G^{\text{ACK}}(i) - m_{\text{count}}^{\text{ACK}}(i) < \bar{M}_{\text{sc}}^{\text{UCI}}(l) \cdot N_L \cdot Q_m$

$d = \left\lfloor \bar{M}_{\text{sc}}^{\text{UCI}}(l) \cdot N_L \cdot Q_m \Big/ \left(G^{\text{ACK}}(i) - m_{\text{count}}^{\text{ACK}}(i)\right) \right\rfloor$;

$m_{\text{count}}^{\text{RE}} = \left\lceil \left(G^{\text{ACK}}(i) - m_{\text{count}}^{\text{ACK}}(i)\right) / \left(N_L \cdot Q_m\right) \right\rceil$;

end if

for $j = 0$ to $m_{\text{count}}^{\text{RE}} - 1$

$k = \bar{\Phi}_l^{\text{UCI}}(j \cdot d)$;

for $v = 0$ to $N_L \cdot Q_m - 1$

$\bar{g}_{l,k,v} = g_{m_{\text{count,all}}^{\text{ACK}}}^{\text{ACK}}$;

$m_{\text{count,all}}^{\text{ACK}} = m_{\text{count,all}}^{\text{ACK}} + 1$;

$m_{\text{count}}^{\text{ACK}}(i) = m_{\text{count}}^{\text{ACK}}(i) + 1$;

end for

end for

$\bar{\Phi}_{l,tmp}^{\text{UCI}} = \varnothing$;

for $j = 0$ to $m_{\text{count}}^{\text{RE}} - 1$

$\bar{\Phi}_{l,tmp}^{\text{UCI}} = \bar{\Phi}_{l,tmp}^{\text{UCI}} \bigcup \bar{\Phi}_l^{\text{UCI}}(j \cdot d)$;

end for

$\bar{\Phi}_l^{\text{UCI}} = \bar{\Phi}_l^{\text{UCI}} \setminus \bar{\Phi}_{l,tmp}^{\text{UCI}}$;

$\bar{\Phi}_l^{\text{UL-SCH}} = \bar{\Phi}_l^{\text{UL-SCH}} \setminus \bar{\Phi}_{l,tmp}^{\text{UCI}}$;

$\bar{M}_{\text{sc}}^{\text{UCI}}(l) = \left|\bar{\Phi}_l^{\text{UCI}}\right|$;

$\bar{M}_{\text{sc}}^{\text{UL-SCH}}(l) = \left|\bar{\Phi}_l^{\text{UL-SCH}}\right|$;

end if

$l = l + 1$;

end while

end for

end if

Step 3:

if CSI is present for transmission on the PUSCH,

Set $m_{\text{count}}^{\text{CSI-part1}}(1) = 0$;

Set $m_{\text{count}}^{\text{CSI-part1}}(2) = 0$;

Set $m_{\text{count,all}}^{\text{CSI-part1}} = 0$;

for $i = 1$ to $N_{\text{hop}}^{\text{PUSCH}}$

$l = l_{\text{CSI}}^{(i)}$;

while $\bar{M}_{\text{sc}}^{\text{UCI}}(l) - \bar{M}_{\text{sc, rvd}}^{\bar{\Phi}}(l) \le 0$

$l = l + 1$;

end while

while $m_{\text{count}}^{\text{CSI-part1}}(i) < G^{\text{CSI-part1}}(i)$

if $\bar{M}_{\text{sc}}^{\text{UCI}}(l) - \bar{M}_{\text{sc, rvd}}^{\bar{\Phi}}(l) > 0$

if $G^{\text{CSI-part1}}(i) - m_{\text{count}}^{\text{CSI-part1}}(i) \ge \left(\bar{M}_{\text{sc}}^{\text{UCI}}(l) - \bar{M}_{\text{sc, rvd}}^{\bar{\Phi}}(l)\right) \cdot N_L \cdot Q_m$

$d = 1$;

$m_{\text{count}}^{\text{RE}} = \bar{M}_{\text{sc}}^{\text{UCI}}(l) - \bar{M}_{\text{sc, rvd}}^{\bar{\Phi}}(l)$;

end if

if $G^{\text{CSI-part1}}(i) - m_{\text{count}}^{\text{CSI-part1}}(i) < \left(\bar{M}_{\text{sc}}^{\text{UCI}}(l) - \bar{M}_{\text{sc, rvd}}^{\bar{\Phi}}(l)\right) \cdot N_L \cdot Q_m$

$d = \left\lfloor \left(\bar{M}_{\text{sc}}^{\text{UCI}}(l) - M_{\text{sc, rvd}}^{\bar{\Phi}}(l)\right) \cdot N_L \cdot Q_m \Big/ \left(G^{\text{CSI-part1}}(i) - m_{\text{count}}^{\text{CSI-part1}}(i)\right) \right\rfloor$;

$m_{\text{count}}^{\text{RE}} = \left\lceil \left(G^{\text{CSI-part1}}(i) - m_{\text{count}}^{\text{CSI-part1}}(i)\right) / \left(N_L \cdot Q_m\right) \right\rceil$;

end if

$\bar{\Phi}_l^{\text{temp}} = \bar{\Phi}_l^{\text{UCI}} \setminus \bar{\Phi}_l^{\text{rvd}}$;

for $j = 0$ to $m_{\text{count}}^{\text{RE}} - 1$

$k = \bar{\Phi}_l^{\text{temp}}(j \cdot d)$;

for $v = 0$ to $N_L \cdot Q_m - 1$

$\bar{g}_{l,k,v} = g_{m_{\text{count, all}}^{\text{CSI-part1}}}^{\text{CSI-part1}}$;

$m_{\text{count,all}}^{\text{CSI-part1}} = m_{\text{count,all}}^{\text{CSI-part1}} + 1$;

$m_{\text{count}}^{\text{CSI-part1}}(i) = m_{\text{count}}^{\text{CSI-part1}}(i) + 1$;

end for

end for

$\bar{\Phi}_{l,tmp}^{\text{UCI}} = \varnothing$;

for $j = 0$ to $m_{\text{count}}^{\text{RE}} - 1$

$\bar{\Phi}_{l,tmp}^{\text{UCI}} = \bar{\Phi}_{l,tmp}^{\text{UCI}} \bigcup \bar{\Phi}_l^{\text{temp}}(j \cdot d)$;

end for

$\bar{\Phi}_l^{\text{UCI}} = \bar{\Phi}_l^{\text{UCI}} \setminus \bar{\Phi}_{l,tmp}^{\text{UCI}}$;

$\bar{\Phi}_l^{\text{UL-SCH}} = \bar{\Phi}_l^{\text{UL-SCH}} \setminus \bar{\Phi}_{l,tmp}^{\text{UCI}}$;

$\bar{M}_{\text{sc}}^{\text{UCI}}(l) = \left|\bar{\Phi}_l^{\text{UCI}}\right|$;

$\bar{M}_{\text{sc}}^{\text{UL-SCH}}(l) = \left|\bar{\Phi}_l^{\text{UL-SCH}}\right|$;

end if

$l = l + 1$;

end while

end for

Set $m_{\text{count}}^{\text{CSI-part2}}(1) = 0$;

Set $m_{\text{count}}^{\text{CSI-part2}}(2) = 0$;

Set $m_{\text{count,all}}^{\text{CSI-part2}} = 0$;

for $i = 1$ to $N_{\text{hop}}^{\text{PUSCH}}$

$l = l_{\text{CSI}}^{(i)}$;

while $\bar{M}_{\text{sc}}^{\text{UCI}}(l) \le 0$

$l = l + 1$;

end while

while $m_{\text{count}}^{\text{CSI-part2}}(i) < G^{\text{CSI-part2}}(i)$

if $\bar{M}_{\text{sc}}^{\text{UCI}}(l) > 0$

if $G^{\text{CSI-part2}}(i) - m_{\text{count}}^{\text{CSI-part2}}(i) \ge \bar{M}_{\text{sc}}^{\text{UCI}}(l) \cdot N_L \cdot Q_m$

$d = 1$;

$m_{\text{count}}^{\text{RE}} = \bar{M}_{\text{sc}}^{\text{UCI}}(l)$;

end if

if $G^{\text{CSI-part2}}(i) - m_{\text{count}}^{\text{CSI-part2}}(i) < \bar{M}_{\text{sc}}^{\text{UCI}}(l) \cdot N_L \cdot Q_m$

$d = \left\lfloor \bar{M}_{\text{sc}}^{\text{UCI}}(l) \cdot N_L \cdot Q_m \Big/ \left(G^{\text{CSI-part2}}(i) - m_{\text{count}}^{\text{CSI-part2}}(i)\right) \right\rfloor$;

$m_{\text{count}}^{\text{RE}} = \left\lceil \left(G^{\text{CSI-part2}}(i) - m_{\text{count}}^{\text{CSI-part2}}(i)\right) / \left(N_L \cdot Q_m\right) \right\rceil$;

end if

for $j = 0$ to $m_{\text{count}}^{\text{RE}} - 1$

$k = \bar{\Phi}_l^{\text{UCI}}(j \cdot d)$;

for $v = 0$ to $N_L \cdot Q_m - 1$

$\bar{g}_{l,k,v} = g_{m_{\text{count, all}}^{\text{CSI-part2}}}^{\text{CSI-part2}}$;

$m_{\text{count,all}}^{\text{CSI-part2}} = m_{\text{count,all}}^{\text{CSI-part2}} + 1$;

$m_{\text{count}}^{\text{CSI-part2}}(i) = m_{\text{count}}^{\text{CSI-part2}}(i) + 1$;

end for

end for

$\bar{\Phi}_{l,tmp}^{\text{UCI}} = \varnothing$;

for $j = 0$ to $m_{\text{count}}^{\text{RE}} - 1$

$\bar{\Phi}_{l,tmp}^{\text{UCI}} = \bar{\Phi}_{l,tmp}^{\text{UCI}} \bigcup \bar{\Phi}_{l}^{\text{UCI}}(j \cdot d)$;

end for

$\bar{\Phi}_{l}^{\text{UCI}} = \bar{\Phi}_{l}^{\text{UCI}} \setminus \bar{\Phi}_{l,tmp}^{\text{UCI}}$;

$\bar{\Phi}_{l}^{\text{UL-SCH}} = \bar{\Phi}_{l}^{\text{UL-SCH}} \setminus \bar{\Phi}_{l,tmp}^{\text{UCI}}$;

$\bar{M}_{\text{sc}}^{\text{UCI}}(l) = \left|\bar{\Phi}_{l}^{\text{UCI}}\right|$;

$\bar{M}_{\text{sc}}^{\text{UL-SCH}}(l) = \left|\bar{\Phi}_{l}^{\text{UL-SCH}}\right|$;

end if

$l = l + 1$;

end while

end for

end if

Step 4:

if UL-SCH is present for transmission on the PUSCH,

Set $m_{\text{count}}^{\text{UL–SCH}} = 0$;

for $l = 0$ to $N_{\text{symb,all}}^{\text{PUSCH}} - 1$

if $\bar{M}_{\text{sc}}^{\text{UL-SCH}}(l) > 0$

for $j = 0$ to $\bar{M}_{\text{sc}}^{\text{UL-SCH}}(l) - 1$

$k = \bar{\Phi}_{l}^{\text{UL-SCH}}(j)$;

for $v = 0$ to $N_L \cdot Q_m - 1$

$\bar{g}_{l,k,v} = g_{m_{\text{count}}^{\text{UL–SCH}}}^{\text{UL–SCH}}$;

$m_{\text{count}}^{\text{UL–SCH}} = m_{\text{count}}^{\text{UL–SCH}} + 1$;

end for

end for

end if

end for

end if

Step 5:

if HARQ-ACK is present for transmission on the PUSCH and the number of HARQ-ACK information bits is no more than 2,

Set $m_{\text{count}}^{\text{ACK}}(1) = 0$;

Set $m_{\text{count}}^{\text{ACK}}(2) = 0$;

Set $m_{\text{count,all}}^{\text{ACK}} = 0$;

for $i = 1$ to $N_{\text{hop}}^{\text{PUSCH}}$

$l = l^{(i)}$;

while $m_{\text{count}}^{\text{ACK}}(i) < G^{\text{ACK}}(i)$

if $\bar{M}_{\text{sc, rvd}}^{\bar{\Phi}}(l) > 0$

if $G^{\text{ACK}}(i) - m_{\text{count}}^{\text{ACK}}(i) \geq \bar{M}_{\text{sc, rvd}}^{\bar{\Phi}}(l) \cdot N_L \cdot Q_m$

$d = 1$;

$m_{\text{count}}^{\text{RE}} = \bar{M}_{\text{sc, rvd}}^{\bar{\Phi}}(l)$;

end if

if $G^{\text{ACK}}(i) - m_{\text{count}}^{\text{ACK}}(i) < \bar{M}_{\text{sc, rvd}}^{\bar{\Phi}}(l) \cdot N_L \cdot Q_m$

$d = \left\lfloor \bar{M}_{\text{sc, rvd}}^{\bar{\Phi}}(l) \cdot N_L \cdot Q_m \Big/ \left(G^{\text{ACK}}(i) - m_{\text{count}}^{\text{ACK}}(i)\right) \right\rfloor$;

$m_{\text{count}}^{\text{RE}} = \left\lceil \left(G^{\text{ACK}}(i) - m_{\text{count}}^{\text{ACK}}(i)\right) / \left(N_L \cdot Q_m\right) \right\rceil$;

end if

for $j = 0$ to $m_{\text{count}}^{\text{RE}} - 1$

$k = \bar{\Phi}_l^{\text{rvd}}(j \cdot d)$;

for $v = 0$ to $N_L \cdot Q_m - 1$

$\bar{g}_{l,k,v} = g_{m_{\text{count,all}}^{\text{ACK}}}^{\text{ACK}}$;

$m_{\text{count,all}}^{\text{ACK}} = m_{\text{count,all}}^{\text{ACK}} + 1$;

$m_{\text{count}}^{\text{ACK}}(i) = m_{\text{count}}^{\text{ACK}}(i) + 1;$

end for

end for

end if

$l = l + 1;$

end while

end for

end if

Step 6:

Set $t = 0;$

for $l = 0$ to $N_{\text{symb,all}}^{\text{PUSCH}} - 1$

for $j = 0$ to $M_{\text{sc}}^{\text{UL-SCH}}(l) - 1$

$k = \Phi_l^{\text{UL-SCH}}(j);$

for $v = 0$ to $N_L \cdot Q_m - 1$

$g_t = \bar{g}_{l,k,v};$

$t = t + 1;$

end for

end for

end for

6.3 Uplink control information

6.3.1 Uplink control information on PUCCH

The procedure in this subclause applies to PUCCH formats 2/3/4.

6.3.1.1 UCI bit sequence generation

6.3.1.1.1 HARQ-ACK/SR only

If only HARQ-ACK bits are transmitted on a PUCCH, the UCI bit sequence $a_0, a_1, a_2, a_3, ..., a_{A-1}$ is determined by setting $a_i = \tilde{o}_i^{ACK}$ for $i = 0, 1, ..., O^{\text{ACK}} - 1$ and $A = O^{\text{ACK}}$, where the HARQ-ACK bit sequence $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK}, ..., \tilde{o}_{O^{ACK}-1}^{ACK}$ is given by Subclause 9.1 of [5, TS38.213].

If only HARQ-ACK and SR bits are transmitted on a PUCCH, the UCI bit sequence $a_0, a_1, a_2, a_3, ..., a_{A-1}$ is determined by setting $a_i = \tilde{o}_i^{ACK}$ for $i = 0, 1, ..., O^{\text{ACK}} - 1$, $a_i = \tilde{o}_i^{SR}$ for $i = O^{\text{ACK}}, O^{\text{ACK}} + 1, ..., O^{\text{ACK}} + O^{\text{SR}} - 1$, and $A = O^{\text{ACK}} + O^{\text{SR}}$, where the HARQ-ACK bit sequence $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK}, ..., \tilde{o}_{O^{ACK}-1}^{ACK}$ is given by Subclause 9.1 of [5, TS 38.213], and the SR bit sequence $\tilde{o}_0^{SR}, \tilde{o}_1^{SR}, ..., \tilde{o}_{O^{\text{SR}}-1}^{SR}$ is given by Subclause 9.2.5.1 of [5, TS 38.213].

6.3.1.1.2 CSI only

The bitwidth for PMI of *codebookType=typeI-SinglePanel* with 2 CSI-RS ports is 2 for Rank=1 and 1 for Rank=2, according to Subclause 5.2.2.2.1 in [6, TS 38.214].

The bitwidth for PMI of *codebookType=typeI-SinglePanel* with more than 2 CSI-RS ports is provided in Tables 6.3.1.1.2-1, where the values of (N_1, N_2) and (O_1, O_2) are given by Subclause 5.2.2.2.1 in [6, TS 38.214].

Table 6.3.1.1.2-1: PMI of *codebookType=typeI-SinglePanel*

	Information field X_1 for wideband PMI			Information field X_2 for wideband PMI or per subband PMI	
	$(i_{1,1}, i_{1,2})$		$i_{1,3}$	i_2	
	codebookMode=1	*codebookMode*=2		*codebookMode*=1	*codebookMode*=2
Rank = 1 with >2 CSI-RS ports, $N_2 > 1$	$\lceil \log_2(N_1O_1 \cdot N_2O_2) \rceil$	$\left\lceil \log_2\left(\frac{N_1O_1}{2} \cdot \frac{N_2O_2}{2}\right) \right\rceil$	N/A	2	4
Rank = 1 with >2 CSI-RS ports, $N_2 = 1$	$\lceil \log_2(N_1O_1 \cdot N_2O_2) \rceil$	$\left\lceil \log_2\left(\frac{N_1O_1}{2}\right) \right\rceil$	N/A	2	4
Rank=2 with 4 CSI-RS ports, $N_2 = 1$	$\lceil \log_2(N_1O_1 \cdot N_2O_2) \rceil$	$\left\lceil \log_2\left(\frac{N_1O_1}{2}\right) \right\rceil$	1	1	3
Rank=2 with >4 CSI-RS ports, $N_2 > 1$	$\lceil \log_2(N_1O_1 \cdot N_2O_2) \rceil$	$\left\lceil \log_2\left(\frac{N_1O_1}{2} \cdot \frac{N_2O_2}{2}\right) \right\rceil$	2	1	3
Rank=2 with >4 CSI-RS ports, $N_2 = 1$	$\lceil \log_2(N_1O_1 \cdot N_2O_2) \rceil$	$\left\lceil \log_2\left(\frac{N_1O_1}{2}\right) \right\rceil$	2	1	3
Rank=3 or 4, with 4 CSI-RS ports	$\lceil \log_2(N_1O_1 \cdot N_2O_2) \rceil$		0	1	
Rank=3 or 4, with 8 or 12 CSI-RS ports	$\lceil \log_2(N_1O_1 \cdot N_2O_2) \rceil$		2	1	
Rank=3 or 4 , with >=16 CSI-RS ports	$\left\lceil \log_2\left(\frac{N_1O_1}{2} \cdot N_2O_2\right) \right\rceil$		2	1	
Rank=5 or 6	$\lceil \log_2(N_1O_1 \cdot N_2O_2) \rceil$		N/A	1	
Rank=7 or 8, $N_1 = 4, N_2 = 1$	$\left\lceil \log_2\left(\frac{N_1O_1}{2} \cdot N_2O_2\right) \right\rceil$		N/A	1	
Rank=7 or 8, $N_1 > 2, N_2 = 2$	$\left\lceil \log_2\left(N_1O_1 \cdot \frac{N_2O_2}{2}\right) \right\rceil$		N/A	1	
Rank=7 or 8, with	$\lceil \log_2(N_1O_1 \cdot N_2O_2) \rceil$		N/A	1	

$N_1 > 4, N_2 = 1$ or $N_1 = 2, N_2 = 2$ or $N_1 > 2, N_2 > 2$			

The bitwidth for PMI of *codebookType= typeI-MultiPanel* is provided in Tables 6.3.1.1.2-2, where the values of (N_g, N_1, N_2) and (O_1, O_2) are given by Subclause 5.2.2.2.2 in [6, TS 38.214].

Table 6.3.1.1.2-2: PMI of *codebookType= typeI-MultiPanel*

	Information fields X_1 for wideband					Information fields X_2 for wideband or per subband			
	$(i_{1,1}, i_{1,2})$	$i_{1,3}$	$i_{1,4,1}$	$i_{1,4,2}$	$i_{1,4,3}$	i_2	$i_{2,0}$	$i_{2,1}$	$i_{2,2}$
Rank=1 with $N_g = 2$ *codebookMode=1*	$\lceil \log_2(N_1O_1 \cdot N_2O_2) \rceil$	N/A	2	N/A	N/A	2	N/A	N/A	N/A
Rank=1 with $N_g = 4$ *codebookMode=1*	$\lceil \log_2(N_1O_1 \cdot N_2O_2) \rceil$	N/A	2	2	2	2	N/A	N/A	N/A
Rank=2 with $N_g = 2$, $N_1N_2 = 2$ *codebookMode=1*	$\lceil \log_2(N_1O_1 \cdot N_2O_2) \rceil$	1	2	N/A	N/A	1	N/A	N/A	N/A
Rank=3 or 4 with $N_g = 2$, $N_1N_2 = 2$ *codebookMode=1*	$\lceil \log_2(N_1O_1 \cdot N_2O_2) \rceil$	0	2	N/A	N/A	1	N/A	N/A	N/A
Rank=2 or 3 or 4 with $N_g = 2$, $N_1N_2 > 2$ *codebookMode=1*	$\lceil \log_2(N_1O_1 \cdot N_2O_2) \rceil$	2	2	N/A	N/A	1	N/A	N/A	N/A
Rank=2 with $N_g = 4$, $N_1N_2 = 2$ *codebookMode=1*	$\lceil \log_2(N_1O_1 \cdot N_2O_2) \rceil$	1	2	2	2	1	N/A	N/A	N/A
Rank=3 or 4 with $N_g = 4$, $N_1N_2 = 2$ *codebookMode=1*	$\lceil \log_2(N_1O_1 \cdot N_2O_2) \rceil$	0	2	2	2	1	N/A	N/A	N/A
Rank=2 or 3 or 4 with $N_g = 4$, $N_1N_2 > 2$ *codebookMode=1*	$\lceil \log_2(N_1O_1 \cdot N_2O_2) \rceil$	2	2	2	2	1	N/A	N/A	N/A
Rank=1 with $N_g = 2$ *codebookMode=2*	$\lceil \log_2(N_1O_1 \cdot N_2O_2) \rceil$	N/A	2	2	N/A	N/A	2	1	1

Rank=2 with $N_g = 2$, $N_1 N_2 = 2$ *codebookMode=2*	$\lceil \log_2(N_1 O_1 \cdot N_2 O_2) \rceil$	1	2	2	N/A	N/A	1	1	1
Rank=3 or 4 with $N_g = 2$, $N_1 N_2 = 2$ *codebookMode=2*	$\lceil \log_2(N_1 O_1 \cdot N_2 O_2) \rceil$	0	2	2	N/A	N/A	1	1	1
Rank=2 or 3 or 4 with $N_g = 2$, $N_1 N_2 > 2$ *codebookMode=2*	$\lceil \log_2(N_1 O_1 \cdot N_2 O_2) \rceil$	2	2	2	N/A	N/A	1	1	1

The bitwidth for PMI with 1 CSI-RS port is 0.

The bitwidth for RI/LI/CQI/CRI of *codebookType=typeI-SinglePanel* is provided in Tables 6.3.1.1.2-3.

Table 6.3.1.1.2-3: RI, LI, CQI, and CRI of *codebookType=typeI-SinglePanel*

Field	Bitwidth				
	1 antenna port	2 antenna ports	4 antenna ports	>4 antenna ports	
				Rank1~4	Rank5~8
Rank Indicator	0	$\min(1, \lceil \log_2 n_{\text{RI}} \rceil)$	$\min(2, \lceil \log_2 n_{\text{RI}} \rceil)$	$\lceil \log_2 n_{\text{RI}} \rceil$	$\lceil \log_2 n_{\text{RI}} \rceil$
Layer Indicator	0	$\min(2, \lceil \log_2 \text{RI} \rceil)$	$\min(2, \lceil \log_2 \text{RI} \rceil)$	$\min(2, \lceil \log_2 \text{RI} \rceil)$	$\min(2, \lceil \log_2 \text{RI} \rceil)$
Wide-band CQI	4	4	4	4	8
Subband differential CQI	2	2	2	2	4
CRI	$\lceil \log_2(K_s^{\text{CSI-RS}}) \rceil$	$\lceil \log_2(K_s^{\text{CSI-RS}}) \rceil$	$\lceil \log_2(K_s^{\text{CSI-RS}}) \rceil$	$\lceil \log_2(K_s^{\text{CSI-RS}}) \rceil$	$\lceil \log_2(K_s^{\text{CSI-RS}}) \rceil$

If the higher layer parameter *nrofCQIsPerReport*=1, n_{RI} in Table 6.3.1.1.2-3 is the number of allowed rank indicator values in the 4 LSBs of the higher layer parameter *typeI-SinglePanel-ri-Restriction* according to Subclause 5.2.2.2.1 [6, TS 38.214]; otherwise n_{RI} in Table 6.3.1.1.2-3 is the number of allowed rank indicator values according to Subclause 5.2.2.2.1 [6, TS 38.214]. The value of $K_s^{\text{CSI-RS}}$ is the number of CSI-RS resources in the corresponding resource set.

The bitwidth for RI/LI/CQI/CRI of *codebookType= typeI-MultiPanel* is provided in Table 6.3.1.1.2-4.

Table 6.3.1.1.2-4: RI, LI, CQI, and CRI of *codebookType=typeI-MultiPanel*

Field	Bitwidth
Rank Indicator	$\min(2, \lceil \log_2 n_{\text{RI}} \rceil)$
Layer Indicator	$\min(2, \lceil \log_2 \text{RI} \rceil)$
Wide-band CQI	4
Subband differential CQI	2
CRI	$\lceil \log_2(K_s^{\text{CSI-RS}}) \rceil$

where n_{RI} is the number of allowed rank indicator values according to Subclause 5.2.2.2.2 [6, TS 38.214], and $K_s^{\text{CSI-RS}}$ is the number of CSI-RS resources in the corresponding resource set.

The bitwidth for RI/LI/CQI of *codebookType= typeII* or *codebookType=typeII-PortSelection* is provided in Table 6.3.1.1.2-5.

Table 6.3.1.1.2-5: RI, LI, and CQI of *codebookType=typeII or typeII-PortSelection*

Field	Bitwidth
Rank Indicator	$\min(1, \lceil \log_2 n_{\text{RI}} \rceil)$
Layer Indicator	$\min(2, \lceil \log_2 \text{RI} \rceil)$
Wide-band CQI	4
Subband differential CQI	2
Indicator of the number of non-zero wideband amplitude coefficients M_l for layer l	$\lceil \log_2(2L-1) \rceil$

where n_{RI} is the number of allowed rank indicator values according to Subclauses 5.2.2.2.3 and 5.2.2.2.4 [6, TS 38.214].

The bitwidth for CRI, SSBRI, RSRP, and differential RSRP are provided in Table 6.3.1.1.2-6.

Table 6.3.1.1.2-6: CRI, SSBRI, and RSRP

Field	Bitwidth
CRI	$\lceil \log_2(K_s^{\text{CSI-RS}}) \rceil$
SSBRI	$\lceil \log_2(K_s^{\text{SSB}}) \rceil$
RSRP	7
Differential RSRP	4

where $K_s^{\text{CSI-RS}}$ is the number of CSI-RS resources in the corresponding resource set, and K_s^{SSB} is the configured number of SS/PBCH blocks in the corresponding resource set for reporting 'ssb-Index-RSRP'.

Table 6.3.1.1.2-7: Mapping order of CSI fields of one CSI report, *pmi-FormatIndicator=widebandPMI* and *cqi-FormatIndicator=widebandCQI*

CSI report number	CSI fields
CSI report #n	CRI as in Tables 6.3.1.1.2-3/4, if reported
	Rank Indicator as in Tables 6.3.1.1.2-3/4, if reported
	Layer Indicator as in Tables 6.3.1.1.2-3/4, if reported
	Zero padding bits O_P, if needed
	PMI wideband information fields X_1, from left to right as in Tables 6.3.1.1.2-1/2, if reported
	PMI wideband information fields X_2, from left to right as in Tables 6.3.1.1.2-1/2, if reported
	Wideband CQI as in Tables 6.3.1.1.2-3/4/5, if reported

The number of zero padding bits O_P in Table 6.3.1.1.2-7 is 0 for 1 CSI-RS port and $O_P = N_{\max} - N_{\text{reported}}$ for more than 1 CSI-RS port, where

- $N_{\max} = \max_{r \in S_{\text{Rank}}} B(r)$ and S_{Rank} is the set of rank values r that are allowed to be reported;
- $N_{\text{reported}} = B(R)$, where R is the reported rank;
- For 2 CSI-RS ports, $B(r) = N_{\text{PMI}}(r) + N_{\text{CQI}}(r) + N_{\text{LI}}(r)$;
- For more than 2 CSI-RS ports, $B(r) = N_{\text{PMI,i1}}(r) + N_{\text{PMI,i2}}(r) + N_{\text{CQI}}(r) + N_{\text{LI}}(r)$;

- if PMI is reported, $N_{\text{PMI}}(1)=2$ and $N_{\text{PMI}}(2)=1$; otherwise, $N_{\text{PMI}}(r)=0$;
- if PMI $i1$ is reported, $N_{\text{PMI,i1}}(r)$ is obtained according to Tables 6.3.1.1.2-1/2; otherwise, $N_{\text{PMI,i1}}(r)=0$;
- if PMI $i2$ is reported, $N_{\text{PMI,i2}}(r)$ is obtained according to Tables 6.3.1.1.2-1/2; otherwise, $N_{\text{PMI,i2}}(r)=0$;
- if CQI is reported, $N_{\text{CQI}}(r)$ is obtained according to Tables 6.3.1.1.2-3/4; otherwise, $N_{\text{CQI}}(r)=0$;
- if LI is reported, $N_{\text{LI}}(r)$ is obtained according to Tables 6.3.1.1.2-3/4; otherwise, $N_{\text{LI}}(r)=0$.

Table 6.3.1.1.2-8: Mapping order of CSI fields of one report for CRI/RSRP or SSBRI/RSRP reporting

CSI report number	CSI fields
CSI report #n	CRI or SSBRI #1 as in Table 6.3.1.1.2-6, if reported
	CRI or SSBRI #2 as in Table 6.3.1.1.2-6, if reported
	CRI or SSBRI #3 as in Table 6.3.1.1.2-6, if reported
	CRI or SSBRI #4 as in Table 6.3.1.1.2-6, if reported
	RSRP #1 as in Table 6.3.1.1.2-6, if reported
	Differential RSRP #2 as in Table 6.3.1.1.2-6, if reported
	Differential RSRP #3 as in Table 6.3.1.1.2-6, if reported
	Differential RSRP #4 as in Table 6.3.1.1.2-6, if reported

Table 6.3.1.1.2-9: Mapping order of CSI fields of one CSI report, CSI part 1, *pmi-FormatIndicator= subbandPMI* or *cqi-FormatIndicator=subbandCQI*

CSI report number	CSI fields
CSI report #n CSI part 1	CRI as in Tables 6.3.1.1.2-3/4, if reported
	Rank Indicator as in Tables 6.3.1.1.2-3/4/5, if reported
	Wideband CQI for the first TB as in Tables 6.3.1.1.2-3/4/5, if reported
	Subband differential CQI for the first TB as in Tables 6.3.1.1.2-3/4/5, if reported
	Indicator of the number of non-zero wideband amplitude coefficients M_l for layer l as in Table 6.3.1.1.2-5, if reported

Table 6.3.1.1.2-10: Mapping order of CSI fields of one CSI report, CSI part 2 wideband, *pmi-FormatIndicator= subbandPMI* or *cqi-FormatIndicator=subbandCQI*

CSI report number	CSI fields
CSI report #n CSI part 2 wideband	Wideband CQI for the second TB as in Tables 6.3.1.1.2-3/4/5, if present and reported
	Layer Indicator as in Tables 6.3.1.1.2-3/4/5, if reported
	PMI wideband information fields X_1, from left to right as in Tables 6.3.1.1.2-1/2, if reported
	PMI wideband information fields X_2, from left to right as in Tables 6.3.1.1.2-1/2, if *pmi-FormatIndicator= widebandPMI* and if reported

Table 6.3.1.1.2-11: Mapping order of CSI fields of one CSI report, CSI part 2 subband, *pmi-FormatIndicator= subbandPMI* or *cqi-FormatIndicator=subbandCQI*

CSI report #n Part 2 subband	Subband differential CQI for the second TB of all even subbands with increasing order of subband number, as in Tables 6.3.1.1.2-3/4/5, if *cqi-FormatIndicator=subbandCQI* and if reported
	PMI subband information fields X_2 of all even subbands with increasing order of subband number, from left to right as in Tables 6.3.1.1.2-1/2, if *pmi-FormatIndicator= subbandPMI* and if reported
	Subband differential CQI for the second TB of all odd subbands with increasing order of subband number, as in Tables 6.3.1.1.2-3/4/5, if *cqi-FormatIndicator=subbandCQI* and if reported
	PMI subband information fields X_2 of all odd subbands with increasing order of subband number, from left to right as in Tables 6.3.1.1.2-1/2, if *pmi-FormatIndicator= subbandPMI* and if reported

If none of the CSI reports for transmission on a PUCCH is of two parts, the CSI fields of all CSI reports, in the order from upper part to lower part in Table 6.3.1.1.2-12, are mapped to the UCI bit sequence $a_0, a_1, a_2, a_3, ..., a_{A-1}$ starting with a_0.

Table 6.3.1.1.2-12: Mapping order of CSI reports to UCI bit sequence $a_0, a_1, a_2, a_3, ..., a_{A-1}$, without two-part CSI report(s)

UCI bit sequence	CSI report number
a_0	CSI report #1 as in Table 6.3.1.1.2-7/8
a_1	CSI report #2 as in Table 6.3.1.1.2-7/8
a_2	…
a_3	CSI report #n as in Table 6.3.1.1.2-7/8
⋮	
a_{A-1}	

If at least one of the CSI reports for transmission on a PUCCH is of two parts, two UCI bit sequences are generated, $a_0^{(1)}, a_1^{(1)}, a_2^{(1)}, a_3^{(1)}, ..., a_{A^{(1)}-1}^{(1)}$ and $a_0^{(2)}, a_1^{(2)}, a_2^{(2)}, a_3^{(2)}, ..., a_{A^{(2)}-1}^{(2)}$. The CSI fields of all CSI reports, in the order from upper part to lower part in Table 6.3.1.1.2-13, are mapped to the UCI bit sequence $a_0^{(1)}, a_1^{(1)}, a_2^{(1)}, a_3^{(1)}, ..., a_{A^{(1)}-1}^{(1)}$ starting with $a_0^{(1)}$. The CSI fields of all CSI reports, in the order from upper part to lower part in Table 6.3.1.1.2-14, are mapped to the UCI bit sequence $a_0^{(2)}, a_1^{(2)}, a_2^{(2)}, a_3^{(2)}, ..., a_{A^{(2)}-1}^{(2)}$ starting with $a_0^{(2)}$. If the length of UCI bit sequence $a_0^{(2)}, a_1^{(2)}, a_2^{(2)}, a_3^{(2)}, ..., a_{A^{(2)}-1}^{(2)}$ is less than 3 bits, zeros shall be appended to the UCI bit sequence until its length equals 3.

Table 6.3.1.1.2-13: Mapping order of CSI reports to UCI bit sequence $a_0^{(1)}, a_1^{(1)}, a_2^{(1)}, a_3^{(1)}, ..., a_{A^{(1)}-1}^{(1)}$, with two-part CSI report(s)

UCI bit sequence	CSI report number
$a_0^{(1)}$ $a_1^{(1)}$ $a_2^{(1)}$ $a_3^{(1)}$ ⋮ $a_{A^{(1)}-1}^{(1)}$	CSI report #1 if CSI report #1 is not of two parts, or CSI report #1, CSI part 1, if CSI report #1 is of two parts, as in Table 6.3.1.1.2-7/8/9
	CSI report #2 if CSI report #2 is not of two parts, or CSI report #2, CSI part 1, if CSI report #2 is of two parts, as in Table 6.3.1.1.2-7/8/9
	…
	CSI report #n if CSI report #n is not of two parts, or CSI report #n, CSI part 1, if CSI report #n is of two parts, as in Table 6.3.1.1.2-7/8/9

where CSI report #1, CSI report #2, …, CSI report #n in Table 6.3.1.1.2-13 correspond to the CSI reports in increasing order of CSI report priority values according to Subclause 5.2.5 of [6, TS38.214].

Table 6.3.1.1.2-14: Mapping order of CSI reports to UCI bit sequence $a_0^{(2)}, a_1^{(2)}, a_2^{(2)}, a_3^{(2)}, ..., a_{A^{(2)}-1}^{(2)}$, with two-part CSI report(s)

UCI bit sequence	CSI report number
$a_0^{(2)}$ $a_1^{(2)}$ $a_2^{(2)}$ $a_3^{(2)}$ ⋮ $a_{A^{(2)}-1}^{(2)}$	CSI report #1, CSI part 2 wideband, as in Table 6.3.1.1.2-10 if CSI part 2 exists for CSI report #1
	CSI report #2, CSI part 2 wideband, as in Table 6.3.1.1.2-10 if CSI part 2 exists for CSI report #2
	…
	CSI report #n, CSI part 2 wideband, as in Table 6.3.1.1.2-10 if CSI part 2 exists for CSI report #n
	CSI report #1, CSI part 2 subband, as in Table 6.3.1.1.2-11 if CSI part 2 exists for CSI report #1
	CSI report #2, CSI part 2 subband, as in Table 6.3.1.1.2-11 if CSI part 2 exists for CSI report #2
	…
	CSI report #n, CSI part 2 subband, as in Table 6.3.1.1.2-11 if CSI part 2 exists for CSI report #n

where CSI report #1, CSI report #2, …, CSI report #n in Table 6.3.1.1.2-14 correspond to the CSI reports in increasing order of CSI report priority values according to Subclause 5.2.5 of [6, TS38.214].

6.3.1.1.3 HARQ-ACK/SR and CSI

If none of the CSI reports for transmission on a PUCCH is of two parts, the UCI bit sequence $a_0, a_1, a_2, a_3, ..., a_{A-1}$ is generated according to the following, where $A = O^{\text{ACK}} + O^{\text{SR}} + O^{\text{CSI}}$:

- if there is HARQ-ACK for transmission on the PUCCH, the HARQ-ACK bits are mapped to the UCI bit sequence $a_0, a_1, a_2, a_3, ..., a_{O^{\text{ACK}}-1}$, where $a_i = \tilde{o}_i^{ACK}$ for $i = 0, 1, ..., O^{\text{ACK}} - 1$, the HARQ-ACK bit sequence $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK}, ..., \tilde{o}_{O^{ACK}-1}^{ACK}$ is given by Subclause 9.1 of [5, TS38.213], and O^{ACK} is number of HARQ-ACK bits; if there is no HARQ-ACK for transmission on the PUCCH, set $O^{\text{ACK}} = 0$;

- if there is SR for transmission on the PUCCH, set $a_i = \tilde{o}_i^{SR}$ for $i = O^{\text{ACK}}, O^{\text{ACK}}+1,...,O^{\text{ACK}}+O^{\text{SR}}-1$, where the SR bit sequence $\tilde{o}_0^{SR}, \tilde{o}_1^{SR},...,\tilde{o}_{O^{\text{SR}}-1}^{SR}$ is given by Subclause 9.2.5.1 of [5, TS 38.213]; if there is no SR for transmission on the PUCCH, set $O^{\text{SR}} = 0$;
- the CSI fields of all CSI reports, in the order from upper part to lower part in Table 6.3.1.1.2-12, are mapped to the UCI bit sequence $a_{O^{\text{ACK}}+O^{\text{SR}}}, a_{O^{\text{ACK}}+O^{\text{SR}}+1},...,a_{O^{\text{ACK}}+O^{\text{SR}}+O^{\text{CSI}}-1}$ starting with $a_{O^{\text{ACK}}+O^{\text{SR}}}$, where O^{CSI} is the number of CSI bits.

If at least one of the CSI reports for transmission on a PUCCH is of two parts, two UCI bit sequences are generated, $a_0^{(1)}, a_1^{(1)}, a_2^{(1)}, a_3^{(1)},..., a_{A^{(1)}-1}^{(1)}$ and $a_0^{(2)}, a_1^{(2)}, a_2^{(2)}, a_3^{(2)},..., a_{A^{(2)}-1}^{(2)}$, according to the following, where $A^{(1)} = O^{\text{ACK}} + O^{\text{SR}} + O^{\text{CSI-part1}}$ and $A^{(2)} = O^{\text{CSI-part2}}$:

- if there is HARQ-ACK for transmission on the PUCCH, the HARQ-ACK bits are mapped to the UCI bit sequence $a_0^{(1)}, a_1^{(1)}, a_2^{(1)}, a_3^{(1)},..., a_{O^{\text{ACK}}-1}^{(1)}$, where $a_i^{(1)} = \tilde{o}_i^{ACK}$ for $i = 0, 1, ..., O^{\text{ACK}}-1$, the HARQ-ACK bit sequence $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK},...,\tilde{o}_{O^{ACK}-1}^{ACK}$ is given by Subclause 9.1 of [5, TS38.213], and O^{ACK} is number of HARQ-ACK bits; if there is no HARQ-ACK for transmission on the PUCCH, set $O^{\text{ACK}} = 0$;
- if there is SR for transmission on the PUCCH, set $a_i = \tilde{o}_i^{SR}$ for $i = O^{\text{ACK}}, O^{\text{ACK}}+1,...,O^{\text{ACK}}+O^{\text{SR}}-1$, where the SR bit sequence $\tilde{o}_0^{SR}, \tilde{o}_1^{SR},...,\tilde{o}_{O^{\text{SR}}-1}^{SR}$ is given by Subclause 9.2.5.1 of [5, TS 38.213]; if there is no SR for transmission on the PUCCH, set $O^{\text{SR}} = 0$;
- the CSI fields of all CSI reports, in the order from upper part to lower part in Table 6.3.1.1.2-13, are mapped to the UCI bit sequence $a_{O^{\text{ACK}}+O^{\text{SR}}}^{(1)}, a_{O^{\text{ACK}}+O^{\text{SR}}+1}^{(1)},..., a_{O^{\text{ACK}}+O^{\text{SR}}+O^{\text{CSI-part1}}-1}^{(1)}$ starting with $a_{O^{\text{ACK}}+O^{\text{SR}}}^{(1)}$, where $O^{\text{CSI-part1}}$ is the number of CSI bits in CSI part 1 of all CSI reports;
- the CSI fields of all CSI reports, in the order from upper part to lower part in Table 6.3.1.1.2-14, are mapped to the UCI bit sequence $a_0^{(2)}, a_1^{(2)}, a_2^{(2)}, a_3^{(2)},..., a_{A^{(2)}-1}^{(2)}$ starting with $a_0^{(2)}$, where $O^{\text{CSI-part2}}$ is the number of CSI bits in CSI part 2 of all CSI reports. If the length of UCI bit sequence $a_0^{(2)}, a_1^{(2)}, a_2^{(2)}, a_3^{(2)},..., a_{A^{(2)}-1}^{(2)}$ is less than 3 bits, zeros shall be appended to the UCI bit sequence until its length equals 3.

6.3.1.2 Code block segmentation and CRC attachment

The UCI bit sequence from subclause 6.3.1.1 is denoted by $a_0, a_1, a_2, a_3,..., a_{A-1}$, where A is the payload size. The procedure in 6.3.1.2.1 applies for $A \geq 12$ and the procedure in Subclause 6.3.1.2.2 applies for $A \leq 11$.

6.3.1.2.1 UCI encoded by Polar code

If the payload size $A \geq 12$, code block segmentation and CRC attachment is performed according to Subclause 5.2.1. If ($A \geq 360$ and $E \geq 1088$) or if $A \geq 1013$, $I_{seg} = 1$; otherwise $I_{seg} = 0$, where E is the rate matching output sequence length as given in Subclause 6.3.1.4.1.

If $12 \leq A \leq 19$, the parity bits $p_{r0}, p_{r1}, p_{r2},..., p_{r(L-1)}$ in Subclause 5.2.1 are computed by setting L to 6 bits and using the generator polynomial $g_{\text{CRC6}}(D)$ in Subclause 5.1, resulting in the sequence $c_{r0}, c_{r1}, c_{r2}, c_{r3},..., c_{r(K_r-1)}$ where r is the code block number and K_r is the number of bits for code block number r.

If $A \geq 20$, the parity bits $p_{r0}, p_{r1}, p_{r2},..., p_{r(L-1)}$ in Subclause 5.2.1 are computed by setting L to 11 bits and using the generator polynomial $g_{\text{CRC11}}(D)$ in Subclause 5.1, resulting in the sequence $c_{r0}, c_{r1}, c_{r2}, c_{r3},..., c_{r(K_r-1)}$ where r is the code block number and K_r is the number of bits for code block number r.

6.3.1.2.2 UCI encoded by channel coding of small block lengths

If the payload size $A \leq 11$, CRC bits are not attached.

The output bit sequence is denoted by $c_0, c_1, c_2, c_3, ..., c_{K-1}$, where $c_i = a_i$ for $i = 0, 1, ..., A-1$ and $K = A$.

6.3.1.3 Channel coding of UCI

6.3.1.3.1 UCI encoded by Polar code

Information bits are delivered to the channel coding block. They are denoted by $c_{r0}, c_{r1}, c_{r2}, c_{r3}, ..., c_{r(K_r-1)}$, where r is the code block number, and K_r is the number of bits in code block number r. The total number of code blocks is denoted by C and each code block is individually encoded by the following:

If $18 \le K_r \le 25$, the information bits are encoded via Polar coding according to Subclause 5.3.1, by setting $n_{\max} = 10$, $I_{IL} = 0$, $n_{PC} = 3$, $n_{PC}^{wm} = 1$ if $E_r - K_r + 3 > 192$ and $n_{PC}^{wm} = 0$ if $E_r - K_r + 3 \le 192$, where E_r is the rate matching output sequence length as given in Subclause 6.3.1.4.1.

If $K_r > 30$, the information bits are encoded via Polar coding according to Subclause 5.3.1, by setting $n_{\max} = 10$, $I_{IL} = 0$, $n_{PC} = 0$, and $n_{PC}^{wm} = 0$.

