

**PROVISIONAL APPLICATION FOR UNITED STATES PATENT
IN THE NAMES OF**

Seung June YI, Young Dae LEE, Sung Duck CHUN, Sung Jun PARK,
Sung Hoon JUNG and Sun Hee KIM

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BEARER MAPPING IN RELAY NODE

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Foreword

This Technical Report 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:

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1 Scope

This document is related to the technical report for physical layer aspect of the study item "Further advancements for E-UTRA" [1]. The purpose of this TR is to help TSG RAN WG1 to define and describe the potential physical layer evolution under consideration and compare the benefits of each evolution techniques, along with the complexity evaluation of each technique.

This activity involves the Radio Access work area of the 3GPP studies and has impacts both on the Mobile Equipment and Access Network of the 3GPP systems.

This document is intended to gather all information in order to compare the solutions and gains vs. complexity, and draw a conclusion on way forward.

This document is a 'living' document, i.e. it is permanently updated and presented to TSG-RAN meetings.

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 TD RP-080137: "Proposed SID on LTE-Advanced".
- [2] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".
- [3] 3GPP TR 36.913: "Requirements for Evolved UTRA (E-UTRA) and Evolved UTRAN (E-UTRAN)".
- [4] ITU-R Report M.2135, Guidelines for evaluation of radio interface technologies for IMT-Advanced, 2008-11, <http://www.itu.int/publ/R-REP-M.2135-2008/en>

3 Definitions, symbols and abbreviations

3.1 Definitions

Void

3.2 Symbols

Void

3.3 Abbreviations

For the purposes of the present document, the abbreviations defined in 3GPP TS 21.905 [2] and the following apply:

4 Introduction

At the 3GPP TSG RAN #39 meeting, the Study Item description on "Further Advancements for E-UTRA (LTE-Advanced)" was approved [1]. The study item covers technology components to be considered for the evolution of E-UTRA, e.g. to fulfil the requirements on IMT-Advanced. This technical report covers the physical-layer aspects of these technology components.

5 Support of wider bandwidth

Editor's note: This section will capture means to support wider bandwidth as part of the evolution of E-UTRA

Carrier aggregation, where two or more component carriers are aggregated, is considered for LTE-Advanced in order to support wider transmission bandwidths e.g. up to 100MHz and for spectrum aggregation..

A terminal may simultaneously receive or transmit one or multiple component carriers depending on its capabilities:

- An LTE-Advanced terminal with reception and/or transmission capabilities for carrier aggregation can simultaneously receive and/or transmit on multiple component carriers.
- An LTE Rel-8 terminal can receive and transmit on a single component carrier only, provided that the structure of the component carrier follows the Rel-8 specifications.
 - It shall be possible to configure all component carriers LTE Release 8 compatible, at least when the aggregated numbers of component carriers in the UL and the DL are same. Consideration of non-backward-compatible configurations of LTE-A component carriers is not precluded

The L1 specification shall support carrier aggregation for both contiguous and non-contiguous component carriers with each component carrier limited to a maximum of 110 Resource Blocks using the Release 8 numerology

- For contiguous carrier aggregation, the needed frequency spacing between the contiguous component carriers will be studied by RAN WG4. This study should include the supported number of RBs per component carrier and the needed guard bands between and at the edges for a certain aggregation case.
- If possible, the same solution should be used in the L1 specifications for contiguous and non-contiguous aggregation.

It will be possible to configure a UE to aggregate a different number of component carriers of possibly different bandwidths in the UL and the DL. In typical TDD deployments, the number of component carriers and the bandwidth of each component carrier in UL and DL will be the same. RAN WG4 will study the supported combinations of aggregated component carrier and bandwidths.

5.1 MAC-PHY interface

From a UE perspective, there is one transport block (in absence of spatial multiplexing) and one hybrid-ARQ entity per scheduled component carrier. Each transport block is mapped to a single component carrier only. A UE may be scheduled over multiple component carriers simultaneously.