After encoding the bits are denoted by $d_{r0}, d_{r1}, d_{r2}, d_{r3}, ..., d_{r(N_r-1)}$, where N_r is the number of coded bits in code block number r.

6.3.1.3.2 UCI encoded by channel coding of small block lengths

Information bits are delivered to the channel coding block. They are denoted by $c_0, c_1, c_2, c_3, ..., c_{K-1}$, where K is the number of bits.

The information bits are encoded according to Subclause 5.3.3.

After encoding the bits are denoted by $d_0, d_1, d_2, d_3, ..., d_{N-1}$, where N is the number of coded bits.

6.3.1.4 Rate matching

For PUCCH formats 2/3/4, the total rate matching output sequence length E_{tot} is given by Table 6.3.1.4-1, where $N_{\text{symb, UCI}}^{\text{PUCCH, 2}}$, $N_{\text{symb, UCI}}^{\text{PUCCH, 3}}$, and $N_{\text{symb, UCI}}^{\text{PUCCH, 4}}$ are the number of symbols carrying UCI for PUCCH formats 2/3/4 respectively; $N_{\text{PRB}}^{\text{PUCCH, 2}}$ and $N_{\text{PRB}}^{\text{PUCCH, 3}}$ are the number of PRBs that are determined by the UE for PUCCH formats 2/3 transmission respectively according to Subclause 9.2 of [5, TS38.213]; and $N_{\text{SF}}^{\text{PUCCH, 4}}$ is the spreading factor for PUCCH format 4.

Table 6.3.1.4-1: Total rate matching output sequence length E_{tot}

PUCCH format	***Modulation order***	
	QPSK	π/2-BPSK
PUCCH format 2	$16 \cdot N_{\text{symb, UCI}}^{\text{PUCCH, 2}} \cdot N_{\text{PRB}}^{\text{PUCCH, 2}}$	N/A
PUCCH format 3	$24 \cdot N_{\text{symb, UCI}}^{\text{PUCCH, 3}} \cdot N_{\text{PRB}}^{\text{PUCCH, 3}}$	$12 \cdot N_{\text{symb, UCI}}^{\text{PUCCH, 3}} \cdot N_{\text{PRB}}^{\text{PUCCH, 3}}$
PUCCH format 4	$24 \cdot N_{\text{symb, UCI}}^{\text{PUCCH, 4}} / N_{\text{SF}}^{\text{PUCCH, 4}}$	$12 \cdot N_{\text{symb, UCI}}^{\text{PUCCH, 4}} / N_{\text{SF}}^{\text{PUCCH, 4}}$

6.3.1.4.1 UCI encoded by Polar code

The input bit sequence to rate matching is $d_{r0}, d_{r1}, d_{r2}, d_{r3}, ..., d_{r(N_r-1)}$ where r is the code block number, and N_r is the number of coded bits in code block number r.

Table 6.3.1.4.1-1: Rate matching output sequence length E_{UCI}

UCI(s) for transmission on a PUCCH	UCI for encoding	Value of E_{UCI}
HARQ-ACK	HARQ-ACK	$E_{\text{UCI}} = E_{\text{tot}}$
HARQ-ACK, SR	HARQ-ACK, SR	$E_{\text{UCI}} = E_{\text{tot}}$
CSI (CSI not of two parts)	CSI	$E_{\text{UCI}} = E_{\text{tot}}$
HARQ-ACK, CSI (CSI not of two parts)	HARQ-ACK, CSI	$E_{\text{UCI}} = E_{\text{tot}}$
HARQ-ACK, SR, CSI (CSI not of two parts)	HARQ-ACK, SR, CSI	$E_{\text{UCI}} = E_{\text{tot}}$
CSI (CSI of two parts)	CSI part 1	$E_{\text{UCI}} = \min\left(E_{\text{tot}}, \left\lceil \left(O^{\text{CSI-part1}} + L\right) / R_{\text{UCI}}^{\max} / Q_m \right\rceil \cdot Q_m \right)$
	CSI part 2	$E_{\text{UCI}} = E_{\text{tot}} - \min\left(E_{\text{tot}}, \left\lceil \left(O^{\text{CSI-part1}} + L\right) / R_{\text{UCI}}^{\max} / Q_m \right\rceil \cdot Q_m \right)$
HARQ-ACK, CSI (CSI of two parts)	HARQ-ACK, CSI part 1	$E_{\text{UCI}} = \min\left(E_{\text{tot}}, \left\lceil \left(O^{\text{ACK}} + O^{\text{CSI-part1}} + L\right) / R_{\text{UCI}}^{\max} / Q_m \right\rceil \cdot Q_m \right)$
	CSI part 2	$E_{\text{UCI}} = E_{\text{tot}} - \min\left(E_{\text{tot}}, \left\lceil \left(O^{\text{ACK}} + O^{\text{CSI-part1}} + L\right) / R_{\text{UCI}}^{\max} / Q_m \right\rceil \cdot Q_m \right)$
HARQ-ACK, SR, CSI (CSI of two parts)	HARQ-ACK, SR, CSI part 1	$E_{\text{UCI}} = \min\left(E_{\text{tot}}, \left\lceil \left(O^{\text{ACK}} + O^{\text{SR}} + O^{\text{CSI-part1}} + L\right) / R_{\text{UCI}}^{\max} / Q_m \right\rceil \cdot Q_m \right)$
	CSI part 2	$E_{\text{UCI}} = E_{\text{tot}} - \min\left(E_{\text{tot}}, \left\lceil \left(O^{\text{ACK}} + O^{\text{SR}} + O^{\text{CSI-part1}} + L\right) / R_{\text{UCI}}^{\max} / Q_m \right\rceil \cdot Q_m \right)$

Rate matching is performed according to Subclause 5.4.1 by setting $I_{BIL} = 1$ and the rate matching output sequence length to $E_r = \lfloor E_{\text{UCI}} / C_{\text{UCI}} \rfloor$, where C_{UCI} is the number of code blocks for UCI determined according to Subclause 6.3.1.2.1 and the value of E_{UCI} is given by Table 6.3.1.4.1-1:

- O^{ACK} is the number of bits for HARQ-ACK for transmission on the current PUCCH;
- O^{SR} is the number of bits for SR for transmission on the current PUCCH;
- $O^{\text{CSI-part1}}$ is the number of bits for CSI part 1 for transmission on the current PUCCH;
- $O^{\text{CSI-part2}}$ is the number of bits for CSI part 2 for transmission on the current PUCCH;
- if $A \geq 360$, $L = 11$; otherwise, L is the number of CRC bits determined according to subclause 6.3.1.2.1, where A equals $O^{\text{CSI-part1}}$ for "CSI (CSI of two parts)", equals $O^{\text{ACK}} + O^{\text{CSI-part1}}$ for "HARQ-ACK, CSI (CSI of two parts)", and equals $O^{\text{ACK}} + O^{\text{SR}} + O^{\text{CSI-part1}}$ for "HARQ-ACK, SR, CSI (CSI of two parts)" respectively in Table 6.3.1.4.1-1;;
- $R_{\text{UCI}}^{\max}$ is the configured maximum PUCCH coding rate;
- E_{tot} is given by Table 6.3.1.4-1.

The output bit sequence after rate matching is denoted as $f_{r0}, f_{r1}, f_{r2}, ..., f_{r(E_r-1)}$ where E_r is the length of rate matching output sequence in code block number r.

6.3.1.4.2 UCI encoded by channel coding of small block lengths

The input bit sequence to rate matching is $d_0, d_1, d_2, ..., d_{N-1}$.

The value of E_{UCI} is determined according to Table 6.3.1.4.1-1 by setting $L = 0$.

Rate matching is performed according to Subclause 5.4.3 by setting the rate matching output sequence length $E = E_{\text{UCI}}$.

The output bit sequence after rate matching is denoted as $f_0, f_1, f_2, ..., f_{E-1}$.

6.3.1.5 Code block concatenation

The input bit sequence for the code block concatenation block are the sequences $f_{r0}, f_{r1}, f_{r2},..., f_{r(E_r-1)}$, for $r = 0,..., C-1$ and where E_r is the number of rate matched bits for the r-th code block.

Code block concatenation is performed according to Subclause 5.5.

The bits after code block concatenation are denoted by $g_0, g_1, g_2, g_3,..., g_{G'-1}$, where $G' = \lfloor E_{\text{UCI}} / C_{\text{UCI}} \rfloor \cdot C_{\text{UCI}}$ with the values of E_{UCI} and C_{UCI} given in Subclause 6.3.1.4.1. Let G be the total number of coded bits for transmission and $G = G' + \text{mod}(E_{\text{UCI}}, C_{\text{UCI}})$. Set $g_i = 0$ for $i = G', G'+1,..., G-1$.

6.3.1.6 Multiplexing of coded UCI bits to PUCCH

If CSI of two parts are transmitted on a PUCCH, the coded bits corresponding to UCI bit sequence $a_0^{(1)}, a_1^{(1)}, a_2^{(1)}, a_3^{(1)},..., a_{A^{(1)}-1}^{(1)}$ is denoted by $g_0^{(1)}, g_1^{(1)}, g_2^{(1)}, g_3^{(1)},..., g_{G^{(1)}-1}^{(1)}$ and the coded bits corresponding to UCI bit sequence $a_0^{(2)}, a_1^{(2)}, a_2^{(2)}, a_3^{(2)},..., a_{A^{(2)}-1}^{(2)}$ is denoted by $g_0^{(2)}, g_1^{(2)}, g_2^{(2)}, g_3^{(2)},..., g_{G^{(2)}-1}^{(2)}$. The coded bit sequence $g_0, g_1, g_2, g_3,..., g_{G-1}$, where $G = G^{(1)} + G^{(2)}$, is generated according to the following.

Table 6.3.1.6-1: PUCCH DMRS and UCI symbols

PUCCH duration (symbols)	PUCCH DMRS symbol indices	Number of UCI symbol indices sets $N_{\text{UCI}}^{\text{set}}$	1st UCI symbol indices set $S_{\text{UCI}}^{(1)}$	2nd UCI symbol indices set $S_{\text{UCI}}^{(2)}$	3rd UCI symbol indices set $S_{\text{UCI}}^{(3)}$
4	{1}	2	{0,2}	{3}	-
4	{0,2}	1	{1,3}	-	-
5	{0, 3}	1	{1, 2, 4}	-	-
6	{1, 4}	1	{0, 2, 3, 5}	-	-
7	{1, 4}	2	{0, 2, 3, 5}	{6}	-
8	{1, 5}	2	{0, 2, 4, 6}	{3, 7}	-
9	{1, 6}	2	{0, 2, 5, 7}	{3, 4, 8}	-
10	{2, 7}	2	{1, 3, 6, 8}	{0, 4, 5, 9}	-
10	{1, 3, 6, 8}	1	{0,2,4,5,7,9}	-	-
11	{2, 7}	3	{1,3,6,8}	{0,4,5,9}	{10}
11	{1,3,6,9}	1	{0,2,4,5,7,8,10}	-	-
12	{2, 8}	3	{1,3,7,9}	{0,4,6,10}	{5, 11}
12	{1,4,7,10}	1	{0,2,3,5,6,8,9,11}	-	-
13	{2, 9}	3	{1,3,8,10}	{0,4,7,11}	{5,6,12}
13	{1,4,7,11}	2	{0,2,3,5,6,8,10,12}	{9}	-
14	{3, 10}	3	{2,4,9,11}	{1,5,8,12}	{0,6,7,13}
14	{1,5,8,12}	2	{0,2,4,6,7,9,11,13}	{3, 10}	-

Denote s_l as UCI OFDM symbol index. Denote $N_{\text{UCI}}^{(i)}$ as the number of elements in UCI symbol indices set $S_{\text{UCI}}^{(i)}$ for $i = 1,..., N_{\text{UCI}}^{\text{set}}$, where $S_{\text{UCI}}^{(i)}$ and $N_{\text{UCI}}^{\text{set}}$ are given by Table 6.3.1.6-1 according to the PUCCH duration and the PUCCH DMRS configuration. Denote $N_{\text{symb,UCI}}^{\text{PUCCH}} = \sum_{i=1}^{N_{\text{UCI}}^{\text{set}}} N_{\text{UCI}}^{(i)}$ as the number of OFDM symbols carrying UCI in the PUCCH.

Denote Q_m as the modulation order of the PUCCH.

For PUCCH format 3, set $N_{\text{UCI}}^{\text{symbol}} = 12 \cdot N_{\text{PRB}}^{\text{PUCCH,3}}$, where $N_{\text{PRB}}^{\text{PUCCH,3}}$ is the number of PRBs that is determined by the UE for PUCCH format 3 transmission according to Subclause 9.2 of [5, TS 38.213].

For PUCCH format 4, set $N_{\text{UCI}}^{\text{symbol}} = 12 / N_{\text{SF}}^{\text{PUCCH,4}}$, where $N_{\text{SF}}^{\text{PUCCH, 4}}$ is the spreading factor for PUCCH format 4.

Find the smallest $j > 0$ such that $\left(\sum_{i=1}^{j} N_{\text{UCI}}^{(i)} \right) \cdot N_{\text{UCI}}^{\text{symbol}} \cdot Q_m \geq G^{(1)}$.

Set $n_1 = 0$;

Set $n_2 = 0$;

Set $\overline{N}_{\text{UCI}}^{\text{symbol}} = \left\lfloor \left(G^{(1)} - \left(\sum_{i=1}^{j-1} N_{\text{UCI}}^{(i)} \right) \cdot N_{\text{UCI}}^{\text{symbol}} \cdot Q_m \right) \middle/ \left(N_{\text{UCI}}^{(j)} \cdot Q_m \right) \right\rfloor$;

Set $M = \text{mod}\left(\left(G^{(1)} - \left(\sum_{i=1}^{j-1} N_{\text{UCI}}^{(i)} \right) \cdot N_{\text{UCI}}^{\text{symbol}} \cdot Q_m \right) \middle/ Q_m, N_{\text{UCI}}^{(j)} \right)$;

for $l = 0$ to $N_{\text{symb, UCI}}^{\text{PUCCH,}} - 1$

if $s_l \in \bigcup_{i=1}^{j-1} S_{\text{UCI}}^{(i)}$

for $k = 0$ to $N_{\text{UCI}}^{\text{symbol}} - 1$

for $v = 0$ to $Q_m - 1$

$\overline{g}_{l,k,v} = g_{n_1}^{(1)}$;

$n_1 = n_1 + 1$;

end for

end for

elseif $s_l \in S_{\text{UCI}}^{(j)}$

if $M > 0$

$\gamma = 1$;

else

$\gamma = 0$;

end if

$M = M - 1$;

for $k = 0$ to $\overline{N}_{\text{UCI}}^{\text{symbol}} + \gamma - 1$

for $v = 0$ to $Q_m - 1$

$\overline{g}_{l,k,v} = g_{n_1}^{(1)}$;

$n_1 = n_1 + 1$;

end for

end for

for $k = \overline{N}_{\text{UCI}}^{\text{symbol}} + \gamma$ to $N_{\text{UCI}}^{\text{symbol}} - 1$

for $v = 0$ to $Q_m - 1$

$\bar{g}_{l,k,v} = g^{(2)}_{n_2}$;

$n_2 = n_2 + 1$;

end for

end for

else

for $k = 0$ to $N^{\text{symbol}}_{\text{UCI}} - 1$

for $v = 0$ to $Q_m - 1$

$\bar{g}_{l,k,v} = g^{(2)}_{n_2}$;

$n_2 = n_2 + 1$;

end for

end for

end if

end for

Set $n = 0$

for $l = 0$ to $N^{\text{PUCCH,}}_{\text{symb, UCI}} - 1$

for $k = 0$ to $N^{\text{symbol}}_{\text{UCI}} - 1$

for $v = 0$ to $Q_m - 1$

$g_n = \bar{g}_{l,k,v}$;

$n = n + 1$;

end for

end for

end for

6.3.2 Uplink control information on PUSCH

6.3.2.1 UCI bit sequence generation

6.3.2.1.1 HARQ-ACK

If HARQ-ACK bits are transmitted on a PUSCH, the UCI bit sequence $a_0, a_1, a_2, a_3, ..., a_{A-1}$ is determined as follows:

- If UCI is transmitted on PUSCH without UL-SCH and the UCI includes CSI part 1 without CSI part 2,
  - if there is no HARQ-ACK bit given by Subclause 9.1 of [5, TS 38.213], set $a_0 = 0$, $a_1 = 0$, and $A = 2$;
  - if there is only one HARQ-ACK bit $\tilde{o}_0^{ACK}$ given by Subclause 9.1 of [5, TS 38.213], set $a_0 = \tilde{o}_0^{ACK}$, $a_1 = 0$, and $A = 2$;

- otherwise, ser $a_i = \tilde{o}_i^{ACK}$ for $i = 0, 1, ..., O^{\text{ACK}} - 1$ and $A = O^{\text{ACK}}$, where the HARQ-ACK bit sequence $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK}, ..., \tilde{o}_{O^{ACK}-1}^{ACK}$ is given by Subclause 9.1 of [5, TS 38.213].

6.3.2.1.2 CSI

The bitwidth for PMI of *codebookType=typeII* is provided in Tables 6.3.2.1.2-1, where the values of (N_1, N_2), (O_1, O_2), L, N_{PSK}, M_1, M_2, and $K^{(2)}$ are given by Subclause 5.2.2.2.3 in [6, TS 38.214].

Table 6.3.2.1.2-1: PMI of *codebookType= typeII*

	Information fields for wideband PMI						Information fields per subband PMI			
	$i_{1,1}$	$i_{1,2}$	$i_{1,3,1}$	$i_{1,4,1}$	$i_{1,3,2}$	$i_{1,4,2}$	$i_{2,1,1}$	$i_{2,1,2}$	$i_{2,2,1}$	$i_{2,2,2}$
Rank=1 SBAmp off	$\lceil \log_2(O_1 O_2) \rceil$	$\left\lceil \log_2 \binom{N_1 N_2}{L} \right\rceil$	$\lceil \log_2(2L) \rceil$	$3(2L-1)$	N/A	N/A	$(M_1 - 1) \cdot \log_2 N_{\text{PSK}}$	N/A	N/A	N/A
Rank=2 SBAmp off	$\lceil \log_2(O_1 O_2) \rceil$	$\left\lceil \log_2 \binom{N_1 N_2}{L} \right\rceil$	$\lceil \log_2(2L) \rceil$	$3(2L-1)$	$\lceil \log_2(2L) \rceil$	$3(2L-1)$	$(M_1 - 1) \cdot \log_2 N_{\text{PSK}}$	$(M_2 - 1) \cdot \log_2 N_{\text{PSK}}$	N/A	N/A
Rank=1 SBAmp on	$\lceil \log_2(O_1 O_2) \rceil$	$\left\lceil \log_2 \binom{N_1 N_2}{L} \right\rceil$	$\lceil \log_2(2L) \rceil$	$3(2L-1)$	N/A	N/A	$\min(M_1, K^{(2)}) \cdot \log_2 N_{\text{PSK}} - \log_2 N_{\text{PSK}} + 2 \cdot (M_1 - \min(M_1, K^{(2)}))$	N/A	$\min(M_1, K^{(2)}) - 1$	N/A
Rank=2 SBAmp on	$\lceil \log_2(O_1 O_2) \rceil$	$\left\lceil \log_2 \binom{N_1 N_2}{L} \right\rceil$	$\lceil \log_2(2L) \rceil$	$3(2L-1)$	$\lceil \log_2(2L) \rceil$	$3(2L-1)$	$\min(M_1, K^{(2)}) \cdot \log_2 N_{\text{PSK}} - \log_2 N_{\text{PSK}} + 2 \cdot (M_1 - \min(M_1, K^{(2)}))$	$\min(M_2, K^{(2)}) \cdot \log_2 N_{\text{PSK}} - \log_2 N_{\text{PSK}} + 2 \cdot (M_2 - \min(M_2, K^{(2)}))$	$\min(M_1, K^{(2)}) - 1$	$\min(M_2, K^{(2)}) - 1$

The bitwidth for PMI of *codebookType= typeII-PortSelection* is provided in Tables 6.3.2.1.2-2, where the values of P_{CSI-RS}, d, L, N_{PSK}, M_1, M_2, and $K^{(2)}$ are given by Subclause 5.2.2.2.4 in [6, TS 38.214].

Table 6.3.2.1.2-2: PMI of *codebookType= typeII-PortSelection*

	Information fields for wideband PMI					Information fields per subband PMI			
	$i_{1,1}$	$i_{1,3,1}$	$i_{1,4,1}$	$i_{1,3,2}$	$i_{1,4,2}$	$i_{2,1,1}$	$i_{2,1,2}$	$i_{2,2,1}$	$i_{2,2,2}$
Rank=1 SBAmp off	$\left\lceil \log_2 \left\lceil \frac{P_{CSI-RS}}{2d} \right\rceil \right\rceil$	$\lceil \log_2(2L) \rceil$	$3(2L-1)$	N/A	N/A	$(M_1 - 1) \cdot \log_2 N_{\text{PSK}}$	N/A	N/A	N/A
Rank=2 SBAmp off	$\left\lceil \log_2 \left\lceil \frac{P_{CSI-RS}}{2d} \right\rceil \right\rceil$	$\lceil \log_2(2L) \rceil$	$3(2L-1)$	$\lceil \log_2(2L) \rceil$	$3(2L-1)$	$(M_1 - 1) \cdot \log_2 N_{\text{PSK}}$	$(M_2 - 1) \cdot \log_2 N_{\text{PSK}}$	N/A	N/A
Rank=1 SBAmp on	$\left\lceil \log_2 \left\lceil \frac{P_{CSI-RS}}{2d} \right\rceil \right\rceil$	$\lceil \log_2(2L) \rceil$	$3(2L-1)$	N/A	N/A	$\min(M_1, K^{(2)}) \cdot \log_2 N_{\text{PSK}} - \log_2 N_{\text{PSK}} + 2 \cdot (M_1 - \min(M_1, K^{(2)}))$	N/A	$\min(M_1, K^{(2)}) - 1$	N/A
Rank=2 SBAmp on	$\left\lceil \log_2 \left\lceil \frac{P_{CSI-RS}}{2d} \right\rceil \right\rceil$	$\lceil \log_2(2L) \rceil$	$3(2L-1)$	$\lceil \log_2(2L) \rceil$	$3(2L-1)$	$\min(M_1, K^{(2)}) \cdot \log_2 N_{\text{PSK}} - \log_2 N_{\text{PSK}} + 2 \cdot (M_1 - \min(M_1, K^{(2)}))$	$\min(M_2, K^{(2)}) \cdot \log_2 N_{\text{PSK}} - \log_2 N_{\text{PSK}} + 2 \cdot (M_2 - \min(M_2, K^{(2)}))$	$\min(M_1, K^{(2)}) - 1$	$\min(M_2, K^{(2)}) - 1$

For CSI on PUSCH, two UCI bit sequences are generated, $a_0^{(1)},a_1^{(1)},a_2^{(1)},a_3^{(1)},...,a_{A^{(1)}-1}^{(1)}$ and $a_0^{(2)},a_1^{(2)},a_2^{(2)},a_3^{(2)},...,a_{A^{(2)}-1}^{(2)}$. The CSI fields of all CSI reports, in the order from upper part to lower part in Table 6.3.2.1.2-6, are mapped to the UCI bit sequence $a_0^{(1)},a_1^{(1)},a_2^{(1)},a_3^{(1)},...,a_{A^{(1)}-1}^{(1)}$ starting with $a_0^{(1)}$. The CSI fields of all CSI reports, in the order from upper part to lower part in Table 6.3.2.1.2-7, are mapped to the UCI bit sequence $a_0^{(2)},a_1^{(2)},a_2^{(2)},a_3^{(2)},...,a_{A^{(2)}-1}^{(2)}$ starting with $a_0^{(2)}$.

Table 6.3.2.1.2-3: Mapping order of CSI fields of one CSI report, CSI part 1

CSI report number	CSI fields
CSI report #n CSI part 1	CRI or SSBRI as in Tables 6.3.1.1.2-3/4/6, if reported
	Rank Indicator as in Tables 6.3.1.1.2-3/4/5, if reported
	Wideband CQI for the first TB as in Tables 6.3.1.1.2-3/4/5, if reported
	Subband differential CQI for the first TB as in Tables 6.3.1.1.2-3/4/5, if reported
	Indicator of the number of non-zero wideband amplitude coefficients M_l for layer l as in Table 6.3.1.1.2-5, if reported
	RSRP as in Table 6.3.1.1.2-6, if reported
	Differential RSRP as in Table 6.3.1.1.2-6, if reported

Table 6.3.2.1.2-4: Mapping order of CSI fields of one CSI report, CSI part 2 wideband

CSI report number	CSI fields
CSI report #n CSI part 2 wideband	Wideband CQI for the second TB as in Tables 6.3.1.1.2-3/4/5, if present and reported
	Layer Indicator as in Tables 6.3.1.1.2-3/4/5, if reported
	PMI wideband information fields X_1, from left to right as in Tables 6.3.1.1.2-1/2 or 6.3.2.1.2-1/2, if reported
	PMI wideband information fields X_2, from left to right as in Tables 6.3.1.1.2-1/2 or 6.3.2.1.2-1/2, if *pmi-FormatIndicator= widebandPMI* and if reported

Table 6.3.2.1.2-5: Mapping order of CSI fields of one CSI report, CSI part 2 subband

CSI report #n Part 2 subband	Subband differential CQI for the second TB of all even subbands with increasing order of subband number, as in Tables 6.3.1.1.2-3/4/5, if *cqi-FormatIndicator=subbandCQI* and if reported
	PMI subband information fields X_2 of all even subbands with increasing order of subband number, from left to right as in Tables 6.3.1.1.2-1/2 or 6.3.2.1.2-1/2, if *pmi-FormatIndicator= subbandPMI* and if reported
	Subband differential CQI for the second TB of all odd subbands with increasing order of subband number, as in Tables 6.3.1.1.2-3/4/5, if *cqi-FormatIndicator=subbandCQI* and if reported
	PMI subband information fields X_2 of all odd subbands with increasing order of subband number, from left to right as in Tables 6.3.1.1.2-1/2 or 6.3.2.1.2-1/2, if *pmi-FormatIndicator= subbandPMI* and if reported

Table 6.3.2.1.2-6: Mapping order of CSI reports to UCI bit sequence $a_0^{(1)}, a_1^{(1)}, a_2^{(1)}, a_3^{(1)}, ..., a_{A^{(1)}-1}^{(1)}$, with two-part CSI report(s)

UCI bit sequence	CSI report number
$a_0^{(1)}$ $a_1^{(1)}$ $a_2^{(1)}$ $a_3^{(1)}$ ⋮ $a_{A^{(1)}-1}^{(1)}$	CSI part 1 of CSI report #1 as in Table 6.3.2.1.2-3
	CSI part 1 of CSI report #2 as in Table 6.3.2.1.2-3
	…
	CSI part 1 of CSI report #n as in Table 6.3.2.1.2-3

where CSI report #1, CSI report #2, …, CSI report #n in Table 6.3.2.1.2-6 correspond to the CSI reports in increasing order of CSI report priority values according to Subclause 5.2.5 of [6, TS38.214].

Table 6.3.2.1.2-7: Mapping order of CSI reports to UCI bit sequence $a_0^{(2)}, a_1^{(2)}, a_2^{(2)}, a_3^{(2)}, ..., a_{A^{(2)}-1}^{(2)}$, with two-part CSI report(s)

UCI bit sequence	CSI report number
$a_0^{(2)}$ $a_1^{(2)}$ $a_2^{(2)}$ $a_3^{(2)}$ ⋮ $a_{A^{(2)}-1}^{(2)}$	CSI report #1, CSI part 2 wideband, as in Table 6.3.2.1.2-4 if CSI part 2 exists for CSI report #1
	CSI report #2, CSI part 2 wideband, as in Table 6.3.2.1.2-4 if CSI part 2 exists for CSI report #2
	…
	CSI report #n, CSI part 2 wideband, as in Table 6.3.2.1.2-4 if CSI part 2 exists for CSI report #n
	CSI report #1, CSI part 2 subband, as in Table 6.3.2.1.2-5 if CSI part 2 exists for CSI report #1
	CSI report #2, CSI part 2 subband, as in Table 6.3.2.1.2-5 if CSI part 2 exists for CSI report #2
	…
	CSI report #n, CSI part 2 subband, as in Table 6.3.2.1.2-5 if CSI part 2 exists for CSI report #n

where CSI report #1, CSI report #2, …, CSI report #n in Table 6.3.2.1.2-7 correspond to the CSI reports in increasing order of CSI report priority values according to Subclause 5.2.5 of [6, TS38.214].

6.3.2.2 Code block segmentation and CRC attachment

Denote the bits of the payload by $a_0, a_1, a_2, a_3, ..., a_{A-1}$, where A is the payload size. The procedure in 6.3.2.2.1 applies for $A \geq 12$ and the procedure in Subclause 6.3.2.2.2 applies for $A \leq 11$.

6.3.2.2.1 UCI encoded by Polar code

Code block segmentation and CRC attachment is performed according to Subclause 6.3.1.2.1.

6.3.2.2.2 UCI encoded by channel coding of small block lengths

The procedure in Subclause 6.3.1.2.2 applies.

6.3.2.3 Channel coding of UCI

6.3.2.3.1 UCI encoded by Polar code

Channel coding is performed according to Subclause 6.3.1.3.1, except that the rate matching output sequence length E_r is given in Subclause 6.3.2.4.1.

6.3.2.3.2 UCI encoded by channel coding of small block lengths

Information bits are delivered to the channel coding block. They are denoted by $c_0, c_1, c_2, c_3, ..., c_{K-1}$, where K is the number of bits.

The information bits are encoded according to Subclause 5.3.3.

After encoding the bits are denoted by $d_0, d_1, d_2, d_3, ..., d_{N-1}$, where N is the number of coded bits.

6.3.2.4 Rate matching

6.3.2.4.1 UCI encoded by Polar code

6.3.2.4.1.1 HARQ-ACK

For HARQ-ACK transmission on PUSCH with UL-SCH, the number of coded modulation symbols per layer for HARQ-ACK transmission, denoted as Q'_{ACK}, is determined as follows:

$$Q'_{\text{ACK}} = \min\left\{ \left\lceil \frac{(O_{\text{ACK}} + L_{\text{ACK}}) \cdot \beta_{\text{offset}}^{\text{PUSCH}} \cdot \sum_{l=0}^{N_{\text{symb,all}}^{\text{PUSCH}}-1} M_{\text{sc}}^{\text{UCI}}(l)}{\sum_{r=0}^{C_{\text{UL-SCH}}-1} K_r} \right\rceil, \left\lceil \alpha \cdot \sum_{l=l_0}^{N_{\text{symb,all}}^{\text{PUSCH}}-1} M_{\text{sc}}^{\text{UCI}}(l) \right\rceil \right\}$$

where

- O_{ACK} is the number of HARQ-ACK bits;
- if $O_{\text{ACK}} \geq 360$, $L_{\text{ACK}} = 11$; otherwise L_{ACK} is the number of CRC bits for HARQ-ACK determined according to Subclause 6.3.1.2.1;
- $\beta_{\text{offset}}^{\text{PUSCH}} = \beta_{\text{offset}}^{\text{HARQ-ACK}}$;
- $C_{\text{UL-SCH}}$ is the number of code blocks for UL-SCH of the PUSCH transmission;
- if the DCI format scheduling the PUSCH transmission includes a CBGTI field indicating that the UE shall not transmit the r-th code block, $K_r = 0$; otherwise, K_r is the r-th code block size for UL-SCH of the PUSCH transmission;
- $M_{\text{sc}}^{\text{PUSCH}}$ is the scheduled bandwidth of the PUSCH transmission, expressed as a number of subcarriers;
- $M_{\text{sc}}^{\text{PT-RS}}(l)$ is the number of subcarriers in OFDM symbol l that carries PTRS, in the PUSCH transmission;
- $M_{\text{sc}}^{\text{UCI}}(l)$ is the number of resource elements that can be used for transmission of UCI in OFDM symbol l, for $l = 0, 1, 2, ..., N_{\text{symb,all}}^{\text{PUSCH}} - 1$, in the PUSCH transmission and $N_{\text{symb,all}}^{\text{PUSCH}}$ is the total number of OFDM symbols of the PUSCH, including all OFDM symbols used for DMRS;
  - for any OFDM symbol that carries DMRS of the PUSCH, $M_{\text{sc}}^{\text{UCI}}(l) = 0$;

- for any OFDM symbol that does not carry DMRS of the PUSCH, $M_{sc}^{UCI}(l) = M_{sc}^{PUSCH} - M_{sc}^{PT\text{-}RS}(l)$;

- α is configured by higher layer parameter *scaling*;

- l_0 is the symbol index of the first OFDM symbol that does not carry DMRS of the PUSCH, after the first DMRS symbol(s), in the PUSCH transmission.

For HARQ-ACK transmission on PUSCH without UL-SCH, the number of coded modulation symbols per layer for HARQ-ACK transmission, denoted as Q'_{ACK}, is determined as follows:

$$Q'_{ACK} = \min\left\{\left\lceil \frac{(O_{ACK} + L_{ACK}) \cdot \beta_{offset}^{PUSCH}}{R \cdot Q_m} \right\rceil, \left\lceil \alpha \cdot \sum_{l=l_0}^{N_{symb,all}^{PUSCH}-1} M_{sc}^{UCI}(l) \right\rceil\right\}$$

where

- O_{ACK} is the number of HARQ-ACK bits;

- if $O_{ACK} \geq 360$, $L_{ACK} = 11$; otherwise L_{ACK} is the number of CRC bits for HARQ-ACK defined according to Subclause 6.3.1.2.1;;

- $\beta_{offset}^{PUSCH} = \beta_{offset}^{HARQ-ACK}$;

- M_{sc}^{PUSCH} is the scheduled bandwidth of the PUSCH transmission, expressed as a number of subcarriers;

- $M_{sc}^{PT\text{-}RS}(l)$ is the number of subcarriers in OFDM symbol l that carries PTRS, in the PUSCH transmission;

- $M_{sc}^{UCI}(l)$ is the number of resource elements that can be used for transmission of UCI in OFDM symbol l, for $l = 0, 1, 2, ..., N_{symb,all}^{PUSCH} - 1$, in the PUSCH transmission and $N_{symb,all}^{PUSCH}$ is the total number of OFDM symbols of the PUSCH, including all OFDM symbols used for DMRS;

  - for any OFDM symbol that carries DMRS of the PUSCH, $M_{sc}^{UCI}(l) = 0$;

  - for any OFDM symbol that does not carry DMRS of the PUSCH, $M_{sc}^{UCI}(l) = M_{sc}^{PUSCH} - M_{sc}^{PT\text{-}RS}(l)$;

- l_0 is the symbol index of the first OFDM symbol that does not carry DMRS of the PUSCH, after the first DMRS symbol(s), in the PUSCH transmission;

- R is the code rate of the PUSCH, determined according to Subclause 6.1.4.1 of [6, TS38.214];

- Q_m is the modulation order of the PUSCH;

- α is configured by higher layer parameter *scaling*.

The input bit sequence to rate matching is $d_{r0}, d_{r1}, d_{r2}, d_{r3}, ..., d_{r(N_r-1)}$ where r is the code block number, and N_r is the number of coded bits in code block number r.

Rate matching is performed according to Subclause 5.4.1 by setting $I_{BIL} = 1$ and the rate matching output sequence length to $E_r = \lfloor E_{UCI} / C_{UCI} \rfloor$, where

- C_{UCI} is the number of code blocks for UCI determined according to Subclause 5.2.1;

- N_L is the number of transmission layers of the PUSCH;

- Q_m is the modulation order of the PUSCH;
- $E_{\text{UCI}} = N_L \cdot Q'_{\text{ACK}} \cdot Q_m$.

The output bit sequence after rate matching is denoted as $f_{r0}, f_{r1}, f_{r2}, ..., f_{r(E_r-1)}$ where E_r is the length of rate matching output sequence in code block number r.

6.3.2.4.1.2 CSI part 1

For CSI part 1 transmission on PUSCH with UL-SCH, the number of coded modulation symbols per layer for CSI part 1 transmission, denoted as $Q'_{\text{CSI-part1}}$, is determined as follows:

$$Q'_{\text{CSI-1}} = \min\left\{ \left\lceil \frac{(O_{\text{CSI-1}} + L_{\text{CSI-1}}) \cdot \beta_{\text{offset}}^{\text{PUSCH}} \cdot \sum_{l=0}^{N_{\text{symb,all}}^{\text{PUSCH}}-1} M_{\text{sc}}^{\text{UCI}}(l)}{\sum_{r=0}^{C_{\text{UL-SCH}}-1} K_r} \right\rceil, \left\lceil \alpha \cdot \sum_{l=0}^{N_{\text{symb,all}}^{\text{PUSCH}}-1} M_{\text{sc}}^{\text{UCI}}(l) \right\rceil - Q'_{\text{ACK}} \right\}$$

where

- $O_{\text{CSI-1}}$ is the number of bits for CSI part 1;
- if $O_{\text{CSI-1}} \geq 360$, $L_{\text{CSI-1}} = 11$; otherwise $L_{\text{CSI-1}}$ is the number of CRC bits for CSI part 1 determined according to Subclause 6.3.1.2.1;
- $\beta_{\text{offset}}^{\text{PUSCH}} = \beta_{\text{offset}}^{\text{CSI-part1}}$;
- $C_{\text{UL-SCH}}$ is the number of code blocks for UL-SCH of the PUSCH transmission;
- if the DCI format scheduling the PUSCH transmission includes a CBGTI field indicating that the UE shall not transmit the r-th code block, $K_r = 0$; otherwise, K_r is the r-th code block size for UL-SCH of the PUSCH transmission;
- $M_{\text{sc}}^{\text{PUSCH}}$ is the scheduled bandwidth of the PUSCH transmission, expressed as a number of subcarriers;
- $M_{\text{sc}}^{\text{PT-RS}}(l)$ is the number of subcarriers in OFDM symbol l that carries PTRS, in the PUSCH transmission;
- Q'_{ACK} is the number of coded modulation symbols per layer for HARQ-ACK transmitted on the PUSCH if number of HARQ-ACK information bits is more than 2, and $Q'_{\text{ACK}} = \sum_{l=0}^{N_{\text{symb,all}}^{\text{PUSCH}}-1} \bar{M}_{\text{sc, rvd}}^{\text{ACK}}(l)$ if the number of HARQ-ACK information bits is no more than 2 bits, where $\bar{M}_{\text{sc, rvd}}^{\text{ACK}}(l)$ is the number of reserved resource elements for potential HARQ-ACK transmission in OFDM symbol l, for $l = 0, 1, 2, ..., N_{\text{symb,all}}^{\text{PUSCH}} - 1$, in the PUSCH transmission, defined in Subclause 6.2.7;
- $M_{\text{sc}}^{\text{UCI}}(l)$ is the number of resource elements that can be used for transmission of UCI in OFDM symbol l, for $l = 0, 1, 2, ..., N_{\text{symb,all}}^{\text{PUSCH}} - 1$, in the PUSCH transmission and $N_{\text{symb,all}}^{\text{PUSCH}}$ is the total number of OFDM symbols of the PUSCH, including all OFDM symbols used for DMRS;
  - for any OFDM symbol that carries DMRS of the PUSCH, $M_{\text{sc}}^{\text{UCI}}(l) = 0$;

- for any OFDM symbol that does not carry DMRS of the PUSCH, $M_{sc}^{UCI}(l) = M_{sc}^{PUSCH} - M_{sc}^{PT\text{-}RS}(l)$;

- α is configured by higher layer parameter *scaling*.

For CSI part 1 transmission on PUSCH without UL-SCH, the number of coded modulation symbols per layer for CSI part 1 transmission, denoted as $Q'_{CSI\text{-}part1}$, is determined as follows:

if there is CSI part 2 to be transmitted on the PUSCH,

$$Q'_{CSI\text{-}1} = \min\left\{\left\lceil \frac{(O_{CSI\text{-}1} + L_{CSI\text{-}1}) \cdot \beta_{offset}^{PUSCH}}{R \cdot Q_m} \right\rceil, \sum_{l=0}^{N_{symb,all}^{PUSCH}-1} M_{sc}^{UCI}(l) - Q'_{ACK}\right\}$$

else

$$Q'_{CSI\text{-}1} = \sum_{l=0}^{N_{symb,all}^{PUSCH}-1} M_{sc}^{UCI}(l) - Q'_{ACK}$$

end if

where

- $O_{CSI\text{-}1}$ is the number of bits for CSI part 1;

- if $O_{CSI\text{-}1} \geq 360$, $L_{CSI\text{-}1} = 11$; otherwise $L_{CSI\text{-}1}$ is the number of CRC bits for CSI part 1 determined according to Subclause 6.3.1.2.1;

- $\beta_{offset}^{PUSCH} = \beta_{offset}^{CSI\text{-}part1}$;

- M_{sc}^{PUSCH} is the scheduled bandwidth of the PUSCH transmission, expressed as a number of subcarriers;

- $M_{sc}^{PT\text{-}RS}(l)$ is the number of subcarriers in OFDM symbol l that carries PTRS, in the PUSCH transmission;

- Q'_{ACK} is the number of coded modulation symbols per layer for HARQ-ACK transmitted on the PUSCH if number of HARQ-ACK information bits is more than 2, and $Q'_{ACK} = \sum_{l=0}^{N_{symb,all}^{PUSCH}-1} \bar{M}_{sc,\,rvd}^{ACK}(l)$ if the number of HARQ-ACK information bits is no more than 2 bits, where $\bar{M}_{sc,\,rvd}^{ACK}(l)$ is the number of reserved resource elements for potential HARQ-ACK transmission in OFDM symbol l, for $l = 0, 1, 2, ..., N_{symb,all}^{PUSCH} - 1$, in the PUSCH transmission, defined in Subclause 6.2.7;

- $M_{sc}^{UCI}(l)$ is the number of resource elements that can be used for transmission of UCI in OFDM symbol l, for $l = 0, 1, 2, ..., N_{symb,all}^{PUSCH} - 1$, in the PUSCH transmission and $N_{symb,all}^{PUSCH}$ is the total number of OFDM symbols of the PUSCH, including all OFDM symbols used for DMRS;

  - for any OFDM symbol that carries DMRS of the PUSCH, $M_{sc}^{UCI}(l) = 0$;

  - for any OFDM symbol that does not carry DMRS of the PUSCH, $M_{sc}^{UCI}(l) = M_{sc}^{PUSCH} - M_{sc}^{PT\text{-}RS}(l)$;

- R is the code rate of the PUSCH, determined according to Subclause 6.1.4.1 of [6, TS38.214];

- Q_m is the modulation order of the PUSCH.

The input bit sequence to rate matching is $d_{r0}, d_{r1}, d_{r2}, d_{r3}, ..., d_{r(N_r-1)}$ where r is the code block number, and N_r is the number of coded bits in code block number r.

Rate matching is performed according to Subclause 5.4.1 by setting $I_{BIL}=1$ and the rate matching output sequence length to $E_r = \lfloor E_{\text{UCI}} / C_{\text{UCI}} \rfloor$, where

- C_{UCI} is the number of code blocks for UCI determined according to Subclause 5.2.1;
- N_L is the number of transmission layers of the PUSCH;
- Q_m is the modulation order of the PUSCH;
- $E_{\text{UCI}} = N_L \cdot Q'_{\text{CSI,1}} \cdot Q_m$.

The output bit sequence after rate matching is denoted as $f_{r0}, f_{r1}, f_{r2}, ..., f_{r(E_r-1)}$ where E_r is the length of rate matching output sequence in code block number r.

6.3.2.4.1.3 CSI part 2

For CSI part 2 transmission on PUSCH with UL-SCH, the number of coded modulation symbols per layer for CSI part 2 transmission, denoted as $Q'_{\text{CSI-part2}}$, is determined as follows:

$$Q'_{\text{CSI-2}} = \min\left\{ \left\lceil \frac{(O_{\text{CSI-2}} + L_{\text{CSI-2}}) \cdot \beta_{\text{offset}}^{\text{PUSCH}} \cdot \sum_{l=0}^{N_{\text{symb,all}}^{\text{PUSCH}}-1} M_{\text{sc}}^{\text{UCI}}(l)}{\sum_{r=0}^{C_{\text{UL-SCH}}-1} K_r} \right\rceil, \left\lceil \alpha \cdot \sum_{l=0}^{N_{\text{symb,all}}^{\text{PUSCH}}-1} M_{\text{sc}}^{\text{UCI}}(l) \right\rceil - Q'_{\text{ACK}} - Q'_{\text{CSI-1}} \right\}$$

where

- $O_{\text{CSI-2}}$ is the number of bits for CSI part 2;
- if $O_{\text{CSI-2}} \geq 360$, $L_{\text{CSI-2}} = 11$; otherwise $L_{\text{CSI-2}}$ is the number of CRC bits for CSI part 2 determined according to Subclause 6.3.1.2.1;
- $\beta_{\text{offset}}^{\text{PUSCH}} = \beta_{\text{offset}}^{\text{CSI-part2}}$;
- $C_{\text{UL-SCH}}$ is the number of code blocks for UL-SCH of the PUSCH transmission;
- if the DCI format scheduling the PUSCH transmission includes a CBGTI field indicating that the UE shall not transmit the r-th code block, K_r=0; otherwise, K_r is the r-th code block size for UL-SCH of the PUSCH transmission;
- $M_{\text{sc}}^{\text{PUSCH}}$ is the scheduled bandwidth of the PUSCH transmission, expressed as a number of subcarriers;
- $M_{\text{sc}}^{\text{PT-RS}}(l)$ is the number of subcarriers in OFDM symbol l that carries PTRS, in the PUSCH transmission;
- Q'_{ACK} is the number of coded modulation symbols per layer for HARQ-ACK transmitted on the PUSCH if number of HARQ-ACK information bits is more than 2, and $Q'_{\text{ACK}} = 0$ if the number of HARQ-ACK information bits is 1 or 2 bits;
- $Q'_{\text{CSI-1}}$ is the number of coded modulation symbols per layer for CSI part 1 transmitted on the PUSCH;

- $M_{sc}^{UCI}(l)$ is the number of resource elements that can be used for transmission of UCI in OFDM symbol l, for $l = 0, 1, 2, ..., N_{symb,all}^{PUSCH} - 1$, in the PUSCH transmission and $N_{symb,all}^{PUSCH}$ is the total number of OFDM symbols of the PUSCH, including all OFDM symbols used for DMRS;
  - for any OFDM symbol that carries DMRS of the PUSCH, $M_{sc}^{UCI}(l) = 0$;
  - for any OFDM symbol that does not carry DMRS of the PUSCH, $M_{sc}^{UCI}(l) = M_{sc}^{PUSCH} - M_{sc}^{PT\text{-}RS}(l)$.
- α is configured by higher layer parameter *scaling*.