6 Uplink transmission scheme

Editor's note: This section will capture the possible extensions to the E-UTRA uplink transmission scheme, such as extended uplink multi-antenna transmission and hybrid multiple-access schemes

6.1 Uplink spatial multiplexing

Uplink spatial multiplexing of up to four layers is considered for LTE-Advanced.

In the uplink single user spatial multiplexing, up to two transport blocks can be transmitted from a scheduled UE in a subframe per uplink component carrier. Depending on the number of transmission layers, the modulation symbols associated with each of the transport blocks are mapped onto one or two layers according to the same principle as in Rel-8 E-UTRA downlink spatial multiplexing. It is possible to configure the uplink single user spatial multiplexing transmission with or without the layer shifting. In case of the layer shifting, shifting in time domain is supported.

6.2 Uplink multiple access

DFT-precoded OFDM is the transmission scheme used for PUSCH both in absence and presence of spatial multiplexing. In case of multiple component carriers, there is one DFT per component carrier. Both frequency-contiguous and frequency-non-contiguous resource allocation is supported on each component carrier.

Simultaneous transmission of uplink L1/L2 control signalling and data is supported through two mechanisms

- Control signalling is multiplexed with data on PUSCH according to the same principle as in Rel-8
- Control signalling is transmitted on PUCCH simultaneously with data on PUSCH

7 Downlink transmission scheme

Editor's note: This section will capture the possible extensions to the E-UTRA downlink transmission scheme, such as extended downlink multi-antenna transmission

7.1 Downlink spatial multiplexing

Downlink spatial multiplexing of up to eight layers is considered for LTE-Advanced.

In the downlink 8-by-X single user spatial multiplexing, up to two transport blocks can be transmitted to a scheduled UE in a subframe per downlink component carrier. Each transport block is assigned its own modulation and coding scheme. For HARQ ACK/NAK feedback on uplink, one bit is used for each transport block.

7.2 Downlink reference signals

Two types of downlink reference signals are considered for LTE-Advanced:

- Reference signals targeting PDSCH demodulation
- Reference signals targeting CSI estimation (for CQI/PMI/RI/etc reporting when needed)

The reference signal structure can be used to support multiple LTE-Advanced features, e.g. CoMP and spatial multiplexing.

Reference signals targeting PDSCH demodulation are:

- UE-specific, i.e. the PDSCH and the demodulation reference signals intended for a specific UE are subject to the same precoding operation.
- Present only in resource blocks and layers scheduled by the eNodeB for transmission.
- Reference signals transmitted on different layers are mutually orthogonal at the eNodeB.

The design principle for the demodulation reference signals is an extension to multiple layers of the concept of Rel-8 UE-specific reference signals used for beamforming (details on pattern, location, etc are FFS). Complementary use of Rel-8 cell-specific reference signals by the UE is not precluded.

Reference signals targeting CSI estimation are

- cell specific
- sparse in frequency and time.

8 Coordinated multiple point transmission and reception

Editor's note: This section will capture techniques such as enhanced interference coordination and cooperative MIMO

Coordinated multi-point transmission/reception is considered for LTE-Advanced as a tool to improve the coverage of high data rates, the cell-edge throughput and/or to increase system throughput.

8.1 Downlink coordinated multi-point transmission

Downlink coordinated multi-point transmission implies dynamic coordination among multiple geographically separated transmission points. Examples of coordinated transmission schemes include

- Coordinated scheduling and/or beamforming
 - data to a single UE is instantaneously transmitted from *one* of the transmission points
 - scheduling decisions are coordinated to control e.g. the interference generated in a set of coordinated cells.
- Joint processing/transmission
 - data to a single UE is simultaneously transmitted from *multiple* transmission points, e.g. to (coherently or non-coherently) improve the received signal quality and/or cancel actively interference for other UEs

Downlink coordinated multi-point transmission should include the possibility of coordination between different cells. From a radio-interface perspective, there is no difference from the UE perspective if the cells belong to the same eNodeB or different eNodeBs. If inter-eNodeB coordination is supported, information needs to be signaled between eNodeBs.

Potential impact on the radio-interface specifications is foreseen in mainly three areas:

- Feedback and measurement mechanisms from the UE
 - Reporting of dynamic channel conditions between the multiple transmission points and the UE
 - For TDD, channel reciprocity may be exploited
 - Reporting to facilitate the decision on the set of participating transmission points
 - For TDD, channel reciprocity may be exploited
- Preprocessing schemes
 - Joint processing prior to transmission of the signal over the multiple transmission points
 - Downlink control signaling to support the transmission scheme
- Reference signal design
 - Depending on the transmission scheme, specification of additional reference signals may be required.

8.2 Uplink coordinated multi-point reception

Coordinated multi-point reception implies reception of the transmitted signal at multiple, geographically separated points. Uplink coordinated multi-point reception is expected to have very limited, impact on the RAN1 specifications. Scheduling decisions can be coordinated among cells to control interference and may have some RAN1 specification impact. (Editors note: This can be refined as for the downlink section)

9 Relaying functionality

Editor's note: This section will capture techniques such as relaying, repeaters and self-backhauling

Relaying is considered for LTE-Advanced as a tool to improve e.g. the coverage of high data rates, group mobility, temporary network deployment, the cell-edge throughput and/or to provide coverage in new areas.

The relay node is wirelessly connected to radio-access network via a *donor cell*. The connection can be

- *inband*, in which case the network-to-relay link share the same band with direct network-to-UE links within the donor cell. Rel-8 UEs should be able to connect to the donor cell in this case.
- *outband*, in which case the network-to-relay link does not operate in the same band as direct network-to-UE links within the donor cell

With respect to the knowledge in the UE, relays can be classified into

- *transparent*, in which case the UE is not aware of whether or not it communicates with the network via the relay.
- *non-transparent*, in which case the UE is aware of whether or not it is communicating with the network via the relay.

Depending on the relaying strategy, a relay may

- be part of the donor cell
- control cells of its own

In the case the relay is part of the donor cell, the relay does not have a cell identity of its own (but may still have a relay ID). At least part of the RRM is controlled by the eNodeB to which the donor cell belongs, while parts of the RRM may be located in the relay. In this case, a relay should preferably support also LTE Rel-8 UEs. Smart repeaters, decode-and-forward relays and different types of L2 relays are examples of this type of relaying.

In the case the relay is in control of cells of its own, the relay controls one or several cells and a unique physical-layer cell identity is provided in each of the cells controlled by the relay. The same RRM mechanisms are available and from a UE perspective there is no difference in accessing cells controlled by a relay and cells controlled by a "normal" eNodeB. The cells controlled by the relay should support also LTE Rel-8 UEs. Self-backhauling (L3 relay) and "type 1 relay nodes" uses this type of relaying.

At least "Type 1" relay nodes are part of LTE-Advanced. A "type 1" relay node is an inband relaying node characterized by the following:

- It control cells, each of which appears to a UE as a separate cell distinct from the donor cell
- The cells shall have its own Physical Cell ID (defined in LTE Rel-8) and the relay node shall transmit its own synchronization channels, reference symbols, ...
- In the context of single-cell operation, the UE shall receive scheduling information and HARQ feedback directly from the relay node and send its control channels (SR/CQI/ACK) to the relay node
- It shall appear as a Rel-8 eNodeB to Rel-8 UEs (i.e. be backwards compatible)
- To LTE-Advanced UEs, it should be possible for a type 1 relay node to appear differently than Rel-8 eNodeB to allow for further performance enhancement.

9.1 Relay-eNodeB link

For inband relaying, the eNodeB-to-relay link operates in the same frequency spectrum as the relay-to-UE link. Due to the relay transmitter causing interference to its own receiver, simultaneous eNodeB-to-relay and relay-to-UE transmissions on the same frequency resource may not be feasible unless sufficient isolation of the outgoing and incoming signals is provided e.g. by means of specific, well separated and well insulated antenna structures. Similarly, at the relay it may not be possible to receive UE transmissions simultaneously with the relay transmitting to the eNodeB.