For CSI part 2 transmission on PUSCH without UL-SCH, the number of coded modulation symbols per layer for CSI part 2 transmission, denoted as $Q'_{CSI\text{-}part2}$, is determined as follows:

$$Q'_{CSI\text{-}2} = \sum_{l=0}^{N_{symb,all}^{PUSCH}-1} M_{sc}^{UCI}(l) - Q'_{ACK} - Q'_{CSI\text{-}1}$$

where

- M_{sc}^{PUSCH} is the scheduled bandwidth of the PUSCH transmission, expressed as a number of subcarriers;
- $M_{sc}^{PT\text{-}RS}(l)$ is the number of subcarriers in OFDM symbol l that carries PTRS, in the PUSCH transmission;
- Q'_{ACK} is the number of coded modulation symbols per layer for HARQ-ACK transmitted on the PUSCH if number of HARQ-ACK information bits is more than 2, and $Q'_{ACK} = 0$ if the number of HARQ-ACK information bits is 1 or 2 bits;
- $Q'_{CSI\text{-}1}$ is the number of coded modulation symbols per layer for CSI part 1 transmitted on the PUSCH;
- $M_{sc}^{UCI}(l)$ is the number of resource elements that can be used for transmission of UCI in OFDM symbol l, for $l = 0, 1, 2, ..., N_{symb,all}^{PUSCH} - 1$, in the PUSCH transmission and $N_{symb,all}^{PUSCH}$ is the total number of OFDM symbols of the PUSCH, including all OFDM symbols used for DMRS;
  - for any OFDM symbol that carries DMRS of the PUSCH, $M_{sc}^{UCI}(l) = 0$;
  - for any OFDM symbol that does not carry DMRS of the PUSCH, $M_{sc}^{UCI}(l) = M_{sc}^{PUSCH} - M_{sc}^{PT\text{-}RS}(l)$.

The input bit sequence to rate matching is $d_{r0}, d_{r1}, d_{r2}, d_{r3}, ..., d_{r(N_r-1)}$ where r is the code block number, and N_r is the number of coded bits in code block number r.

Rate matching is performed according to Subclause 5.4.1 by setting $I_{BIL} = 1$ and the rate matching output sequence length to $E_r = \lfloor E_{UCI} / C_{UCI} \rfloor$, where

- C_{UCI} is the number of code blocks for UCI determined according to Subclause 5.2.1;
- N_L is the number of transmission layers of the PUSCH;
- Q_m is the modulation order of the PUSCH;
- $E_{UCI} = N_L \cdot Q'_{CSI,2} \cdot Q_m$.

The output bit sequence after rate matching is denoted as $f_{r0}, f_{r1}, f_{r2}, ..., f_{r(E_r-1)}$ where E_r is the length of rate matching output sequence in code block number r.

6.3.2.4.2 UCI encoded by channel coding of small block lengths

6.3.2.4.2.1 HARQ-ACK

For HARQ-ACK transmission on PUSCH with UL-SCH, the number of coded modulation symbols per layer for HARQ-ACK transmission, denoted as Q'_{ACK}, is determined according to Subclause 6.3.2.4.1.1, by setting the number of CRC bits $L = 0$.

The input bit sequence to rate matching is $d_0, d_1, d_2, ..., d_{N-1}$.

Rate matching is performed according to Subclause 5.4.3, by setting the rate matching output sequence length $E = N_L \cdot Q'_{\text{ACK}} \cdot Q_m$, where

- N_L is the number of transmission layers of the PUSCH;
- Q_m is the modulation order of the PUSCH.

The output bit sequence after rate matching is denoted as $f_0, f_1, f_2, ..., f_{E-1}$.

6.3.2.4.2.2 CSI part 1

For CSI part 1 transmission on PUSCH with UL-SCH, the number of coded modulation symbols per layer for CSI part 1 transmission, denoted as $Q'_{\text{CSI,1}}$, is determined according to Subclause 6.3.2.4.1.2, by setting the number of CRC bits $L = 0$.

Rate matching is performed according to Subclause 5.4.3, by setting the rate matching output sequence length $E = N_L \cdot Q'_{\text{CSI,1}} \cdot Q_m$, where

- N_L is the number of transmission layers of the PUSCH;
- Q_m is the modulation order of the PUSCH.

The output bit sequence after rate matching is denoted as $f_0, f_1, f_2, ..., f_{E-1}$.

6.3.2.4.2.3 CSI part 2

For CSI part 2 transmission on PUSCH with UL-SCH, the number of coded modulation symbols per layer for CSI part 2 transmission, denoted as $Q'_{\text{CSI,2}}$, is determined according to Subclause 6.3.2.4.1.3, by setting the number of CRC bits $L = 0$.

Rate matching is performed according to Subclause 5.4.3, by setting the rate matching output sequence length $E = N_L \cdot Q'_{\text{CSI,2}} \cdot Q_m$, where

- N_L is the number of transmission layers of the PUSCH;
- Q_m is the modulation order of the PUSCH.

The output bit sequence after rate matching is denoted as $f_0, f_1, f_2, ..., f_{E-1}$.

6.3.2.5 Code block concatenation

Code block concatenation is performed according to Subclause 6.3.1.5, except that the values of E_{UCI} and C_{UCI} given in Subclause 6.3.2.4.1.

6.3.2.6 Multiplexing of coded UCI bits to PUSCH

The coded UCI bits are multiplexed onto PUSCH according to the procedures in Subclause 6.2.7.

7 Downlink transport channels and control information

7.1 Broadcast channel

Data arrives to the coding unit in the form of a maximum of one transport block every 80ms. The following coding steps can be identified:

- Payload generation
- Scrambling
- Transport block CRC attachment
- Channel coding
- Rate matching

7.1.1 PBCH payload generation

Denote the bits in a transport block delivered to layer 1 by $\bar{a}_0, \bar{a}_1, \bar{a}_2, \bar{a}_3, ..., \bar{a}_{\bar{A}-1}$, where $\bar{A}$ is the payload size generated by higher layers. The lowest order information bit $\bar{a}_0$ is mapped to the most significant bit of the transport block as defined in Subclause [6.1.4] of [8, TS 38.321].

Generate the following additional timing related PBCH payload bits $\bar{a}_{\bar{A}}, \bar{a}_{\bar{A}+1}, \bar{a}_{\bar{A}+2}, \bar{a}_{\bar{A}+3}, ..., \bar{a}_{\bar{A}+7}$, where:

- $\bar{a}_{\bar{A}}, \bar{a}_{\bar{A}+1}, \bar{a}_{\bar{A}+2}, \bar{a}_{\bar{A}+3}$ are the 4th, 3rd, 2nd, and 1st LSB of SFN, respectively;
- $\bar{a}_{\bar{A}+4}$ is the half frame bit $\bar{a}_{\text{HRF}}$;
- if $L_{\text{SSB}} = 64$

  $\bar{a}_{\bar{A}+5}, \bar{a}_{\bar{A}+6}, \bar{a}_{\bar{A}+7}$ are the 6th, 5th, and 4th bits of SS/PBCH block index, respectively.

  else

  $\bar{a}_{\bar{A}+5}$ is the MSB of k_{SSB} as defined in Subclause 7.4.3.1 of [4, TS 38.211].

  $\bar{a}_{\bar{A}+6}, \bar{a}_{\bar{A}+7}$ are reserved.

  end if

Let $A = \bar{A} + 8$; $j_{\text{SFN}} = 0$; $j_{\text{HRF}} = 10$; $j_{\text{SSB}} = 11$; $j_{\text{other}} = 14$;

for $i = 0$ to $A-1$

  if $\bar{a}_i$ is an SFN bit

    $a_{G(j_{\text{SFN}})} = \bar{a}_i$;

    $j_{\text{SFN}} = j_{\text{SFN}} + 1$;

elseif $\overline{a}_i$ is the half radio frame bit

$a_{G(j_{\text{HRF}})} = \overline{a}_i$

elseif $\overline{A}+5 \le i \le \overline{A}+7$

$a_{G(j_{\text{SSB}})} = \overline{a}_i$;

$j_{\text{SSB}} = j_{\text{SSB}} + 1$;

else

$a_{G(j_{\text{Other}})} = \overline{a}_i$;

$j_{\text{Other}} = j_{\text{Other}} + 1$;

end if

end for

where L_{SSB} is the number of candidate SS/PBCH blocks in a half frame according to Subclause 4.1 of [5, TS38.213], and the value of $G(j)$ is given by Table 7.1.1-1.

Table 7.1.1-1: Value of PBCH payload interleaver pattern $G(j)$

j	$G(j)$	j	$G(j)$	j	$G(j)$	j	$G(j)$	j	$G(j)$	j	$G(j)$	j	$G(j)$	j	$G(j)$
0	16	4	8	8	24	12	3	16	9	20	14	24	21	28	27
1	23	5	30	9	7	13	2	17	11	21	15	25	22	29	28
2	18	6	10	10	0	14	1	18	12	22	19	26	25	30	29
3	17	7	6	11	5	15	4	19	13	23	20	27	26	31	31

7.1.2 Scrambling

For PBCH transmission in a frame, the bit sequence $a_0, a_1, a_2, a_3, ..., a_{A-1}$ is scrambled into a bit sequence $a'_0, a'_1, a'_2, a'_3, ..., a'_{A-1}$, where $a'_i = (a_i + s_i) \bmod 2$ for $i = 0,1,...,A-1$ and $s_0, s_1, s_2, s_3, ..., s_{A-1}$ is generated according to the following:

$i = 0$;

$j = 0$;

while $i < A$

if a_i corresponds to any one of the bits belonging to the SS/PBCH block index, the half frame index, and 2nd and 3rd least significant bits of the system frame number

$s_i = 0$;

else

$s_i = c(j + vM)$;

$j = j + 1$;

end if

$i = i + 1$;

end while

The scrambling sequence $c(i)$ is given by Subclause 5.2.1of [4, TS38.211] and initialized with $c_{\text{init}} = N_{ID}^{cell}$ at the start of each SFN satisfying $\text{mod}(SFN,8) = 0$; $M = A-3$ for $L = 4$ or $L = 8$, and $M = A-6$ for $L = 64$, where L is the number of candidate SS/PBCH blocks in a half frame according to Subclause 4.1 of [5, TS38.213]; and v is determined according to Table 7.1.2-1 using the 3rd and 2nd LSB of the SFN in which the PBCH is transmitted.

Table 7.1.2-1: Value of v for PBCH scrambling

(3rd LSB of SFN, 2nd LSB of SFN)	*Value of v*
(0, 0)	0
(0, 1)	1
(1, 0)	2
(1, 1)	3

7.1.3 Transport block CRC attachment

Error detection is provided on BCH transport blocks through a Cyclic Redundancy Check (CRC).

The entire transport block is used to calculate the CRC parity bits. The input bit sequence is denoted by $a'_0, a'_1, a'_2, a'_3, ..., a'_{A-1}$, and the parity bits by $p_0, p_1, p_2, p_3, ..., p_{L-1}$, where A is the payload size and L is the number of parity bits.

The parity bits are computed and attached to the BCH transport block according to Subclause 5.1 by setting L to 24 bits and using the generator polynomial $g_{\text{CRC24C}}(D)$, resulting in the sequence $b_0, b_1, b_2, b_3, ..., b_{B-1}$, where $B = A + L$.

The bit sequence $b_0, b_1, b_2, b_3, ..., b_{B-1}$ is the input bit sequence $c_0, c_1, c_2, c_3, ..., c_{K-1}$ to the channel encoder, where $c_i = b_i$ for $i = 0, 1, ..., B-1$ and $K = B$.

7.1.4 Channel coding

Information bits are delivered to the channel coding block. They are denoted by $c_0, c_1, c_2, c_3, ..., c_{K-1}$, where K is the number of bits, and they are encoded via Polar coding according to Subclause 5.3.1, by setting $n_{\max} = 9$, $I_{IL} = 1$, $n_{PC} = 0$, and $n_{PC}^{wm} = 0$.

After encoding the bits are denoted by $d_0, d_1, d_2, d_3, ..., d_{N-1}$, where N is the number of coded bits.

7.1.5 Rate matching

The input bit sequence to rate matching is $d_0, d_1, d_2, ..., d_{N-1}$.

The rate matching output sequence length $E = 864$.

Rate matching is performed according to Subclause 5.4.1 by setting $I_{BIL} = 0$.

The output bit sequence after rate matching is denoted as $f_0, f_1, f_2, ..., f_{E-1}$.

7.2 Downlink shared channel and paging channel

7.2.1 Transport block CRC attachment

Error detection is provided on each transport block through a Cyclic Redundancy Check (CRC).

The entire transport block is used to calculate the CRC parity bits. Denote the bits in a transport block delivered to layer 1 by $a_0, a_1, a_2, a_3, ..., a_{A-1}$, and the parity bits by $p_0, p_1, p_2, p_3, ..., p_{L-1}$, where A is the payload size and L is the number of parity bits. The lowest order information bit a_0 is mapped to the most significant bit of the transport block as defined in Subclause 6.1.1 of [TS38.321].

The parity bits are computed and attached to the DL-SCH transport block according to Subclause 5.1, by setting L to 24 bits and using the generator polynomial $g_{\text{CRC24A}}(D)$ if $A > 3824$; and by setting L to 16 bits and using the generator polynomial $g_{\text{CRC16}}(D)$ otherwise.

The bits after CRC attachment are denoted by $b_0, b_1, b_2, b_3, ..., b_{B-1}$, where $B = A + L$.

7.2.2 LDPC base graph selection

For initial transmission of a transport block with coding rate R indicated by the MCS index according to Subclause 5.1.3.1 in [6, TS 38.214] and subsequent re-transmission of the same transport block, each code block of the transport block is encoded with either LDPC base graph 1 or 2 according to the following:

- if $A \le 292$, or if $A \le 3824$ and $R \le 0.67$, or if $R \le 0.25$, LDPC base graph 2 is used;
- otherwise, LDPC base graph 1 is used,

where A is the payload size in Subclause 7.2.1.

7.2.3 Code block segmentation and code block CRC attachment

The bits input to the code block segmentation are denoted by $b_0, b_1, b_2, b_3, ..., b_{B-1}$ where B is the number of bits in the transport block (including CRC).

Code block segmentation and code block CRC attachment are performed according to Subclause 5.2.2.

The bits after code block segmentation are denoted by $c_{r0}, c_{r1}, c_{r2}, c_{r3}, ..., c_{r(K_r-1)}$, where r is the code block number and K_r is the number of bits for code block number r according to Subclause 5.2.2.

7.2.4 Channel coding

Code blocks are delivered to the channel coding block. The bits in a code block are denoted by $c_{r0}, c_{r1}, c_{r2}, c_{r3}, ..., c_{r(K_r-1)}$, where r is the code block number, and K_r is the number of bits in code block number r. The total number of code blocks is denoted by C and each code block is individually LDPC encoded according to Subclause 5.3.2.

After encoding the bits are denoted by $d_{r0}, d_{r1}, d_{r2}, d_{r3}, ..., d_{r(N_r-1)}$, where the values of N_r is given in Subclause 5.3.2.

7.2.5 Rate matching

Coded bits for each code block, denoted as $d_{r0}, d_{r1}, d_{r2}, d_{r3}, ..., d_{r(N_r-1)}$, are delivered to the rate match block, where r is the code block number, and N_r is the number of encoded bits in code block number r. The total number of code blocks is denoted by C and each code block is individually rate matched according to Subclause 5.4.2 by setting $I_{LBRM} = 1$.

After rate matching, the bits are denoted by $f_{r0}, f_{r1}, f_{r2}, f_{r3}, ..., f_{r(E_r-1)}$, where E_r is the number of rate matched bits for code block number r.

7.2.6 Code block concatenation

The input bit sequence for the code block concatenation block are the sequences $f_{r0}, f_{r1}, f_{r2}, f_{r3}, ..., f_{r(E_r-1)}$, for $r = 0, ..., C-1$ and where E_r is the number of rate matched bits for the r-th code block.

Code block concatenation is performed according to Subclause 5.5.

The bits after code block concatenation are denoted by $g_0, g_1, g_2, g_3, ..., g_{G-1}$, where G is the total number of coded bits for transmission.

7.3 Downlink control information

A DCI transports downlink control information for one or more cells with one RNTI.

The following coding steps can be identified:

- Information element multiplexing
- CRC attachment
- Channel coding
- Rate matching

7.3.1 DCI formats

The DCI formats defined in table 7.3.1-1 are supported.

Table 7.3.1-1: DCI formats

DCI format	Usage
0_0	Scheduling of PUSCH in one cell
0_1	Scheduling of PUSCH in one cell
1_0	Scheduling of PDSCH in one cell
1_1	Scheduling of PDSCH in one cell
2_0	Notifying a group of UEs of the slot format
2_1	Notifying a group of UEs of the PRB(s) and OFDM symbol(s) where UE may assume no transmission is intended for the UE
2_2	Transmission of TPC commands for PUCCH and PUSCH
2_3	Transmission of a group of TPC commands for SRS transmissions by one or more UEs

The fields defined in the DCI formats below are mapped to the information bits a_0 to a_{A-1} as follows.

Each field is mapped in the order in which it appears in the description, including the zero-padding bit(s), if any, with the first field mapped to the lowest order information bit a_0 and each successive field mapped to higher order information bits. The most significant bit of each field is mapped to the lowest order information bit for that field, e.g. the most significant bit of the first field is mapped to a_0.

If the number of information bits in a DCI format is less than 12 bits, zeros shall be appended to the DCI format until the payload size equals 12.

7.3.1.1 DCI formats for scheduling of PUSCH

7.3.1.1.1 Format 0_0

DCI format 0_0 is used for the scheduling of PUSCH in one cell.

The following information is transmitted by means of the DCI format 0_0 with CRC scrambled by C-RNTI or CS-RNTI or new-RNTI:

- Identifier for DCI formats – 1 bit
  - The value of this bit field is always set to 0, indicating an UL DCI format
- Frequency domain resource assignment – $\lceil \log_2(N_{RB}^{UL,BWP}(N_{RB}^{UL,BWP}+1)/2) \rceil$ bits where
  - $N_{RB}^{UL,BWP}$ is the size of the active UL bandwidth part in case DCI format 0_0 is monitored in the UE specific search space and satisfying

- the total number of different DCI sizes monitored per slot is no more than 4 for the cell, and
- the total number of different DCI sizes with C-RNTI monitored per slot is no more than 3 for the cell

- otherwise, $N_{RB}^{UL,BWP}$ is the size of the initial UL bandwidth part.
- For PUSCH hopping with resource allocation type 1:
  - N_{UL_hop} MSB bits are used to indicate the frequency offset according to Subclause 6.3 of [6, TS 38.214], where $N_{UL_hop}=1$ if the higher layer parameter *frequencyHoppingOffsetLists* contains two offset values and $N_{UL_hop}=2$ if the higher layer parameter *frequencyHoppingOffsetLists* contains four offset values
  - $\lceil \log_2(N_{RB}^{UL,BWP}(N_{RB}^{UL,BWP}+1)/2) \rceil - N_{UL_hop}$ bits provides the frequency domain resource allocation according to Subclause 6.1.2.2.2 of [6, TS 38.214]
- For non-PUSCH hopping with resource allocation type 1:
  - $\lceil \log_2(N_{RB}^{UL,BWP}(N_{RB}^{UL,BWP}+1)/2) \rceil$ bits provides the frequency domain resource allocation according to Subclause 6.1.2.2.2 of [6, TS 38.214]

- Time domain resource assignment – 4 bits as defined in Subclause 6.1.2.1 of [6, TS 38.214]
- Frequency hopping flag – 1 bit.
- Modulation and coding scheme – 5 bits as defined in Subclause 6.1.3 of [6, TS 38.214]
- New data indicator – 1 bit
- Redundancy version – 2 bits as defined in Table 7.3.1.1.1-2
- HARQ process number – 4 bits
- TPC command for scheduled PUSCH – 2 bits as defined in Subclause 7.1.1 of [5, TS 38.213]
- Padding bits, if required.
- UL/SUL indicator – 1 bit for UEs configured with SUL in the cell as defined in Table 7.3.1.1.1-1 and the number of bits for DCI format 1_0 before padding is larger than the number of bits for DCI format 0_0 before padding; 0 bit otherwise. The UL/SUL indicator, if present, locates in the last bit position of DCI format 0_0, after the padding bit(s).
  - If the UL/SUL indicator is present in DCI format 0_0 and the higher layer parameter *pusch-Config* is not configured on both UL and SUL the UE ignores the UL/SUL indicator field in DCI format 0_0, and the corresponding PUSCH scheduled by the DCI format 0_0 is for the UL or SUL for which high layer parameter *pucch-Config* is configured;
  - If the UL/SUL indicator is not present in DCI format 0_0, the corresponding PUSCH scheduled by the DCI format 0_0 is for the UL or SUL for which high layer parameter *pucch-Config* is configured.

The following information is transmitted by means of the DCI format 0_0 with CRC scrambled by TC-RNTI:

- Identifier for DCI formats – 1 bit
  - The value of this bit field is always set to 0, indicating an UL DCI format
- Frequency domain resource assignment – $\lceil \log_2(N_{RB}^{UL,BWP}(N_{RB}^{UL,BWP}+1)/2) \rceil$ bits where
  - $N_{RB}^{UL,BWP}$ is the size of the initial UL bandwidth part.
  - For PUSCH hopping with resource allocation type 1:

- $N_{\text{UL_hop}}$ MSB bits are used to indicate the frequency offset according to Subclause 6.3 of [6, TS 38.214], where $N_{\text{UL_hop}}=1$ if $N_{\text{RB}}^{\text{UL,BWP}}<50$ and $N_{\text{UL_hop}}=2$ otherwise
- $\left\lceil \log_2(N_{\text{RB}}^{\text{UL,BWP}}(N_{\text{RB}}^{\text{UL,BWP}}+1)/2) \right\rceil - N_{\text{UL_hop}}$ bits provides the frequency domain resource allocation according to Subclause 6.1.2.2.2 of [6, TS 38.214]

- For non-PUSCH hopping with resource allocation type 1:
  - $\left\lceil \log_2(N_{\text{RB}}^{\text{UL,BWP}}(N_{\text{RB}}^{\text{UL,BWP}}+1)/2) \right\rceil$ bits provides the frequency domain resource allocation according to Subclause 6.1.2.2.2 of [6, TS 38.214]

- Time domain resource assignment – 4 bits as defined in Subclause 6.1.2.1 of [6, TS 38.214]
- Frequency hopping flag – 1 bit.
- Modulation and coding scheme – 5 bits as defined in Subclause 6.1.3 of [6, TS 38.214], using Table 5.1.3.1-1
- New data indicator – 1 bit, reserved
- Redundancy version – 2 bits as defined in Table 7.3.1.1.1-2
- HARQ process number – 4 bits, reserved
- TPC command for scheduled PUSCH – 2 bits as defined in Subclause 7.1.1 of [5, TS 38.213]
- Padding bits, if required.
- UL/SUL indicator – 1 bit if the cell has two ULs and the number of bits for DCI format 1_0 before padding is larger than the number of bits for DCI format 0_0 before padding; 0 bit otherwise. The UL/SUL indicator, if present, locates in the last bit position of DCI format 0_0, after the padding bit(s).
  - If 1 bit, reserved, and the corresponding PUSCH is always on the same UL carrier as the previous transmission of the same TB

If DCI format 0_0 is monitored in common search space and if the number of information bits in the DCI format 0_0 prior to padding is less than the payload size of the DCI format 1_0 monitored in common search space for scheduling the same serving cell, zeros shall be appended to the DCI format 0_0 until the payload size equals that of the DCI format 1_0.

If DCI format 0_0 is monitored in common search space and if the number of information bits in the DCI format 0_0 prior to padding is larger than the payload size of the DCI format 1_0 monitored in common search space for scheduling the same serving cell, the bitwidth of the frequency domain resource allocation field in the DCI format 0_0 is reduced by truncating the first few most significant bits such that the size of DCI format 0_0 equals to the size of the DCI format 1_0.

If DCI format 0_0 is monitored in UE specific search space but does not satisfy at least one of the following

- the total number of different DCI sizes monitored per slot is no more than 4 for the cell, and
- the total number of different DCI sizes with C-RNTI monitored per slot is no more than 3 for the cell

and if the number of information bits in the DCI format 0_0 prior to padding is less than the payload size of the DCI format 1_0 monitored in common search space for scheduling the same serving cell, zeros shall be appended to the DCI format 0_0 until the payload size equals that of the DCI format 1_0.

If DCI format 0_0 is monitored in UE specific search space but does not satisfy at least one of the following

- the total number of different DCI sizes monitored per slot is no more than 4 for the cell, and
- the total number of different DCI sizes with C-RNTI monitored per slot is no more than 3 for the cell

and if the number of information bits in the DCI format 0_0 prior to padding is larger than the payload size of the DCI format 1_0 monitored in common search space for scheduling the same serving cell, the bitwidth of the frequency

domain resource allocation field in the DCI format 0_0 is reduced by truncating the first few most significant bits such that the size of DCI format 0_0 equals to the size of the DCI format 1_0.

If DCI format 0_0 is monitored in UE specific search space and satisfies both of the following

- the total number of different DCI sizes monitored per slot is no more than 4 for the cell, and
- the total number of different DCI sizes with C-RNTI monitored per slot is no more than 3 for the cell

and if the number of information bits in the DCI format 0_0 prior to padding is less than the payload size of the DCI format 1_0 monitored in UE specific search space for scheduling the same serving cell, zeros shall be appended to the DCI format 0_0 until the payload size equals that of the DCI format 1_0.

Table 7.3.1.1.1-1: UL/SUL indicator

Value of UL/SUL indicator	Uplink
0	The non-supplementary uplink
1	The supplementary uplink

Table 7.3.1.1.1-2: Redundancy version

Value of the Redundancy version field	Value of rv_{id} to be applied
00	0
01	1
10	2
11	3

7.3.1.1.2 Format 0_1

DCI format 0_1 is used for the scheduling of PUSCH in one cell.

The following information is transmitted by means of the DCI format 0_1 with CRC scrambled by C-RNTI or CS-RNTI or SP-CSI-RNTI or new-RNTI:

- Identifier for DCI formats – 1 bit
  - The value of this bit field is always set to 0, indicating an UL DCI format
- Carrier indicator – 0 or 3 bits, as defined in Subclause 10.1 of [5, TS38.213].
- UL/SUL indicator – 0 bit for UEs not configured with SUL in the cell or UEs configured with SUL in the cell but only PUCCH carrier in the cell is configured for PUSCH transmission; 1 bit for UEs configured with SUL in the cell as defined in Table 7.3.1.1.1-1.
- Bandwidth part indicator – 0, 1 or 2 bits as determined by the number of UL BWPs $n_{\text{BWP,RRC}}$ configured by higher layers, excluding the initial UL bandwidth part. The bitwidth for this field is determined as $\lceil \log_2(n_{\text{BWP}}) \rceil$ bits, where
  - $n_{\text{BWP}} = n_{\text{BWP,RRC}} + 1$ if $n_{\text{BWP,RRC}} \leq 3$, in which case the bandwidth part indicator is equivalent to the higher layer parameter *BWP-Id*;
  - otherwise $n_{\text{BWP}} = n_{\text{BWP,RRC}}$, in which case the bandwidth part indicator is defined in Table 7.3.1.1.2-1;

  If a UE does not support active BWP change via DCI, the UE ignores this bit field.
- Frequency domain resource assignment – number of bits determined by the following, where $N_{\text{RB}}^{\text{UL,BWP}}$ is the size of the active UL bandwidth part:

- N_{RBG} bits if only resource allocation type 0 is configured, where N_{RBG} is defined in Subclause 6.1.2.2.1 of [6, TS 38.214],
- $\lceil \log_2(N_{RB}^{UL,BWP}(N_{RB}^{UL,BWP}+1)/2) \rceil$ bits if only resource allocation type 1 is configured, or $\max\left(\lceil \log_2(N_{RB}^{UL,BWP}(N_{RB}^{UL,BWP}+1)/2) \rceil, N_{RBG}\right)+1$ bits if both resource allocation type 0 and 1 are configured.
- If both resource allocation type 0 and 1 are configured, the MSB bit is used to indicate resource allocation type 0 or resource allocation type 1, where the bit value of 0 indicates resource allocation type 0 and the bit value of 1 indicates resource allocation type 1.
- For resource allocation type 0, the N_{RBG} LSBs provide the resource allocation as defined in Subclause 6.1.2.2.1 of [6, TS 38.214].
- For resource allocation type 1, the $\lceil \log_2(N_{RB}^{UL,BWP}(N_{RB}^{UL,BWP}+1)/2) \rceil$ LSBs provide the resource allocation as follows:
  - For PUSCH hopping with resource allocation type 1:
    - N_{UL_hop} MSB bits are used to indicate the frequency offset according to Subclause 6.3 of [6, TS 38.214], where $N_{UL_hop}=1$ if the higher layer parameter *frequencyHoppingOffsetLists* contains two offset values and $N_{UL_hop}=2$ if the higher layer parameter *frequencyHoppingOffsetLists* contains four offset values
    - $\lceil \log_2(N_{RB}^{UL,BWP}(N_{RB}^{UL,BWP}+1)/2) \rceil - N_{UL_hop}$ bits provides the frequency domain resource allocation according to Subclause 6.1.2.2.2 of [6, TS 38.214]
  - For non-PUSCH hopping with resource allocation type 1:
    - $\lceil \log_2(N_{RB}^{UL,BWP}(N_{RB}^{UL,BWP}+1)/2) \rceil$ bits provides the frequency domain resource allocation according to Subclause 6.1.2.2.2 of [6, TS 38.214]

  If "Bandwidth part indicator" field indicates a bandwidth part other than the active bandwidth part and if both resource allocation type 0 and 1 are configured for the indicated bandwidth part, the UE assumes resource allocation type 0 for the indicated bandwidth part if the bitwidth of the "Frequency domain resource assignment" field of the active bandwidth part is smaller than the bitwidth of the "Frequency domain resource assignment" field of the indicated bandwidth part.

- Time domain resource assignment – 0, 1, 2, 3, or 4 bits as defined in Subclause 6.1.2.1 of [6, TS38.214]. The bitwidth for this field is determined as $\lceil \log_2(I) \rceil$ bits, where I the number of entries in the higher layer parameter *pusch-AllocationList.*
- Frequency hopping flag – 0 or 1 bit:
  - 0 bit if only resource allocation type 0 is configured or if the higher layer parameter *frequencyHopping* is not configured;
  - 1 bit according to Table 7.3.1.1.2-34 otherwise, only applicable to resource allocation type 1, as defined in Subclause 6.3 of [6, TS 38.214].
- Modulation and coding scheme – 5 bits as defined in Subclause 6.1.4.1 of [6, TS 38.214]
- New data indicator – 1 bit
- Redundancy version – 2 bits as defined in Table 7.3.1.1.1-2
- HARQ process number – 4 bits
- 1st downlink assignment index – 1 or 2 bits:
  - 1 bit for semi-static HARQ-ACK codebook;

- 2 bits for dynamic HARQ-ACK codebook.

- 2nd downlink assignment index – 0 or 2 bits:
  - 2 bits for dynamic HARQ-ACK codebook with two HARQ-ACK sub-codebooks;
  - 0 bit otherwise.
- TPC command for scheduled PUSCH – 2 bits as defined in Subclause 7.1.1 of [5, TS38.213]
- SRS resource indicator – $\left\lceil \log_2\left(\sum_{k=1}^{\min\{L_{\max}, N_{\text{SRS}}\}} \binom{N_{\text{SRS}}}{k} \right) \right\rceil$ or $\lceil \log_2(N_{\text{SRS}}) \rceil$ bits, where N_{SRS} is the number of configured SRS resources in the SRS resource set associated with the higher layer parameter *usage* of value '*codeBook*' or '*nonCodeBook*', and $L_{\max}^{\text{PUSCH}}$ is the maximum number of supported layers for the PUSCH.
  - $\left\lceil \log_2\left(\sum_{k=1}^{\min\{L_{\max}^{\text{PUSCH}}, N_{\text{SRS}}\}} \binom{N_{\text{SRS}}}{k} \right) \right\rceil$ bits according to Tables 7.3.1.1.2-28/29/30/31 if the higher layer parameter *txConfig* = *nonCodebook*, where N_{SRS} is the number of configured SRS resources in the SRS resource set associated with the higher layer parameter *usage* of value '*nonCodeBook*';
  - $\lceil \log_2(N_{\text{SRS}}) \rceil$ bits according to Tables 7.3.1.1.2-32 if the higher layer parameter *txConfig* = *codebook*, where N_{SRS} is the number of configured SRS resources in the SRS resource set associated with the higher layer parameter *usage* of value '*codeBook*'.
- Precoding information and number of layers – number of bits determined by the following:
  - 0 bits if the higher layer parameter *txConfig* = *nonCodeBook*;
  - 0 bits for 1 antenna port and if the higher layer parameter *txConfig* = *codebook*;
  - 4, 5, or 6 bits according to Table 7.3.1.1.2-2 for 4 antenna ports, if *txConfig* = *codebook*, and according to the values of higher layer parameters *transformPrecoder*, *maxRank*, and *codebookSubset*;
  - 2, 4, or 5 bits according to Table 7.3.1.1.2-3 for 4 antenna ports, if *txConfig* = *codebook*, and according to the values of higher layer parameters *transformPrecoder*, *maxRank*, and *codebookSubset*;
  - 2 or 4 bits according to Table7.3.1.1.2-4 for 2 antenna ports, if *txConfig* = *codebook*, and according to the values of higher layer parameters *maxRank* and *codebookSubset*;
  - 1 or 3 bits according to Table7.3.1.1.2-5 for 2 antenna ports, if *txConfig* = *codebook*, and according to the values of higher layer parameters *maxRank* and *codebookSubset*.
- Antenna ports – number of bits determined by the following
  - 2 bits as defined by Tables 7.3.1.1.2-6, if *transformPrecoder=enabled*, *dmrs-Type*=1, and *maxLength*=1;
  - 4 bits as defined by Tables 7.3.1.1.2-7, if *transformPrecoder=enabled*, *dmrs-Type*=1, and *maxLength*=2;
  - 3 bits as defined by Tables 7.3.1.1.2-8/9/10/11, if *transformPrecoder=disabled*, *dmrs-Type*=1, and *maxLength*=1, and the value of rank is determined according to the SRS resource indicator field if the higher layer parameter *txConfig* = *nonCodebook* and according to the Precoding information and number of layers field if the higher layer parameter *txConfig* = *codebook*;
  - 4 bits as defined by Tables 7.3.1.1.2-12/13/14/15, if *transformPrecoder=disabled*, *dmrs-Type*=1, and *maxLength*=2, and the value of rank is determined according to the SRS resource indicator field if the higher layer parameter *txConfig* = *nonCodebook* and according to the Precoding information and number of layers field if the higher layer parameter *txConfig* = *codebook*;
  - 4 bits as defined by Tables 7.3.1.1.2-16/17/18/19, if *transformPrecoder=disabled*, *dmrs-Type*=2, and *maxLength*=1, and the value of rank is determined according to the SRS resource indicator field if the higher

layer parameter *txConfig = nonCodebook* and according to the Precoding information and number of layers field if the higher layer parameter *txConfig = codebook*;

- 5 bits as defined by Tables 7.3.1.1.2-20/21/22/23, if *transformPrecoder=disabled*, *dmrs-Type*=2, and *maxLength*=2, and the value of rank is determined according to the SRS resource indicator field if the higher layer parameter *txConfig = nonCodebook* and according to the Precoding information and number of layers field if the higher layer parameter *txConfig = codebook*.

where the number of CDM groups without data of values 1, 2, and 3 in Tables 7.3.1.1.2-6 to 7.3.1.1.2-23 refers to CDM groups {0}, {0,1}, and {0, 1,2} respectively.

If a UE is configured with both *dmrs-UplinkForPUSCH-MappingTypeA* and *dmrs-UplinkForPUSCH-MappingTypeB*, the bitwidth of this field equals $\max\{x_A, x_B\}$, where x_A is the "Antenna ports" bitwidth derived according to *dmrs-UplinkForPUSCH-MappingTypeA* and x_B is the "Antenna ports" bitwidth derived according to *dmrs-UplinkForPUSCH-MappingTypeB*. A number of $|x_A - x_B|$ zeros are padded in the MSB of this field, if the mapping type of the PUSCH corresponds to the smaller value of x_A and x_B.

- SRS request – 2 bits as defined by Table 7.3.1.1.2-24 for UEs not configured with SUL in the cell; 3 bits for UEs configured SUL in the cell where the first bit is the non-SUL/SUL indicator as defined in Table 7.3.1.1.1-1 and the second and third bits are defined by Table 7.3.1.1.2-24. This bit field may also indicate the associated CSI-RS according to Subclause 6.1.1.2 of [6, TS 38.214].
- CSI request – 0, 1, 2, 3, 4, 5, or 6 bits determined by higher layer parameter *reportTriggerSize*.
- CBG transmission information (CBGTI) – 0, 2, 4, 6, or 8 bits determined by higher layer parameter *maxCodeBlockGroupsPerTransportBlock* for PUSCH.
- PTRS-DMRS association – number of bits determined as follows
  - 0 bit if *PTRS-UplinkConfig* is not configured and *transformPrecoder=disabled*, or if *transformPrecoder=enabled*, or if *maxRank=1*;
  - 2 bits otherwise, where Table 7.3.1.1.2-25 and 7.3.1.1.2-26 are used to indicate the association between PTRS port(s) and DMRS port(s) for transmission of one PT-RS port and two PT-RS ports respectively, and the DMRS ports are indicated by the Antenna ports field.

If "Bandwidth part indicator" field indicates a bandwidth part other than the active bandwidth part and the "PTRS-DMRS association" field is present for the indicated bandwidth part but not present for the active bandwidth part, the UE assumes the "PTRS-DMRS association" field is not present for the indicated bandwidth part.

- beta_offset indicator – 0 if the higher layer parameter *betaOffsets = semiStatic*; otherwise 2 bits as defined by Table 9.3-3 in [5, TS 38.213].
- DMRS sequence initialization – 0 if the higher layer parameter *transformPrecoder=enabled*; 1 bit if the higher layer parameter *transformPrecoder=disabled* and both *scramblingID0* and *scramblingID1* are configured in *DMRS-UplinkConfig*, for n_{SCID} selection defined in Subclause 6.4.1.1.1.1 of [4, TS 38.211].
- UL-SCH indicator – 1 bit. A value of "1" indicates UL-SCH shall be transmitted on the PUSCH and a value of "0" indicates UL-SCH shall not be transmitted on the PUSCH.

For a UE configured with SUL in a cell, if PUSCH is configured to be transmitted on both the SUL and the non-SUL of the cell and if the number of information bits in format 0_1 for the SUL is not equal to the number of information bits in format 0_1 for the non-SUL, zeros shall be appended to smaller format 0_1 until the payload size equals that of the larger format 0_1.

Table 7.3.1.1.2-1: Bandwidth part indicator

Value of BWP indicator field 2 bits	Bandwidth part
00	First bandwidth part configured by higher layers
01	Second bandwidth part configured by higher layers
10	Third bandwidth part configured by higher layers
11	Fourth bandwidth part configured by higher layers

Table 7.3.1.1.2-2: Precoding information and number of layers, for 4 antenna ports, if *transformPrecoder=disabled* and *maxRank* = 2 or 3 or 4

Bit field mapped to index	*codebookSubset = fullyAndPartialAndNonCoherent*	Bit field mapped to index	*codebookSubset = partialAndNonCoherent*	Bit field mapped to index	*codebookSubset= nonCoherent*
0	1 layer: TPMI=0	0	1 layer: TPMI=0	0	1 layer: TPMI=0
1	1 layer: TPMI=1	1	1 layer: TPMI=1	1	1 layer: TPMI=1
…	…	…	…	…	…
3	1 layer: TPMI=3	3	1 layer: TPMI=3	3	1 layer: TPMI=3
4	2 layers: TPMI=0	4	2 layers: TPMI=0	4	2 layers: TPMI=0
…	…	…	…	…	…
9	2 layers: TPMI=5	9	2 layers: TPMI=5	9	2 layers: TPMI=5
10	3 layers: TPMI=0	10	3 layers: TPMI=0	10	3 layers: TPMI=0
11	4 layers: TPMI=0	11	4 layers: TPMI=0	11	4 layers: TPMI=0
12	1 layer: TPMI=4	12	1 layer: TPMI=4	12-15	reserved
…	…	…	…		
19	1 layer: TPMI=11	19	1 layer: TPMI=11		
20	2 layers: TPMI=6	20	2 layers: TPMI=6		
…	…	…	…		
27	2 layers: TPMI=13	27	2 layers: TPMI=13		
28	3 layers: TPMI=1	28	3 layers: TPMI=1		
29	3 layers: TPMI=2	29	3 layers: TPMI=2		
30	4 layers: TPMI=1	30	4 layers: TPMI=1		
31	4 layers: TPMI=2	31	4 layers: TPMI=2		
32	1 layers: TPMI=12				
…	…				
47	1 layers: TPMI=27				
48	2 layers: TPMI=14				
…	…				
55	2 layers: TPMI=21				
56	3 layers: TPMI=3				
…	…				
59	3 layers: TPMI=6				
60	4 layers: TPMI=3				
61	4 layers: TPMI=4				
62-63	reserved				

Table 7.3.1.1.2-3: Precoding information and number of layers for 4 antenna ports, if *transformPrecoder= enabled*, or if *transformPrecoder=disabled* and *maxRank* = 1

Bit field mapped to index	*codebookSubset = fullyAndPartialAndNonCoherent*	Bit field mapped to index	*codebookSubset= partialAndNonCoherent*	Bit field mapped to index	*codebookSubset= nonCoherent*
0	1 layer: TPMI=0	0	1 layer: TPMI=0	0	1 layer: TPMI=0
1	1 layer: TPMI=1	1	1 layer: TPMI=1	1	1 layer: TPMI=1
…	…	…	…	…	…
3	1 layer: TPMI=3	3	1 layer: TPMI=3	3	1 layer: TPMI=3
4	1 layer: TPMI=4	4	1 layer: TPMI=4		
…	…	…	…		
11	1 layer: TPMI=11	11	1 layer: TPMI=11		
12	1 layers: TPMI=12	12-15	reserved		
…	…				
27	1 layers: TPMI=27				
28-31	reserved				

Table 7.3.1.1.2-4: Precoding information and number of layers, for 2 antenna ports, if *transformPrecoder=disabled* and *maxRank* = 2

Bit field mapped to index	*codebookSubset = fullyAndPartialAndNonCoherent*	Bit field mapped to index	*codebookSubset = nonCoherent*
0	1 layer: TPMI=0	0	1 layer: TPMI=0
1	1 layer: TPMI=1	1	1 layer: TPMI=1
2	2 layers: TPMI=0	2	2 layers: TPMI=0
3	1 layer: TPMI=2	3	reserved
4	1 layer: TPMI=3		
5	1 layer: TPMI=4		
6	1 layer: TPMI=5		
7	2 layers: TPMI=1		
8	2 layers: TPMI=2		
9-15	reserved		

Table 7.3.1.1.2-5: Precoding information and number of layers, for 2 antenna ports, if *transformPrecoder= enabled*, or if *transformPrecoder= disabled* and *maxRank* = 1

Bit field mapped to index	*codebookSubset = fullyAndPartialAndNonCoherent*	Bit field mapped to index	*codebookSubset = nonCoherent*
0	1 layer: TPMI=0	0	1 layer: TPMI=0
1	1 layer: TPMI=1	1	1 layer: TPMI=1
2	1 layer: TPMI=2		
3	1 layer: TPMI=3		
4	1 layer: TPMI=4		
5	1 layer: TPMI=5		
6-7	reserved		

Table 7.3.1.1.2-6: Antenna port(s), *transformPrecoder=enabled*, *dmrs-Type*=1, *maxLength*=1

Value	Number of DMRS CDM group(s) without data	DMRS port(s)
0	2	0
1	2	1
2	2	2
3	2	3

Table 7.3.1.1.2-7: Antenna port(s), *transformPrecoder=enabled*, *dmrs-Type*=1, *maxLength*=2

Value	Number of DMRS CDM group(s) without data	DMRS port(s)	Number of front-load symbols
0	2	0	1
1	2	1	1
2	2	2	1
3	2	3	1
4	2	0	2
5	2	1	2
6	2	2	2
7	2	3	2
8	2	4	2
9	2	5	2
10	2	6	2
11	2	7	2
12-15	Reserved	Reserved	Reserved

Table 7.3.1.1.2-8: Antenna port(s), *transformPrecoder=disabled*, *dmrs-Type*=1, *maxLength*=1, rank = 1

Value	Number of DMRS CDM group(s) without data	DMRS port(s)
0	1	0
1	1	1
2	2	0
3	2	1
4	2	2
5	2	3
6-7	Reserved	Reserved

Table 7.3.1.1.2-9: Antenna port(s), *transformPrecoder=disabled*, *dmrs-Type*=1, *maxLength*=1, rank = 2

Value	Number of DMRS CDM group(s) without data	DMRS port(s)
0	1	0,1
1	2	0,1
2	2	2,3
3	2	0,2
4-7	Reserved	Reserved

Table 7.3.1.1.2-10: Antenna port(s), *transformPrecoder=disabled*, *dmrs-Type*=1, *maxLength*=1, rank = 3

Value	Number of DMRS CDM group(s) without data	DMRS port(s)
0	2	0-2
2-7	Reserved	Reserved

Table 7.3.1.1.2-11: Antenna port(s), *transformPrecoder=disabled*, *dmrs-Type*=1, *maxLength*=1, rank = 4

Value	Number of DMRS CDM group(s) without data	DMRS port(s)
0	2	0-3
2-7	Reserved	Reserved

Table 7.3.1.1.2-12: Antenna port(s), *transformPrecoder=disabled*, *dmrs-Type*=1, *maxLength*=2, rank = 1

Value	Number of DMRS CDM group(s) without data	DMRS port(s)	Number of front-load symbols
0	1	0	1
1	1	1	1
2	2	0	1
3	2	1	1
4	2	2	1
5	2	3	1
6	2	0	2
7	2	1	2
8	2	2	2
9	2	3	2
10	2	4	2
11	2	5	2
12	2	6	2
13	2	7	2
14-15	Reserved	Reserved	Reserved

Table 7.3.1.1.2-13: Antenna port(s), *transformPrecoder=disabled*, *dmrs-Type*=1, *maxLength*=2, rank = 2

Value	Number of DMRS CDM group(s) without data	DMRS port(s)	Number of front-load symbols
0	1	0,1	1
1	2	0,1	1
2	2	2,3	1
3	2	0,2	1
4	2	0,1	2
5	2	2,3	2
6	2	4,5	2
7	2	6,7	2
8	2	0,4	2
9	2	2,6	2
10-15	Reserved	Reserved	Reserved

Table 7.3.1.1.2-14: Antenna port(s), *transformPrecoder=disabled*, *dmrs-Type*=1, *maxLength*=2, rank = 3

Value	Number of DMRS CDM group(s) without data	DMRS port(s)	Number of front-load symbols
0	2	0-2	1
1	2	0,1,4	2
2	2	2,3,6	2
3-15	Reserved	Reserved	Reserved

Table 7.3.1.1.2-15: Antenna port(s), *transformPrecoder=disabled*, *dmrs-Type*=1, *maxLength*=2, rank = 4

Value	Number of DMRS CDM group(s) without data	DMRS port(s)	Number of front-load symbols
0	2	0-3	1
1	2	0,1,4,5	2
2	2	2,3,6,7	2
3	2	0,2,4,6	2
4-15	Reserved	Reserved	Reserved

Table 7.3.1.1.2-16: Antenna port(s), *transformPrecoder=disabled*, *dmrs-Type*=2, *maxLength*=1, rank=1

Value	Number of DMRS CDM group(s) without data	DMRS port(s)
0	1	0
1	1	1
2	2	0
3	2	1
4	2	2
5	2	3
6	3	0
7	3	1
8	3	2
9	3	3
10	3	4
11	3	5
12-15	Reserved	Reserved

Table 7.3.1.1.2-17: Antenna port(s), *transformPrecoder=disabled*, *dmrs-Type*=2, *maxLength*=1, rank=2

Value	Number of DMRS CDM group(s) without data	DMRS port(s)
0	1	0,1
1	2	0,1
2	2	2,3
3	3	0,1
4	3	2,3
5	3	4,5
6	2	0,2
7-15	Reserved	Reserved

Table 7.3.1.1.2-18: Antenna port(s), *transformPrecoder=disabled*, *dmrs-Type*=2, *maxLength*=1, rank =3

Value	Number of DMRS CDM group(s) without data	DMRS port(s)
0	2	0-2
1	3	0-2
2	3	3-5
3-15	Reserved	Reserved

Table 7.3.1.1.2-19: Antenna port(s), *transformPrecoder=disabled*, *dmrs-Type*=2, *maxLength*=1, rank =4

Value	Number of DMRS CDM group(s) without data	DMRS port(s)
0	2	0-3
1	3	0-3
2-15	Reserved	Reserved

Table 7.3.1.1.2-20: Antenna port(s), *transformPrecoder=disabled*, *dmrs-Type*=2, *maxLength*=2, rank=1

Value	Number of DMRS CDM group(s) without data	DMRS port(s)	Number of front-load symbols
0	1	0	1
1	1	1	1
2	2	0	1
3	2	1	1
4	2	2	1
5	2	3	1
6	3	0	1
7	3	1	1
8	3	2	1
9	3	3	1
10	3	4	1
11	3	5	1
12	3	0	2
13	3	1	2
14	3	2	2
15	3	3	2
16	3	4	2
17	3	5	2
18	3	6	2
19	3	7	2
20	3	8	2
21	3	9	2
22	3	10	2
23	3	11	2
24	1	0	2
25	1	1	2
26	1	6	2
27	1	7	2
28-31	Reserved	Reserved	Reserved

Table 7.3.1.1.2-21: Antenna port(s), *transformPrecoder=disabled*, *dmrs-Type*=2, *maxLength*=2, rank=2

Value	Number of DMRS CDM group(s) without data	DMRS port(s)	Number of front-load symbols
0	1	0,1	1
1	2	0,1	1
2	2	2,3	1
3	3	0,1	1
4	3	2,3	1
5	3	4,5	1
6	2	0,2	1
7	3	0,1	2
8	3	2,3	2
9	3	4,5	2
10	3	6,7	2
11	3	8,9	2
12	3	10,11	2
13	1	0,1	2
14	1	6,7	2
15	2	0,1	2
16	2	2,3	2
17	2	6,7	2
18	2	8,9	2
19-31	Reserved	Reserved	Reserved

Table 7.3.1.1.2-22: Antenna port(s), *transformPrecoder=disabled*, *dmrs-Type*=2, *maxLength*=2, rank=3

Value	Number of DMRS CDM group(s) without data	DMRS port(s)	Number of front-load symbols
0	2	0-2	1
1	3	0-2	1
2	3	3-5	1
3	3	0,1,6	2
4	3	2,3,8	2
5	3	4,5,10	2
6-31	Reserved	Reserved	Reserved

Table 7.3.1.1.2-23: Antenna port(s), *transformPrecoder=disabled*, *dmrs-Type*=2, *maxLength*=2, rank=4

Value	Number of DMRS CDM group(s) without data	DMRS port(s)	Number of front-load symbols
0	2	0-3	1
1	3	0-3	1
2	3	0,1,6,7	2
3	3	2,3,8,9	2
4	3	4,5,10,11	2
5-31	Reserved	Reserved	Reserved

Table 7.3.1.1.2-24: SRS request

Value of SRS request field	Triggered aperiodic SRS resource set(s)
00	No aperiodic SRS resource set triggered
01	SRS resource set(s) configured with higher layer parameter *aperiodicSRS-ResourceTrigger* set to 1
10	SRS resource set(s) configured with higher layer parameter *aperiodicSRS-ResourceTrigger* set to 2
11	SRS resource set(s) configured with higher layer parameter *aperiodicSRS-ResourceTrigger* set to 3

Table 7.3.1.1.2-25: PTRS-DMRS association for UL PTRS port 0

Value	DMRS port
0	0
1	1
2	2
3	3

Table 7.3.1.1.2-26: PTRS-DMRS association for UL PTRS ports 0 and 1

Value of MSB	DMRS port		Value of LSB	DMRS port
0	1st DMRS port which shares PTRS port 0		0	1st DMRS port which shares PRTS port 1
1	2nd DMRS port which shares PTRS port 0		1	2nd DMRS port which shares PTRS port 1

Table 7.3.1.1.2-27: void

Table 7.3.1.1.2-28: SRI indication for non-codebook based PUSCH transmission, $L_{\max}=1$

Bit field mapped to index	SRI(s), $N_{SRS}=2$	Bit field mapped to index	SRI(s), $N_{SRS}=3$	Bit field mapped to index	SRI(s), $N_{SRS}=4$
0	0	0	0	0	0
1	1	1	1	1	1
		2	2	2	2
		3	reserved	3	3

Table 7.3.1.1.2-29: SRI indication for non-codebook based PUSCH transmission, $L_{\max}=2$

Bit field mapped to index	SRI(s), $N_{SRS}=2$	Bit field mapped to index	SRI(s), $N_{SRS}=3$	Bit field mapped to index	SRI(s), $N_{SRS}=4$
0	0	0	0	0	0
1	1	1	1	1	1
2	0,1	2	2	2	2
3	reserved	3	0,1	3	3
		4	0,2	4	0,1
		5	1,2	5	0,2
		6-7	reserved	6	0,3
				7	1,2
				8	1,3
				9	2,3
				10-15	reserved

Table 7.3.1.1.2-30: SRI indication for non-codebook based PUSCH transmission, $L_{\max}=3$

Bit field mapped to index	SRI(s), $N_{SRS}=2$	Bit field mapped to index	SRI(s), $N_{SRS}=3$	Bit field mapped to index	SRI(s), $N_{SRS}=4$
0	0	0	0	0	0
1	1	1	1	1	1
2	0,1	2	2	2	2
3	reserved	3	0,1	3	3
		4	0,2	4	0,1
		5	1,2	5	0,2
		6	0,1,2	6	0,3
		7	reserved	7	1,2
				8	1,3
				9	2,3
				10	0,1,2
				11	0,1,3
				12	0,2,3
				13	1,2,3
				14-15	reserved

Table 7.3.1.1.2-31: SRI indication for non-codebook based PUSCH transmission, $L_{max} = 4$

Bit field mapped to index	SRI(s), $N_{SRS} = 2$	Bit field mapped to index	SRI(s), $N_{SRS} = 3$	Bit field mapped to index	SRI(s), $N_{SRS} = 4$
0	0	0	0	0	0
1	1	1	1	1	1
2	0,1	2	2	2	2
3	reserved	3	0,1	3	3
		4	0,2	4	0,1
		5	1,2	5	0,2
		6	0,1,2	6	0,3
		7	reserved	7	1,2
				8	1,3
				9	2,3
				10	0,1,2
				11	0,1,3
				12	0,2,3
				13	1,2,3
				14	0,1,2,3
				15	reserved

Table 7.3.1.1.2-32: SRI indication for codebook based PUSCH transmission

Bit field mapped to index	SRI(s), $N_{SRS} = 2$
0	0
1	1

Table 7.3.1.1.2-33: VRB-to-PRB mapping

Bit field mapped to index	VRB-to-PRB mapping
0	Non-interleaved
1	Interleaved

Table 7.3.1.1.2-34: Frequency hopping indication

Bit field mapped to index	**PUSCH frequency hopping**
0	Disabled
1	Enabled

7.3.1.2 DCI formats for scheduling of PDSCH

7.3.1.2.1 Format 1_0

DCI format 1_0 is used for the scheduling of PDSCH in one DL cell.

The following information is transmitted by means of the DCI format 1_0 with CRC scrambled by C-RNTI or CS-RNTI or new-RNTI:

- Identifier for DCI formats – 1 bits
  - The value of this bit field is always set to 1, indicating a DL DCI format
- Frequency domain resource assignment – $\lceil \log_2(N_{RB}^{DL,BWP}(N_{RB}^{DL,BWP}+1)/2) \rceil$ bits
  - $N_{RB}^{DL,BWP}$ is the size of the active DL bandwidth part in case DCI format 1_0 is monitored in the UE specific search space and satisfying

- the total number of different DCI sizes monitored per slot is no more than 4 for the cell, and
- the total number of different DCI sizes with C-RNTI monitored per slot is no more than 3 for the cell

otherwise, $N_{RB}^{DL,BWP}$ is the size of the initial DL bandwidth part.

If the CRC of the DCI format 1_0 is scrambled by C-RNTI and the "Frequency domain resource assignment" field are of all ones, the DCI format 1_0 is for random access procedure initiated by a PDCCH order, with all remaining fields set as follows:

- Random Access Preamble index – 6 bits according to *ra-PreambleIndex* in Subclause 5.1.2 of [8, TS38.321]
- UL/SUL indicator – 1 bit. If the value of the "Random Access Preamble index" is not all zeros and if the UE is configured with SUL in the cell, this field indicates which UL carrier in the cell to transmit the PRACH according to Table 7.3.1.1.1-1; otherwise, this field is reserved
- SS/PBCH index – 6 bits. If the value of the "Random Access Preamble index" is not all zeros, this field indicates the SS/PBCH that shall be used to determine the RACH occasion for the PRACH transmission; otherwise, this field is reserved.
- PRACH Mask index – 4 bits. If the value of the "Random Access Preamble index" is not all zeros, this field indicates the RACH occasion associated with the SS/PBCH indicated by "SS/PBCH index" for the PRACH transmission, according to Subclause 5.1.1 of [8, TS38.321]; otherwise, this field is reserved
- Reserved bits – 10 bits

Otherwise, all remaining fields are set as follows:

- Time domain resource assignment – 4 bits as defined in Subclause 5.1.2.1 of [6, TS 38.214]
- VRB-to-PRB mapping – 1 bit according to Table 7.3.1.1.2-33
- Modulation and coding scheme – 5 bits as defined in Subclause 5.1.3 of [6, TS 38.214]
- New data indicator – 1 bit
- Redundancy version – 2 bits as defined in Table 7.3.1.1.1-2
- HARQ process number – 4 bits
- Downlink assignment index – 2 bits as defined in Subclause 9.1.3 of [5, TS 38.213], as counter DAI
- TPC command for scheduled PUCCH – 2 bits as defined in Subclause 7.2.1 of [5, TS 38.213]
- PUCCH resource indicator – 3 bits as defined in Subclause 9.2.3 of [5, TS 38.213]
- PDSCH-to-HARQ_feedback timing indicator – 3 bits as defined in Subclause 9.2.3 of [5, TS38.213]

The following information is transmitted by means of the DCI format 1_0 with CRC scrambled by P-RNTI:

- Short Messages Indicator – 2 bits according to Table 7.3.1.2.1-1.
- Short Messages – [8] bits, according to Subclause x.x of [9, TS38.331]. If only the scheduling information for Paging is carried, this bit field is reserved.
- Frequency domain resource assignment – $\lceil \log_2(N_{RB}^{DL,BWP}(N_{RB}^{DL,BWP}+1)/2) \rceil$ bits. If only the short message is carried, this bit field is reserved.
  - $N_{RB}^{DL,BWP}$ is the size of the initial DL bandwidth part
- Time domain resource assignment – 4 bits as defined in Subclause 5.1.2.1 of [6, TS38.214]. If only the short message is carried, this bit field is reserved.

- VRB-to-PRB mapping – 1 bit according to Table 7.3.1.1.2-33. If only the short message is carried, this bit field is reserved.
- Modulation and coding scheme – 5 bits as defined in Subclause 5.1.3 of [6, TS38.214], using Table 5.1.3.1-1. If only the short message is carried, this bit field is reserved.
- TB scaling – 2 bits as defined in Subclause 5.1.3.2 of [6, TS38.214]. If only the short message is carried, this bit field is reserved.
- Reserved bits – 6 bits

The following information is transmitted by means of the DCI format 1_0 with CRC scrambled by SI-RNTI:

- Frequency domain resource assignment – $\lceil \log_2(N_{RB}^{DL,BWP}(N_{RB}^{DL,BWP}+1)/2) \rceil$ bits
  - $N_{RB}^{DL,BWP}$ is the size of the initial DL bandwidth part
- Time domain resource assignment – 4 bits as defined in Subclause 5.1.2.1 of [6, TS38.214]

[- VRB-to-PRB mapping – 1 bit according to Table 7.3.1.1.2-33]

- Modulation and coding scheme – 5 bits as defined in Subclause 5.1.3 of [6, TS38.214], using Table 5.1.3.1-1
- Redundancy version – 2 bits as defined in Table 7.3.1.1.1-2
- Reserved bits – [16] bits

The following information is transmitted by means of the DCI format 1_0 with CRC scrambled by RA-RNTI:

- Frequency domain resource assignment – $\lceil \log_2(N_{RB}^{DL,BWP}(N_{RB}^{DL,BWP}+1)/2) \rceil$ bits
  - $N_{RB}^{DL,BWP}$ is the size of the initial DL bandwidth part
- Time domain resource assignment – 4 bits as defined in Subclause 5.1.2.1 of [6, TS38.214]
- VRB-to-PRB mapping – 1 bit according to Table 7.3.1.1.2-33
- Modulation and coding scheme – 5 bits as defined in Subclause 5.1.3 of [6, TS38.214], using Table 5.1.3.1-1
- TB scaling – 2 bits as defined in Subclause 5.1.3.2 of [6, TS38.214]
- Reserved bits – 16 bits

The following information is transmitted by means of the DCI format 1_0 with CRC scrambled by TC-RNTI:

- Identifier for DCI formats – 1 bit
  - The value of this bit field is always set to 1, indicating a DL DCI format
- Frequency domain resource assignment – $\lceil \log_2(N_{RB}^{DL,BWP}(N_{RB}^{DL,BWP}+1)/2) \rceil$ bits
  - $N_{RB}^{DL,BWP}$ is the size of the initial DL bandwidth part
- Time domain resource assignment – 4 bits as defined in Subclause 5.1.2.1 of [6, TS38.214]
- VRB-to-PRB mapping – 1 bit according to Table 7.3.1.1.2-33
- Modulation and coding scheme – 5 bits as defined in Subclause 5.1.3 of [6, TS38.214], using Table 5.1.3.1-1
- New data indicator – 1 bit

- Redundancy version – 2 bits as defined in Table 7.3.1.1.1-2
- HARQ process number – 4 bits
- Downlink assignment index – 2 bits, reserved
- TPC command for scheduled PUCCH – 2 bits as defined in Subclause 7.2.1 of [5, TS38.213]
- PUCCH resource indicator – 3 bits as defined in Subclause 9.2.3 of [5, TS38.213]
- PDSCH-to-HARQ_feedback timing indicator – 3 bits as defined in Subclause 9.2.3 of [5, TS38.213]

If DCI format 1_0 is monitored in UE specific search space and satisfies both of the following

- the total number of different DCI sizes monitored per slot is no more than 4 for the cell, and
- the total number of different DCI sizes with C-RNTI monitored per slot is no more than 3 for the cell

and if the number of information bits in the DCI format 1_0 prior to padding is less than the payload size of the DCI format 0_0 monitored in UE specific search space for scheduling the same serving cell, zeros shall be appended to the DCI format 1_0 until the payload size equals that of the DCI format 0_0.

Table 7.3.1.2.1-1: Short Message indicator

Bit field	PUSCH frequency hopping
00	Reserved
01	Only scheduling information for Paging is present in the DCI
10	Only short message is present in the DCI
11	Both scheduling information for Paging and short message are present in the DCI

7.3.1.2.2 Format 1_1

DCI format 1_1 is used for the scheduling of PDSCH in one cell.

The following information is transmitted by means of the DCI format 1_1 with CRC scrambled by C-RNTI or CS-RNTI or new-RNTI:

- Identifier for DCI formats – 1 bits
  - The value of this bit field is always set to 1, indicating a DL DCI format
- Carrier indicator – 0 or 3 bits as defined in Subclause 10.1 of [5, TS 38.213].
- Bandwidth part indicator – 0, 1 or 2 bits as determined by the number of DL BWPs $n_{\text{BWP,RRC}}$ configured by higher layers, excluding the initial DL bandwidth part. The bitwidth for this field is determined as $\lceil \log_2(n_{\text{BWP}}) \rceil$ bits, where
  - $n_{\text{BWP}} = n_{\text{BWP,RRC}} + 1$ if $n_{\text{BWP,RRC}} \leq 3$, in which case the bandwidth part indicator is equivalent to the higher layer parameter *BWP-Id*;
  - otherwise $n_{\text{BWP}} = n_{\text{BWP,RRC}}$, in which case the bandwidth part indicator is defined in Table 7.3.1.1.2-1;

  If a UE does not support active BWP change via DCI, the UE ignores this bit field.
- Frequency domain resource assignment – number of bits determined by the following, where $N_{\text{RB}}^{\text{DL,BWP}}$ is the size of the active DL bandwidth part:
  - N_{RBG} bits if only resource allocation type 0 is configured, where N_{RBG} is defined in Subclause 5.1.2.2.1 of [6, TS38.214],
  - $\lceil \log_2(N_{\text{RB}}^{\text{DL,BWP}}(N_{\text{RB}}^{\text{DL,BWP}}+1)/2) \rceil$ bits if only resource allocation type 1 is configured, or

- $\max\left(\left\lceil \log_2\left(N_{RB}^{DL,BWP}\left(N_{RB}^{DL,BWP}+1\right)/2\right)\right\rceil, N_{RBG}\right)+1$ bits if both resource allocation type 0 and 1 are configured.
- If both resource allocation type 0 and 1 are configured, the MSB bit is used to indicate resource allocation type 0 or resource allocation type 1, where the bit value of 0 indicates resource allocation type 0 and the bit value of 1 indicates resource allocation type 1.
- For resource allocation type 0, the N_{RBG} LSBs provide the resource allocation as defined in Subclause 5.1.2.2.1 of [6, TS 38.214].
- For resource allocation type 1, the $\left\lceil \log_2\left(N_{RB}^{DL,BWP}\left(N_{RB}^{DL,BWP}+1\right)/2\right)\right\rceil$ LSBs provide the resource allocation as defined in Subclause 5.1.2.2.2 of [6, TS 38.214]

If "Bandwidth part indicator" field indicates a bandwidth part other than the active bandwidth part and if both resource allocation type 0 and 1 are configured for the indicated bandwidth part, the UE assumes resource allocation type 0 for the indicated bandwidth part if the bitwidth of the "Frequency domain resource assignment" field of the active bandwidth part is smaller than the bitwidth of the "Frequency domain resource assignment" field of the indicated bandwidth part.

- Time domain resource assignment – 0, 1, 2, 3, or 4 bits as defined in Subclause 5.1.2.1 of [6, TS 38.214]. The bitwidth for this field is determined as $\lceil \log_2(I) \rceil$ bits, where I is the number of entries in the higher layer parameter *pdsch-AllocationList*.
- VRB-to-PRB mapping – 0 or 1 bit:
  - 0 bit if only resource allocation type 0 is configured;
  - 1 bit according to Table 7.3.1.1.2-33 otherwise, only applicable to resource allocation type 1, as defined in Subclause 7.3.1.6 of [4, TS 38.211].
- PRB bundling size indicator – 0 bit if the higher layer parameter *prb-BundlingType* is not configured or is set to 'static', or 1 bit if the higher layer parameter *prb-BundlingType* is set to 'dynamic' according to Subclause 5.1.2.3 of [6, TS 38.214].
- Rate matching indicator – 0, 1, or 2 bits according to higher layer parameter *rateMatchPattern*.
- ZP CSI-RS trigger – 0, 1, or 2 bits as defined in Subclause 5.1.4.2 of [6, TS 38.214]. The bitwidth for this field is determined as $\lceil \log_2(n_{ZP}+1) \rceil$ bits, where n_{ZP} is the number of ZP CSI-RS resource sets in the higher layer parameter *zp-CSI-RS-Resource*.

For transport block 1:

- Modulation and coding scheme – 5 bits as defined in Subclause 5.1.3.1 of [6, TS 38.214]
- New data indicator – 1 bit
- Redundancy version – 2 bits as defined in Table 7.3.1.1.1-2

For transport block 2 (only present if *maxNrofCodeWordsScheduledByDCI* equals 2):

- Modulation and coding scheme – 5 bits as defined in Subclause 5.1.3.1 of [6, TS 38.214]
- New data indicator – 1 bit
- Redundancy version – 2 bits as defined in Table 7.3.1.1.1-2

If "Bandwidth part indicator" field indicates a bandwidth part other than the active bandwidth part and the value of *maxNrofCodeWordsScheduledByDCI* for the indicated bandwidth part equals 2 and the value of *maxNrofCodeWordsScheduledByDCI* for the active bandwidth part equals 1, the UE assumes zeros are padded when interpreting the "Modulation and coding scheme", "New data indicator", and "Redundancy version" fields of transport block 2 according to Subclause 12 of [5, TS38.213], and the UE ignores the "Modulation and coding scheme", "New data indicator", and "Redundancy version" fields of transport block 2 for the indicated bandwidth part.

- HARQ process number – 4 bits
- Downlink assignment index – number of bits as defined in the following
  - 4 bits if more than one serving cell are configured in the DL and the higher layer parameter *pdsch-HARQ-ACK-Codebook=dynamic*, where the 2 MSB bits are the counter DAI and the 2 LSB bits are the total DAI;
  - 2 bits if only one serving cell is configured in the DL and the higher layer parameter *pdsch-HARQ-ACK-Codebook=dynamic*, where the 2 bits are the counter DAI;
  - 0 bits otherwise.
- TPC command for scheduled PUCCH – 2 bits as defined in Subclause 7.2.1 of [5, TS 38.213]
- PUCCH resource indicator – 3 bits as defined in Subclause 9.2.3 of [5, TS 38.213]
- PDSCH-to-HARQ_feedback timing indicator – 0, 1, 2, or 3 bits as defined in Subclause 9.2.3 of [5, TS 38.213]. The bitwidth for this field is determined as $\lceil \log_2(I) \rceil$ bits, where I is the number of entries in the higher layer parameter *dl-DataToUL-ACK*.
- Antenna port(s) – 4, 5, or 6 bits as defined by Tables 7.3.1.2.2-1/2/3/4, where the number of CDM groups without data of values 1, 2, and 3 refers to CDM groups {0}, {0,1}, and {0, 1,2} respectively. The antenna ports $\{p_{0,\ldots,}p_{\upsilon-1}\}$ shall be determined according to the ordering of DMRS port(s) given by Tables 7.3.1.2.2-1/2/3/4.

  If a UE is configured with both *dmrs-DownlinkForPDSCH-MappingTypeA* and *dmrs-DownlinkForPDSCH-MappingTypeB*, the bitwidth of this field equals $\max\{x_A, x_B\}$, where x_A is the "Antenna ports" bitwidth derived according to *dmrs-DownlinkForPDSCH-MappingTypeA* and x_B is the "Antenna ports" bitwidth derived according to *dmrs-DownlinkForPDSCH-MappingTypeB*. A number of $|x_A - x_B|$ zeros are padded in the MSB of this field, if the mapping type of the PDSCH corresponds to the smaller value of x_A and x_B.
- Transmission configuration indication – 0 bit if higher layer parameter *tci-PresentInDCI* is not enabled; otherwise 3 bits as defined in Subclause 5.1.5 of [6, TS38.214].

  If "Bandwidth part indicator" field indicates a bandwidth part other than the active bandwidth part and the "Transmission configuration indication" field is not present in the DCI format 1_1, the UE assumes *tci-PresentInDCI* is not enabled for the indicated bandwidth part.
- SRS request – 2 bits as defined by Table 7.3.1.1.2-24 for UEs not configured with SUL in the cell; 3 bits for UEs configured SUL in the cell where the first bit is the non-SUL/SUL indicator as defined in Table 7.3.1.1.1-1 and the second and third bits are defined by Table 7.3.1.1.2-24. This bit field may also indicate the associated CSI-RS according to Subclause 6.1.1.2 of [6, TS 38.214].
- CBG transmission information (CBGTI) – 0, 2, 4, 6, or 8 bits as defined in Subclause 5.1.7 of [6, TS38.214], determined by the higher layer parameters *maxCodeBlockGroupsPerTransportBlock* and *Number-MCS-HARQ-DL-DCI* for the PDSCH.
- CBG flushing out information (CBGFI) – 0 or 1 bit as defined in Subclause 5.1.7 of [6, TS38.214], determined by higher layer parameter *codeBlockGroupFlushIndicator*.
- DMRS sequence initialization – 1 bit if both *scramblingID0* and *scramblingID1* are configured in *DMRS-DownlinkConfig* for n_{SCID} selection defined in Subclause 7.4.1.1.1 of [4, TS 38.211]; 0 bit otherwise.

If DCI formats 1_1 are monitored in multiple search spaces associated with multiple CORESETs in a BWP, zeros shall be appended until the payload size of the DCI formats 1_1 monitored in the multiple search spaces equal to the maximum payload size of the DCI format 1_1 monitored in the multiple search spaces.

Table 7.3.1.2.2-1: Antenna port(s) (1000 + DMRS port), *dmrs-Type*=1, *maxLength*=1

One Codeword: Codeword 0 enabled, Codeword 1 disabled		
Value	**Number of DMRS CDM group(s) without data**	**DMRS port(s)**
0	1	0
1	1	1
2	1	0,1
3	2	0
4	2	1
5	2	2
6	2	3
7	2	0,1
8	2	2,3
9	2	0-2
10	2	0-3
11	2	0,2
12-15	Reserved	Reserved

Table 7.3.1.2.2-2: Antenna port(s) (1000 + DMRS port), *dmrs-Type*=1, *maxLength*=2

One Codeword: Codeword 0 enabled, Codeword 1 disabled				Two Codewords: Codeword 0 enabled, Codeword 1 enabled			
Value	**Number of DMRS CDM group(s) without data**	**DMRS port(s)**	**Number of front-load symbols**	**Value**	**Number of DMRS CDM group(s) without data**	**DMRS port(s)**	**Number of front-load symbols**
0	1	0	1	0	2	0-4	2
1	1	1	1	1	2	0,1,2,3,4,6	2
2	1	0,1	1	2	2	0,1,2,3,4,5,6	2
3	2	0	1	3	2	0,1,2,3,4,5,6,7	2
4	2	1	1	4-31	reserved	reserved	reserved
5	2	2	1				
6	2	3	1				
7	2	0,1	1				
8	2	2,3	1				
9	2	0-2	1				
10	2	0-3	1				
11	2	0,2	1				
12	2	0	2				
13	2	1	2				
14	2	2	2				
15	2	3	2				
16	2	4	2				
17	2	5	2				
18	2	6	2				
19	2	7	2				
20	2	0,1	2				
21	2	2,3	2				
22	2	4,5	2				
23	2	6,7	2				
24	2	0,4	2				
25	2	2,6	2				
26	2	0,1,4	2				
27	2	2,3,6	2				
28	2	0,1,4,5	2				
29	2	2,3,6,7	2				
30	2	0,2,4,6	2				
31	Reserved	Reserved	Reserved				

Table 7.3.1.2.2-3: Antenna port(s) (1000 + DMRS port), *dmrs-Type*=2, *maxLength*=1

One codeword: Codeword 0 enabled, Codeword 1 disabled			Two codewords: Codeword 0 enabled, Codeword 1 enabled		
Value	**Number of DMRS CDM group(s) without data**	**DMRS port(s)**	**Value**	**Number of DMRS CDM group(s) without data**	**DMRS port(s)**
0	1	0	0	3	0-4
1	1	1	1	3	0-5
2	1	0,1	2-31	reserved	reserved
3	2	0			
4	2	1			
5	2	2			
6	2	3			
7	2	0,1			
8	2	2,3			
9	2	0-2			
10	2	0-3			
11	3	0			
12	3	1			
13	3	2			
14	3	3			
15	3	4			
16	3	5			
17	3	0,1			
18	3	2,3			
19	3	4,5			
20	3	0-2			
21	3	3-5			
22	3	0-3			
23	2	0,2			
24-31	Reserved	Reserved			

Table 7.3.1.2.2-4: Antenna port(s) (1000 + DMRS port), *dmrs-Type*=2, *maxLength*=2

One codeword: Codeword 0 enabled, Codeword 1 disabled				Two Codewords: Codeword 0 enabled, Codeword 1 enabled			
Value	Number of DMRS CDM group(s) without data	DMRS port(s)	Number of front-load symbols	Value	Number of DMRS CDM group(s) without data	DMRS port(s)	Number of front-load symbols
0	1	0	1	0	3	0-4	1
1	1	1	1	1	3	0-5	1
2	1	0,1	1	2	2	0,1,2,3,6	2
3	2	0	1	3	2	0,1,2,3,6,8	2
4	2	1	1	4	2	0,1,2,3,6,7,8	2
5	2	2	1	5	2	0,1,2,3,6,7,8,9	2
6	2	3	1	6-63	Reserved	Reserved	Reserved
7	2	0,1	1				
8	2	2,3	1				
9	2	0-2	1				
10	2	0-3	1				
11	3	0	1				
12	3	1	1				
13	3	2	1				
14	3	3	1				
15	3	4	1				
16	3	5	1				
17	3	0,1	1				
18	3	2,3	1				
19	3	4,5	1				
20	3	0-2	1				
21	3	3-5	1				
22	3	0-3	1				
23	2	0,2	1				
24	3	0	2				
25	3	1	2				
26	3	2	2				
27	3	3	2				
28	3	4	2				
29	3	5	2				
30	3	6	2				
31	3	7	2				
32	3	8	2				
33	3	9	2				
34	3	10	2				
35	3	11	2				
36	3	0,1	2				
37	3	2,3	2				
38	3	4,5	2				
39	3	6,7	2				
40	3	8,9	2				
41	3	10,11	2				
42	3	0,1,6	2				
43	3	2,3,8	2				
44	3	4,5,10	2				
45	3	0,1,6,7	2				
46	3	2,3,8,9	2				
47	3	4,5,10,11	2				
48	1	0	2				
49	1	1	2				
50	1	6	2				
51	1	7	2				
52	1	0,1	2				
53	1	6,7	2				
54	2	0,1	2				
55	2	2,3	2				
56	2	6,7	2				

57	2	8,9	2				
58-63	Reserved	Reserved	Reserved				

7.3.1.3 DCI formats for other purposes

7.3.1.3.1 Format 2_0

DCI format 2_0 is used for notifying the slot format.

The following information is transmitted by means of the DCI format 2_0 with CRC scrambled by SFI-RNTI:

- Slot format indicator 1, Slot format indicator 2, …, Slot format indicator *N*.

The size of DCI format 2_0 is configurable by higher layers up to 128 bits, according to Subclause 11.1.1 of [5, TS 38.213].

7.3.1.3.2 Format 2_1

DCI format 2_1 is used for notifying the PRB(s) and OFDM symbol(s) where UE may assume no transmission is intended for the UE.

The following information is transmitted by means of the DCI format 2_1 with CRC scrambled by INT-RNTI:

- Pre-emption indication 1, Pre-emption indication 2, …, Pre-emption indication *N*.

The size of DCI format 2_1 is configurable by higher layers up to 126 bits, according to Subclause 11.2 of [5, TS 38.213]. Each pre-emption indication is 14 bits.

7.3.1.3.3 Format 2_2

DCI format 2_2 is used for the transmission of TPC commands for PUCCH and PUSCH.

The following information is transmitted by means of the DCI format 2_2 with CRC scrambled by TPC-PUSCH-RNTI or TPC-PUCCH-RNTI:

- block number 1, block number 2,…, block number *N*

The parameter *tpc-PUSCH* or *tpc-PUCCH* provided by higher layers determines the index to the block number for an UL of a cell, with the following fields defined for each block:

- Closed loop indicator – 0 or 1 bit.
  - For DCI format 2_2 with TPC-PUSCH-RNTI, 0 bit if the UE is not configured with high layer parameter *twoPUSCH-PC-AdjustmentStates*, in which case UE assumes each block in the DCI format 2_2 is of 2 bits; 1 bit otherwise, in which case UE assumes each block in the DCI format 2_2 is of 3 bits;
  - For DCI format 2_2 with TPC-PUCCH-RNTI, 0 bit if the UE is not configured with high layer parameter *twoPUCCH-PC-AdjustmentStates*, in which case UE assumes each block in the DCI format 2_2 is of 2 bits; 1 bit otherwise, in which case UE assumes each block in the DCI format 2_2 is of 3 bits;
- TPC command –2 bits

If the number of information bits in format 2_2 is less than the payload size of format 0_0 as defined in the initial DL bandwidth part in the same serving cell, zeros shall be appended to format 2_2 until the payload size equals that of format 0_0 as defined in the initial DL bandwidth part in the same serving cell.

7.3.1.3.4 Format 2_3

DCI format 2_3 is used for the transmission of a group of TPC commands for SRS transmissions by one or more UEs. Along with a TPC command, a SRS request may also be transmitted.

The following information is transmitted by means of the DCI format 2_3 with CRC scrambled by TPC-SRS-RNTI:

- block number 1, block number 2, …, block number *B*

where the starting position of a block is determined by the parameter *startingBitOfFormat2-3* provided by higher layers for the UE configured with the block.

If the UE is configured with higher layer parameter *srs-TPC-PDCCH-Group* = *typeA* for an UL without PUCCH and PUSCH or an UL on which the SRS power control is not tied with PUSCH power control, one block is configured for the UE by higher layers, with the following fields defined for the block:

- SRS request – 0 or 2 bits. The presence of this field is according to the definition in Subclause 11.4 of [5, TS38.213]. If present, this field is interpreted as defined by Table 7.3.1.1.2-24.
- TPC command number 1, TPC command number 2, ..., TPC command number *N*, where each TPC command applies to a respective UL carrier provided by higher layer parameter *cc-IndexInOneCC-Set*

If the UE is configured with higher layer parameter *srs-TPC-PDCCH-Group* = *typeB* for an UL without PUCCH and PUSCH or an UL on which the SRS power control is not tied with PUSCH power control, one block or more blocks is configured for the UE by higher layers where each block applies to an UL carrier, with the following fields defined for each block:

- SRS request – 0 or 2 bits. The presence of this field is according to the definition in Subclause 11.4 of [5, TS38.213]. If present, this field is interpreted as defined by Table 7.3.1.1.2-24.
- TPC command –2 bits

If the number of information bits in format 2_3 is less than the payload size of format 0_0 as defined in the initial DL bandwidth part in the same serving cell, zeros shall be appended to format 2_3 until the payload size equals that of format 0_0 as defined in the initial DL bandwidth part in the same serving cell.

7.3.2 CRC attachment

Error detection is provided on DCI transmissions through a Cyclic Redundancy Check (CRC).

The entire payload is used to calculate the CRC parity bits. Denote the bits of the payload by $a_0, a_1, a_2, a_3, ..., a_{A-1}$, and the parity bits by $p_0, p_1, p_2, p_3, ..., p_{L-1}$, where A is the payload size and L is the number of parity bits. Let $a'_0, a'_1, a'_2, a'_3, ..., a'_{A+L-1}$ be a bit sequence such that $a'_i = 1$ for $i = 0,1,...,L-1$ and $a'_i = a_{i-L}$ for $i = L, L+1, ..., A+L-1$. The parity bits are computed with input bit sequence $a'_0, a'_1, a'_2, a'_3, ..., a'_{A+L-1}$ and attached according to Subclause 5.1 by setting L to 24 bits and using the generator polynomial $g_{\text{CRC24C}}(D)$. The output bit $b_0, b_1, b_2, b_3, ..., b_{K-1}$ is

$b_k = a_k$ for $k = 0,1,2,...,A-1$

$b_k = p_{k-A}$ for $k = A, A+1, A+2, ..., A+L-1$,

where $K = A + L$.

After attachment, the CRC parity bits are scrambled with the corresponding RNTI $x_{rnti,0}, x_{rnti,1}, ..., x_{rnti,15}$, where $x_{rnti,0}$ corresponds to the MSB of the RNTI, to form the sequence of bits $c_0, c_1, c_2, c_3, ..., c_{K-1}$. The relation between c_k and b_k is:

$c_k = b_k$ for k = 0, 1, 2, …, $A + 7$

$c_k = (b_k + x_{rnti,k-A-8}) \bmod 2$ for k = $A+8$, $A+9$, $A+10$, ..., $A+23$.

7.3.3 Channel coding

Information bits are delivered to the channel coding block. They are denoted by $c_0, c_1, c_2, c_3, ..., c_{K-1}$, where K is the number of bits, and they are encoded via Polar coding according to Subclause 5.3.1, by setting $n_{\max} = 9$, $I_{IL} = 1$, $n_{PC} = 0$, and $n_{PC}^{wm} = 0$.

After encoding the bits are denoted by $d_0, d_1, d_2, d_3, ..., d_{N-1}$, where N is the number of coded bits.

7.3.4 Rate matching

The input bit sequence to rate matching is $d_0, d_1, d_2, ..., d_{N-1}$.

Rate matching is performed according to Subclause 5.4.1 by setting $I_{BIL} = 0$.

The output bit sequence after rate matching is denoted as $f_0, f_1, f_2, ..., f_{E-1}$.

Annex <A> (informative): Change history

Change history							
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
2017-05	RAN1#89	R1-1707082				Draft skeleton	0.0.0
2017-07	AH_NR2	R1-1712014				Inclusion of LDPC related agreements	0.0.1
2017-08	RAN1#90	R1-1714564				Inclusion of Polar coding related agreements	0.0.2
2017-08	RAN1#90	R1-1714659				Endorsed version by RAN1#90 as basis for further updates	0.1.0
2017-09	RAN1#90	R1-1715322				Capturing additional agreements on LDPC and Polar code from RAN1 #90	0.1.1
2017-09	RAN#77	RP-171991				For information to plenary	1.0.0
2017-09	RAN1#90b	R1-1716928				Capturing additional agreements on LDPC and Polar code from RAN1 NR AH#3	1.0.1
2017-10	RAN1#90b	R1-1719106				Endorsed as v1.1.0	1.1.0
2017-11	RAN1#91	R1-1719225				Capturing additional agreements on channel coding, etc.	1.1.1
2017-11	RAN1#91	R1-1719245				Capturing additional agreements on DCI format, channel coding, etc.	1.1.2
2017-11	RAN1#91	R1-1721049				Endorsed as v1.2.0	1.2.0
2017-12	RAN1#91	R1-1721342				Capturing additional agreements on UCI, DCI, channel coding, etc.	1.2.1
2017-12	RAN#78	RP-172668				Endorsed version for approval by plenary.	2.0.0
2017-12	RAN#78					Approved by plenary – Rel-15 spec under change control	15.0.0
2018-03	RAN#79	RP-180200	0001	-	F	CR capturing the Jan18 ad-hoc and RAN1#92 meeting agreements	15.1.0
2018-04	RAN#79					MCC: correction of typo in DCI format 0_1 (time domain resource assignment) – higher layer parameter should be *pusch-AllocationList*	15.1.1
2018-06	RAN#80	RP-181172	0002	1	F	CR to 38.212 capturing the RAN1#92bis and RAN1#93 meeting agreements	15.2.0
2018-06	RAN#80	RP-181257	0003	-	B	CR to 38.212 capturing the RAN1#92bis and RAN1#93 meeting agreements related to URLLC	15.2.0

History

Document history		
V15.2.0	July 2018	Publication

EXHIBIT P

ETSI TS 138 321 V15.2.0 (2018-09)

5G;
NR;
Medium Access Control (MAC) protocol specification
(3GPP TS 38.321 version 15.2.0 Release 15)

Reference
RTS/TSGR-0238321vf20

Keywords
5G

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Important notice

The present document can be downloaded from:
http://www.etsi.org/standards-search

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the only prevailing document is the print of the Portable Document Format (PDF) version kept on a specific network drive within ETSI Secretariat.

Users of the present document should be aware that the document may be subject to revision or change of status.
Information on the current status of this and other ETSI documents is available at
https://portal.etsi.org/TB/ETSIDeliverableStatus.aspx

If you find errors in the present document, please send your comment to one of the following services:
https://portal.etsi.org/People/CommiteeSupportStaff.aspx

Copyright Notification

No part may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm except as authorized by written permission of ETSI.
The content of the PDF version shall not be modified without the written authorization of ETSI.
The copyright and the foregoing restriction extend to reproduction in all media.

© ETSI 2018.
All rights reserved.

DECT™, **PLUGTESTS**™, **UMTS**™ and the ETSI logo are trademarks of ETSI registered for the benefit of its Members.
3GPP™ and **LTE**™ are trademarks of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners.
oneM2M logo is protected for the benefit of its Members.
GSM® and the GSM logo are trademarks registered and owned by the GSM Association.

Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (https://ipr.etsi.org/).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

Foreword

This Technical Specification (TS) has been produced by ETSI 3rd Generation Partnership Project (3GPP).

The present document may refer to technical specifications or reports using their 3GPP identities, UMTS identities or GSM identities. These should be interpreted as being references to the corresponding ETSI deliverables.

The cross reference between GSM, UMTS, 3GPP and ETSI identities can be found under http://webapp.etsi.org/key/queryform.asp.

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

Contents

Intellectual Property Rights 2
Foreword 2
Modal verbs terminology 2
Foreword 6
1 Scope 7
2 References 7
3 Definitions, symbols and abbreviations 7
3.1 Definitions 7
3.2 Abbreviations 8
4 General 8
4.1 Introduction 8
4.2 MAC architecture 9
4.2.1 General 9
4.2.2 MAC Entities 9
4.3 Services 10
4.3.1 Services provided to upper layers 10
4.3.2 Services expected from physical layer 11
4.4 Functions 11
4.5 Channel structure 11
4.5.1 General 11
4.5.2 Transport Channels 11
4.5.3 Logical Channels 12
4.5.4 Mapping of Transport Channels to Logical Channels 12
4.5.4.1 General 12
4.5.4.2 Uplink mapping 12
4.5.4.3 Downlink mapping 12
5 MAC procedures 12
5.1 Random Access procedure 12
5.1.1 Random Access procedure initialization 12
5.1.2 Random Access Resource selection 15
5.1.3 Random Access Preamble transmission 17
5.1.4 Random Access Response reception 18
5.1.5 Contention Resolution 20
5.1.6 Completion of the Random Access procedure 21
5.2 Maintenance of Uplink Time Alignment 21
5.3 DL-SCH data transfer 22
5.3.1 DL Assignment reception 22
5.3.2 HARQ operation 24
5.3.2.1 HARQ Entity 24
5.3.2.2 HARQ process 24
5.3.3 Disassembly and demultiplexing 25
5.4 UL-SCH data transfer 25
5.4.1 UL Grant reception 25
5.4.2 HARQ operation 27
5.4.2.1 HARQ Entity 27
5.4.2.2 HARQ process 28
5.4.3 Multiplexing and assembly 29
5.4.3.1 Logical channel prioritization 29
5.4.3.1.1 General 29
5.4.3.1.2 Selection of logical channels 29
5.4.3.1.3 Allocation of resources 30
5.4.3.2 Multiplexing of MAC Control Elements and MAC SDUs 31
5.4.4 Scheduling Request 31
5.4.5 Buffer Status Reporting 32

5.4.6 Power Headroom Reporting 34
5.5 PCH reception 36
5.6 BCH reception 36
5.7 Discontinuous Reception (DRX) 36
5.8 Transmission and reception without dynamic scheduling 38
5.8.1 Downlink 38
5.8.2 Uplink 39
5.9 Activation/Deactivation of SCells 40
5.10 Activation/Deactivation of PDCP duplication 41
5.11 MAC reconfiguration 41
5.12 MAC Reset 42
5.13 Handling of unknown, unforeseen and erroneous protocol data 42
5.14 Handling of measurement gaps 42
5.15 Bandwidth Part (BWP) operation 43
5.16 SUL operation 45
5.17 Beam Failure Detection and Recovery procedure 45
5.18 Handling of MAC CEs 46
5.18.1 General 46
5.18.2 Activation/Deactivation of Semi-persistent CSI-RS/CSI-IM resource set 46
5.18.3 Aperiodic CSI Trigger State subselection 46
5.18.4 Activation/Deactivation of UE-specific PDSCH TCI state 47
5.18.5 Indication of TCI state for UE-specific PDCCH 47
5.18.6 Activation/Deactivation of Semi-persistent CSI reporting on PUCCH 47
5.18.7 Activation/Deactivation of Semi-persistent SRS 47
5.18.8 Activation/Deactivation of spatial relation of PUCCH resource 47
5.18.9 Activation/Deactivation of semi-persistent ZP CSI-RS resource set 48
5.18.10 Recommended Bit Rate 48

6 Protocol Data Units, formats and parameters 48
6.1 Protocol Data Units 48
6.1.1 General 48
6.1.2 MAC PDU (DL-SCH and UL-SCH except transparent MAC and Random Access Response) 49
6.1.3 MAC Control Elements (CEs) 50
6.1.3.1 Buffer Status Report MAC CEs 50
6.1.3.2 C-RNTI MAC CE 54
6.1.3.3 UE Contention Resolution Identity MAC CE 54
6.1.3.4 Timing Advance Command MAC CE 54
6.1.3.5 DRX Command MAC CE 55
6.1.3.6 Long DRX Command MAC CE 55
6.1.3.7 Configured Grant Confirmation MAC CE 55
6.1.3.8 Single Entry PHR MAC CE 55
6.1.3.9 Multiple Entry PHR MAC CE 56
6.1.3.10 SCell Activation/Deactivation MAC CEs 58
6.1.3.11 Duplication Activation/Deactivation MAC CE 59
6.1.3.12 SP CSI-RS / CSI-IM Resource Set Activation/Deactivation MAC CE 59
6.1.3.13 Aperiodic CSI Trigger State Subselection MAC CE 60
6.1.3.14 TCI States Activation/Deactivation for UE-specific PDSCH MAC CE 61
6.1.3.15 TCI State Indication for UE-specific PDCCH MAC CE 61
6.1.3.16 SP CSI reporting on PUCCH Activation/Deactivation MAC CE 62
6.1.3.17 SP SRS Activation/Deactivation MAC CE 62
6.1.3.18 PUCCH spatial relation Activation/Deactivation MAC CE 64
6.1.3.19 SP ZP CSI-RS Resource Set Activation/Deactivation MAC CE 64
6.1.3.20 Recommended bit rate MAC CE 65
6.1.4 MAC PDU (transparent MAC) 66
6.1.5 MAC PDU (Random Access Response) 66
6.2 Formats and parameters 67
6.2.1 MAC subheader for DL-SCH and UL-SCH 67
6.2.2 MAC subheader for Random Access Response 68
6.2.3 MAC payload for Random Access Response 69

7 Variables and constants 69
7.1 RNTI values 69

7.2 Backoff Parameter values 70
7.3 DELTA_PREAMBLE values 71
7.4 PRACH Mask Index values 71

Annex A (informative): Change history 72

History 73

Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

- x the first digit:
  - 1 presented to TSG for information;
  - 2 presented to TSG for approval;
  - 3 or greater indicates TSG approved document under change control.
- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The present document specifies the NR MAC protocol.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 38.300: "NR; Overall description; Stage 2".