One possibility to handle the interference problem is to operate the relay such that the relay is not transmitting to terminals when it is supposed to receive data from the donor eNodeB, i.e. to create "gaps" in the relay-to-UE

transmission. These “gaps” during which terminals (including Rel-8 terminals) are not supposed to expect any relay transmission can be created by configuring MBSFN subframes as exemplified in Figure 9.1. Relay-to-eNodeB transmissions can be facilitated by not allowing any terminal-to-relay transmissions in some subframes.

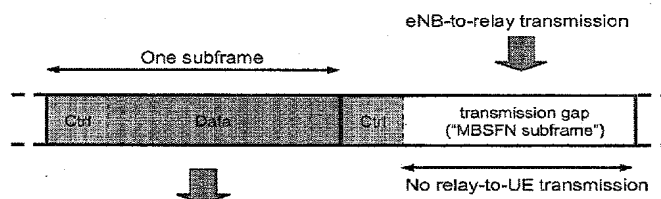


Figure 9.1: Example of relay-to-UE communication using normal subframes (left) and eNodeB-to-relay communication using MBSFN subframes (right).

10 Further enhanced MBMS

11 Mobility enhancement

12 Evaluation of techniques for Advanced E-UTRA

Annex A: Simulation model

Editor's note: This annex will capture the evaluation model such as case in 25.814, micro cell, indoor and rural/high-speed for performance evaluation in RAN WG1.

A.1 Link simulation Scenarios

[...]

Link simulation analyses with (8x8) DL MIMO configuration can be conducted in relation to studies concerning the peak data rate requirements set forth in [36.913].

A.2 System simulation Scenarios

A.2.1 System simulation assumptions

[...]

A.2.1.1 Reference system deployments

This section describes the reference system deployments to use for the different system evaluations.

A.2.1.1.1 Homogeneous deployments

The minimum set of simulation cases is given in Table A.2.1.1-1 along with additional assumptions related to carrier frequency (CF), Inter-site distance (ISD), operating bandwidth (BW), penetration loss (P_{Loss}) and UE speed.

For 3GPP cases only, the system simulation baseline parameters for the macro-cell deployment model are as specified in [TR 25.814], with the modifications given in Table A.2.1.1-2.

For the ITU cases, simulation parameters should be aligned with the ITU guidelines in [IMT Eval], some of which are reflected in Table A.2.1.1-1. Note that [IMT.EVAL] section-8 defines different antenna horizontal and vertical pattern from those defined in Table A.2.1.1-2 which is for 3GPP case evaluation only.

Table A.2.1.1-1 – E-UTRA simulation case minimum set

Simulation Cases	CF (GHz)	ISD (meters)	BW (MHz)	P _{Loss} (dB)	Speed (km/h)	Additional Simulation Parameters
3GPP case 1	2.0	500	FDD:10+10 TDD: 20	20	3	Table A.2.1.1-2 and 25.814
3GPP case 1 extended	2.0	500	FDD:80+40* TDD: 80*	20	3	Table A.2.1.1-2 and 25.814
3GPP case 3	2.0	1732	FDD:10+10 TDD: 20	20	3	Table A.2.1.1-2 and 25.814
ITU Indoor, Indoor hotspot scenario	3.4	60	FDD:20+20 TDD: 40*	N.A.	3	[IMT Eval] Section 8
ITU Indoor extended, Indoor hotspot scenario	3.4	60	FDD:80+40* TDD: 80*	N.A.	3	[IMT Eval] Section 8
ITU Microcellular, Urban micro-cell scenario	2.5	200	FDD:10+10 TDD: 20	See [IMT Eval] Annex.1	3	[IMT Eval] Section 8
ITU Base coverage urban, Urban macro-cell scenario	2.0	500	FDD:10+10 TDD: 20	See [IMT Eval] Annex.1	30	[IMT Eval] Section 8
ITU Base coverage urban extended, Urban macro-cell scenario	2.0	500	FDD:80+40* TDD: 80*	See [IMT Eval] Annex.1	30	[IMT Eval] Section 8
ITU High speed, Rural macro-cell scenario	0.8	1732	FDD:10+10 TDD: 20	See [IMT Eval] Annex.1	120	[IMT Eval] Section 8

(*) Pending availability of applicable channel model.