[3] 3GPP TS 38.322: "NR; Radio Link Control (RLC) protocol specification".

[4] 3GPP TS 38.323: "NR; Packet Data Convergence Protocol (PDCP) protocol specification".

[5] 3GPP TS 38.331: "NR; Radio Resource Control (RRC); Protocol specification".

[6] 3GPP TS 38.213: "NR; Physical Layer Procedures for control".

[7] 3GPP TS 38.214: "NR; Physical Layer Procedures for data".

[8] 3GPP TS 38.211: "NR; Physical channels and modulation".

[9] 3GPP TS 38.212: "NR; Multiplexing and channel coding".

[10] 3GPP TS 38.101: "NR; User Equipment (UE) radio transmission and reception".

[11] 3GPP TS 38.133: "NR; Requirements for support of radio resource management".

[12] 3GPP TS 36.133: "Evolved Universal Terrestrial Radio Access (E-UTRA); Requirements for support of radio resource management".

[13] 3GPP TS 26.114: "Technical Specification Group Services and System Aspects; IP Multimedia Subsystem (IMS); Multimedia Telephony; Media handling and interaction"

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

HARQ information: HARQ information for DL-SCH or for UL-SCH transmissions consists of New Data Indicator (NDI), Transport Block size (TBS), Redundancy Version (RV), and HARQ process ID.

Msg3: Message transmitted on UL-SCH containing a C-RNTI MAC CE or CCCH SDU, submitted from upper layer and associated with the UE Contention Resolution Identity, as part of a random access procedure.

PDCCH occasion: A time duration (i.e. one or a consecutive number of symbols) during which the MAC entity is configured to monitor the PDCCH.

Serving Cell: A PCell, a PSCell, or an SCell in TS 38.331 [5].

Special Cell: For Dual Connectivity operation the term Special Cell refers to the PCell of the MCG or the PSCell of the SCG depending on if the MAC entity is associated to the MCG or the SCG, respectively. Otherwise the term Special Cell refers to the PCell. A Special Cell supports PUCCH transmission and contention-based Random Access, and is always activated.

Timing Advance Group: A group of Serving Cells that is configured by RRC and that, for the cells with a UL configured, using the same timing reference cell and the same Timing Advance value. A Timing Advance Group containing the SpCell of a MAC entity is referred to as Primary Timing Advance Group (PTAG), whereas the term Secondary Timing Advance Group (STAG) refers to other TAGs.

NOTE: A timer is running once it is started, until it is stopped or until it expires; otherwise it is not running. A timer can be started if it is not running or restarted if it is running. A Timer is always started or restarted from its initial value.

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

BSR	Buffer Status Report
BWP	Bandwidth Part
CE	Control Element
CSI	Channel State Information
CSI-IM	CSI Intereference Measurement
CSI-RS	CSI Reference Signal
CS-RNTI	Configured Scheduling RNTI
INT-RNTI	Interruption RNTI
LCG	Logical Channel Group
MCG	Master Cell Group
NUL	Normal Uplink
NZP CSI-RS	Non-Zero Power CSI-RS
PHR	Power Headroom Report
PTAG	Primary Timing Advance Group
QCL	Quasi co-location
RS	Reference Signal
SCG	Secondary Cell Group
SFI-RNTI	Slot Format Indication RNTI
SI	System Information
SpCell	Special Cell
SP	Semi-Persistent
SP-CSI-RNTI	Semi-Persistent CSI RNTI
SPS	Semi-Persistent Scheduling
SR	Scheduling Request
SS	Synchronization Signals
SSB	Synchronization Signal Block
STAG	Secondary Timing Advance Group
SUL	Supplementary Uplink
TAG	Timing Advance Group
TCI	Transmission Configuration Indicator
TPC-SRS-RNTI	Transmit Power Control-Sounding Reference Symbols-RNTI
ZP CSI-RS	Zero Power CSI-RS

4 General

4.1 Introduction

The objective of this section is to describe the MAC architecture and the MAC entity of the UE from a functional point of view.

4.2 MAC architecture

4.2.1 General

This subclause describes a model of the MAC i.e. it does not specify or restrict implementations.

RRC is in control of the MAC configuration.

4.2.2 MAC Entities

The MAC entity of the UE handles the following transport channels:

- Broadcast Channel (BCH);
- Downlink Shared Channel(s) (DL-SCH);
- Paging Channel (PCH);
- Uplink Shared Channel(s) (UL-SCH);
- Random Access Channel(s) (RACH).

When the UE is configured with SCG, two MAC entities are configured to the UE: one for the MCG and one for the SCG.

The functions of the different MAC entities in the UE operate independently unless otherwise specified. The timers and parameters used in each MAC entity are configured independently unless otherwise specified. The Serving Cells, C-RNTI, radio bearers, logical channels, upper and lower layer entities, LCGs, and HARQ entities considered by each MAC entity refer to those mapped to that MAC entity unless otherwise specified.

If the MAC entity is configured with one or more SCells, there are multiple DL-SCH and there may be multiple UL-SCH as well as multiple RACH per MAC entity; one DL-SCH, one UL-SCH, and one RACH on the SpCell, one DL-SCH, zero or one UL-SCH and zero or one RACH for each SCell.

If the MAC entity is not configured with any SCell, there is one DL-SCH, one UL-SCH, and one RACH per MAC entity.

Figure 4.2.2-1 illustrates one possible structure of the MAC entity when SCG is not configured.

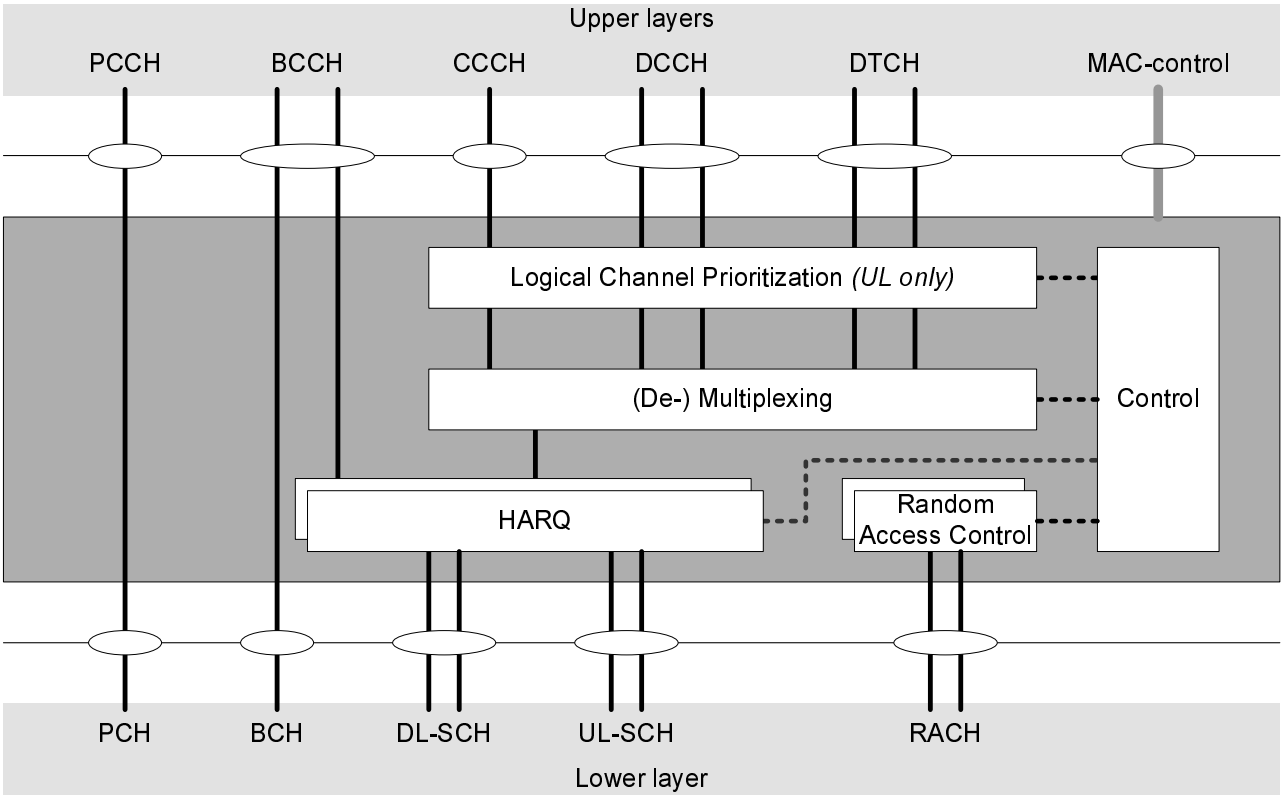


Figure 4.2.2-1: MAC structure overview

Figure 4.2.2-2 illustrates one possible structure for the MAC entities when MCG and SCG are configured.

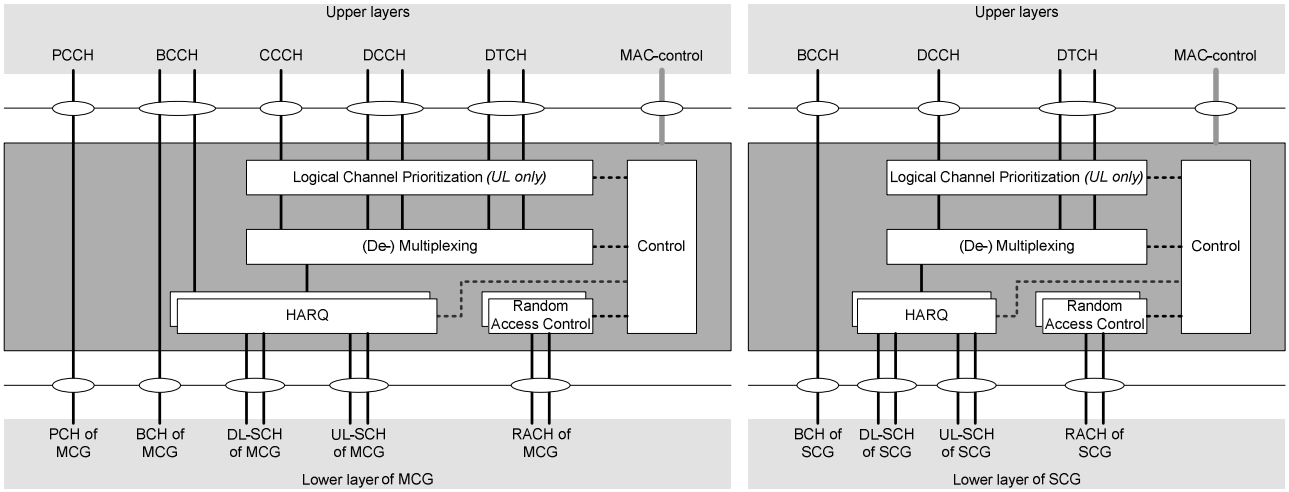


Figure 4.2.2-2: MAC structure overview with two MAC entities

4.3 Services

4.3.1 Services provided to upper layers

The MAC sublayer provides the following services to upper layers:

- data transfer;
- radio resource allocation.

4.3.2 Services expected from physical layer

The MAC sublayer expects the following services from the physical layer:

- data transfer services;
- signalling of HARQ feedback;
- signalling of Scheduling Request;
- measurements (e.g. Channel Quality Indication (CQI)).

4.4 Functions

The MAC sublayer supports the following functions:

- mapping between logical channels and transport channels;
- multiplexing of MAC SDUs from one or different logical channels onto transport blocks (TB) to be delivered to the physical layer on transport channels;
- demultiplexing of MAC SDUs to one or different logical channels from transport blocks (TB) delivered from the physical layer on transport channels;
- scheduling information reporting;
- error correction through HARQ;
- logical channel prioritisation.

The relevance of MAC functions for uplink and downlink is indicated in Table 4.4-1.

Table 4.4-1: The link direction association of MAC functions.

MAC function	Downlink	Uplink
Mapping between logical channels and transport channels	X	X
Multiplexing		X
Demultiplexing	X	
Scheduling information reporting		X
Error correction through HARQ	X	X
Logical Channel prioritisation		X

4.5 Channel structure

4.5.1 General

The MAC sublayer operates on the channels defined below; transport channels are SAPs between MAC and Layer 1, logical channels are SAPs between MAC and RLC.

4.5.2 Transport Channels

The MAC sublayer uses the transport channels listed in Table 4.5.2-1 below.

Table 4.5.2-1: Transport channels used by MAC

Transport channel name	Acronym	Downlink	Uplink
Broadcast Channel	BCH	X	
Downlink Shared Channel	DL-SCH	X	
Paging Channel	PCH	X	
Uplink Shared Channel	UL-SCH		X
Random Access Channel	RACH		X

4.5.3 Logical Channels

The MAC sublayer provides data transfer services on logical channels. To accommodate different kinds of data transfer services, multiple types of logical channels are defined i.e. each supporting transfer of a particular type of information.

Each logical channel type is defined by what type of information is transferred.

The MAC sublayer provides the control and traffic channels listed in Table 4.5.3-1 below.

Table 4.5.3-1: Logical channels provided by MAC.

Logical channel name	Acronym	Control channel	Traffic channel
Broadcast Control Channel	BCCH	X	
Paging Control Channel	PCCH	X	
Common Control Channel	CCCH	X	
Dedicated Control Channel	DCCH	X	
Dedicated Traffic Channel	DTCH		X

4.5.4 Mapping of Transport Channels to Logical Channels

4.5.4.1 General

Both for uplink and downlink, the MAC entity is responsible for mapping logical channels onto transport channels. This mapping depends on the multiplexing that is configured by RRC.

4.5.4.2 Uplink mapping

The uplink logical channels can be mapped as described in Table 4.5.4.2-1.

Table 4.5.4.2-1: Uplink channel mapping.

Transport channel / Logical channel	UL-SCH	RACH
CCCH	X	
DCCH	X	
DTCH	X	

4.5.4.3 Downlink mapping

The downlink logical channels can be mapped as described in Table 4.5.4.3-1.

Table 4.5.4.3-1: Downlink channel mapping.

Transport channel / Logical channel	BCH	PCH	DL-SCH
BCCH	X		X
PCCH		X	
CCCH			X
DCCH			X
DTCH			X

5 MAC procedures

5.1 Random Access procedure

5.1.1 Random Access procedure initialization

The Random Access procedure described in this subclause is initiated by a PDCCH order, by the MAC entity itself, or by RRC for the events in accordance with TS 38.300 [2]. There is only one Random Access procedure ongoing at any

point in time in a MAC entity. The Random Access procedure on an SCell shall only be initiated by a PDCCH order with *ra-PreambleIndex* different from 0b000000.

NOTE 1: If the MAC entity receives a request for a new Random Access procedure while another is already ongoing in the MAC entity, it is up to UE implementation whether to continue with the ongoing procedure or start with the new procedure (e.g. for SI request).

RRC configures the following parameters for the Random Access procedure:

- *prach-ConfigIndex*: the available set of PRACH occasions for the transmission of the Random Access Preamble;
- *preambleReceivedTargetPower*: initial Random Access Preamble power;
- *rsrp-ThresholdSSB*: an RSRP threshold for the selection of the SSB and corresponding Random Access Preamble and/or PRACH occasion. If the Random Access procedure is initiated for beam failure recovery, *rsrp-ThresholdSSB* refers to *rsrp-ThresholdSSB* in *BeamFailureRecoveryConfig* IE;
- *rsrp-ThresholdCSI-RS*: an RSRP threshold for the selection of CSI-RS and corresponding Random Access Preamble and/or PRACH occasion. If the Random Access procedure is initiated for beam failure recovery, *rsrp-ThresholdCSI-RS* shall be set to a value calculated by multiplying *rsrp-ThresholdSSB* in *BeamFailureRecoveryConfig* IE by *powerControlOffset* as specified in TS 38.214 [6];
- *rsrp-ThresholdSSB-SUL*: an RSRP threshold for the selection between the NUL carrier and the SUL carrier;
- *powerControlOffset*: a power offset between *rsrp-ThresholdSSB* and *rsrp-ThresholdCSI-RS* to be used when the Random Access procedure is initiated for beam failure recovery;
- *powerRampingStep*: the power-ramping factor;
- *powerRampingStepHighPriority*: the power-ramping factor in case of differentiated Random Access procedure;
- *scalingFactorBI*: a scaling factor for differentiated Random Access procedure;
- *ra-PreambleIndex*: Random Access Preamble;
- *ra-ssb-OccasionMaskIndex*: defines PRACH occasion(s) associated with an SSB in which the MAC entity may transmit a Random Access Preamble (see subclause 7.4);
- *ra-OccasionList*: defines PRACH occasion(s) associated with a CSI-RS in which the MAC entity may transmit a Random Access Preamble;
- *preambleTransMax*: the maximum number of Random Access Preamble transmission;
- *ssb-perRACH-OccasionAndCB-PreamblesPerSSB* (SpCell only): defines the number of SSBs mapped to each PRACH occasion and the number of Random Access Preambles mapped to each SSB;
- if *groupBconfigured* is configured, then Random Access Preambles group B is configured.
  - The Random Access Preambles in Random Access Preamble group A are the Random Access Preambles 0 to *numberOfRA-PreamblesGroupA* – 1, if Random Access Preambles group B is configured; Otherwise, the Random Access Preambles in Random Access Preamble group A are the Random Access Preambles 0 to the number of Random Access Preamles per SSB configured by *ssb-perRACH-OccasionAndCB-PreamblesPerSSB*;
  - The Random Access Preambles in Random Access Preamble group B, if configured, are the Random Access Preambles *numberOfRA-PreamblesGroupA* to the number of Random Access Preamles per SSB configured by *ssb-perRACH-OccasionAndCB-PreamblesPerSSB*.

NOTE 2: If Random Access Preambles group B is supported by the cell and SSBs are mapped to Random Access Preambles, Random Access Preambles group B is included in each SSB.

- if Random Access Preambles group B is configured:
  - *ra-Msg3SizeGroupA* (per cell): the threshold to determine the groups of Random Access Preambles;
  - *msg3-DeltaPreamble*: $\Delta_{PREAMBLE_Msg3}$ in TS 38.213 [6];

- *messagePowerOffsetGroupB*: the power offset for preamble selection;
- *numberOfRA-PreamblesGroupA* (SpCell only): defines the number of Random Access Preambles in Random Access Preamble group A for each SSB.

- the set of Random Access Preambles and/or PRACH occasions for SI request, if any;
- the set of Random Access Preambles and/or PRACH occasions for beam failure recovery request, if any;
- *ra-ResponseWindow*: the time window to monitor RA response(s) (SpCell only);
- *ra-ContentionResolutionTimer*: the Contention Resolution Timer (SpCell only).

In addition, the following information for related Serving Cell is assumed to be available for UEs:

- if Random Access Preambles group B is configured:
  - if the Serving Cell for the Random Access procedure is configured with *supplementaryUplink*, and SUL carrier is selected for performing Random Access Procedure:
    - $P_{CMAX,f,c}$ of the SUL carrier as specified in TS 38.101 [10].
  - else:
    - $P_{CMAX,f,c}$ of the NUL carrier as specified in TS 38.101 [10].

The following UE variables are used for the Random Access procedure:

- *PREAMBLE_INDEX*;
- *PREAMBLE_TRANSMISSION_COUNTER*;
- *PREAMBLE_POWER_RAMPING_COUNTER*;
- *PREAMBLE_POWER_RAMPING_STEP*;
- *PREAMBLE_RECEIVED_TARGET_POWER*;
- *PREAMBLE_BACKOFF*;
- *PCMAX*;
- *SCALING_FACTOR_BI*;
- *TEMPORARY_C-RNTI*.

When the Random Access procedure is initiated on a Serving Cell, the MAC entity shall:

1> flush the Msg3 buffer;

1> set the *PREAMBLE_TRANSMISSION_COUNTER* to 1;

1> set the *PREAMBLE_POWER_RAMPING_COUNTER* to 1;

1> set the *PREAMBLE_BACKOFF* to 0 ms;

1> if the carrier to use for the Random Access procedure is explicitly signalled:

2> select the signalled carrier for performing Random Access procedure;

2> set the *PCMAX* to $P_{CMAX,f,c}$ of the signalled carrier.

1> else if the carrier to use for the Random Access procedure is not explicitly signalled; and

1> if the Serving Cell for the Random Access procedure is configured with *supplementaryUplink*; and

1> if the RSRP of the downlink pathloss reference is less than *rsrp-ThresholdSSB-SUL*:

2> select the SUL carrier for performing Random Access procedure;

2> set the *PCMAX* to $P_{CMAX,f,c}$ of the SUL carrier.

1> else:

2> select the NUL carrier for performing Random Access procedure;

2> set the *PCMAX* to $P_{CMAX,f,c}$ of the NUL carrier.

1> set *PREAMBLE_POWER_RAMPING_STEP* to *preamblePowerRampingStep*;

1> if *powerRampingStepHighPriority* is configured:

2> if the Random Access procedure was initiated for beam failure recovery (as specified in subclause 5.1.7); or

2> if the Random Access procedure was initiated for handover:

3> set the *PREAMBLE_POWER_RAMPING_STEP* to *powerRampingStepHighPriority*;

1> set *SCALING_FACTOR_BI* to 1;

1> if *scalingFactorBI* is configured:

2> if the Random Access procedure was initiated for beam failure recovery (as specified in subclause 5.1.7); or

2> if the Random Access procedure was initiated for handover:

3> set the *SCALING_FACTOR_BI* to *scalingFactorBI*;

1> perform the Random Access Resource selection procedure (see subclause 5.1.2).

5.1.2 Random Access Resource selection

The MAC entity shall:

1> if the Random Access procedure was initiated for beam failure recovery (as specified in subclause 5.17); and

1> if the *beamFailureRecoveryTimer* (in subclause 5.17) is either running or not configured; and

1> if the contention-free Random Access Resources for beam failure recovery request associated with any of the SSBs and/or CSI-RSs have been explicitly provided by RRC; and

1> if at least one of the SSBs with SS-RSRP above *rsrp-ThresholdSSB* amongst the SSBs in *candidateBeamRSList* or the CSI-RSs with CSI-RSRP above *rsrp-ThresholdCSI-RS* amongst the CSI-RSs in *candidateBeamRSList* is available:

2> select an SSB with SS-RSRP above *rsrp-ThresholdSSB* amongst the SSBs in *candidateBeamRSList* or a CSI-RS with CSI-RSRP above *rsrp-ThresholdCSI-RS* amongst the CSI-RSs in *candidateBeamRSList*;

2> if CSI-RS is selected, and there is no *ra-PreambleIndex* associated with the selected CSI-RS:

3> set the *PREAMBLE_INDEX* to a ra-PreambleIndex corresponding to the SSB in *candidateBeamRSList* which is quasi-collocated with the selected CSI-RS as specified in TS 38.214 [7].

2> else:

3> set the *PREAMBLE_INDEX* to a *ra-PreambleIndex* corresponding to the selected SSB or CSI-RS from the set of Random Access Preambles for beam failure recovery request.

1> else if the *ra-PreambleIndex* has been explicitly provided by either PDCCH or RRC; and

1> if the *ra-PreambleIndex* is not 0b000000; and

1> if contention-free Random Access Resource associated with SSBs or CSI-RSs have not been explicitly provided by RRC:

2> set the *PREAMBLE_INDEX* to the signalled *ra-PreambleIndex*.

1> else if the contention-free Random Access Resources associated with SSBs have been explicitly provided by RRC and at least one SSB with SS-RSRP above *rsrp-ThresholdSSB* amongst the associated SSBs is available:

2> select an SSB with SS-RSRP above *rsrp-ThresholdSSB* amongst the associated SSBs;

2> set the *PREAMBLE_INDEX* to a *ra-PreambleIndex* corresponding to the selected SSB.

1> else if the contention-free Random Access Resources associated with CSI-RSs have been explicitly provided by RRC and at least one CSI-RS with CSI-RSRP above *rsrp-ThresholdCSI-RS* amongst the associated CSI-RSs is available:

2> select a CSI-RS with CSI-RSRP above *rsrp-ThresholdCSI-RS* amongst the associated CSI-RSs;

2> set the *PREAMBLE_INDEX* to a *ra-PreambleIndex* corresponding to the selected CSI-RS.

1> else:

2> if at least one of the SSBs with SS-RSRP above *rsrp-ThresholdSSB* is available:

3> select an SSB with SS-RSRP above *rsrp-ThresholdSSB*.

2> else:

3> select any SSB.

2> if Msg3 has not yet been transmitted:

3> if Random Access Preambles group B is configured:

4> if the potential Msg3 size (UL data available for transmission plus MAC header and, where required, MAC CEs) is greater than *ra-Msg3SizeGroupA* and the pathloss is less than *PCMAX* (of the Serving Cell performing the Random Access Procedure) – *preambleReceivedTargetPower* – *msg3-DeltaPreamble* – *messagePowerOffsetGroupB*; or

4> if the Random Access procedure was initiated for the CCCH logical channel and the CCCH SDU size plus MAC subheader is greater than *ra-Msg3SizeGroupA*:

5> select the Random Access Preambles group B.

4> else:

5> select the Random Access Preambles group A.

3> else:

4> select the Random Access Preambles group A.

2> else (i.e. Msg3 is being retransmitted):

3> select the same group of Random Access Preambles as was used for the Random Access Preamble transmission attempt corresponding to the first transmission of Msg3.

2> if the association between Random Access Preambles and SSBs is configured:

3> select a *ra-PreambleIndex* randomly with equal probability from the Random Access Preambles associated with the selected SSB and the selected Random Access Preambles group.

2> else:

3> select a *ra-PreambleIndex* randomly with equal probability from the Random Access Preambles within the selected Random Access Preambles group.

2> set the *PREAMBLE_INDEX* to the selected *ra-PreambleIndex*.

1> if an SSB is selected above and an association between PRACH occasions and SSBs is configured:

2> determine the next available PRACH occasion from the PRACH occasions corresponding to the selected SSB permitted by the restrictions given by the *ra-ssb-OccasionMaskIndex* if configured (the MAC entity

shall select a PRACH occasion randomly with equal probability amongst the PRACH occasions occurring simultaneously but on different subcarriers, corresponding to the selected SSB; the MAC entity may take into account the possible occurrence of measurement gaps when determining the next available PRACH occasion corresponding to the selected SSB).

1> else if a CSI-RS is selected above and an association between PRACH occasions and CSI-RSs is configured:

2> determine the next available PRACH occasion from the PRACH occasions in *ra-OccasionList* corresponding to the selected CSI-RS (the MAC entity shall select a PRACH occasion randomly with equal probability amongst the PRACH occasions occurring simultaneously but on different subcarriers, corresponding to the selected CSI-RS; the MAC entity may take into account the possible occurrence of measurement gaps when determining the next available PRACH occasion corresponding to the selected CSI-RS).

1> else if Random Access procedure was initiated for beam failure recovery; and

1> if a CSI-RS is selected above and there is no contention-free Random Access Resource associated with the selected CSI-RS:

2> determine the next available PRACH occasion from the PRACH occasions, permitted by the restrictions given by the *ra-ssb-OccasionMaskIndex* if configured, corresponding to the SSB in *candidateBeamRSList* which is quasi-collocated with the selected CSI-RS as specified in TS 38.214 [7] (the MAC entity may take into account the possible occurrence of measurement gaps when determining the next available PRACH occasion corresponding to the SSB which is quasi-collacted with the selected CSI-RS).

1> else:

2> determine the next available PRACH occasion (the MAC entity shall select a PRACH occasion randomly with equal probability amongst the PRACH occasions occurring simultaneously but on different subcarriers; the MAC entity may take into account the possible occurrence of measurement gaps when determining the next available PRACH occasion).

1> perform the Random Access Preamble transmission procedure (see subclause 5.1.3).

5.1.3 Random Access Preamble transmission

The MAC entity shall, for each Random Access Preamble:

1> if *PREAMBLE_TRANSMISSION_COUNTER* is greater than one; and

1> if the notification of suspending power ramping counter has not been received from lower layers; and

1> if SSB selected is not changed (i.e. same as the previous Random Access Preamble transmission):

2> increment *PREAMBLE_POWER_RAMPING_COUNTER* by 1.

1> select the value of *DELTA_PREAMBLE* according to subclause 7.3;

1> set *PREAMBLE_RECEIVED_TARGET_POWER* to *preambleReceivedTargetPower* + *DELTA_PREAMBLE* + (*PREAMBLE_POWER_RAMPING_COUNTER* – 1) × *PREAMBLE_POWER_RAMPING_STEP*;

1> except for contention-free Random Access Preamble for beam failure recovery request, compute the RA-RNTI associated with the PRACH occasion in which the Random Access Preamble is transmitted;

1> instruct the physical layer to transmit the Random Access Preamble using the selected PRACH, corresponding RA-RNTI (if available), *PREAMBLE_INDEX* and *PREAMBLE_RECEIVED_TARGET_POWER*.

The RA-RNTI associated with the PRACH in which the Random Access Preamble is transmitted, is computed as:

$$\text{RA-RNTI} = 1 + s_id + 14 \times t_id + 14 \times 80 \times f_id + 14 \times 80 \times 8 \times ul_carrier_id$$

where s_id is the index of the first OFDM symbol of the specified PRACH ($0 \leq s_id < 14$), t_id is the index of the first slot of the specified PRACH in a system frame ($0 \leq t_id < 80$), f_id is the index of the specified PRACH in the frequency domain ($0 \leq f_id < 8$), and ul_carrier_id is the UL carrier used for Msg1 transmission (0 for NUL carrier, and 1 for SUL carrier).

5.1.4 Random Access Response reception

Once the Random Access Preamble is transmitted and regardless of the possible occurrence of a measurement gap, the MAC entity shall:

1> if the contention-free Random Access Preamble for beam failure recovery request was transmitted by the MAC entity:

2> start the *ra-ResponseWindow* configured in *BeamFailureRecoveryConfig* at the first PDCCH occasion as specified in TS 38.213 [6] from the end of the Random Access Preamble transmission;

2> monitor the PDCCH of the SpCell for response to beam failure recovery request identified by the C-RNTI while *ra-ResponseWindow* is running.

1> else:

2> start the *ra-ResponseWindow* configured in *RACH-ConfigCommon* at the first PDCCH occasion as specified in TS 38.213 [6] from the end of the Random Access Preamble transmission;

2> monitor the PDCCH of the SpCell for Random Access Response(s) identified by the RA-RNTI while the *ra-ResponseWindow* is running.

1> if notification of a reception of a PDCCH transmission is received from lower layers; and

1> if PDCCH transmission is addressed to the C-RNTI; and

1> if the contention-free Random Access Preamble for beam failure recovery request was transmitted by the MAC entity:

2> consider the Random Access procedure successfully completed.

1> else if a downlink assignment has been received on the PDCCH for the RA-RNTI and the received TB is successfully decoded:

2> if the Random Access Response contains a MAC subPDU with Backoff Indicator:

3> set the *PREAMBLE_BACKOFF* to value of the BI field of the MAC subPDU using Table 7.2-1, multiplied with *SCALING_FACTOR_BI*.

2> else:

3> set the *PREAMBLE_BACKOFF* to 0 ms.

2> if the Random Access Response contains a MAC subPDU with Random Access Preamble identifier corresponding to the transmitted *PREAMBLE_INDEX* (see subclause 5.1.3):

3> consider this Random Access Response reception successful.

2> if the Random Access Response reception is considered successful:

3> if the Random Access Response includes a MAC subPDU with RAPID only:

4> consider this Random Access procedure successfully completed;

4> indicate the reception of an acknowledgement for SI request to upper layers.

3> else:

4> apply the following actions for the Serving Cell where the Random Access Preamble was transmitted:

5> process the received Timing Advance Command (see subclause 5.2);

5> indicate the *preambleReceivedTargetPower* and the amount of power ramping applied to the latest Random Access Preamble transmission to lower layers (i.e. (*PREAMBLE_POWER_RAMPING_COUNTER* – 1) × *PREAMBLE_POWER_RAMPING_STEP*);

5> if the Serving Cell for the Random Access procedure is SRS-only SCell:

6> ignore the received UL grant.

5> else:

6> process the received UL grant value and indicate it to the lower layers.

4> if the Random Access Preamble was not selected by the MAC entity among the contention-based Random Access Preamble(s):

5> consider the Random Access procedure successfully completed.

4> else:

5> set the *TEMPORARY_C-RNTI* to the value received in the Random Access Response;

5> if this is the first successfully received Random Access Response within this Random Access procedure:

6> if the transmission is not being made for the CCCH logical channel:

7> indicate to the Multiplexing and assembly entity to include a C-RNTI MAC CE in the subsequent uplink transmission.

6> obtain the MAC PDU to transmit from the Multiplexing and assembly entity and store it in the Msg3 buffer.

1> if *ra-ResponseWindow* configured in *RACH-ConfigCommon* expires, and if the Random Access Response containing Random Access Preamble identifiers that matches the transmitted *PREAMBLE_INDEX* has not been received; or

1> if *ra-ResponseWindow* configured in *BeamFailureRecoveryConfig* expires and if the PDCCH addressed to the C-RNTI has not been received:

2> consider the Random Access Response reception not successful;

2> increment *PREAMBLE_TRANSMISSION_COUNTER* by 1;

2> if *PREAMBLE_TRANSMISSION_COUNTER* = *preambleTransMax* + 1:

3> if the Random Access Preamble is transmitted on the SpCell:

4> indicate a Random Access problem to upper layers;

4> if this Random Access procedure was triggered for SI request:

5> consider the Random Access procedure unsuccessfully completed.

3> else if the Random Access Preamble is transmitted on a SCell:

4> consider the Random Access procedure unsuccessfully completed.

2> if the Random Access procedure is not completed:

3> if in this Random Access procedure, the Random Access Preamble was selected by MAC among the contention-based Random Access Preambles:

4> select a random backoff time according to a uniform distribution between 0 and the *PREAMBLE_BACKOFF*;

4> delay the subsequent Random Access Preamble transmission by the backoff time.

3> perform the Random Access Resource selection procedure (see subclause 5.1.2).

The MAC entity may stop *ra-ResponseWindow* (and hence monitoring for Random Access Response(s)) after successful reception of a Random Access Response containing Random Access Preamble identifiers that matches the transmitted *PREAMBLE_INDEX*.

HARQ operation is not applicable to the Random Access Response transmission.

5.1.5 Contention Resolution

Contention Resolution is based on either C-RNTI on PDCCH of the SpCell or UE Contention Resolution Identity on DL-SCH.

Once Msg3 is transmitted, the MAC entity shall:

1> start the *ra-ContentionResolutionTimer* and restart the *ra-ContentionResolutionTimer* at each HARQ retransmission in the first symbol after the end of the Msg3 transmission;

1> monitor the PDCCH while the *ra-ContentionResolutionTimer* is running regardless of the possible occurrence of a measurement gap;

1> if notification of a reception of a PDCCH transmission is received from lower layers:

2> if the C-RNTI MAC CE was included in Msg3:

3> if the Random Access procedure was initiated by the MAC sublayer itself or by the RRC sublayer and the PDCCH transmission is addressed to the C-RNTI and contains a UL grant for a new transmission; or

3> if the Random Access procedure was initiated by a PDCCH order and the PDCCH transmission is addressed to the C-RNTI; or

3> if the Random Access procedure was initiated for beam failure recovery (as specified in subclause 5.17) and the PDCCH transmission is addressed to the C-RNTI:

4> consider this Contention Resolution successful;

4> stop *ra-ContentionResolutionTimer*;

4> discard the *TEMPORARY_C-RNTI*;

4> consider this Random Access procedure successfully completed.

2> else if the CCCH SDU was included in Msg3 and the PDCCH transmission is addressed to its *TEMPORARY_C-RNTI*:

3> if the MAC PDU is successfully decoded:

4> stop *ra-ContentionResolutionTimer*;

4> if the MAC PDU contains a UE Contention Resolution Identity MAC CE; and

4> if the UE Contention Resolution Identity in the MAC CE matches the CCCH SDU transmitted in Msg3:

5> consider this Contention Resolution successful and finish the disassembly and demultiplexing of the MAC PDU;

5> if this Random Access procedure was initiated for SI request:

6> indicate the reception of an acknowledgement for SI request to upper layers.

5> else:

6> set the C-RNTI to the value of the *TEMPORARY_C-RNTI*;

5> discard the *TEMPORARY_C-RNTI*;

5> consider this Random Access procedure successfully completed.

4> else

5> discard the *TEMPORARY_C-RNTI*;

5> consider this Contention Resolution not successful and discard the successfully decoded MAC PDU.

1> if *ra-ContentionResolutionTimer* expires:

2> discard the *TEMPORARY_C-RNTI*;

2> consider the Contention Resolution not successful.

1> if the Contention Resolution is considered not successful:

2> flush the HARQ buffer used for transmission of the MAC PDU in the Msg3 buffer;

2> increment *PREAMBLE_TRANSMISSION_COUNTER* by 1;

2> if *PREAMBLE_TRANSMISSION_COUNTER* = *preambleTransMax* + 1:

3> indicate a Random Access problem to upper layers.

3> if this Random Access procedure was triggered for SI request:

4> consider the Random Access procedure unsuccessfully completed.

2> if the Random Access procedure is not completed:

3> select a random backoff time according to a uniform distribution between 0 and the *PREAMBLE_BACKOFF*;

3> delay the subsequent Random Access Preamble transmission by the backoff time;

3> perform the Random Access Resource selection procedure (see subclause 5.1.2).

5.1.6 Completion of the Random Access procedure

Upon completion of the Random Access procedure, the MAC entity shall:

1> discard explicitly signalled contention-free Random Access Resources except contention-free Random Access Resources for beam failure recovery request, if any;

1> flush the HARQ buffer used for transmission of the MAC PDU in the Msg3 buffer.

5.2 Maintenance of Uplink Time Alignment

RRC configures the following parameters for the maintenance of UL time alignment:

- *timeAlignmentTimer* (per TAG) which controls how long the MAC entity considers the Serving Cells belonging to the associated TAG to be uplink time aligned.

The MAC entity shall:

1> when a Timing Advance Command MAC CE is received, and if an N_{TA} (as defined in TS 38.211 [8]) has been maintained with the indicated TAG:

2> apply the Timing Advance Command for the indicated TAG;

2> start or restart the *timeAlignmentTimer* associated with the indicated TAG.

1> when a Timing Advance Command is received in a Random Access Response message for a Serving Cell belonging to a TAG:

2> if the Random Access Preamble was not selected by the MAC entity among the contention-based Random Access Preamble:

3> apply the Timing Advance Command for this TAG;

3> start or restart the *timeAlignmentTimer* associated with this TAG.

2> else if the *timeAlignmentTimer* associated with this TAG is not running:

3> apply the Timing Advance Command for this TAG;

3> start the *timeAlignmentTimer* associated with this TAG;

3> when the Contention Resolution is considered not successful as described in subclause 5.1.5; or

3> when the Contention Resolution is considered successful for SI request as described in subclause 5.1.5, after transmitting HARQ feedback for MAC PDU including UE Contention Resolution Identity MAC CE:

4> stop *timeAlignmentTimer* associated with this TAG.

2> else:

3> ignore the received Timing Advance Command.

1> when a *timeAlignmentTimer* expires:

2> if the *timeAlignmentTimer* is associated with the PTAG:

3> flush all HARQ buffers for all Serving Cells;

3> notify RRC to release PUCCH for all Serving Cells, if configured;

3> notify RRC to release SRS for all Serving Cells, if configured;

3> clear any configured downlink assignments and configured uplink grants;

3> consider all running *timeAlignmentTimer*s as expired;

3> maintain N_{TA} (defined in TS 38.211 [8]) of all TAGs.

2> else if the *timeAlignmentTimer* is associated with an STAG, then for all Serving Cells belonging to this TAG:

3> flush all HARQ buffers;

3> notify RRC to release PUCCH, if configured;

3> notify RRC to release SRS, if configured;

3> clear any configured downlink assignments and configured uplink grants;

3> maintain N_{TA} (defined in TS 38.211 [8]) of this TAG.

When the MAC entity stops uplink transmissions for an SCell due to the fact that the maximum uplink transmission timing difference between TAGs of the MAC entity or the maximum uplink transmission timing difference between TAGs of any MAC entity of the UE is exceeded, the MAC entity considers the *timeAlignmentTimer* associated with the SCell as expired.

The MAC entity shall not perform any uplink transmission on a Serving Cell except the Random Access Preamble transmission when the *timeAlignmentTimer* associated with the TAG to which this Serving Cell belongs is not running. Furthermore, when the *timeAlignmentTimer* associated with the PTAG is not running, the MAC entity shall not perform any uplink transmission on any Serving Cell except the Random Access Preamble transmission on the SpCell.

5.3 DL-SCH data transfer

5.3.1 DL Assignment reception

Downlink assignments received on the PDCCH both indicate that there is a transmission on a DL-SCH for a particular MAC entity and provide the relevant HARQ information.

When the MAC entity has a C-RNTI, Temporary C-RNTI, or CS-RNTI, the MAC entity shall for each PDCCH occasion during which it monitors PDCCH and for each Serving Cell:

1> if a downlink assignment for this PDCCH occasion and this Serving Cell has been received on the PDCCH for the MAC entity's C-RNTI, or Temporary C-RNTI:

2> if this is the first downlink assignment for this Temporary C-RNTI:

3> consider the NDI to have been toggled.

2> if the downlink assignment is for the MAC entity's C-RNTI, and if the previous downlink assignment indicated to the HARQ entity of the same HARQ process was either a downlink assignment received for the MAC entity's CS-RNTI or a configured downlink assignment:

3> consider the NDI to have been toggled regardless of the value of the NDI.

2> indicate the presence of a downlink assignment and deliver the associated HARQ information to the HARQ entity.

1> else if a downlink assignment for this PDCCH occasion has been received for this Serving Cell on the PDCCH for the MAC entity's CS-RNTI:

2> if the NDI in the received HARQ information is 1:

3> consider the NDI for the corresponding HARQ process not to have been toggled;

3> indicate the presence of a downlink assignment for this Serving Cell and deliver the associated HARQ information to the HARQ entity.

2> if the NDI in the received HARQ information is 0:

3> if PDCCH contents indicate SPS deactivation:

4> clear the configured downlink assignment for this Serving Cell (if any);

4> if the timeAlignmentTimer associated with the PTAG is running:

5> indicate a positive acknowledgement for the SPS deactivation to the physical layer.

3> else if PDCCH content indicates SPS activation:

4> store the downlink assignment for this Serving Cell and the associated HARQ information as configured downlink assignment;

4> initialise or re-initialise the configured downlink assignment for this Serving Cell to start in the associated PDSCH duration and to recur according to rules in subclause 5.8.1;

4> set the HARQ Process ID to the HARQ Process ID associated with this PDSCH duration;

4> consider the NDI bit for the corresponding HARQ process to have been toggled;

4> indicate the presence of a configured downlink assignment for this Serving Cell and deliver the stored HARQ information to the HARQ entity.

For each Serving Cell and each configured downlink assignment, if configured and activated, the MAC entity shall:

1> if the PDSCH duration of the configured downlink assignment does not overlap with the PDSCH duration of a downlink assignment received on the PDCCH for this Serving Cell:

2> instruct the physical layer to receive, in this PDSCH duration, transport block on the DL-SCH according to the configured downlink assignment and to deliver it to the HARQ entity;

2> set the HARQ Process ID to the HARQ Process ID associated with this PDSCH duration;

2> consider the NDI bit to have been toggled;

2> indicate the presence of a configured downlink assignment and deliver the stored HARQ information to the HARQ entity.

For configured downlink assignments, the HARQ Process ID associated with the slot where the DL transmission starts is derived from the following equation:

HARQ Process ID = [floor (CURRENT_slot × 10 / (*numberOfSlotsPerFrame* × *periodicity*))] modulo *nrofHARQ-Processes*

where CURRENT_slot = [(SFN × *numberOfSlotsPerFrame*) + slot number in the frame] and *numberOfSlotsPerFrame* refers to the number of consecutive slots per frame as specified in TS 38.211 [8].

When the MAC entity needs to read BCCH, the MAC entity may, based on the scheduling information from RRC:

1> if a downlink assignment for this PDCCH occasion has been received on the PDCCH for the SI-RNTI;

2> indicate a downlink assignment and redundancy version for the dedicated broadcast HARQ process to the HARQ entity.

5.3.2 HARQ operation

5.3.2.1 HARQ Entity

The MAC entity includes a HARQ entity for each Serving Cell, which maintains a number of parallel HARQ processes. Each HARQ process is associated with a HARQ process identifier. The HARQ entity directs HARQ information and associated TBs received on the DL-SCH to the corresponding HARQ processes (see subclause 5.3.2.2).

The number of parallel DL HARQ processes per HARQ entity is specified in TS 38.214 [7]. The dedicated broadcast HARQ process is used for BCCH.

The HARQ process supports one TB when the physical layer is not configured for downlink spatial multiplexing. The HARQ process supports one or two TBs when the physical layer is configured for downlink spatial multiplexing.

When the MAC entity is configured with *pdsch-AggregationFactor* > 1, the parameter *pdsch-AggregationFactor* provides the number of transmissions of a TB within a bundle of the dynamic downlink assignment. Bundling operation relies on the HARQ entity for invoking the same HARQ process for each transmission that is part of the same bundle. After the initial transmission, *pdsch-AggregationFactor* – 1 HARQ retransmissions follow within a bundle.

The MAC entity shall:

1> if a downlink assignment has been indicated:

2> allocate the TB(s) received from the physical layer and the associated HARQ information to the HARQ process indicated by the associated HARQ information.

1> if a downlink assignment has been indicated for the broadcast HARQ process:

2> allocate the received TB to the broadcast HARQ process.

5.3.2.2 HARQ process

When a transmission takes place for the HARQ process, one or two (in case of downlink spatial multiplexing) TBs and the associated HARQ information are received from the HARQ entity.

For each received TB and associated HARQ information, the HARQ process shall:

1> if the NDI, when provided, has been toggled compared to the value of the previous received transmission corresponding to this TB; or

1> if the HARQ process is equal to the broadcast process, and this is the first received transmission for the TB according to the system information schedule indicated by RRC; or

1> if this is the very first received transmission for this TB (i.e. there is no previous NDI for this TB):

2> consider this transmission to be a new transmission.

1> else:

2> consider this transmission to be a retransmission.

The MAC entity then shall:

1> if this is a new transmission:

2> attempt to decode the received data.

1> else if this is a retransmission:

2> if the data for this TB has not yet been successfully decoded:

3> instruct the physical layer to combine the received data with the data currently in the soft buffer for this TB and attempt to decode the combined data.

1> if the data which the MAC entity attempted to decode was successfully decoded for this TB; or

1> if the data for this TB was successfully decoded before:

2> if the HARQ process is equal to the broadcast process:

3> deliver the decoded MAC PDU to upper layers.

2> else if this is the first successful decoding of the data for this TB:

3> deliver the decoded MAC PDU to the disassembly and demultiplexing entity.

1> else:

2> instruct the physical layer to replace the data in the soft buffer for this TB with the data which the MAC entity attempted to decode.

1> if the HARQ process is associated with a transmission indicated with a Temporary C-RNTI and the Contention Resolution is not yet successful (see subclause 5.1.5); or

1> if the HARQ process is equal to the broadcast process; or

1> if the *timeAlignmentTimer*, associated with the TAG containing the Serving Cell on which the HARQ feedback is to be transmitted, is stopped or expired:

2> not instruct the physical layer to generate acknowledgement(s) of the data in this TB.

1> else:

2> instruct the physical layer to generate acknowledgement(s) of the data in this TB.

The MAC entity shall ignore NDI received in all downlink assignments on PDCCH for its Temporary C-RNTI when determining if NDI on PDCCH for its C-RNTI has been toggled compared to the value in the previous transmission.

5.3.3 Disassembly and demultiplexing

The MAC entity shall disassemble and demultiplex a MAC PDU as defined in subclause 6.1.2.

5.4 UL-SCH data transfer

5.4.1 UL Grant reception

Uplink grant is either received dynamically on the PDCCH, in a Random Access Response, or configured semi-persistently by RRC. The MAC entity shall have an uplink grant to transmit on the UL-SCH. To perform the requested transmissions, the MAC layer receives HARQ information from lower layers.

If the MAC entity has a C-RNTI, a Temporary C-RNTI, or CS-RNTI, the MAC entity shall for each PDCCH occasion and for each Serving Cell belonging to a TAG that has a running *timeAlignmentTimer* and for each grant received for this PDCCH occasion:

1> if an uplink grant for this Serving Cell has been received on the PDCCH for the MAC entity's C-RNTI or Temporary C-RNTI; or

1> if an uplink grant has been received in a Random Access Response:

2> if the uplink grant is for MAC entity's C-RNTI and if the previous uplink grant delivered to the HARQ entity for the same HARQ process was either an uplink grant received for the MAC entity's CS-RNTI or a configured uplink grant:

3> consider the NDI to have been toggled for the corresponding HARQ process regardless of the value of the NDI.

2> if the uplink grant is for MAC entity's C-RNTI, and the identified HARQ process is configured for a configured uplink grant:

3> start or restart the *configuredGrantTimer* for the correponding HARQ process, if configured.

2> deliver the uplink grant and the associated HARQ information to the HARQ entity.

1> else if an uplink grant for this PDCCH occasion has been received for this Serving Cell on the PDCCH for the MAC entity's CS-RNTI:

2> if the NDI in the received HARQ information is 1:

3> consider the NDI for the corresponding HARQ process not to have been toggled;

3> start or restart the *configuredGrantTimer* for the corresponding HARQ process, if configured;

3> deliver the uplink grant and the associated HARQ information to the HARQ entity.

2> else if the NDI in the received HARQ information is 0:

3> if PDCCH contents indicate configured grant Type 2 deactivation:

4> trigger configured uplink grant confirmation.

3> else if PDCCH contents indicate configured grant Type 2 activation:

4> trigger configured uplink grant confirmation;

4> store the uplink grant for this Serving Cell and the associated HARQ information as configured uplink grant;

4> initialise or re-initialise the configured uplink grant for this Serving Cell to start in the associated PUSCH duration and to recur according to rules in subclause 5.8.2;

4> set the HARQ Process ID to the HARQ Process ID associated with this PUSCH duration;

4> consider the NDI bit for the corresponding HARQ process to have been toggled;

4> stop the *configuredGrantTimer* for the corresponding HARQ process, if running;

4> deliver the configured uplink grant and the associated HARQ information to the HARQ entity.

For each Serving Cell and each configured uplink grant, if configured and activated, the MAC entity shall:

1> if the PUSCH duration of the configured uplink grant does not overlap with the PUSCH duration of an uplink grant received on the PDCCH for this Serving Cell:

2> set the HARQ Process ID to the HARQ Process ID associated with this PUSCH duration;

2> if the *configuredGrantTimer* for the corresponding HARQ process is not running:

3> consider the NDI bit for the corresponding HARQ process to have been toggled;

3> deliver the configured uplink grant and the associated HARQ information to the HARQ entity.

For configured uplink grants, the HARQ Process ID associated with the first symbol of a UL transmission is derived from the following equation:

HARQ Process ID = [floor(CURRENT_symbol/*periodicity*)] modulo *nrofHARQ-Processes*

where CURRENT_symbol=(SFN × *numberOfSlotsPerFrame* × *numberOfSymbolsPerSlot* + slot number in the frame × *numberOfSymbolsPerSlot* + symbol number in the slot), and *numberOfSlotsPerFrame* and *numberOfSymbolsPerSlot* refer to the number of consecutive slots per frame and the number of consecutive symbols per slot, respectively as specified in TS 38.211 [8].

NOTE 1: CURRENT_symbol refers to the symbol index of the first transmission occasion of a repetition bundle that takes place.

NOTE 2: A HARQ process is configured for a configured uplink grant if the configured uplink grant is activated and the associated HARQ process ID is less than *nrofHARQ-Processes*.

5.4.2 HARQ operation

5.4.2.1 HARQ Entity

The MAC entity includes a HARQ entity for each Serving Cell with configured uplink (including the case when it is configured with *supplementaryUplink*), which maintains a number of parallel HARQ processes.

The number of parallel UL HARQ processes per HARQ entity is specified in TS 38.214 [7].

Each HARQ process supports one TB.

Each HARQ process is associated with a HARQ process identifier. For UL transmission with UL grant in RA Response, HARQ process identifier 0 is used.

When the MAC entity is configured with *pusch-AggregationFactor* > 1, the parameter *pusch-AggregationFactor* provides the number of transmissions of a TB within a bundle of the dynamic grant. After the initial transmission, *pusch-AggregationFactor* – 1 HARQ retransmissions follow within a bundle. When the MAC entity is configured with *repK* > 1, the parameter *repK* provides the number of transmissions of a TB within a bundle of the configured uplink grant. After the initial transmission, HARQ retransmissions follow within a bundle. For both dynamic grant and configured uplink grant, bundling operation relies on the HARQ entity for invoking the same HARQ process for each transmission that is part of the same bundle. Within a bundle, HARQ retransmissions are triggered without waiting for feedback from previous transmission according to *pusch-AggregationFactor* for a dynamic grant and *repK* for a configured uplink grant, respectively. Each transmission within a bundle is a separate uplink grant after the initial uplink grant within a bundle is delivered to the HARQ entity.

For each transmission within a bundle of the dynamic grant, the sequence of redundancy versions is determined according to subclause 6.1.4 of TS 38.214 [7]. For each transmission within a bundle of the configured uplink grant, the sequence of redundancy versions is determined according to subclause 6.1.2.3 of TS 38.214 [7].

For each uplink grant, the HARQ entity shall:

1> identify the HARQ process associated with this grant, and for each identified HARQ process:

2> if the received grant was not addressed to a Temporary C-RNTI on PDCCH, and the NDI provided in the associated HARQ information has been toggled compared to the value in the previous transmission of this TB of this HARQ process; or

2> if the uplink grant was received on PDCCH for the C-RNTI and the HARQ buffer of the identified process is empty; or

2> if the uplink grant was received in a Random Access Response; or

2> if the uplink grant is part of a bundle of the configured uplink grant, and may be used for initial transmission according to subclause 6.1.2.3 of TS 38.214 [7], and if no MAC PDU has been obtained for this bundle:

3> if there is a MAC PDU in the Msg3 buffer and the uplink grant was received in a Random Access Response:

4> obtain the MAC PDU to transmit from the Msg3 buffer.

3> else:

4> obtain the MAC PDU to transmit from the Multiplexing and assembly entity, if any;

3> if a MAC PDU to transmit has been obtained:

4> deliver the MAC PDU and the uplink grant and the HARQ information of the TB to the identified HARQ process;

4> instruct the identified HARQ process to trigger a new transmission;

4> if the uplink grant is addressed to CS-RNTI; or

4> if the uplink grant is a configured uplink grant; or

4> if the uplink grant is addressed to C-RNTI, and the identified HARQ process is configured for a configured uplink grant:

5> start or restart the *configuredGrantTimer*, if configured, for the corresponding HARQ process when the transmission is performed.

3> else:

4> flush the HARQ buffer of the identified HARQ process.

2> else (i.e. retransmission):

3> if the uplink grant received on PDCCH was addressed to CS-RNTI and if the HARQ buffer of the identified process is empty; or

3> if the uplink grant is part of a bundle and if no MAC PDU has been obtained for this bundle; or

3> if the uplink grant is part of a bundle of the configured uplink grant, and the PUSCH of the uplink grant overlaps with a PUSCH of another uplink grant received on the PDCCH for this Serving Cell:

4> ignore the uplink grant.

3> else:

4> deliver the uplink grant and the HARQ information (redundancy version) of the TB to the identified HARQ process;

4> instruct the identified HARQ process to trigger a retransmission;

4> if the uplink grant is addressed to CS-RNTI; or

4> if the uplink grant is addressed to C-RNTI, and the identified HARQ process is configured for a configured uplink grant:

5> start or restart the *configuredGrantTimer*, if configured, for the corresponding HARQ process when the transmission is performed.

When determining if NDI has been toggled compared to the value in the previous transmission the MAC entity shall ignore NDI received in all uplink grants on PDCCH for its Temporary C-RNTI.

5.4.2.2 HARQ process

Each HARQ process is associated with a HARQ buffer.

New transmissions are performed on the resource and with the MCS indicated on either PDCCH, Random Access Response, or RRC. Retransmissions are performed on the resource and, if provided, with the MCS indicated on PDCCH, or on the same resource and with the same MCS as was used for last made transmission attempt within a bundle.

If the HARQ entity requests a new transmission for a TB, the HARQ process shall:

1> store the MAC PDU in the associated HARQ buffer;

1> store the uplink grant received from the HARQ entity;

1> generate a transmission as described below.

If the HARQ entity requests a retransmission for a TB, the HARQ process shall:

1> store the uplink grant received from the HARQ entity;

1> generate a transmission as described below.

To generate a transmission for a TB, the HARQ process shall:

1> if the MAC PDU was obtained from the Msg3 buffer; or

1> if there is no measurement gap at the time of the transmission and, in case of retransmission, the retransmission does not collide with a transmission for a MAC PDU obtained from the Msg3 buffer:

2> instruct the physical layer to generate a transmission according to the stored uplink grant.

5.4.3 Multiplexing and assembly

5.4.3.1 Logical channel prioritization

5.4.3.1.1 General

The Logical Channel Prioritization procedure is applied whenever a new transmission is performed.

RRC controls the scheduling of uplink data by signalling for each logical channel per MAC entity:

- *priority* where an increasing priority value indicates a lower priority level;
- *prioritisedBitRate* which sets the Prioritized Bit Rate (PBR);
- *bucketSizeDuration* which sets the Bucket Size Duration (BSD).

RRC additionally controls the LCP procedure by configuring mapping restrictions for each logical channel:

- *allowedSCS-List* which sets the allowed Subcarrier Spacing(s) for transmission;
- *maxPUSCH-Duration* which sets the maximum PUSCH duration allowed for transmission;
- *configuredGrantType1Allowed* which sets whether a configured grant Type 1 can be used for transmission;
- *allowedServingCells* which sets the allowed cell(s) for transmission.

The following UE variable is used for the Logical channel prioritization procedure:

- *Bj* which is maintained for each logical channel *j*.

The MAC entity shall initialize *Bj* of the logical channel to zero when the logical channel is established.

For each logical channel *j*, the MAC entity shall:

1> increment *Bj* by the product PBR × T before every instance of the LCP procedure, where T is the time elapsed since *Bj* was last incremented;

1> if the value of *Bj* is greater than the bucket size (i.e. PBR × BSD):

2> set *Bj* to the bucket size.

NOTE: The exact moment(s) when the UE updates *Bj* between LCP procedures is up to UE implementation, as long as *Bj* is up to date at the time when a grant is processed by LCP.

5.4.3.1.2 Selection of logical channels

The MAC entity shall, when a new transmission is performed:

1> select the logical channels for each UL grant that satisfy all the following conditions:

2> the set of allowed Subcarrier Spacing index values in *allowedSCS-List*, if configured, includes the Subcarrier Spacing index associated to the UL grant; and

2> *maxPUSCH-Duration*, if configured, is larger than or equal to the PUSCH transmission duration associated to the UL grant; and

2> *configuredGrantType1Allowed*, if configured, is set to TRUE in case the UL grant is a Configured Grant Type 1; and

2> *allowedServingCells*, if configured, includes the Cell information associated to the UL grant.

NOTE: The Subcarrier Spacing index, PUSCH transmission duration and Cell information are included in Uplink transmission information received from lower layers for the corresponding scheduled uplink transmission.

5.4.3.1.3 Allocation of resources

The MAC entity shall, when a new transmission is performed:

1> allocate resources to the logical channels as follows:

2> logical channels selected in subclause 5.4.3.1.2 for the UL grant with *Bj* > 0 are allocated resources in a decreasing priority order. If the PBR of a logical channel is set to "infinity", the MAC entity shall allocate resources for all the data that is available for transmission on the logical channel before meeting the PBR of the lower priority logical channel(s);

2> decrement *Bj* by the total size of MAC SDUs served to logical channel *j* above;

2> if any resources remain, all the logical channels selected in subclause 5.4.3.1.2 are served in a strict decreasing priority order (regardless of the value of *Bj*) until either the data for that logical channel or the UL grant is exhausted, whichever comes first. Logical channels configured with equal priority should be served equally.

NOTE: The value of *Bj* can be negative.

If the MAC entity is requested to simultaneously transmit multiple MAC PDUs, or if the MAC entity receives the multiple UL grants within one or more coinciding PDCCH occasions (i.e. on different Serving Cells), it is up to UE implementation in which order the grants are processed.

The UE shall also follow the rules below during the scheduling procedures above:

- the UE should not segment an RLC SDU (or partially transmitted SDU or retransmitted RLC PDU) if the whole SDU (or partially transmitted SDU or retransmitted RLC PDU) fits into the remaining resources of the associated MAC entity;
- if the UE segments an RLC SDU from the logical channel, it shall maximize the size of the segment to fill the grant of the associated MAC entity as much as possible;
- the UE should maximise the transmission of data;
- if the MAC entity is given a UL grant size that is equal to or larger than 8 bytes while having data available for transmission, the MAC entity shall not transmit only padding BSR and/or padding.

The MAC entity shall not generate a MAC PDU for the HARQ entity if the following conditions are satisfied:

- the MAC entity is configured with *skipUplinkTxDynamic* and the grant indicated to the HARQ entity was addressed to a C-RNTI, or the grant indicated to the HARQ entity is a configured uplink grant; and
- there is no aperiodic CSI requested for this PUSCH transmission as specified in TS 38.212 [9]; and
- the MAC PDU includes zero MAC SDUs; and
- the MAC PDU includes only the periodic BSR and there is no data available for any LCG, or the MAC PDU includes only the padding BSR.

Logical channels shall be prioritised in accordance with the following order (highest priority listed first):

- C-RNTI MAC CE or data from UL-CCCH;
- Configured Grant Confirmation MAC CE;
- MAC CE for BSR, with exception of BSR included for padding;
- Single Entry PHR MAC CE or Multiple Entry PHR MAC CE;
- data from any Logical Channel, except data from UL-CCCH;
- MAC CE for Recommended bit rate query;

- MAC CE for BSR included for padding.

5.4.3.2 Multiplexing of MAC Control Elements and MAC SDUs

The MAC entity shall multiplex MAC CEs and MAC SDUs in a MAC PDU according to subclauses 5.4.3.1 and 6.1.2.

5.4.4 Scheduling Request

The Scheduling Request (SR) is used for requesting UL-SCH resources for new transmission.

The MAC entity may be configured with zero, one, or more SR configurations. An SR configuration consists of a set of PUCCH resources for SR across different BWPs and cells. For a logical channel, at most one PUCCH resource for SR is configured per BWP.

Each SR configuration corresponds to one or more logical channels. Each logical channel may be mapped to zero or one SR configuration, which is configured by RRC. The SR configuration of the logical channel that triggered the BSR (subclause 5.4.5) (if such a configuration exists) is considered as corresponding SR configuration for the triggered SR.

RRC configures the following parameters for the scheduling request procedure:

- *sr-ProhibitTimer* (per SR configuration);
- *sr-TransMax* (per SR configuration);
- *sr-ConfigIndex*.

The following UE variables are used for the scheduling request procedure:

- *SR_COUNTER* (per SR configuration).

If an SR is triggered and there are no other SRs pending corresponding to the same SR configuration, the MAC entity shall set the *SR_COUNTER* of the corresponding SR configuration to 0.

When an SR is triggered, it shall be considered as pending until it is cancelled. All pending SR(s) triggered prior to the MAC PDU assembly shall be cancelled and each respective *sr-ProhibitTimer* shall be stopped when the MAC PDU is transmitted and this PDU includes a BSR MAC CE which contains buffer status up to (and including) the last event that triggered a BSR (see subclause 5.4.5) prior to the MAC PDU assembly. All pending SR(s) shall be cancelled when the UL grant(s) can accommodate all pending data available for transmission.

Only PUCCH resources on a BWP which is active at the time of SR transmission occasion are considered valid.

As long as at least one SR is pending, the MAC entity shall for each pending SR:

1> if the MAC entity has no valid PUCCH resource configured for the pending SR:

2> initiate a Random Access procedure (see subclause 5.1) on the SpCell and cancel the pending SR.

1> else, for the SR configuration corresponding to the pending SR:

2> when the MAC entity has an SR transmission occasion on the valid PUCCH resource for SR configured; and

2> if *sr-ProhibitTimer* is not running at the time of the SR transmission occasion; and

2> if the PUCCH resource for the SR transmission occasion does not overlap with a measurement gap; and

2> if the PUCCH resource for the SR transmission occasion does not overlap with a UL-SCH resource:

3> if *SR_COUNTER* < *sr-TransMax*:

4> increment *SR_COUNTER* by 1;

4> instruct the physical layer to signal the SR on one valid PUCCH resource for SR;

4> start the *sr-ProhibitTimer*.

3> else:

4> notify RRC to release PUCCH for all Serving Cells;

4> notify RRC to release SRS for all Serving Cells;

4> clear any configured downlink assignments and uplink grants;

4> initiate a Random Access procedure (see subclause 5.1) on the SpCell and cancel all pending SRs.

NOTE: The selection of which valid PUCCH resource for SR to signal SR on when the MAC entity has more than one overlapping valid PUCCH resource for the SR transmission occasion is left to UE implementation.

The MAC entity may stop, if any, ongoing Random Access procedure due to a pending SR which has no valid PUCCH resources configured, which was initiated by MAC entity prior to the MAC PDU assembly. Such a Random Access procedure may be stopped when the MAC PDU is transmitted using a UL grant other than a UL grant provided by Random Access Response, and this PDU includes a BSR MAC CE which contains buffer status up to (and including) the last event that triggered a BSR (see subclause 5.4.5) prior to the MAC PDU assembly, or when the UL grant(s) can accommodate all pending data available for transmission.

5.4.5 Buffer Status Reporting

The Buffer Status reporting (BSR) procedure is used to provide the serving gNB with information about UL data volume in the MAC entity.

RRC configures the following parameters to control the BSR:

- *periodicBSR-Timer*;
- *retxBSR-Timer*;
- *logicalChannelSR-DelayTimerApplied*;
- *logicalChannelSR-DelayTimer*;
- *logicalChannelSR-Mask*;
- *logicalChannelGroup*.

Each logical channel may be allocated to an LCG using the *logicalChannelGroup*. The maximum number of LCGs is eight.

The MAC entity determines the amount of UL data available for a logical channel according to the data volume calculation procedure in TSs 38.322 and 38.323 [3] [4].

A BSR shall be triggered if any of the following events occur:

- the MAC entity has new UL data available for a logical channel which belongs to an LCG; and either
  - the new UL data belongs to a logical channel with higher priority than the priority of any logical channel containing available UL data which belong to any LCG; or
  - none of the logical channels which belong to an LCG contains any available UL data.

  in which case the BSR is referred below to as 'Regular BSR';
- UL resources are allocated and number of padding bits is equal to or larger than the size of the Buffer Status Report MAC CE plus its subheader, in which case the BSR is referred below to as 'Padding BSR';
- *retxBSR-Timer* expires, and at least one of the logical channels which belong to an LCG contains UL data, in which case the BSR is referred below to as 'Regular BSR';
- *periodicBSR-Timer* expires, in which case the BSR is referred below to as 'Periodic BSR'.

For Regular BSR, the MAC entity shall:

1> if the BSR is triggered for a logical channel for which *logicalChannelSR-DelayTimerApplied* is configured by upper layers:

2> start or restart the *logicalChannelSR-DelayTimer*.

1> else:

2> if running, stop the *logicalChannelSR-DelayTimer*.

For Regular and Periodic BSR, the MAC entity shall:

1> if more than one LCG has data available for transmission when the MAC PDU containing the BSR is to be built:

2> report Long BSR for all LCGs which have data available for transmission.

1> else:

2> report Short BSR.

For Padding BSR:

1> if the number of padding bits is equal to or larger than the size of the Short BSR plus its subheader but smaller than the size of the Long BSR plus its subheader:

2> if more than one LCG has data available for transmission when the BSR is to be built:

3> if the number of padding bits is equal to the size of the Short BSR plus its subheader:

4> report Short Truncated BSR of the LCG with the highest priority logical channel with data available for transmission.

3> else:

4> report Long Truncated BSR of the LCG(s) with the logical channels having data available for transmission following a decreasing order of priority, and in case of equal priority, in increasing order of LCGID.

2> else:

3> report Short BSR.

1> else if the number of padding bits is equal to or larger than the size of the Long BSR plus its subheader:

2> report Long BSR for all LCGs which have data available for transmission.

For BSR triggered by *retxBSR-Timer* expiry, the MAC entity considers that the logical channel that triggered the BSR is the highest priority logical channel that has data available for transmission at the time the BSR is triggered.

The MAC entity shall:

1> if the Buffer Status reporting procedure determines that at least one BSR has been triggered and not cancelled:

2> if UL-SCH resources are available for a new transmission:

3> instruct the Multiplexing and Assembly procedure to generate the BSR MAC CE(s);

3> start or restart *periodicBSR-Timer* except when all the generated BSRs are long or short Truncated BSRs;

3> start or restart *retxBSR-Timer*.

2> if a Regular BSR has been triggered and *logicalChannelSR-DelayTimer* is not running:

3> if there is no UL-SCH resource available for a new transmission; or

3> if the MAC entity is configured with configured uplink grant(s) and the Regular BSR was not triggered for a logical channel for which logical channel SR masking (*logicalChannelSR-Mask*) is setup by upper layers; or

3> if the UL-SCH resources available for a new transmission do not meet the LCP mapping restrictions (see subclause 5.4.3.1) configured for the logical channel(s) that triggered the BSR(s):

4> trigger a Scheduling Request.

A MAC PDU shall contain at most one BSR MAC CE, even when multiple events have triggered a BSR. The Regular BSR and the Periodic BSR shall have precedence over the padding BSR.

The MAC entity shall restart *retxBSR-Timer* upon reception of a grant for transmission of new data on any UL-SCH.

All triggered BSRs may be cancelled when the UL grant(s) can accommodate all pending data available for transmission but is not sufficient to additionally accommodate the BSR MAC CE plus its subheader. All BSRs triggered prior to MAC PDU assembly shall be cancelled when a MAC PDU which includes a BSR MAC CE is transmitted.

5.4.6 Power Headroom Reporting

The Power Headroom reporting procedure is used to provide the serving gNB with information about the difference between the nominal UE maximum transmit power and the estimated power for UL-SCH transmission or SRS transmission per activated Serving Cell and also with information about the difference between the nominal UE maximum power and the estimated power for UL-SCH and PUCCH transmission on SpCell and PUCCH SCell.

RRC controls Power Headroom reporting by configuring the following parameters:

- *phr-PeriodicTimer*;
- *phr-ProhibitTimer*;
- *phr-Tx-PowerFactorChange*;
- *phr-Type2SpCell*;
- *phr-Type2OtherCell*;
- *phr-ModeOtherCG*;
- *multiplePHR*.

A Power Headroom Report (PHR) shall be triggered if any of the following events occur:

- *phr-ProhibitTimer* expires or has expired and the path loss has changed more than *phr-Tx-PowerFactorChange* dB for at least one activated Serving Cell of any MAC entity which is used as a pathloss reference since the last transmission of a PHR in this MAC entity when the MAC entity has UL resources for new transmission;

NOTE 1: The path loss variation for one cell assessed above is between the pathloss measured at present time on the current pathloss reference and the pathloss measured at the transmission time of the last transmission of PHR on the pathloss reference in use at that time, irrespective of whether the pathloss reference has changed in between.

- *phr-PeriodicTimer* expires;
- upon configuration or reconfiguration of the power headroom reporting functionality by upper layers, which is not used to disable the function;
- activation of an SCell of any MAC entity with configured uplink;
- addition of the PSCell (i.e. PSCell is newly added or changed);
- *phr-ProhibitTimer* expires or has expired, when the MAC entity has UL resources for new transmission, and the following is true for any of the activated Serving Cells of any MAC entity with configured uplink:
  - there are UL resources allocated for transmission or there is a PUCCH transmission on this cell, and the required power backoff due to power management (as allowed by $P\text{-}MPR_c$ as specified in TS 38.101 [10]) for this cell has changed more than *phr-Tx-PowerFactorChange* dB since the last transmission of a PHR when the MAC entity had UL resources allocated for transmission or PUCCH transmission on this cell.

NOTE 2: The MAC entity should avoid triggering a PHR when the required power backoff due to power management decreases only temporarily (e.g. for up to a few tens of milliseconds) and it should avoid reflecting such temporary decrease in the values of $P_{CMAX,f,c}$/PH when a PHR is triggered by other triggering conditions.

If the MAC entity has UL resources allocated for a new transmission the MAC entity shall:

1> if it is the first UL resource allocated for a new transmission since the last MAC reset:

2> start *phr-PeriodicTimer*;

1> if the Power Headroom reporting procedure determines that at least one PHR has been triggered and not cancelled, and;

1> if the allocated UL resources can accommodate the MAC CE for PHR which the MAC entity is configured to transmit, plus its subheader, as a result of logical channel prioritization:

2> if *multiplePHR* is configured:

3> for each activated Serving Cell with configured uplink associated with any MAC entity:

4> obtain the value of the Type 1 or Type 3 power headroom for the corresponding uplink carrier;

4> if this MAC entity has UL resources allocated for transmission on this Serving Cell; or

4> if the other MAC entity, if configured, has UL resources allocated for transmission on this Serving Cell and *phr-ModeOtherCG* is set to real by upper layers:

5> obtain the value for the corresponding $P_{CMAX,f,c}$ field from the physical layer.

3> if *phr-Type2SpCell* is configured:

4> obtain the value of the Type 2 power headroom for the SpCell of this MAC entity;

4> obtain the value for the corresponding $P_{CMAX,f,c}$ field from the physical layer.

3> if *phr-Type2OtherCell* is configured:

4> if other CG is configured:

5> obtain the value of the Type 2 power headroom for the SpCell of the other MAC entity;

5> if *phr-ModeOtherCG* is set to real by upper layers:

6> obtain the value for the corresponding $P_{CMAX,f,c}$ field for the SpCell of the other MAC entity from the physical layer.

4> else if PUCCH SCell is configured and activated:

5> obtain the value of the Type 2 power headroom for the PUCCH SCell;

5> obtain the value for the corresponding $P_{CMAX,f,c}$ field from the physical layer.

3> instruct the Multiplexing and Assembly procedure to generate and transmit a PHR MAC CE according to configured *ServCellIndex* and the PUCCH(s) for the MAC entity as defined in subclause 6.1.3.9 based on the values reported by the physical layer.

2> else (i.e. Single Entry PHR format is used):

3> obtain the value of the Type 1 power headroom from the physical layer for the corresponding uplink carrier of the PCell;

3> obtain the value for the corresponding $P_{CMAX,f,c}$ field from the physical layer;

3> instruct the Multiplexing and Assembly procedure to generate and transmit a PHR MAC CE as defined in subclause 6.1.3.8 based on the value reported by the physical layer.

2> start or restart *phr-PeriodicTimer*;

2> start or restart *phr-ProhibitTimer*;

2> cancel all triggered PHR(s).

5.5 PCH reception

When the MAC entity needs to receive PCH, the MAC entity shall:

1> if a PCH assignment has been received on the PDCCH for the P-RNTI:

2> attempt to decode the TB on the PCH as indicated by the PDCCH information;

2> if the TB on the PCH has been successfully decoded:

3> deliver the decoded MAC PDU to upper layers.

5.6 BCH reception

When the MAC entity needs to receive BCH, the MAC entity shall:

1> receive and attempt to decode the BCH;

1> if a TB on the BCH has been successfully decoded:

2> deliver the decoded MAC PDU to upper layers.

5.7 Discontinuous Reception (DRX)

The MAC entity may be configured by RRC with a DRX functionality that controls the UE's PDCCH monitoring activity for the MAC entity's C-RNTI, CS-RNTI, INT-RNTI, SFI-RNTI, SP-CSI-RNTI, TPC-PUCCH-RNTI, TPC-PUSCH-RNTI, and TPC-SRS-RNTI. When using DRX operation, the MAC entity shall also monitor PDCCH according to requirements found in other subclauses of this specification. When in RRC_CONNECTED, if DRX is configured, the MAC entity may monitor the PDCCH discontinuously using the DRX operation specified in this subclause; otherwise the MAC entity shall monitor the PDCCH continuously.

RRC controls DRX operation by configuring the following parameters:

- *drx-onDurationTimer*: the duration at the beginning of a DRX Cycle;
- *drx-SlotOffset*: the delay before starting the *drx-onDurationTimer*;
- *drx-StartOffset*: the subframe where the DRX Cycle starts;
- *drx-InactivityTimer*: the duration after the PDCCH occasion in which a PDCCH indicates a new UL or DL transmission for the MAC entity;
- *drx-RetransmissionTimerDL* (per DL HARQ process): the maximum duration until a DL retransmission is received;
- *drx-RetransmissionTimerUL* (per UL HARQ process): the maximum duration until a grant for UL retransmission is received;
- *drx-LongCycle*: the Long DRX cycle;
- *drx-ShortCycle* (optional): the Short DRX cycle;
- *drx-ShortCycleTimer* (optional): the duration the UE shall follow the Short DRX cycle;
- *drx-HARQ-RTT-TimerDL* (per DL HARQ process): the minimum duration before a DL assignment for HARQ retransmission is expected by the MAC entity;
- *drx-HARQ-RTT-TimerUL* (per UL HARQ process): the minimum duration before a UL HARQ retransmission grant is expected by the MAC entity.

When a DRX cycle is configured, the Active Time includes the time while:

- *drx-onDurationTimer* or *drx-InactivityTimer* or *drx-RetransmissionTimerDL* or *drx-RetransmissionTimerUL* or *ra-ContentionResolutionTimer* (as described in subclause 5.1.5) is running; or
- a Scheduling Request is sent on PUCCH and is pending (as described in subclause 5.4.4); or

- a PDCCH indicating a new transmission addressed to the C-RNTI of the MAC entity has not been received after successful reception of a Random Access Response for the Random Access Preamble not selected by the MAC entity among the contention-based Random Access Preamble (as described in subclause 5.1.4).

When DRX is configured, the MAC entity shall:

1> if a MAC PDU is transmitted in a configured uplink grant:

2> start the *drx-HARQ-RTT-TimerUL* for the corresponding HARQ process in the first symbol after the end of the first repetition of the corresponding PUSCH transmission;

2> stop the *drx-RetransmissionTimerUL* for the corresponding HARQ process.

1> if a *drx-HARQ-RTT-TimerDL* expires:

2> if the data of the corresponding HARQ process was not successfully decoded:

3> start the *drx-RetransmissionTimerDL* for the corresponding HARQ process in the first symbol after the expiry of *drx-HARQ-RTT-TimerDL*.

1> if a *drx-HARQ-RTT-TimerUL* expires:

2> start the *drx-RetransmissionTimerUL* for the corresponding HARQ process in the first symbol after the expiry of *drx-HARQ-RTT-TimerUL*.

1> if a DRX Command MAC CE or a Long DRX Command MAC CE is received:

2> stop *drx-onDurationTimer*;

2> stop *drx-InactivityTimer*.

1> if *drx-InactivityTimer* expires or a DRX Command MAC CE is received:

2> if the Short DRX cycle is configured:

3> start or restart *drx-ShortCycleTimer* in the first symbol after the expiry of *drx-InactivityTimer* or in the first symbol after the end of DRX Command MAC CE reception;

3> use the Short DRX Cycle.

2> else:

3> use the Long DRX cycle.

1> if *drx-ShortCycleTimer* expires:

2> use the Long DRX cycle.

1> if a Long DRX Command MAC CE is received:

2> stop *drx-ShortCycleTimer*;

2> use the Long DRX cycle.

1> if the Short DRX Cycle is used, and [(SFN × 10) + subframe number] modulo (*drx-ShortCycle*) = (*drx-StartOffset*) modulo (*drx-ShortCycle*); or

1> if the Long DRX Cycle is used, and [(SFN × 10) + subframe number] modulo (*drx-LongCycle*) = *drx-StartOffset*:

2> start *drx-onDurationTimer* after *drx-SlotOffset* from the beginning of the subframe.

1> if the MAC entity is in Active Time:

2> monitor the PDCCH;

2> if the PDCCH indicates a DL transmission or if a DL assignment has been configured:

3> start the *drx-HARQ-RTT-TimerDL* for the corresponding HARQ process in the first symbol after the end of the corresponding PUCCH transmission;

3> stop the *drx-RetransmissionTimerDL* for the corresponding HARQ process.

2> if the PDCCH indicates a UL transmission:

3> start the *drx-HARQ-RTT-TimerUL* for the corresponding HARQ process in the first symbol after the end of the first repetition of the corresponding PUSCH transmission;

3> stop the *drx-RetransmissionTimerUL* for the corresponding HARQ process.

2> if the PDCCH indicates a new transmission (DL or UL):

3> start or restart *drx-InactivityTimer* in the first symbol after the end of the PDCCH reception.

1> else (i.e. not part of the Active Time):

2> not transmit type-0-triggered SRS defined in TS 38.214 [7].

1> if CQI masking (*cqi-Mask*) is setup by upper layers:

2> if *drx-onDurationTimer* is not running:

3> not report CSI on PUCCH.

1> else:

2> if the MAC entity is not in Active Time:

3> not report CSI on PUCCH.

Regardless of whether the MAC entity is monitoring PDCCH or not, the MAC entity transmits HARQ feedback and type-1-triggered SRS defined in TS 38.214 [7] when such is expected.

The MAC entity needs not to monitor the PDCCH if it is not a complete PDCCH occasion (e.g. the Active Time starts or expires in the middle of a PDCCH occasion).

5.8 Transmission and reception without dynamic scheduling

5.8.1 Downlink

Semi-Persistent Scheduling (SPS) is configured by RRC per Serving Cell and per BWP. Multiple configurations can be active simultaneously only on different Serving Cells. Activation and deactivation of the DL SPS are independent among the Serving Cells.

For the DL SPS, a DL assignment is provided by PDCCH, and stored or cleared based on L1 signalling indicating SPS activation or deactivation.

RRC configures the following parameters when SPS is configured:

- *cs-RNTI*: CS-RNTI for activation, deactivation, and retransmission;
- *nrofHARQ-Processes*: the number of configured HARQ processes for SPS;
- *periodicity*: Interval of SPS.

When SPS is released by upper layers, all the corresponding configurations shall be released.

After a downlink assignment is configured for SPS, the MAC entity shall consider sequentially that the N^{th} downlink assignment occurs in the slot for which:

$$(numberOfSlotsPerFrame \times SFN + \text{slot number in the frame}) = [(numberOfSlotsPerFrame \times SFN_{\text{start time}} + slot_{\text{start time}}) + N \times periodicity \times numberOfSlotsPerFrame / 10] \text{ modulo } (1024 \times numberOfSlotsPerFrame)$$

where $SFN_{start\ time}$ and $slot_{start\ time}$ are the SFN and slot, respectively, of the first transmission of PDSCH where the configured downlink assignment was (re-)initialised.

5.8.2 Uplink

There are two types of transmission without dynamic grant:

- configured grant Type 1 where an uplink grant is provided by RRC, and stored as configured uplink grant;
- configured grant Type 2 where an uplink grant is provided by PDCCH, and stored or cleared as configured uplink grant based on L1 signalling indicating configured uplink grant activation or deactivation.

Type 1 and Type 2 are configured by RRC per Serving Cell and per BWP. Multiple configurations can be active simultaneously only on different Serving Cells. For Type 2, activation and deactivation are independent among the Serving Cells. For the same Serving Cell, the MAC entity is configured with either Type 1 or Type 2.

RRC configures the following parameters when the configured grant Type 1 is configured:

- *cs-RNTI*: CS-RNTI for retransmission;
- *periodicity*: periodicity of the configured grant Type 1;
- *timeDomainOffset*: Offset of a resource with respect to SFN=0 in time domain;
- *timeDomainAllocation*: Allocation of configured uplink grant in time domain which contains *startSymbolAndLength* (i.e. *SLIV* in TS 38.214 [7]);
- *nrofHARQ-Processes*: the number of HARQ processes.

RRC configures the following parameters when the configured grant Type 2 is configured:

- *cs-RNTI*: CS-RNTI for both activation, deactivation, and retransmission;
- *periodicity*: periodicity of the configured grant Type 2;
- *nrofHARQ-Processes*: the number of HARQ processes.

Upon configuration of a configured grant Type 1 for a Serving Cell by upper layers, the MAC entity shall:

1> store the uplink grant provided by upper layers as a configured uplink grant for the indicated Serving Cell;

1> initialise or re-initialise the configured uplink grant to start in the symbol according to *timeDomainOffset* and *S* (derived from *SLIV* as specified in TS 38.214 [7]), and to reoccur with *periodicity*.

After an uplink grant is configured for a configured grant Type 1, the MAC entity shall consider sequentially that the N^{th} uplink grant occurs associated with the symbol for which:

$$[(SFN \times numberOfSlotsPerFrame \times numberOfSymbolsPerSlot) + (\text{slot number in the frame} \times numberOfSymbolsPerSlot) + \text{symbol number in the slot}] = (timeDomainOffset \times numberOfSymbolsPerSlot + S + N \times periodicity) \bmod (1024 \times numberOfSlotsPerFrame \times numberOfSymbolsPerSlot)$$

After an uplink grant is configured for a configured grant Type 2, the MAC entity shall consider sequentially that the N^{th} uplink grant occurs associated with the symbol for which:

$$[(SFN \times numberOfSlotsPerFrame \times numberOfSymbolsPerSlot) + (\text{slot number in the frame} \times numberOfSymbolsPerSlot) + \text{symbol number in the slot}] = [(SFN_{start\ time} \times numberOfSlotsPerFrame \times numberOfSymbolsPerSlot + slot_{start\ time} \times numberOfSymbolsPerSlot + symbol_{start\ time}) + N \times periodicity] \bmod (1024 \times numberOfSlotsPerFrame \times numberOfSymbolsPerSlot)$$

where $SFN_{start\ time}$, $slot_{start\ time}$, and $symbol_{start\ time}$ are the SFN, slot, and symbol, respectively, of the first transmission of PUSCH where the configured uplink grant was (re-)initialised.

When a configured uplink grant is released by upper layers, all the corresponding configurations shall be released and all corresponding uplink grants shall be cleared immediately.

The MAC entity shall:

1> if the configured uplink grant confirmation has been triggered and not cancelled; and

1> if the MAC entity has UL resources allocated for new transmission:

2> instruct the Multiplexing and Assembly procedure to generate an Configured Grant Confirmation MAC CE as defined in subclause 6.1.3.7;

2> cancel the triggered configured uplink grant confirmation.

For a configured grant Type 2, the MAC entity shall clear the configured uplink grant immediately after first transmission of Configured Grant Confirmation MAC CE triggered by the configured uplink grant deactivation.

Retransmissions except for repetition of configured uplink grants use uplink grants addressed to CS-RNTI.

5.9 Activation/Deactivation of SCells

If the MAC entity is configured with one or more SCells, the network may activate and deactivate the configured SCells. Upon configuration of an SCell, the SCell is deactivated.

The configured SCell(s) is activated and deactivated by:

- receiving the SCell Activation/Deactivation MAC CE described in subclause 6.1.3.10;
- configuring *sCellDeactivationTimer* timer per configured SCell (except the SCell configured with PUCCH, if any): the associated SCell is deactivated upon its expiry.

The MAC entity shall for each configured SCell:

1> if an SCell Activation/Deactivation MAC CE is received activating the SCell:

2> activate the SCell according to the timing defined in TS 38.213 [6]; i.e. apply normal SCell operation including:

3> SRS transmissions on the SCell;

3> CSI reporting for the SCell;

3> PDCCH monitoring on the SCell;

3> PDCCH monitoring for the SCell;

3> PUCCH transmissions on the SCell, if configured.

2> start or restart the *sCellDeactivationTimer* associated with the SCell in the slot when the SCell Activation/Deactivation MAC CE was received;

2> (re-)initialize any suspended configured uplink grants of configured grant Type 1 associated with this SCell according to the stored configuration, if any, and to start in the symbol according to rules in subclause 5.8.2;

2> trigger PHR according to subclause 5.4.6.

1> else if an SCell Activation/Deactivation MAC CE is received deactivating the SCell; or

1> if the *sCellDeactivationTimer* associated with the activated SCell expires:

2> deactivate the SCell according to the timing defined in TS 38.213 [6];

2> stop the *sCellDeactivationTimer* associated with the SCell;

2> stop the *bwp-InactivityTimer* associated with the SCell;

2> clear any configured downlink assignment and any configured uplink grant Type 2 associated with the SCell respectively;

2> suspend any configured uplink grant Type 1 associated with the SCell;

2> flush all HARQ buffers associated with the SCell.

1> if PDCCH on the activated SCell indicates an uplink grant or downlink assignment; or

1> if PDCCH on the Serving Cell scheduling the activated SCell indicates an uplink grant or a downlink assignment for the activated SCell; or

1> if a MAC PDU is transmitted in a configured uplink grant or received in a configured downlink assignment:

2> restart the *sCellDeactivationTimer* associated with the SCell.

1> if the SCell is deactivated:

2> not transmit SRS on the SCell;

2> not report CSI for the SCell;

2> not transmit on UL-SCH on the SCell;

2> not transmit on RACH on the SCell;

2> not monitor the PDCCH on the SCell;

2> not monitor the PDCCH for the SCell;

2> not transmit PUCCH on the SCell.

HARQ feedback for the MAC PDU containing SCell Activation/Deactivation MAC CE shall not be impacted by PCell, PSCell and PUCCH SCell interruptions due to SCell activation/deactivation in TS 38.133 [11].

When SCell is deactivated, the ongoing Random Access procedure on the SCell, if any, is aborted.

5.10 Activation/Deactivation of PDCP duplication

If one or more DRBs are configured with PDCP duplication, the network may activate and deactivate the PDCP duplication for the configured DRB(s).