Table A.2.1.1-2 – 3GPP Case 1 and 3 (Macro-cell) system simulation baseline parameters modifications as compared to TR 25.814

Parameter	Assumption
Antenna pattern (horizontal) (For 3-sector cell sites with fixed antenna patterns)	$A_H(\varphi) = -\min \left[12 \left(\frac{\varphi}{\varphi_{3dB}} \right)^2, A_m \right]$

	$\phi_{3dB} = 70$ degrees, $A_m = 25$ dB
Antenna pattern (vertical) (For 3-sector cell sites with fixed antenna patterns)	$A_v(\theta) = -\min \left[12 \left(\frac{\theta - \theta_{etilt}}{\theta_{3dB}} \right)^2, SLA_v \right]$ $\theta_{3dB} = 10, \quad SLA_v = 20 \text{ dB}$ The parameter θ_{etilt} is the electrical antenna downtilt. The value for this parameter, as well as for a potential additional mechanical tilt, is not specified here, but may be set to fit other RRM techniques used. For calibration purposes, the values $\theta_{etilt} = 15$ degrees for 3GPP case 1 and $\theta_{etilt} = 6$ degrees for 3GPP case 3 may be used. Antenna height at the base station is set to 32m. Antenna height at the UE is set to 1.5m.
Combining method in 3D antenna pattern	$A(\phi, \theta) = -\min \{ -[A_H(\phi) + A_v(\theta)], A_m \}$
Channel model	3GPP Spatial Channel Model (SCM) [TR 25.996] For single transmit antenna evaluations, the Typical Urban (TU) channel model may be used
Total BS TX power (Ptotal)	43dBm – 1.25, 5MHz carrier, 46/49dBm – 10, 20MHz carrier Some evaluations to exploit carrier aggregation techniques may use wider bandwidths e.g. 60 or 80 MHz (FDD). For these evaluations [49 dBm] Total BS Tx power should be used.
UE power class	23dBm (200mW) This corresponds to the sum of PA powers in multiple Tx antenna case
In addition to the antenna bore-sight orientation in TR25.814 (center direction points to the flat side), an optional orientation as shown can be used if needed in Coordinated Multipoint study (i.e., point to corners)	

A.2.1.1.2 Heterogeneous deployments

Heterogeneous deployments consist of deployments where low power nodes are placed throughout a macro-cell layout. A subset of the macro-cell layouts described in section A.2.1.1.1 could be used for heterogeneous network deployments evaluation. For calibration purpose, the following cases should be used

- Case 1
- Case 3
- Rural/high speed

To assess the benefit of adding low-power nodes to become a heterogeneous network, performance comparison should be made to homogeneous macro-cell only deployment.

The categorization of the low power nodes is as described in Table A.2.1.1.2-1.

Table A.2.1.1.2-1. Categorization of new nodes

	Backhaul	Access	Notes
Remote radio head (RRH) cells	Several μ s latency to macro	Open to all UEs	Placed outdoors
Hotzone cells	X2	Open to all UEs	Placed outdoors
Femto cells	FFS	Closed Subscriber Group (CSG)	Placed indoors
Relay nodes	Through air-interface with a macro-cell (for in-band RN case)	Open to all UEs	Placed outdoors

Note: The reference to Femto cells in this TR and its corresponding characteristics is applicable to evaluations in this TR only.