The PDCP duplication for the configured DRB(s) is activated and deactivated by:

- receiving the Duplication Activation/Deactivation MAC CE described in subclause 6.1.3.11.

The MAC entity shall for each DRB configured with PDCP duplication:

1> if a Duplication Activation/Deactivation MAC CE is received activating the PDCP duplication of the DRB:

2> indicate the activation of PDCP duplication of the DRB to upper layers;

2> apply the *allowedServingCells* to the logical channels of the DRB.

1> if a Duplication Activation/Deactivation MAC CE is received deactivating the PDCP duplication of the DRB:

2> indicate the deactivation of PDCP duplication of the DRB to upper layers;

2> not apply the *allowedServingCells* to the logical channels of the DRB.

5.11 MAC reconfiguration

When a reconfiguration of the MAC entity is requested by upper layers, the MAC entity shall:

1> initialize the corresponding HARQ entity upon addition of an SCell;

1> remove the corresponding HARQ entity upon removal of an SCell;

1> apply the new value for timers when the timer is (re)started;

1> apply the new maximum parameter value when counters are initialized;

1> apply immediately the configurations received from upper layers for other parameters.

5.12 MAC Reset

If a reset of the MAC entity is requested by upper layers, the MAC entity shall:

1> initialize *Bj* for each logical channel to zero;

1> stop (if running) all timers;

1> consider all *timeAlignmentTimer*s as expired and perform the corresponding actions in subclause 5.2;

1> set the NDIs for all uplink HARQ processes to the value 0;

1> stop, if any, ongoing RACH procedure;

1> discard explicitly signalled contention-free Random Access Resources, if any;

1> flush Msg3 buffer;

1> cancel, if any, triggered Scheduling Request procedure;

1> cancel, if any, triggered Buffer Status Reporting procedure;

1> cancel, if any, triggered Power Headroom Reporting procedure;

1> flush the soft buffers for all DL HARQ processes;

1> for each DL HARQ process, consider the next received transmission for a TB as the very first transmission;

1> release, if any, Temporary C-RNTI;

1> reset *BFI_COUNTER*.

5.13 Handling of unknown, unforeseen and erroneous protocol data

When a MAC entity receives a MAC PDU for the MAC entity's C-RNTI or CS-RNTI, or by the configured downlink assignment, containing a Reserved LCID value, or an LCID value the MAC Entity does not support, the MAC entity shall at least:

1> discard the received subPDU and any remaining subPDUs in the MAC PDU.

When a MAC entity receives a MAC PDU for the MAC entity's C-RNTI or CS-RNTI, or by the configured downlink assignment, containing an LCID value which is not configured, the MAC entity shall at least:

1> discard the received subPDU.

5.14 Handling of measurement gaps

During a measurement gap, the MAC entity shall:

1> not perform the transmission of HARQ feedback, SR, and CSI;

1> not report SRS;

1> not transmit on UL-SCH except for Msg3 as specified in subclause 5.4.2.2;

1> if the *ra-ResponseWindow* or the *ra-ContentionResolutionTimer* is running:

2> monitor the PDCCH as specified in subclauses 5.1.4 and 5.1.5.

1> else:

2> not monitor the PDCCH.

5.15 Bandwidth Part (BWP) operation

In addition to clause 12 of TS 38.213 [6], this subclause specifies requirements on BWP operation.

A Serving Cell may be configured with one or multiple BWPs, and the maximum number of BWP per Serving Cell is specified in TS 38.213 [6].

The BWP switching for a Serving Cell is used to activate an inactive BWP and deactivate an active BWP at a time. The BWP switching is controlled by the PDCCH indicating a downlink assignment or an uplink grant, by the *bwp-InactivityTimer*, by RRC signalling, or by the MAC entity itself upon initiation of Random Access procedure. Upon addition of SpCell or activation of an SCell, the DL BWP and UL BWP indicated by *firstActiveDownlinkBWP-Id* and *firstActiveUplinkBWP-Id* respectively (as specified in TS 38.331 [5]) is active without receiving PDCCH indicating a downlink assignment or an uplink grant. The active BWP for a Serving Cell is indicated by either RRC or PDCCH (as specified in TS 38.213 [6]). For unpaired spectrum, a DL BWP is paired with a UL BWP, and BWP switching is common for both UL and DL.

For each activated Serving Cell configured with a BWP, the MAC entity shall:

1> if a BWP is activated:

2> transmit on UL-SCH on the BWP;

2> transmit on RACH on the BWP;

2> monitor the PDCCH on the BWP;

2> transmit PUCCH on the BWP;

2> transmit SRS on the BWP;

2> receive DL-SCH on the BWP;

2> (re-)initialize any suspended configured uplink grants of configured grant Type 1 on the active BWP according to the stored configuration, if any, and to start in the symbol according to rules in subclause 5.8.2.

1> if a BWP is deactivated:

2> not transmit on UL-SCH on the BWP;

2> not transmit on RACH on the BWP;

2> not monitor the PDCCH on the BWP;

2> not transmit PUCCH on the BWP;

2> not report CSI for the BWP;

2> not transmit SRS on the BWP;

2> not receive DL-SCH on the BWP;

2> clear any configured downlink assignment and configured uplink grant of configured grant Type 2 on the BWP;

2> suspend any configured uplink grant of configured grant Type 1 on the inactive BWP.

Upon initiation of the Random Access procedure on a Serving Cell, the MAC entity shall for this Serving Cell:

1> if PRACH occasions are not configured for the active UL BWP:

2> switch the active UL BWP to BWP indicated by *initialUplinkBWP*;

2> if the Serving Cell is a SpCell:

3> switch the active DL BWP to BWP indicated by *initialDownlinkBWP*.

1> else:

2> if the Serving Cell is a SpCell:

3> if the active DL BWP does not have the same *bwp-Id* as the active UL BWP:

4> switch the active DL BWP to the DL BWP with the same *bwp-Id* as the active UL BWP.

1> perform the Random Access procedure on the active DL BWP of SpCell and active UL BWP of this Serving Cell.

If the MAC entity receives a PDCCH for BWP switching of a serving cell, the MAC entity shall:

1> if there is no ongoing Random Access procedure associated with this Serving Cell; or

1> if the ongoing Random Access procedure associated with this Serving Cell is successfully completed upon reception of this PDCCH addressed to C-RNTI (as specified in subclauses 5.1.4 and 5.1.5):

2> perform BWP switching to a BWP indicated by the PDCCH.

If the MAC entity receives a PDCCH for BWP switching for a Serving Cell while a Random Access procedure associated with that Serving Cell is ongoing in the MAC entity, it is up to UE implementation whether to switch BWP or ignore the PDCCH for BWP switching, except for the PDCCH reception for BWP switching addressed to the C-RNTI for successful Random Access procedure completion (as specified in subclauses 5.1.4 and 5.1.5) in which case the UE shall perform BWP switching to a BWP indicated by the PDCCH. Upon reception of the PDCCH for BWP switching other than successful contention resolution, if the MAC entity decides to perform BWP switching, the MAC entity shall stop the ongoing Random Access procedure and initiate a Random Access procedure on the new activated BWP; if the MAC decides to ignore the PDCCH for BWP switching, the MAC entity shall continue with the ongoing Random Access procedure on the active BWP.

If the *bwp-InactivityTimer* is configured, the MAC entity shall for each activated Serving Cell:

1> if the *defaultDownlinkBWP* is configured, and the active DL BWP is not the BWP indicated by the *defaultDownlinkBWP*; or

1> if the *defaultDownlinkBWP* is not configured, and the active DL BWP is not the *initialDownlinkBWP*:

2> if a PDCCH addressed to C-RNTI or CS-RNTI indicating downlink assignment or uplink grant is received on the active BWP; or

2> if a PDCCH addressed to C-RNTI or CS-RNTI indicating downlink assignment or uplink grant is received for the active BWP; or

2> if a MAC PDU is transmitted in a configured uplink grant or received in a configured downlink assignment:

3> if there is no ongoing random access procedure associated with this Serving Cell; or

3> if the ongoing Random Access procedure associated with this Serving Cell is successfully completed upon reception of this PDCCH addressed to C-RNTI (as specified in subclauses 5.1.4 and 5.1.5):

4> start or restart the *bwp-InactivityTimer* associated with the active DL BWP.

2> if a PDCCH for BWP switching is received on the active DL BWP, and the MAC entity switches the active BWP:

3> start or restart the *bwp-InactivityTimer* associated with the active DL BWP.

2> if Random Access procedure is initiated on this Serving Cell:

3> stop the *bwp-InactivityTimer* associated with the active DL BWP of this Serving Cell, if running.

3> if the Serving Cell is SCell:

4> stop the *bwp-InactivityTimer* associated with the active DL BWP of SpCell, if running.

2> if the *bwp-InactivityTimer* associated with the active DL BWP expires:

3> if the *defaultDownlinkBWP* is configured:

4> perform BWP switching to a BWP indicated by the *defaultDownlinkBWP*.

3> else:

4> perform BWP switching to the *initialDownlinkBWP*.

5.16 SUL operation

The Supplementary UL (SUL) carrier can be configured as a complement to the normal UL (NUL) carrier. Switching between the NUL carrier and the SUL carrier means that the UL transmissions move from the PUSCH on one carrier to the other carrier. This is done via an indication in DCI. If the MAC entity receives a UL grant indicating a SUL switch while a Random Access procedure is ongoing, the MAC entity shall ignore the UL grant.

The Serving Cell configured with *supplementaryUplink* belongs to a single TAG.

5.17 Beam Failure Detection and Recovery procedure

The MAC entity may be configured by RRC with a beam failure recovery procedure which is used for indicating to the serving gNB of a new SSB or CSI-RS when beam failure is detected on the serving SSB(s)/CSI-RS(s). Beam failure is detected by counting beam failure instance indication from the lower layers to the MAC entity.

RRC configures the following parameters in the *BeamFailureRecoveryConfig* for the Beam Failure Detection and Recovery procedure:

- *beamFailureInstanceMaxCount* for the beam failure detection;
- *beamFailureDetectionTimer* for the beam failure detection;
- *beamFailureRecoveryTimer* for the beam failure recovery procedure;
- *rsrp-ThresholdSSB*: an RSRP threshold for the beam failure recovery;
- *powerRampingStep*: *powerRampingStep* for the beam failure recovery;
- *preambleReceivedTargetPower*: *preambleReceivedTargetPower* for the beam failure recovery;
- *preambleTransMax*: *preambleTransMax* for the beam failure recovery;
- *ra-ResponseWindow*: the time window to monitor response(s) for the beam failure recovery using contention-free Random Access Preamble;
- *prach-ConfigIndex*: *prach-ConfigIndex* for the beam failure recovery;
- *ra-ssb-OccasionMaskIndex*: *ra-ssb-OccasionMaskIndex* for the beam failure recovery;
- *ra-OccasionList*: *ra-OccasionList* for the beam failure recovery.

The following UE variables are used for the beam failure detection procedure:

- *BFI_COUNTER*: counter for beam failure instance indication which is initially set to 0.

The MAC entity shall:

1> if beam failure instance indication has been received from lower layers:

2> start or restart the *beamFailureDetectionTimer*;

2> increment *BFI_COUNTER* by 1;

2> if *BFI_COUNTER* >= *beamFailureInstanceMaxCount*:

3> if *beamFailureRecoveryConfig* is configured:

4> start the *beamFailureRecoveryTimer*, if configured;

4> initiate a Random Access procedure (see subclause 5.1) on the SpCell by applying the parameters *powerRampingStep*, *preambleReceivedTargetPower*, and *preambleTransMax* configured in *beamFailureRecoveryConfig*.

3> else:

4> initiate a Random Access procedure (see subclause 5.1) on the SpCell.

1> if the *beamFailureDetectionTimer* expires:

2> set *BFI_COUNTER* to 0.

1> if the Random Access procedure is successfully completed (see subclause 5.1):

2> stop the *beamFailureRecoveryTimer*, if configured;

2> consider the Beam Failure Recovery procedure successfully completed.

5.18 Handling of MAC CEs

5.18.1 General

This subclause specifies the requirements upon reception of the following MAC CEs:

- SP CSI-RS / CSI-IM Resource Set Activation/Deactivation MAC CE;
- Aperiodic CSI Trigger State Subselection MAC CE;
- TCI States Activation/Deactivation for UE-specific PDSCH MAC CE;
- TCI State Indication for UE-specific PDCCH MAC CE;
- SP CSI reporting on PUCCH Activation/Deactivation MAC CE;
- SP SRS Activation/Deactivation MAC CE;
- PUCCH spatial relation Activation/Deactivation MAC CE;
- SP ZP CSI-RS Resource Set Activation/Deactivation MAC CE;
- Recommended Bit Rate MAC CE.

5.18.2 Activation/Deactivation of Semi-persistent CSI-RS/CSI-IM resource set

The network may activate and deactivate the configured Semi-persistent CSI-RS/CSI-IM resource sets of a Serving Cell by sending the SP CSI-RS / CSI-IM Resource Set Activation/Deactivation MAC CE described in subclause 6.1.3.12. The configured Semi-persistent CSI-RS/CSI-IM resource sets are initially deactivated upon configuration and after a handover.

The MAC entity shall:

1> if the MAC entity receives an SP CSI-RS / CSI-IM Resource Set Activation/Deactivation MAC CE on a Serving Cell:

2> indicate to lower layers the information regarding the SP CSI-RS / CSI-IM Resource Set Activation/Deactivation MAC CE.

5.18.3 Aperiodic CSI Trigger State subselection

The network may select among the configured aperiodic CSI trigger states of a Serving Cell by sending the Aperiodic CSI Trigger State Subselection MAC CE described in subclause 6.1.3.13.

The MAC entity shall:

1> if the MAC entity receives an Aperiodic CSI trigger State Subselection MAC CE on a Serving Cell:

2> indicate to lower layers the information regarding Aperiodic CSI trigger State Subselection MAC CE.

5.18.4 Activation/Deactivation of UE-specific PDSCH TCI state

The network may activate and deactivate the configured TCI states for PDSCH of a Serving Cell by sending the TCI States Activation/Deactivation for UE-specific PDSCH MAC CE described in subclause 6.1.3.14. The configured TCI states for PDSCH are initially deactivated upon configuration and after a handover.

The MAC entity shall:

1> if the MAC entity receives an TCI States Activation/Deactivation for UE-specific PDSCH MAC CE on a Serving Cell:

2> indicate to lower layers the information regarding the TCI States Activation/Deactivation for UE-specific PDSCH MAC CE.

5.18.5 Indication of TCI state for UE-specific PDCCH

The network may indicate a TCI state for PDCCH reception for a CORESET of a Serving Cell by sending the TCI State Indication for UE-specific PDCCH MAC CE described in subclause 6.1.3.15.

The MAC entity shall:

1> if the MAC entity receives a TCI State Indication for UE-specific PDCCH MAC CE on a Serving Cell:

2> indicate to lower layers the information regarding the TCI State Indication for UE-specific PDCCH MAC CE.

5.18.6 Activation/Deactivation of Semi-persistent CSI reporting on PUCCH

The network may activate and deactivate the configured Semi-persistent CSI reporting on PUCCH of a Serving Cell by sending the SP CSI reporting on PUCCH Activation/Deactivation MAC CE described in subclause 6.1.3.16. The configured Semi-persistent CSI reporting on PUCCH is initially deactivated upon configuration and after a handover.

The MAC entity shall:

1> if the MAC entity receives an SP CSI reporting on PUCCH Activation/Deactivation MAC CE on a Serving Cell:

2> indicate to lower layers the information regarding the SP CSI reporting on PUCCH Activation/Deactivation MAC CE.

5.18.7 Activation/Deactivation of Semi-persistent SRS

The network may activate and deactivate the configured Semi-persistent SRS resource sets of a Serving Cell by sending the SP SRS Activation/Deactivation MAC CE described in subclause 6.1.3.17. The configured Semi-persistent SRS resource sets are initially deactivated upon configuration and after a handover.

The MAC entity shall:

1> if the MAC entity receives an SP SRS Activation/Deactivation MAC CE on a Serving Cell:

2> indicate to lower layers the information regarding the SP SRS Activation/Deactivation MAC CE.

5.18.8 Activation/Deactivation of spatial relation of PUCCH resource

The network may activate and deactivate a spatial relation for a PUCCH resource of a Serving Cell by sending the PUCCH spatial relation Activation/Deactivation MAC CE described in subclause 6.1.3.18.

The MAC entity shall:

1> if the MAC entity receives a PUCCH spatial relation Activation/Deactivation MAC CE on a Serving Cell:

2> indicate to lower layers the information regarding the PUCCH spatial relation Activation/Deactivation MAC CE.

5.18.9 Activation/Deactivation of semi-persistent ZP CSI-RS resource set

The network may activate and deactivate the configured Semi-persistent ZP CSI-RS resource set of a Serving Cell by sending the SP ZP CSI-RS Resource Set Activation/Deactivation MAC CE described in subclause 6.1.3.19. The configured Semi-persistent ZP CSI-RS resource sets are initially deactivated upon configuration and after a handover.

The MAC entity shall:

1> if the MAC entity receives an SP ZP CSI-RS Resource Set Activation/Deactivation MAC CE on a Serving Cell:

2> indicate to lower layers the information regarding the SP ZP CSI-RS Resource Set Activation/Deactivation MAC CE.

5.18.10 Recommended Bit Rate

The recommended bit rate procedure is used to provide the MAC entity with information about the bit rate which the gNB recommends. The bit rate is the recommended bit rate of the physical layer. Averaging window of default value 2000 ms will apply (3GPP TS 26.114 [13]).

The gNB may transmit the Recommended bit rate MAC control element to the MAC entity to indicate the recommended bit rate for the UE for a specific logical channel and a specific direction (either uplink or downlink). Upon reception of a Recommended bit rate MAC control element the MAC entity shall:

- indicate to upper layers the recommended bit rate for the indicated logical channel and direction

The MAC entity may request the gNB to indicate the recommended bit rate for a specific logical channel and a specific direction. If the MAC entity is requested by upper layers to query the gNB for the recommended bit rate for a logical channel and for a direction (i.e. for uplink or downlink), the MAC entity shall:

1> if a Recommended bit rate query for this logical channel and this direction has not been triggered:

2> trigger a Recommended bit rate query for this logical channel, direction, and desired bit rate.

If the MAC entity has UL resources allocated for new transmission the MAC entity shall:

1> for each Recommended bit rate query that the Recommended Bit Rate procedure determines has been triggered and not cancelled:

2> if *bitRateQueryProhibitTimer* for the logical channel and the direction of this Recommended bit rate query is configured, and it is not running; and

2> if the MAC entity has UL resources allocated for new transmission and the allocated UL resources can accommodate a Recommended bit rate MAC control element plus its subheader as a result of logical channel prioritization:

3> instruct the Multiplexing and Assembly procedure to generate the Recommended bit rate MAC control element for the logical channel and the direction of this Recommended bit rate query;

3> start the *bitRateQueryProhibitTimer* for the logical channel and the direction of this Recommended bit rate query

3> cancel this Recommended bit rate query.

6 Protocol Data Units, formats and parameters

6.1 Protocol Data Units

6.1.1 General

A MAC PDU is a bit string that is byte aligned (i.e. multiple of 8 bits) in length. In the figures in clause 6, bit strings are represented by tables in which the most significant bit is the leftmost bit of the first line of the table, the least significant bit is the rightmost bit on the last line of the table, and more generally the bit string is to be read from left to right and

then in the reading order of the lines. The bit order of each parameter field within a MAC PDU is represented with the first and most significant bit in the leftmost bit and the last and least significant bit in the rightmost bit.

A MAC SDU is a bit string that is byte aligned (i.e. multiple of 8 bits) in length. A MAC SDU is included into a MAC PDU from the first bit onward.

A MAC CE is a bit string that is byte aligned (i.e. multiple of 8 bits) in length.

A MAC subheader is a bit string that is byte aligned (i.e. multiple of 8 bits) in length. Each MAC subheader is placed immediately in front of the corresponding MAC SDU, MAC CE, or padding.

The MAC entity shall ignore the value of the Reserved bits in downlink MAC PDUs.

6.1.2 MAC PDU (DL-SCH and UL-SCH except transparent MAC and Random Access Response)

A MAC PDU consists of one or more MAC subPDUs. Each MAC subPDU consists of one of the following:

- A MAC subheader only (including padding);
- A MAC subheader and a MAC SDU;
- A MAC subheader and a MAC CE;
- A MAC subheader and padding.

The MAC SDUs are of variable sizes.

Each MAC subheader corresponds to either a MAC SDU, a MAC CE, or padding.

A MAC subheader except for fixed sized MAC CE, padding, and a MAC SDU of CCCH of size 48 bits consists of the four header fields R/F/LCID/L. A MAC subheader for fixed sized MAC CE, padding, and a MAC SDU of CCCH of size 48 bits consists of the two header fields R/LCID.

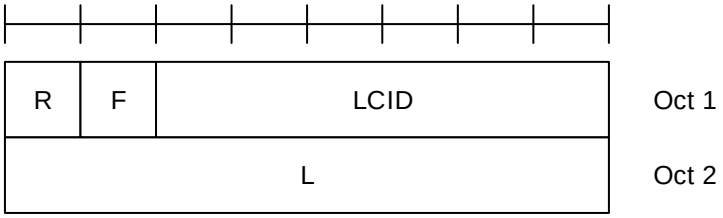


Figure 6.1.2-1: R/F/LCID/L MAC subheader with 8-bit L field

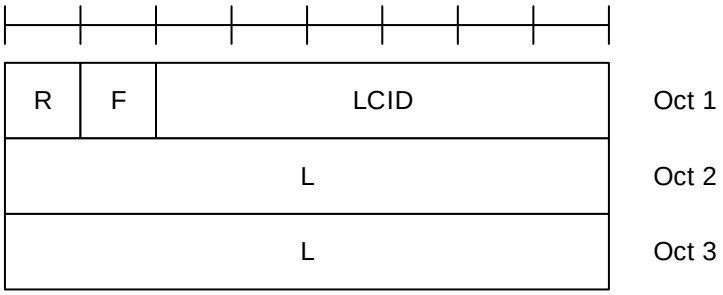


Figure 6.1.2-2: R/F/LCID/L MAC subheader with 16-bit L field

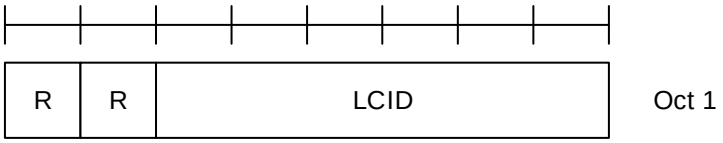


Figure 6.1.2-3: R/LCID MAC subheader

MAC CEs are placed together. DL MAC subPDU(s) with MAC CE(s) is placed before any MAC subPDU with MAC SDU and MAC subPDU with padding as depicted in Figure 6.1.2-4. UL MAC subPDU(s) with MAC CE(s) is placed after all the MAC subPDU(s) with MAC SDU and before the MAC subPDU with padding in the MAC PDU as depicted in Figure 6.1.2-5. The size of padding can be zero.

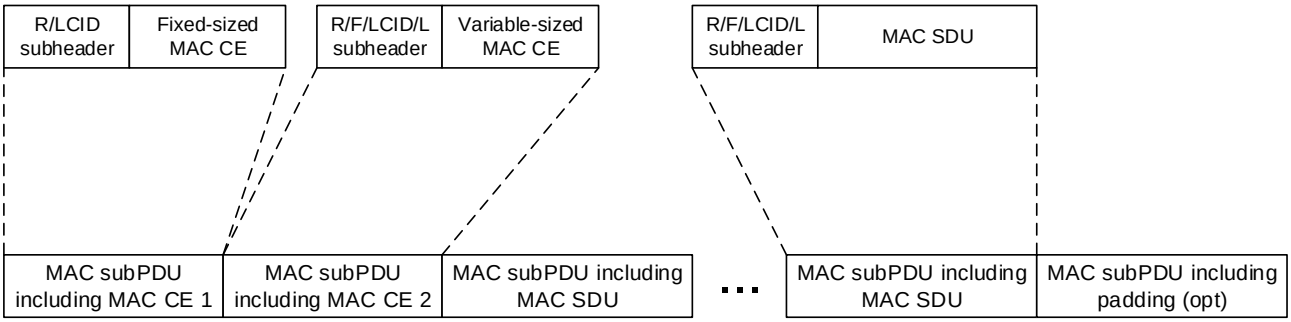


Figure 6.1.2-4: Example of a DL MAC PDU

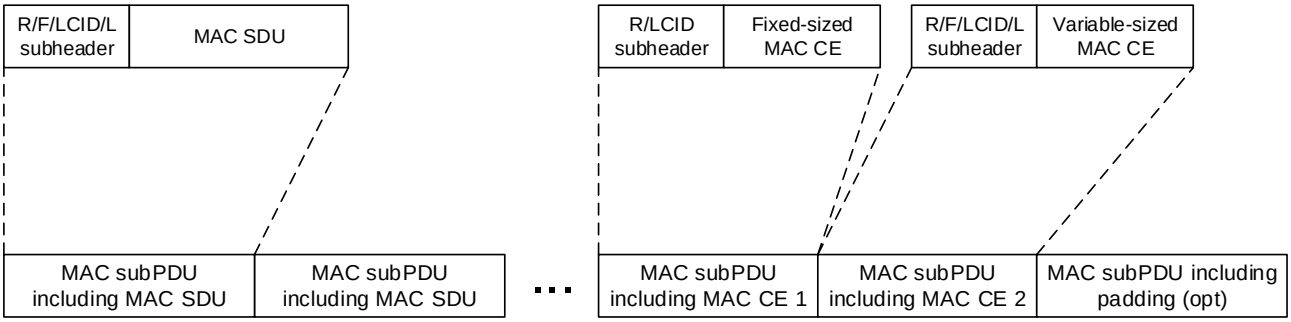


Figure 6.1.2-5: Example of a UL MAC PDU

A maximum of one MAC PDU can be transmitted per TB per MAC entity.

6.1.3 MAC Control Elements (CEs)

6.1.3.1 Buffer Status Report MAC CEs

Buffer Status Report (BSR) MAC CEs consist of either:

- Short BSR format (fixed size); or
- Long BSR format (variable size); or
- Short Truncated BSR format (fixed size); or
- Long Truncated BSR format (variable size).

The BSR formats are identified by MAC PDU subheaders with LCIDs as specified in Table 6.2.1-2.

The fields in the BSR MAC CE are defined as follows:

- LCG ID: The Logical Channel Group ID field identifies the group of logical channel(s) whose buffer status is being reported. The length of the field is 3 bits;
- LCG_i: For the Long BSR format, this field indicates the presence of the Buffer Size field for the logical channel group i. The LCG_i field set to "1" indicates that the Buffer Size field for the logical channel group i is reported. The LCG_i field set to "0" indicates that the Buffer Size field for the logical channel group i is not reported. For the Long Truncated BSR format, this field indicates whether logical channel group i has data available. The LCG_i field set to "1" indicates that logical channel group i has data available. The LCG_i field set to "0" indicates that logical channel group i does not have data available;
- Buffer Size: The Buffer Size field identifies the total amount of data available according to the data volume calculation procedure in TSs 38.322 and 38.323 [3] [4] across all logical channels of a logical channel group after the MAC PDU has been built (i.e. after the logical channel prioritization procedure, which may result the

value of the Buffer Size field to zero). The amount of data is indicated in number of bytes. The size of the RLC and MAC headers are not considered in the buffer size computation. The length of this field for the Short BSR format and the Short Truncated BSR format is 5 bits. The length of this field for the Long BSR format and the Long Truncated BSR format is 8 bits. The values for the 5-bit and 8-bit Buffer Size fields are shown in Tables 6.1.3.1-1 and 6.1.3.1-2, respectively. For the Long BSR format and the Long Truncated BSR format, the Buffer Size fields are included in ascending order based on the LCG_i. For the Long Truncated BSR format the number of Buffer Size fields included is maximised, while not exceeding the number of padding bits.

NOTE: The number of the Buffer Size fields in the Long BSR and Long Truncated BSR format can be zero.

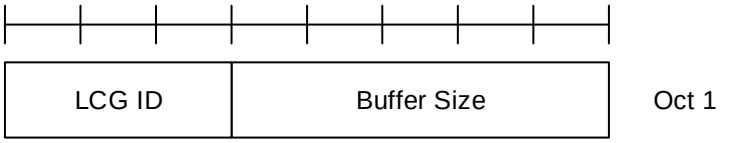


Figure 6.1.3.1-1: Short BSR and Short Truncated BSR MAC CE

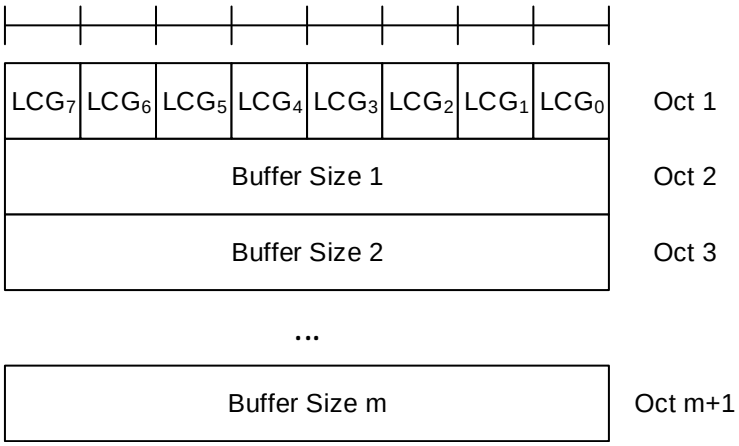


Figure 6.1.3.1-2: Long BSR and Long Truncated BSR MAC CE

Table 6.1.3.1-1: Buffer size levels (in bytes) for 5-bit Buffer Size field

Index	BS value	Index	BS value	Index	BS value	Index	BS value
0	0	8	≤ 102	16	≤ 1446	24	≤ 20516
1	≤ 10	9	≤ 142	17	≤ 2014	25	≤ 28581
2	≤ 14	10	≤ 198	18	≤ 2806	26	≤ 39818
3	≤ 20	11	≤ 276	19	≤ 3909	27	≤ 55474
4	≤ 28	12	≤ 384	20	≤ 5446	28	≤ 77284
5	≤ 38	13	≤ 535	21	≤ 7587	29	≤ 107669
6	≤ 53	14	≤ 745	22	≤ 10570	30	≤ 150000
7	≤ 74	15	≤ 1038	23	≤ 14726	31	> 150000

Table 6.1.3.1-2: Buffer size levels (in bytes) for 8-bit Buffer Size field

Index	BS value	Index	BS value	Index	BS value	Index	BS value
0	0	64	≤ 560	128	≤ 31342	192	≤ 1754595
1	≤ 10	65	≤ 597	129	≤ 33376	193	≤ 1868488
2	≤ 11	66	≤ 635	130	≤ 35543	194	≤ 1989774
3	≤ 12	67	≤ 677	131	≤ 37850	195	≤ 2118933
4	≤ 13	68	≤ 720	132	≤ 40307	196	≤ 2256475
5	≤ 14	69	≤ 767	133	≤ 42923	197	≤ 2402946
6	≤ 15	70	≤ 817	134	≤ 45709	198	≤ 2558924
7	≤ 16	71	≤ 870	135	≤ 48676	199	≤ 2725027
8	≤ 17	72	≤ 926	136	≤ 51836	200	≤ 2901912
9	≤ 18	73	≤ 987	137	≤ 55200	201	≤ 3090279
10	≤ 19	74	≤ 1051	138	≤ 58784	202	≤ 3290873
11	≤ 20	75	≤ 1119	139	≤ 62599	203	≤ 3504487
12	≤ 22	76	≤ 1191	140	≤ 66663	204	≤ 3731968
13	≤ 23	77	≤ 1269	141	≤ 70990	205	≤ 3974215
14	≤ 25	78	≤ 1351	142	≤ 75598	206	≤ 4232186
15	≤ 26	79	≤ 1439	143	≤ 80505	207	≤ 4506902
16	≤ 28	80	≤ 1532	144	≤ 85730	208	≤ 4799451
17	≤ 30	81	≤ 1631	145	≤ 91295	209	≤ 5110989
18	≤ 32	82	≤ 1737	146	≤ 97221	210	≤ 5442750
19	≤ 34	83	≤ 1850	147	≤ 103532	211	≤ 5796046
20	≤ 36	84	≤ 1970	148	≤ 110252	212	≤ 6172275
21	≤ 38	85	≤ 2098	149	≤ 117409	213	≤ 6572925
22	≤ 40	86	≤ 2234	150	≤ 125030	214	≤ 6999582
23	≤ 43	87	≤ 2379	151	≤ 133146	215	≤ 7453933
24	≤ 46	88	≤ 2533	152	≤ 141789	216	≤ 7937777
25	≤ 49	89	≤ 2698	153	≤ 150992	217	≤ 8453028
26	≤ 52	90	≤ 2873	154	≤ 160793	218	≤ 9001725
27	≤ 55	91	≤ 3059	155	≤ 171231	219	≤ 9586039
28	≤ 59	92	≤ 3258	156	≤ 182345	220	≤ 10208280
29	≤ 62	93	≤ 3469	157	≤ 194182	221	≤ 10870913
30	≤ 66	94	≤ 3694	158	≤ 206786	222	≤ 11576557
31	≤ 71	95	≤ 3934	159	≤ 220209	223	≤ 12328006
32	≤ 75	96	≤ 4189	160	≤ 234503	224	≤ 13128233
33	≤ 80	97	≤ 4461	161	≤ 249725	225	≤ 13980403
34	≤ 85	98	≤ 4751	162	≤ 265935	226	≤ 14887889
35	≤ 91	99	≤ 5059	163	≤ 283197	227	≤ 15854280
36	≤ 97	100	≤ 5387	164	≤ 301579	228	≤ 16883401
37	≤ 103	101	≤ 5737	165	≤ 321155	229	≤ 17979324
38	≤ 110	102	≤ 6109	166	≤ 342002	230	≤ 19146385
39	≤ 117	103	≤ 6506	167	≤ 364202	231	≤ 20389201
40	≤ 124	104	≤ 6928	168	≤ 387842	232	≤ 21712690
41	≤ 132	105	≤ 7378	169	≤ 413018	233	≤ 23122088
42	≤ 141	106	≤ 7857	170	≤ 439827	234	≤ 24622972
43	≤ 150	107	≤ 8367	171	≤ 468377	235	≤ 26221280
44	≤ 160	108	≤ 8910	172	≤ 498780	236	≤ 27923336
45	≤ 170	109	≤ 9488	173	≤ 531156	237	≤ 29735875
46	≤ 181	110	≤ 10104	174	≤ 565634	238	≤ 31666069
47	≤ 193	111	≤ 10760	175	≤ 602350	239	≤ 33721553
48	≤ 205	112	≤ 11458	176	≤ 641449	240	≤ 35910462
49	≤ 218	113	≤ 12202	177	≤ 683087	241	≤ 38241455
50	≤ 233	114	≤ 12994	178	≤ 727427	242	≤ 40723756
51	≤ 248	115	≤ 13838	179	≤ 774645	243	≤ 43367187
52	≤ 264	116	≤ 14736	180	≤ 824928	244	≤ 46182206
53	≤ 281	117	≤ 15692	181	≤ 878475	245	≤ 49179951
54	≤ 299	118	≤ 16711	182	≤ 935498	246	≤ 52372284
55	≤ 318	119	≤ 17795	183	≤ 996222	247	≤ 55771835
56	≤ 339	120	≤ 18951	184	≤ 1060888	248	≤ 59392055
57	≤ 361	121	≤ 20181	185	≤ 1129752	249	≤ 63247269
58	≤ 384	122	≤ 21491	186	≤ 1203085	250	≤ 67352729
59	≤ 409	123	≤ 22885	187	≤ 1281179	251	≤ 71724679
60	≤ 436	124	≤ 24371	188	≤ 1364342	252	≤ 76380419
61	≤ 464	125	≤ 25953	189	≤ 1452903	253	≤ 81338368
62	≤ 494	126	≤ 27638	190	≤ 1547213	254	> 81338368
63	≤ 526	127	≤ 29431	191	≤ 1647644	255	Reserved

6.1.3.2 C-RNTI MAC CE

The C-RNTI MAC CE is identified by MAC PDU subheader with LCID as specified in Table 6.2.1-2.

It has a fixed size and consists of a single field defined as follows (Figure 6.1.3.2-1):

- C-RNTI: This field contains the C-RNTI of the MAC entity. The length of the field is 16 bits.

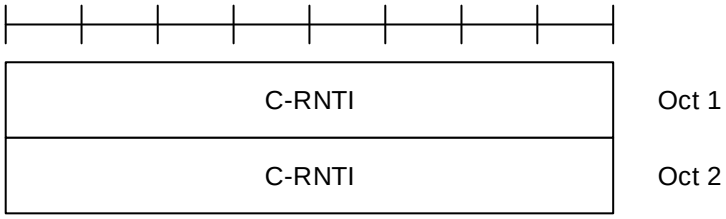


Figure 6.1.3.2-1: C-RNTI MAC CE

6.1.3.3 UE Contention Resolution Identity MAC CE

The UE Contention Resolution Identity MAC CE is identified by MAC PDU subheader with LCID as specified in Table 6.2.1-1.

It has a fixed 48-bit size and consists of a single field defined as follows (Figure 6.1.3.3-1):

- UE Contention Resolution Identity: This field contains the UL CCCH SDU. If the UL CCCH SDU is longer than 48 bits, this field contains the first 48 bits of the UL CCCH SDU.

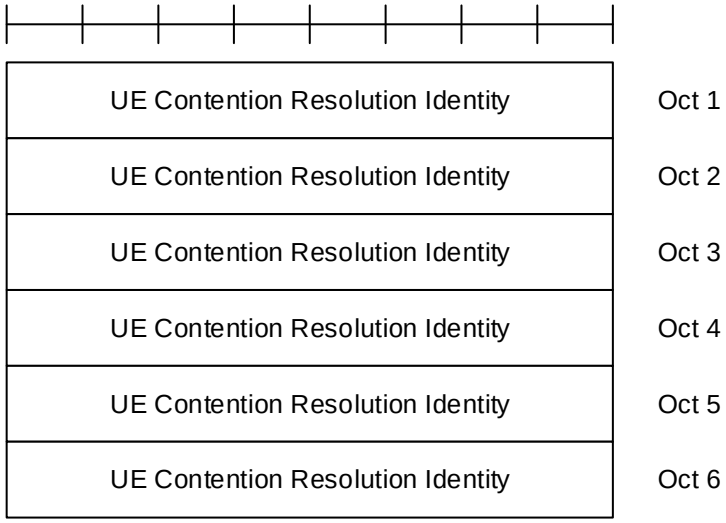


Figure 6.1.3.3-1: UE Contention Resolution Identity MAC CE

6.1.3.4 Timing Advance Command MAC CE

The Timing Advance Command MAC CE is identified by MAC PDU subheader with LCID as specified in Table 6.2.1-1.

It has a fixed size and consists of a single octet defined as follows (Figure 6.1.3.4-1):

- TAG Identity (TAG ID): This field indicates the TAG Identity of the addressed TAG. The TAG containing the SpCell has the TAG Identity 0. The length of the field is 2 bits;
- Timing Advance Command: This field indicates the index value T_A (0, 1, 2… 63) used to control the amount of timing adjustment that MAC entity has to apply (as specified in TS 38.213 [6]). The length of the field is 6 bits.

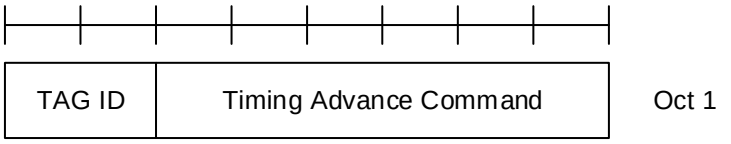


Figure 6.1.3.4-1: Timing Advance Command MAC CE

6.1.3.5 DRX Command MAC CE

The DRX Command MAC CE is identified by a MAC PDU subheader with LCID as specified in Table 6.2.1-1.

It has a fixed size of zero bits.

6.1.3.6 Long DRX Command MAC CE

The Long DRX Command MAC CE is identified by a MAC PDU subheader with LCID as specified in Table 6.2.1-1.

It has a fixed size of zero bits.

6.1.3.7 Configured Grant Confirmation MAC CE

The Configured Grant Confirmation MAC CE is identified by a MAC PDU subheader with LCID as specified in Table 6.2.1-2.

It has a fixed size of zero bits.

6.1.3.8 Single Entry PHR MAC CE

The Single Entry PHR MAC CE is identified by a MAC PDU subheader with LCID as specified in Table 6.2.1-2.

It has a fixed size and consists of two octet defined as follows (figure 6.1.3.8-1):

- R: Reserved bit, set to "0";
- Power Headroom (PH): This field indicates the power headroom level. The length of the field is 6 bits. The reported PH and the corresponding power headroom levels are shown in Table 6.1.3.8-1 below (the corresponding measured values in dB are specified in TS 38.133 [11]);
- $P_{CMAX,f,c}$: This field indicates the $P_{CMAX,f,c}$ (as specified in TS 38.213 [6]) used for calculation of the preceding PH field. The reported $P_{CMAX,f,c}$ and the corresponding nominal UE transmit power levels are shown in Table 6.1.3.8-2 (the corresponding measured values in dBm are specified in TS 38.133 [11]).

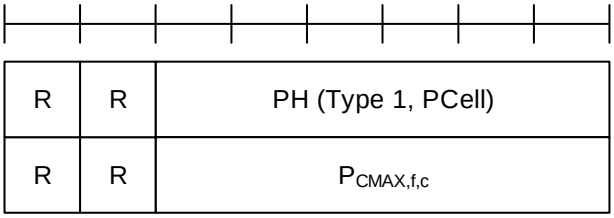


Figure 6.1.3.8-1: Single Entry PHR MAC CE

Table 6.1.3.8-1: Power Headroom levels for PHR

PH	Power Headroom Level
0	POWER_HEADROOM_0
1	POWER_HEADROOM_1
2	POWER_HEADROOM_2
3	POWER_HEADROOM_3
…	…
60	POWER_HEADROOM_60
61	POWER_HEADROOM_61
62	POWER_HEADROOM_62
63	POWER_HEADROOM_63

Table 6.1.3.8-2: Nominal UE transmit power level for PHR

$P_{CMAX,f,c}$	Nominal UE transmit power level
0	PCMAX_C_00
1	PCMAX_C_01
2	PCMAX_C_02
…	…
61	PCMAX_C_61
62	PCMAX_C_62
63	PCMAX_C_63

6.1.3.9 Multiple Entry PHR MAC CE

The Multiple Entry PHR MAC CE is identified by a MAC PDU subheader with LCID as specified in Table 6.2.1-2.

It has a variable size, and includes the bitmap, a Type 2 PH field and an octet containing the associated $P_{CMAX,f,c}$ field (if reported) for the SpCell of this MAC entity, a Type 2 PH field and an octet containing the associated $P_{CMAX,f,c}$ field (if reported) for either SpCell of the other MAC entity or PUCCH SCell, a Type 1 PH field and an octet containing the associated $P_{CMAX,f,c}$ field (if reported) for the PCell. It further includes, in ascending order based on the *ServCellIndex*, one or multiple of Type X PH fields and octets containing the associated $P_{CMAX,f,c}$ fields (if reported) for Serving Cells other than PCell indicated in the bitmap. X is either 1 or 3 according to TS 38.213 [6].

The presence of Type 2 PH field for SpCell of this MAC entity is configured by *phr-Type2SpCell*, and the presence of Type 2 PH field for either SpCell of the other MAC entity or for PUCCH SCell of this MAC entity is configured by *phr-Type2OtherCell*.

A single octet bitmap is used for indicating the presence of PH per Serving Cell when the highest *ServCellIndex* of Serving Cell with configured uplink is less than 8, otherwise four octets are used.

UE determines whether PH value for an activated Serving Cell is based on real transmission or a reference format by considering the downlink control information which has been received until and including the PDCCH occasion in which the first UL grant for a new transmission is received since a PHR has been triggered.

The PHR MAC CEs are defined as follows:

- C_i: This field indicates the presence of a PH field for the Serving Cell with *ServCellIndex* i as specified in TS 38.331 [5]. The C_i field set to "1" indicates that a PH field for the Serving Cell with *ServCellIndex* i is reported. The C_i field set to "0" indicates that a PH field for the Serving Cell with *ServCellIndex* i is not reported;

- R: Reserved bit, set to "0";

- V: This field indicates if the PH value is based on a real transmission or a reference format. For Type 1 PH, V=0 indicates real transmission on PUSCH and V=1 indicates that a PUSCH reference format is used. For Type 2 PH, V=0 indicates real transmission on PUCCH and V=1 indicates that a PUCCH reference format is used. For Type 3 PH, V=0 indicates real transmission on SRS and V=1 indicates that an SRS reference format is used. Furthermore, for Type 1, Type 2, and Type 3 PH, V=0 indicates the presence of the octet containing the associated $P_{CMAX,f,c}$ field, and V=1 indicates that the octet containing the associated $P_{CMAX,f,c}$ field is omitted;

- Power Headroom (PH): This field indicates the power headroom level. The length of the field is 6 bits. The reported PH and the corresponding power headroom levels are shown in Table 6.1.3.8-1 (the corresponding measured values in dB for the NR Serving Cell are specified in TS 38.133 [11] while the corresponding measured values in dB for the E-UTRA Serving Cell are specified in TS 36.133 [12]);

- P: This field indicates whether the MAC entity applies power backoff due to power management. The MAC entity shall set P=1 if the corresponding $P_{CMAX,f,c}$ field would have had a different value if no power backoff due to power management had been applied;

- $P_{CMAX,f,c}$: If present, this field indicates the $P_{CMAX,f,c}$ or $\tilde{P}_{CMAX,f,c}$ (as specified in TS 38.213 [6]) used for calculation of the preceding PH field. The reported $P_{CMAX,f,c}$ and the corresponding nominal UE transmit power levels are shown in Table 6.1.3.8-2 (the corresponding measured values in dBm for the NR Serving Cell are specified in TS 38.133 [11] while the corresponding measured values in dBm for the E-UTRA Serving Cell are specified in TS 36.133 [12]).

C_7	C_6	C_5	C_4	C_3	C_2	C_1	R
P	V	PH (Type 2, SpCell of this MAC entity)					
R	R	$P_{CMAX,f,c}$ 1					
P	V	PH (Type 2, SpCell of the other MAC entity or PUCCH SCell)					
R	R	$P_{CMAX,f,c}$ 2					
P	V	PH (Type 1, PCell)					
R	R	$P_{CMAX,f,c}$ 3					
P	V	PH (Type X, Serving Cell 1)					
R	R	$P_{CMAX,f,c}$ 4					
...							
P	V	PH (Type X, Serving Cell n)					
R	R	$P_{CMAX,f,c}$ m					

Figure 6.1.3.9-1: Multiple Entry PHR MAC CE with the highest *ServCellIndex* of Serving Cell with configured uplink is less than 8

C_7	C_6	C_5	C_4	C_3	C_2	C_1	R
C_{15}	C_{14}	C_{13}	C_{12}	C_{11}	C_{10}	C_9	C_8
C_{23}	C_{22}	C_{21}	C_{20}	C_{19}	C_{18}	C_{17}	C_{16}
C_{31}	C_{30}	C_{29}	C_{28}	C_{27}	C_{26}	C_{25}	C_{24}
P	V	PH (Type 2, SpCell of this MAC entity)					
R	R	$P_{CMAX,f,c}$ 1					
P	V	PH (Type 2, SpCell of the other MAC entity or PUCCH SCell)					
R	R	$P_{CMAX,f,c}$ 2					
P	V	PH (Type 1, PCell)					
R	R	$P_{CMAX,f,c}$ 3					
P	V	PH (Type X, Serving Cell 1)					
R	R	$P_{CMAX,f,c}$ 4					
...							
P	V	PH (Type X, Serving Cell n)					
R	R	$P_{CMAX,f,c}$ m					

Figure 6.1.3.9-2: Multiple Entry PHR MAC CE with the highest ServCellIndex of Serving Cell with configured uplink is equal to or higher than 8

6.1.3.10 SCell Activation/Deactivation MAC CEs

The SCell Activation/Deactivation MAC CE of one octet is identified by a MAC PDU subheader with LCID as specified in Table 6.2.1-1. It has a fixed size and consists of a single octet containing seven C-fields and one R-field. The SCell Activation/Deactivation MAC CE with one octet is defined as follows (Figure 6.1.3.10-1).

The SCell Activation/Deactivation MAC CE of four octets is identified by a MAC PDU subheader with LCID as specified in Table 6.2.1-1. It has a fixed size and consists of four octets containing 31 C-fields and one R-field. The SCell Activation/Deactivation MAC CE of four octets is defined as follows (Figure 6.1.3.10-2).

For the case with no Serving Cell with a *ServCellIndex* as specified in TS 38.331 [8] larger than 7, SCell Activation/Deactivation MAC CE of one octet is applied, otherwise SCell Activation/Deactivation MAC CE of four octets is applied.

- C_i: If there is an SCell configured for the MAC entity with *SCellIndex* i as specified in TS 38.331 [8], this field indicates the activation/deactivation status of the SCell with *SCellIndex* i, else the MAC entity shall ignore the C_i field. The C_i field is set to "1" to indicate that the SCell with *SCellIndex* i shall be activated. The Ci field is set to "0" to indicate that the SCell with *SCellIndex* i shall be deactivated;

- R: Reserved bit, set to "0".

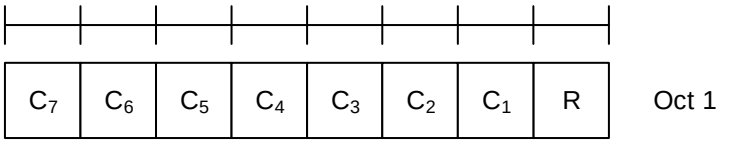


Figure 6.1.3.10-1: SCell Activation/Deactivation MAC CE of one octet

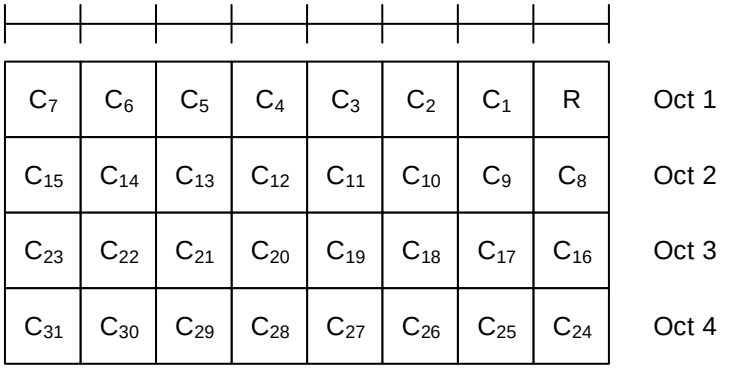


Figure 6.1.3.10-2: SCell Activation/Deactivation MAC CE of four octets

6.1.3.11 Duplication Activation/Deactivation MAC CE

The Duplication Activation/Deactivation MAC CE of one octet is identified by a MAC PDU subheader with LCID as specified in Table 6.2.1-1. It has a fixed size and consists of a single octet containing eight D-fields. The Duplication Activation/Deactivation MAC CE is defined, for a MAC entity, as follows (Figure 6.1.3.11-1).

- D_i: This field indicates the activation/deactivation status of the PDCP duplication of DRB i where i is the ascending order of the DRB ID among the DRBs configured with PDCP duplication and with RLC entity(ies) associated with this MAC entity. The D_i field is set to one to indicate that the PDCP duplication of DRB i shall be activated. The D_i field is set to zero to indicate that the PDCP duplication of DRB i shall be deactivated.

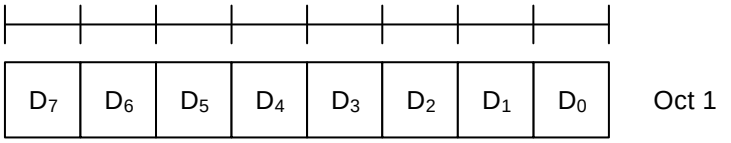


Figure 6.1.3.11-1: Duplication Activation/Deactivation MAC CE

6.1.3.12 SP CSI-RS / CSI-IM Resource Set Activation/Deactivation MAC CE

The SP CSI-RS / CSI-IM Resource Set Activation/Deactivation MAC CE is identified by a MAC PDU subheader with LCID as specified in Table 6.2.1-1. It has a variable size and consists of the following fields:

- A/D: This field indicates whether the MAC CE is used to activate or deactivate indicated SP CSI-RS and CSI-IM resource set(s). The field is set to "1" to indicate activation, otherwise it indicates deactivation;

- Serving Cell ID: This field indicates the identity of the Serving Cell for which the MAC CE applies. The length of the field is 5 bits;

- BWP ID: This field contains *BWP-Id*, as specified in TS 38.331 [8], of a downlink bandwidth part for which the MAC CE applies. The length of the BWP ID field is 2 bits;

- SP CSI-RS resource set ID: This field contains an index of *NZP-CSI-RS-ResourceSet* containing Semi Persistent NZP CSI-RS resources, as specified in TS 38.331 [8], indicating the Semi Persistent NZP CSI-RS resource set, which should be activated or deactivated. The length of the field is 6 bits;

- IM: This field indicates whether SP CSI-IM resource set indicated with SP CSI-IM resource set ID field should be activated/deactivated. If IM field is set to "1", SP CSI-IM resource set should be activated or deactivated (depending on A/D field setting). If IM field is set to "0", the octet containing SP CSI-IM resource set ID field is not present;

- SP CSI-IM resource set ID: This field contains an index of *CSI-IM-ResourceSet* containing Semi Persistent CSI-IM resources, as specified in TS 38.331 [8], indicating the Semi Persistent CSI-IM resource set, which should be activated or deactivated. The length of the field is 6 bits;

- TCI State ID_i: This field contains *TCI-StateId*, as specified in TS 38.331 [8], of a TCI State, which is used as QCL source for the resource within the Semi Persistent NZP CSI-RS resource set indicated by SP CSI-RS resource set ID field. TCI State ID_0 indicates TCI State for the first resource within the set, TCI State ID_1 for the second one and so on. The length of the field is 6 bits. If A/D field is set to "0" then the octet containing this field is not present;

- R: Reserved bit, set to "0".

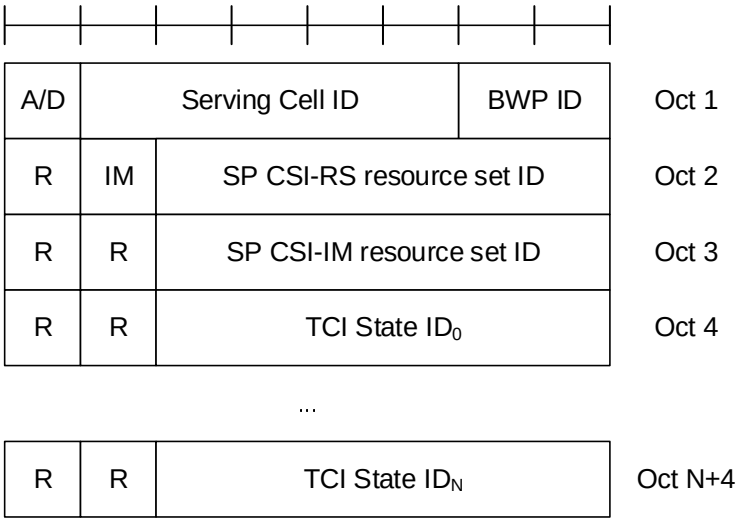


Figure 6.1.3.12-1: SP CSI-RS / CSI-IM Resource Set Activation/Deactivation MAC CE

6.1.3.13 Aperiodic CSI Trigger State Subselection MAC CE

The Aperiodic CSI Trigger State Subselection MAC CE is identified by a MAC PDU subheader with LCID as specified in Table 6.2.1-1. It has a variable size consisting of following fields:

- Serving Cell ID: This field indicates the identity of the Serving Cell for which the MAC CE applies. The length of the field is 5 bits;

- BWP ID: This field contains *BWP-Id*, as specified in TS 38.331 [8], of a downlink bandwidth part for which the MAC CE applies. The length of the BWP ID field is 2 bits;

- T_i: This field indicates the selection status of the Aperiodic Trigger States configured within *CSI-aperiodicTriggerStateList*, as specified in TS 38.331 [8]. T_0 refers to the first trigger state within the list, T_1 to the second one and so on. If the list does not contain entry with index i, MAC entity shall ignore the T_i field. The T_i field is set to "1" to indicate that the Aperiodic Trigger State i shall be mapped to the codepoint of the DCI *CSI request* field, as specified in TS 38.214 [7]. The codepoint to which the Aperiodic Trigger State is mapped is determined by its ordinal position among all the Aperiodic Trigger States with T_i field set to "1", i.e. the first Aperiodic Trigger State with T_i field set to "1" shall be mapped to the codepoint value 1, second Aperiodic Trigger State with T_i field set to "1" shall be mapped to the codepoint value 2 and so on. The maximum number of mapped Aperiodic Trigger States is 63;

- R: Reserved bit, set to "0".

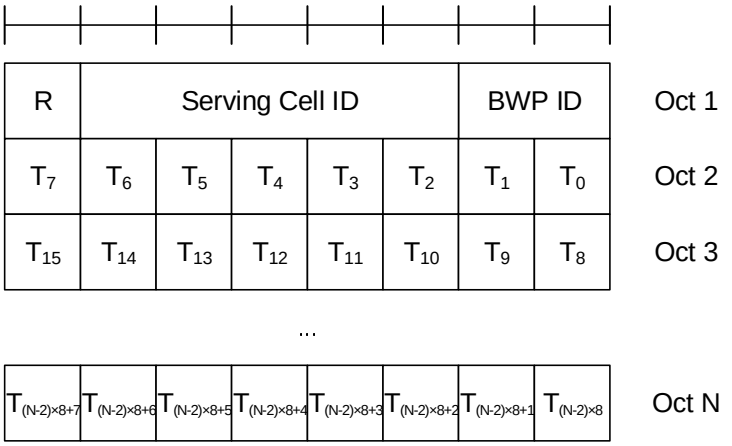


Figure 6.1.3.13-1: Aperiodic CSI Trigger State Subselection MAC CE

6.1.3.14 TCI States Activation/Deactivation for UE-specific PDSCH MAC CE

The TCI States Activation/Deactivation for UE-specific PDSCH MAC CE is identified by a MAC PDU subheader with LCID as specified in Table 6.2.1-1. It has a variable size consisting of following fields:

- Serving Cell ID: This field indicates the identity of the Serving Cell for which the MAC CE applies. The length of the field is 5 bits;
- BWP ID: This field contains *BWP-Id*, as specified in TS 38.331 [8], of a downlink bandwidth part for which the MAC CE applies. The length of the BWP ID field is 2 bits;
- T_i: If there is a TCI state with *TCI-StateId* i as specified in TS 38.331 [8], this field indicates the activation/deactivation status of the TCI state with *TCI-StateId* i, otherwise MAC entity shall ignore the T_i field. The T_i field is set to "1" to indicate that the TCI state with *TCI-StateId* i shall be activated and mapped to the codepoint of the DCI *Transmission Configuration Indication* field, as specified in TS 38.214 [7]. The T_i field is set to "0" to indicate that the TCI state with *TCI-StateId* i shall be deactivated and is not mapped to the codepoint of the DCI *Transmission Configuration Indication* field. The codepoint to which the TCI State is mapped is determined by its ordinal position among all the TCI States with T_i field set to "1", i.e. the first TCI State with T_i field set to "1" shall be mapped to the codepoint value 0, second TCI State with T_i field set to "1" shall be mapped to the codepoint value 1 and so on. The maximum number of activated TCI states is 8;
- R: Reserved bit, set to "0".

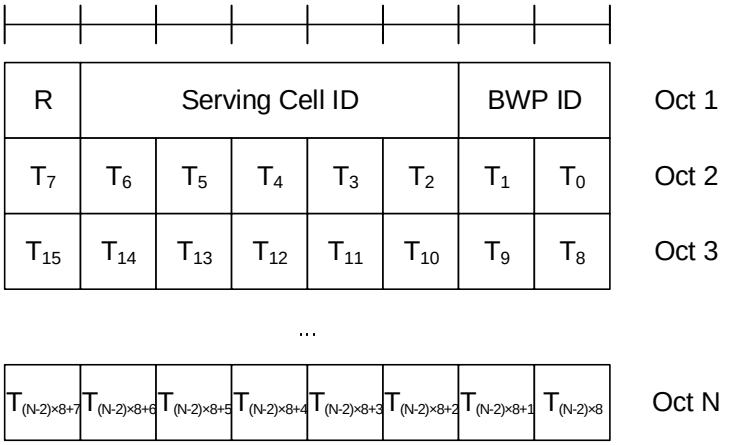


Figure 6.1.3.14-1: TCI States Activation/Deactivation for UE-specific PDSCH MAC CE

6.1.3.15 TCI State Indication for UE-specific PDCCH MAC CE

The TCI State Indication for UE-specific PDCCH MAC CE is identified by a MAC PDU subheader with LCID as specified in Table 6.2.1-1. It has a fixed size of 16 bits with following fields:

- Serving Cell ID: This field indicates the identity of the Serving Cell for which the MAC CE applies. The length of the field is 5 bits;
- BWP ID: This field contains *BWP-Id*, as specified in TS 38.331 [8], of a downlink bandwidth part for which the MAC CE applies. The length of the BWP ID field is 2 bits;
- CORESET ID: This field indicates a Control Resource Set identified with *ControlResourceSetId* as specified in TS 38.331 [8], for which the TCI State is being indicated. The length of the field is 2 bits;
- TCI State ID: This field indicates the TCI state identified by *TCI-StateId* as specified in TS 38.331 [8] applicable to the Control Resource Set identified by CORESET ID field. The length of the field is 6 bits;
- R: Reserved bit, set to "0".

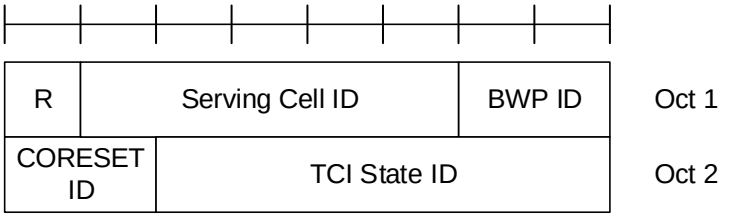


Figure 6.1.3.15-1: TCI State Indication for UE-specific PDCCH MAC CE

6.1.3.16 SP CSI reporting on PUCCH Activation/Deactivation MAC CE

The SP CSI reporting on PUCCH Activation/Deactivation MAC CE is identified by a MAC PDU subheader with LCID as specified in Table 6.2.1-1. It has a fixed size of 16 bits with following fields:

- Serving Cell ID: This field indicates the identity of the Serving Cell for which the MAC CE applies. The length of the field is 5 bits;
- BWP ID: This field contains *BWP-Id*, as specified in TS 38.331 [8], of a downlink bandwidth part for which the MAC CE applies. The length of the BWP ID field is 2 bits;
- S_i: This field indicates the activation/deactivation status of the Semi-Persistent CSI report configuration within *csi-ReportConfigToAddModList*, as specified in TS 38.331 [8]. S_0 refers to the first report configuration within the list with type set to "semiPersistentOnPUCCH", S_1 to the second report configuration within the list with type set to "semiPersistentOnPUCCH" and so on. The S_i field is set to "1" to indicate that the Semi-Persistent CSI report configuration i shall be activated. The Si field is set to "0" to indicate that the Semi-Persistent CSI report configuration i shall be deactivated. If there is no Semi-Persistent CSI report configuration i within the list, MAC entity shall ignore this field;
- R: Reserved bit, set to "0".

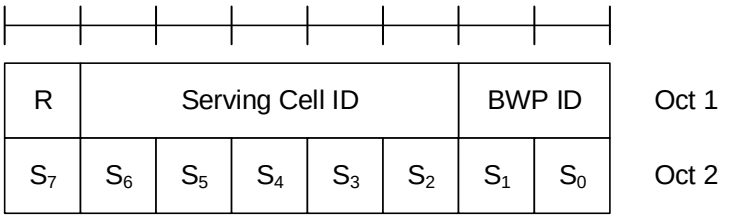


Figure 6.1.3.16-1: SP CSI reporting on PUCCH Activation/Deactivation MAC CE

6.1.3.17 SP SRS Activation/Deactivation MAC CE

The SP SRS Activation/Deactivation MAC CE is identified by a MAC PDU subheader with LCID as specified in Table 6.2.1-1. It has a variable size with following fields:

- A/D: This field indicates whether the MAC CE is used to activate or deactivate indicated SP SRS resource set. The field is set to "1" to indicate activation, otherwise it indicates deactivation;
- SRS Resource Set's Cell ID: This field indicates the identity of the Serving Cell, which contains activated/deactivated SP SRS Resource Set. The length of the field is 5 bits;

- SRS Resource Set's BWP ID: This field contains *BWP-Id*, as specified in TS 38.331 [8], of an uplink bandwidth part, which contains activated/deactivated SP SRS Resource Set. The length of the field is 2 bits;
- C: This field indicates whether the octets containing Resource Serving Cell ID field(s) and Resource BWP ID field(s) are present. If this field is set to "1", the octets containing Resource Serving Cell ID field(s) and Resource BWP ID field(s) are present. If this field is set to "0", they are not present and all resources indicated in the Resource IDi fields are located one the Serving Cell and BWP indicated by SRS Resource Set's cell ID and SRS Resource Set's BWP ID fields;
- SUL: This field indicates whether the MAC CE applies to the NUL carrier or SUL carrier configuration. This field is set to "1" to indicate it applies to the SUL carrier configuration, it is set to "0" to indicate it applies to the NUL carrier configuration;
- SP SRS Resource Set ID: This field indicates the SP SRS Resource Set ID identified by *SRS-ResourceSetId* as specified in TS 38.331 [8], which is to be activated or deactivated. The length of the field is 4 bits;
- F_i: This field indicates the type of a resource used as a spatial relationship for SRS resource within SP SRS Resource Set indicated with SP SRS Resource Set ID field. F_0 refers to the first SRS resource within the resource set, F_1 to the second one and so on. The field is set to "1" to indicate NZP CSI-RS resource index is used, it is set to "0" to indicate either SSB index or SRS resource index is used. The length of the field is 1 bit. This field is only present if MAC CE is used for activation, i.e. A/D field is set to "1";
- Resource ID_i: This field contains an identifier of the resource used for spatial relationship derivation for SRS resource i. Resource ID_0 refers to the first SRS resource within the resource set, Resource ID_1 to the second one and so on. If F_i is set to "0" and the first bit of this field is set to "1", then the remainder of this field contains *SSB-Index* as specified in TS 38.331 [8], if F_i is set to "0" and the first bit of this field is set to "0" then the remainder this field contains *SRS-ResourceId* as specified in TS 38.331 [8]. The length of the field is 7 bits. This field is only present if MAC CE is used for activation, i.e. A/D field is set to "1";
- Resource Serving Cell ID_i: This field indicates the identity of the Serving Cell on which the resource used for spatial relationship derivation for SRS resource i is located. The length of the field is 5 bits;
- Resource BWP ID_i: This field contains *BWP-Id*, as specified in TS 38.331 [8], of an uplink bandwidth part on which the resource used for spatial relationship derivation for SRS resource i is located. The length of the field is 2 bits;
- R: Reserved bit, set to "0".

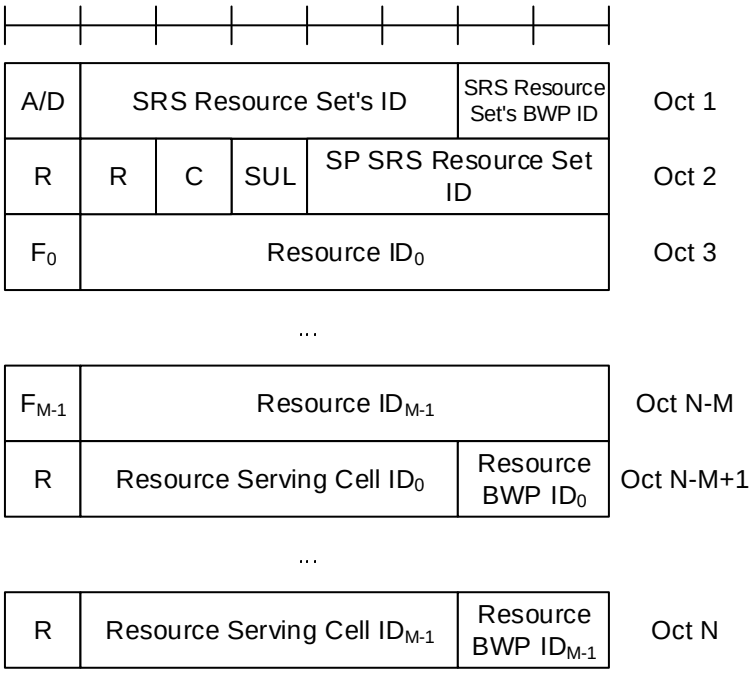


Figure 6.1.3.17-1: SP SRS Activation/Deactivation MAC CE

6.1.3.18 PUCCH spatial relation Activation/Deactivation MAC CE

The PUCCH spatial relation Activation/Deactivation MAC CE is identified by a MAC PDU subheader with LCID as specified in Table 6.2.1-1. It has a fixed size of 24 bits with following fields:

- Serving Cell ID: This field indicates the identity of the Serving Cell for which the MAC CE applies. The length of the field is 5 bits;
- BWP ID: This field contains *BWP-Id*, as specified in TS 38.331 [8], of an uplink bandwidth part for which the MAC CE applies. The length of the BWP ID field is 2 bits;
- PUCCH Resource ID: This field contains an identifier of the PUCCH resource ID identified by *PUCCH-ResourceId* as specified in TS 38.331 [8]. The length of the field is 7 bits;
- S_i: If there is a PUCCH Spatial Relation Info with *PUCCH-SpatialRelationInfoId* i as specified in TS 38.331 [8], configured for the uplink bandwidth part indicated by BWP ID field, S_i indicates the activation status of PUCCH Spatial Relation Info with *PUCCH-SpatialRelationInfoId* i, otherwise MAC entity shall ignore this field. The S_i field is set to "1" to indicate PUCCH Spatial Relation Info with *PUCCH-SpatialRelationInfoId* i should be activated. The S_i field is set to "0" to indicate PUCCH Spatial Relation Info with *PUCCH-SpatialRelationInfoId* i should be deactivated. Only a single PUCCH Spatial Relation Info can be active for a PUCCH Resource at a time;
- R: Reserved bit, set to "0".

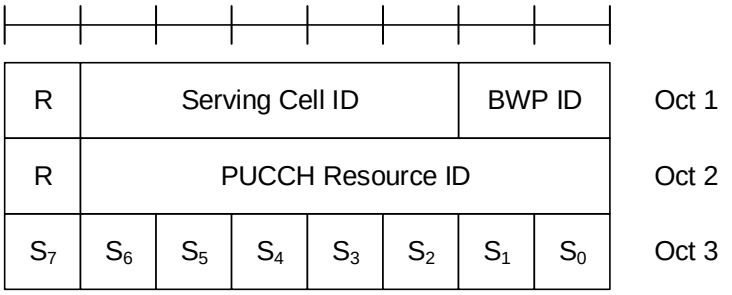


Figure 6.1.3.18-1: PUCCH spatial relation Activation/Deactivation MAC CE

6.1.3.19 SP ZP CSI-RS Resource Set Activation/Deactivation MAC CE

The SP ZP CSI-RS Resource Set Activation/Deactivation MAC CE is identified by a MAC PDU subheader with LCID as specified in Table 6.2.1-1. It has a fixed size of 16 bits with following fields:

- A/D: This field indicates whether the MAC CE is used to activate or deactivate indicated SP ZP CSI-RS resource set. The field is set to "1" to indicate activation, otherwise it indicates deactivation;
- Serving Cell ID: This field indicates the identity of the Serving Cell for which the MAC CE applies. The length of the field is 5 bits;
- BWP ID: This field contains *BWP-Id*, as specified in TS 38.331 [8], of a downlink bandwidth part for which the MAC CE applies. The length of the BWP ID field is 2 bits;
- SP ZP CSI-RS resource set ID: This field contains an index of *sp-ZP-CSI-RS-ResourceSetsToAddModList*, as specified in TS 38.331 [8], indicating the Semi Persistent ZP CSI-RS resource set, which should be activated or deactivated. The length of the field is 4 bits;
- R: Reserved bit, set to "0".

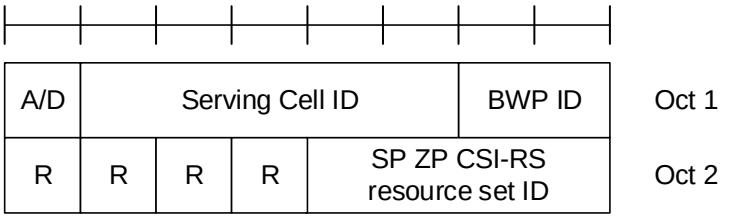


Figure 6.1.3.19-1: SP ZP CSI-RS Resource Set Activation/Deactivation MAC CE

6.1.3.20 Recommended bit rate MAC CE

The recommended bit rate MAC CE is identified by a MAC PDU subheader with LCID as specified in Tables 6.2.1-1 and 6.2.1-2 for bit rate recommendation message from the gNB to the UE and bit rate recommendation query message from the UE to the gNB, respectively. It has a fixed size and consists of two octets defined as follows (Figure 6.1.3.20-1):

- LCID: This field indicates the identity of the logical channel for which the recommended bit rate or the recommended bit rate query is applicable. The length of the field is 6 bits;
- Uplink/Downlink (UL/DL): This field indicates whether the recommended bit rate or the recommended bit rate query applies to uplink or downlink. The length of the field is 1 bit. The UL/DL field set to "0" indicates downlink. The UL/DL field set to "1" indicates uplink;
- Bit Rate: This field indicates an index to Table 6.1.3.20-1. The length of the field is 6 bits. For bit rate recommendation the value indicates the recommended bit rate. For bit rate recommendation query the value indicates the desired bit rate;
- R: reserved bit, set to "0".

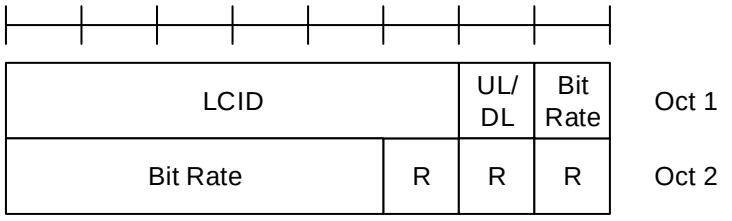


Figure 6.1.3.20-1: Recommended bit rate MAC CE

Table 6.1.3.20-1: Values (kbit/s) for Bit Rate field

Index	NR Recommended Bit Rate value [kbit/s]	Index	NR Recommended Bit Rate value [kbit/s]
0		32	700
1	0	33	800
2	9	34	900
3	11	35	1000
4	13	36	1100
5	17	37	1200
6	21	38	1300
7	25	39	1400
8	29	40	1500
9	32	41	1750
10	36	42	2000
11	40	43	2250
12	48	44	2500
13	56	45	2750
14	72	46	3000
15	88	47	3500
16	104	48	4000
17	120	49	4500
18	140	50	5000
19	160	51	5500
20	180	52	6000
21	200	53	6500
22	220	54	7000
23	240	55	7500
24	260	56	8000
25	280	57	Reserved
26	300	58	Reserved
27	350	59	Reserved
28	400	60	Reserved
29	450	61	Reserved
30	500	62	Reserved
31	600	63	Reserved

6.1.4 MAC PDU (transparent MAC)

A MAC PDU consists solely of a MAC SDU whose size is aligned to a TB; as described in Figure 6.1.4-1. This MAC PDU is used for transmissions on PCH, BCH, and DL-SCH including BCCH.

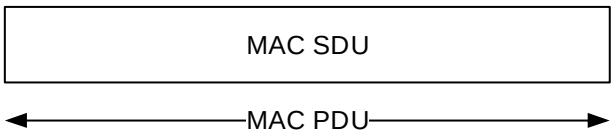


Figure 6.1.4-1: Example of MAC PDU (transparent MAC)

6.1.5 MAC PDU (Random Access Response)

A MAC PDU consists of one or more MAC subPDUs and optionally padding. Each MAC subPDU consists one of the following:

- a MAC subheader with Backoff Indicator only;
- a MAC subheader with RAPID only (i.e. acknowledgment for SI request);
- a MAC subheader with RAPID and MAC RAR.

A MAC subheader with Backoff Indicator consists of five header fields E/T/R/R/BI as described in Figure 6.1.5-1. A MAC subPDU with Backoff Indicator only is placed at the beginning of the MAC PDU, if included. 'MAC subPDU(s) with RAPID only' and 'MAC subPDU(s) with RAPID and MAC RAR' can be placed anywhere between MAC subPDU with Backoff Indicator only (if any) and padding (if any).

A MAC subheader with RAPID consists of three header fields E/T/RAPID as described in Figure 6.1.5-2.

Padding is placed at the end of the MAC PDU if present. Presence and length of padding is implicit based on TB size, size of MAC subPDU(s).

Figure 6.1.5-1: E/T/R/R/BI MAC subheader

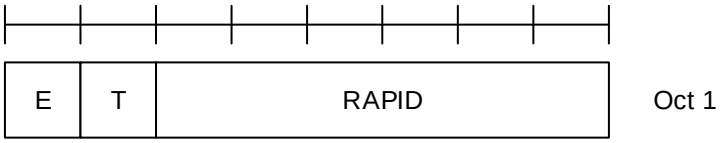


Figure 6.1.5-2: E/T/RAPID MAC subheader

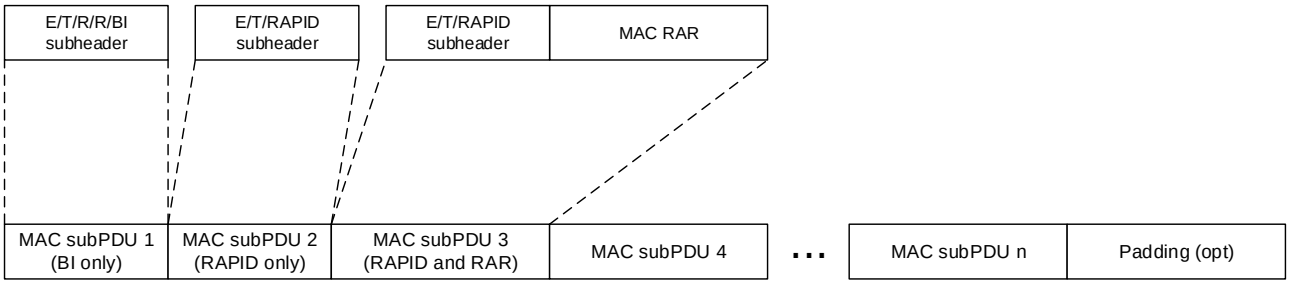


Figure 6.1.5-3: Example of MAC PDU consisting of MAC RARs

6.2 Formats and parameters

6.2.1 MAC subheader for DL-SCH and UL-SCH

The MAC subheader consists of the following fields:

- LCID: The Logical Channel ID field identifies the logical channel instance of the corresponding MAC SDU or the type of the corresponding MAC CE or padding as described in Tables 6.2.1-1 and 6.2.1-2 for the DL-SCH and UL-SCH respectively. There is one LCID field per MAC subheader. The LCID field size is 6 bits;

- L: The Length field indicates the length of the corresponding MAC SDU or variable-sized MAC CE in bytes. There is one L field per MAC subheader except for subheaders corresponding to fixed-sized MAC CEs and padding. The size of the L field is indicated by the F field;

- F: The Format field indicates the size of the Length field. There is one F field per MAC subheader except for subheaders corresponding to fixed-sized MAC CEs and padding. The size of the F field is 1 bit. The value 0 indicates 8 bits of the Length field. The value 1 indicates 16 bits of the Length field;

- R: Reserved bit, set to zero.

The MAC subheader is octet aligned.

Table 6.2.1-1 Values of LCID for DL-SCH

Index	LCID values
000000	CCCH
000001–100000	Identity of the logical channel
100001–101110	Reserved
101111	Recommended bit rate
110000	SP ZP CSI-RS Resource Set Activation/Deactivation
110001	PUCCH spatial relation Activation/Deactivation
110010	SP SRS Activation/Deactivation
110011	SP CSI reporting on PUCCH Activation/Deactivation
110100	TCI State Indication for UE-specific PDCCH
110101	TCI States Activation/Deactivation for UE-specific PDSCH
110110	Aperiodic CSI Trigger State Subselection
110111	SP CSI-RS / CSI-IM Resource Set Activation/Deactivation
111000	Duplication Activation/Deactivation
111001	SCell Activation/Deactivation (four octet)
111010	SCell Activation/Deactivation (one octet)
111011	Long DRX Command
111100	DRX Command
111101	Timing Advance Command
111110	UE Contention Resolution Identity
111111	Padding

Table 6.2.1-2 Values of LCID for UL-SCH

Index	LCID values
000000	CCCH of size other than 48 bits
000001–100000	Identity of the logical channel
100001	CCCH of size 48 bits
100010–110100	Reserved
110101	Recommended bit rate query
110110	Multiple Entry PHR (four octet C_i)
110111	Configured Grant Confirmation
111000	Multiple Entry PHR (one octet C_i)
111001	Single Entry PHR
111010	C-RNTI
111011	Short Truncated BSR
111100	Long Truncated BSR
111101	Short BSR
111110	Long BSR
111111	Padding

6.2.2 MAC subheader for Random Access Response

The MAC subheader consists of the following fields:

- E: The Extension field is a flag indicating if the MAC subPDU including this MAC subheader is the last MAC subPDU or not in the MAC PDU. The E field is set to "1" to indicate at least another MAC subPDU follows. The E field is set to "0" to indicate that the MAC subPDU including this MAC subheader is the last MAC subPDU in the MAC PDU;

- T: The Type field is a flag indicating whether the MAC subheader contains a Random Access Preamble ID or a Backoff Indicator. The T field is set to "0" to indicate the presence of a Backoff Indicator field in the subheader (BI). The T field is set to "1" to indicate the presence of a Random Access Preamble ID field in the subheader (RAPID);

- R: Reserved bit, set to "0";

- BI: The Backoff Indicator field identifies the overload condition in the cell. The size of the BI field is 4 bits;
- RAPID: The Random Access Preamble IDentifier field identifies the transmitted Random Access Preamble (see subclause 5.1.3). The size of the RAPID field is 6 bits. If the RAPID in the MAC subheader of a MAC subPDU corresponds to one of the Random Access Preambles configured for SI request, MAC RAR is not included in the MAC subPDU.

The MAC subheader is octet aligned.

6.2.3 MAC payload for Random Access Response

The MAC RAR is of fixed size as depicted in Figure 6.2.3-1, and consists of the following fields:

- R: Reserved bit, set to "0";
- Timing Advance Command: The Timing Advance Command field indicates the index value T_A used to control the amount of timing adjustment that the MAC entity has to apply in TS 38.213 [6]. The size of the Timing Advance Command field is 12 bits;
- UL Grant: The Uplink Grant field indicates the resources to be used on the uplink in TS 38.213 [6]. The size of the UL Grant field is 25 bits;
- Temporary C-RNTI: The Temporary C-RNTI field indicates the temporary identity that is used by the MAC entity during Random Access. The size of the Temporary C-RNTI field is 16 bits.

The MAC RAR is octet aligned.

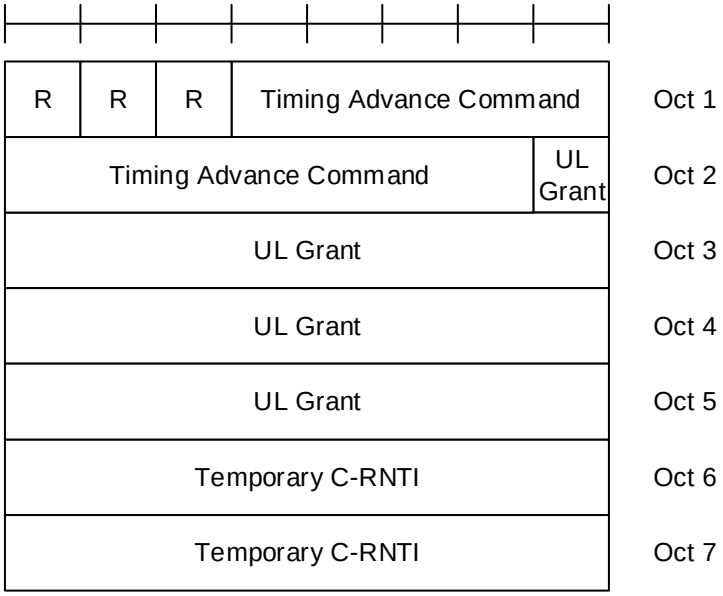


Figure 6.2.3-1: MAC RAR

7 Variables and constants

7.1 RNTI values

RNTI values are presented in Table 7.1-1.

Table 7.1-1: RNTI values.

Value (hexa-decimal)	RNTI
0000	N/A
0001–FFEF	RA-RNTI, Temporary C-RNTI, C-RNTI, CS-RNTI, TPC-PUCCH-RNTI, TPC-PUSCH-RNTI, TPC-SRS-RNTI, INT-RNTI, SFI-RNTI, and SP-CSI-RNTI
FFF0–FFFD	Reserved
FFFE	P-RNTI
FFFF	SI-RNTI

Table 7.1-2: RNTI usage.

RNTI	Usage	Transport Channel	Logical Channel
P-RNTI	Paging and System Information change notification	PCH	PCCH
SI-RNTI	Broadcast of System Information	DL-SCH	BCCH
RA-RNTI	Random Access Response	DL-SCH	N/A
Temporary C-RNTI	Contention Resolution (when no valid C-RNTI is available)	DL-SCH	CCCH
Temporary C-RNTI	Msg3 transmission	UL-SCH	CCCH, DCCH, DTCH
C-RNTI	Dynamically scheduled unicast transmission	UL-SCH	DCCH, DTCH
C-RNTI	Dynamically scheduled unicast transmission	DL-SCH	CCCH, DCCH, DTCH
C-RNTI	Triggering of PDCCH ordered random access	N/A	N/A
CS-RNTI	Configured scheduled unicast transmission (activation, reactivation and retransmission)	DL-SCH, UL-SCH	DCCH, DTCH
CS-RNTI	Configured scheduled unicast transmission (deactivation)	N/A	N/A
TPC-PUCCH-RNTI	PUCCH power control	N/A	N/A
TPC-PUSCH-RNTI	PUSCH power control	N/A	N/A
TPC-SRS-RNTI	SRS trigger and power control	N/A	N/A
INT-RNTI	Indication pre-emption in DL	N/A	N/A
SFI-RNTI	Slot Format Indication on the given cell	N/A	N/A
SP-CSI-RNTI	Activation of Semi-persistent CSI reporting on PUSCH	N/A	N/A

7.2 Backoff Parameter values

Backoff Parameter values are presented in Table 7.2-1.

Table 7.2-1: Backoff Parameter values.

Index	Backoff Parameter value (ms)
0	5
1	10
2	20
3	30
4	40
5	60
6	80
7	120
8	160
9	240
10	320
11	480
12	960
13	1920
14	Reserved
15	Reserved

7.3 DELTA_PREAMBLE values

The DELTA_PREAMBLE preamble format based power offset values are presented in Tables 7.3-1 and 7.3-2.

Table 7.3-1: DELTA_PREAMBLE values for long preamble formats.

Preamble Format	DELTA_PREAMBLE values
0	0 dB
1	-3 dB
2	-6 dB
3	0 dB

Table 7.3-2: DELTA_PREAMBLE values for short preamble formats.

Preamble Format	DELTA_PREAMBLE values (dB)
A1	$8 + 3 \times \mu$
A2	$5 + 3 \times \mu$
A3	$3 + 3 \times \mu$
B1	$8 + 3 \times \mu$
B2	$5 + 3 \times \mu$
B3	$3 + 3 \times \mu$
B4	$3 \times \mu$
C0	$11 + 3 \times \mu$
C2	$5 + 3 \times \mu$

where μ is the sub-carrier spacing configuration determined by *msg1-SubcarrierSpacing* and Table 4.2-1 in TS 38.211 [8], and the preamble formats are given by *prach-ConfigurationIndex* and Tables 6.3.3.2-2 and 6.3.3.2-3 in TS 38.211 [8].

7.4 PRACH Mask Index values

Table 7.4-1: PRACH Mask Index values

PRACH Mask Index	Allowed PRACH occasion(s) of SSB
0	All
1	PRACH occasion index 1
2	PRACH occasion index 2
3	PRACH occasion index 3
4	PRACH occasion index 4
5	PRACH occasion index 5
6	PRACH occasion index 6
7	PRACH occasion index 7
8	PRACH occasion index 8
9	Every even PRACH occasion
10	Every odd PRACH occasion
11	Reserved
12	Reserved
13	Reserved
14	Reserved
15	Reserved

Annex A (informative): Change history

Change history							
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
2017-04	RAN2#97bis	R2-1703006	-	-	-	Skeleton of NR MAC specification	0.0.1
2017-04	RAN2#97bis	R2-1703915	-	-	-	Editorial updates	0.0.2
2017-05	RAN2#98	R2-1704475	-	-	-	To capture agreements from RAN2#97bis	0.0.3
2017-06	RAN2 NR AH#2	R2-1706608	-	-	-	To capture agreements from RAN2#98	0.0.4
2017-06	RAN2 NR AH#2	R2-1707471	-	-	-	Endorsement of v0.0.4 (including minor updates)	0.1.0
2017-08	RAN2#99	R2-1707510	-	-	-	To capture agreements from RAN2 NR AH#2	0.2.0
2017-08	RAN2#99	R2-1709946	-	-	-	To capture agreements from RAN2#99	0.3.0
2017-09	RAN#77	RP-171733	-	-	-	To be presented to RAN for information	1.0.0
2017-11	RAN2#100	R2-1712698	-	-	-	To capture agreements from RAN2#99bis	1.1.0
2017-12	RAN2#100	R2-1714253	-	-	-	To capture agreements from RAN2#100	1.2.0
2017-12	RP-78	RP-172419	-	-	-	To be presented to RAN for approval	2.0.0
2017-12	RP-78					Upgraded to Rel-15	15.0.0
2018-03	RP-79	RP-180440	0039	1	F	General corrections on TS 38.321	15.1.0
2018-03	RP-79	RP-180440	0041	-	B	Introduction of MAC CEs for NR MIMO	15.1.0
2018-06	RP-80	RP-181216	0057	5	F	Miscellaneous corrections	15.2.0
	RP-80	RP-181216	0103	2	F	Addition of the beamFailureRecoveryTimer	15.2.0
	RP-80	RP-181214	0115	-	F	Correction to SR triggering to accommodate the configured grant	15.2.0
	RP-80	RP-181215	0145	1	F	Corrections on the timers in MAC	15.2.0
	RP-80	RP-181215	0148	1	F	Alternative 1 for Cross Carrier Indication for Semi-Persistent SRS MAC CE	15.2.0
	RP-80	RP-181215	0153	2	F	Flush HARQ buffer upon skipping a UL transmission	15.2.0
	RP-80	RP-181215	0166	1	F	Addition of Prioritized Random Access	15.2.0
	RP-80	RP-181216	0185	-	F	Introduction of PDCP duplication	15.2.0
	RP-80	RP-181216	0186	-	B	MAC CE adaptation for NR for TS 38.321	15.2.0

History

Document history		
V15.2.0	September 2018	Publication

AO 120 (Rev. 08/10)

TO:	**Mail Stop 8** **Director of the U.S. Patent and Trademark Office** **P.O. Box 1450** **Alexandria, VA 22313-1450**	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Northern District of Texas on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT Northern District of Texas
PLAINTIFF Competitive Access Systems, Inc.		DEFENDANT Motorola Mobility LLC

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	8,861,349	10/14/2014	Competitive Access Systems, Inc.
2	9,350,649	5/24/2016	Competitive Access Systems, Inc.
3	11,418,641	8/16/2022	Competitive Access Systems, Inc.
4	11,582,343	2/14/2023	Competitive Access Systems, Inc.
5	8,228,801	7/24/2012	Competitive Access Systems, Inc.

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director **Copy 3—Upon termination of action, mail this copy to Director**
Copy 2—Upon filing document adding patent(s), mail this copy to Director **Copy 4—Case file copy**

Print Save As... Reset