Table A.2.1.1.2-2 presents the baseline parameters for initial evaluations in heterogeneous networks. More detailed modelling of new nodes propagation and channel model based on IMT.EVAL should be considered for performance evaluation at a later stage.

Table A.2.1.1.2-2. Heterogeneous system simulation baseline parameters

Parameter		Assumption		
		RRH / Hotzone	Femto	Relay
Nodes per macro-cell		1, 2, 4 or 10 Note: for femto cells, this number represents the number of clusters. The number of femto cells in each cluster is FFS.		
Distance-dependent path loss from new nodes to UE*1		$L=140.7+36.7\log_{10}R$ for 2GHz, R in km	$L=127+30\log_{10}R$ for 2GHz, R in km, the number of floors in the path is assumed to be 0.	Macro to relay: $L=124.5+37.6\log_{10}R$ for 2GHz R in km for backhaul to macro Relay to UE: $L=140.7+36.7\log_{10}R$ for 2GHz, R in km, for UE access Note 1: this path loss models assume in-band relay. Simulations for out-of-band relay should re-examine this assumption. Note 2: relay node has an antenna height of 5m, other antenna heights FFS.
Lognormal Shadowing		Similar to UMTS 30.03, B 1.41.4 [ETSI TR 101 112]		
Shadowing standard deviation		10 dB	10dB	Macro to relay: 6 dB Relay to UE: 10 dB
Shadowing correlation	Between cells*2	0.5	0.5	0.5
	Between sectors	N/A	N/A	N/A

Penetration Loss	20 dB for Case 1,3; See ITU.Eval for ITU Rural	N/A	Macro to relay: 0 dB
			Relay to UE: 20 dB for Case 1,3; See ITU.Eval for ITU Rural
Antenna pattern (horizontal)	$A(\theta)=0$ dB (omnidirectional)	$A(\theta)=0$ dB (omnidirectional)	Macro to relay: $A(\theta)=-\min\left[12\left(\frac{\theta}{\theta_{3dB}}\right)^2,A_m\right]$ $\theta_{3dB}=70$ degrees, $A_m=20$ dB. TDD relay may reuse the same omnidirectional antenna as in relay-UE links.
			Relay to UE: $A(\theta)=0$ dB. Use of antenna downtilt and a corresponding vertical antenna pattern is FFS.
Carrier Frequency	CF= 2GHz for case 1 and case 3 CF = 0.8GHz for high sped rural		
Channel model	If fast fading modelling is disabled in system level simulations for relative evaluations, the impairment of frequency-selective fading channels shall be captured in the physical layer abstraction. For SIMO, the physical layer abstraction is based on TU link curves. For MIMO, the physical layer abstraction is FFS.		
UE speeds of interest	Case 1 and Case 3: 3 km/h Rural high speed: 120 km/h for UEs served by macro, RRH, hotzone or relay nodes. 3 km/h for UEs served by femto cells.		
Doppler of relay-macro link	N/A	N/A	Jakes spectrum with [5]Hz for NLOS component. LOS component [K=10dB].
Total BS TX power (Ptotal)	30 dBm – 10MHz carrier	20 dBm – 10MHz carrier	30 dBm – 10MHz carrier, for relay to macro
			30 dBm – 10MHz carrier, for relay to UE
UE power class	23dBm (200mW) This corresponds to the sum of PA powers in multiple Tx antenna case		
Inter-cell Interference Modelling	UL: Explicit modelling (all cells occupied by UEs), DL: Explicit modelling else cell power = Ptotal		
Antenna configuration	2 tx , 2 rx antenna ports, or 4 tx , 4 rx antenna ports	2 tx , 2 rx antenna ports, or 4 tx , 4 rx antenna ports	2 tx , 2 rx antenna ports, or 4 tx , 4 rx antenna ports for relay donor antenna to macro
			2 tx , 2 rx antenna ports, or 4 tx , 4 rx antenna ports for relay coverage antenna to UE
Antenna gain + connector loss [Motorola: reference for these values?]	5dBi	5dBi	7dBi for relay donor antenna to macro
			5dBi for relay coverage antenna to UE

Placing of new nodes and Ues	See Table A.2.1.1.2-3	See Table A.2.1.1.2-4	See Table A.2.1.1.2-3
Minimum distance between new node and regular nodes	$\geq 35\text{m}$		
Minimum distance between UE and regular node	$\geq 35\text{m}$		
Minimum distance between UE and new node (RRH/Hotzone, Femto, Relay)	$> 10\text{m}$	$\geq 3\text{m}$	$> 10\text{m}$
Minimum distance among new nodes	FFS	FFS	FFS

*1 RRH/Hotzone and relay to UE link path loss is based on IMT-EVAL UMi NLOS model; femto path loss is based on ITU-R M1225 single floor indoor office model; macro to relay path loss is based on 3GPP TR 25.814 with modified 5m antenna height.

*2 Cells including macro cells of the overlay network and new nodes.

Table A.2.1.1.2-3. Placing of new nodes and UEs

Configuration	UE density across macro cells*	UE distribution within a macro cell	New node distribution within a macro cell	Comments
1	Uniform 25/macro cell	Uniform	Uncorrelated	Capacity enhancement
2	Non-uniform [10 – 100]/macro cell	Uniform	Uncorrelated	Sensitivity to non-uniform UE density across macro cells
3	Non-uniform [10 – 100]/macro cell	Uniform	Correlated**	Cell edge enhancement
4	Non-uniform [10 – 100]/macro cell	Clusters	Correlated**	Hotspot capacity enhancement

* New node density is proportional to the UE density in each macro cell. UE density is defined as the number of UEs in the geographic area of a macro cell.

**Relay and hotzone nodes, often deployed by planning, may be placed by [TBD] method.

Table A.2.1.1.2-4. Placing of femto cells and UEs

Configuration	Macro-femto Deployment	Placing of nodes	Placing of UEs
1	Independent channel	Clustered	Random placing of UEs within X meters of the femto cell
2	Co-channel	Clustered	Random placing of UEs within X meters of the femto cell

A.2.1.1.3 Backhaul Assumptions for Coordinated Multi point Transmission and Reception Evaluation

The performance of downlink/uplink multi-point transmission and reception, and advanced ICIC techniques is sensitive to the backhaul capacity and latency. In general, the backhaul latency could be classified into the following –categories

- Minimal latency (in the order of μs) for eNB to RRH links
- Low latency ($<1\text{ ms}$) associated with co-located cells or cells connected with fibre links and only limited number of routers in between

- Typical inter-cell latency associated with X2 interfaces.

The X2 backhaul latency, or more generally latency between new nodes, or new nodes and eNBs, or between eNBs, is highly deployment dependent such as whether there is a dedicated X2 fibre network or a generic IP network.

The proponents should describe and justify the model assumed in particular studies.

A.2.1.2 Channel models

Annex B describes the IMT-Advanced Channel Models, which are specified in the IMT.EVAL of ITU-R[15].

A.2.1.3 Traffic models

Proposed traffic models for system performance evaluations are given in Table A.2.1.3-1. System throughput studies shall be assessed using full-buffer traffic model capturing continuous traffic and non-varying interference. Additionally, evaluations with time-varying interference shall be carried out using bursty traffic models. Table A.2.1.3-1 proposes a Poisson-based traffic model to exercise system performance studies in bursty traffic.

Table A.2.1.3-1. Traffic Models

Traffic Models	Model Applies to
Full buffer	DL and UL. Continuous traffic.
Poisson-based Burst of fixed size S. Arrival of bursts model as a Poisson process with arrival rate λ . Inter-arrival time starts after the packet has been delivered.	DL and UL. Bursty traffic.
VoIP	DL and UL Real time services

A.2.1.4 System performance metrics

For evaluations with full-buffer traffic model, the following performance metrics need to be considered:

- Mean user throughput
- Throughput CDF
- Median and 5% worst user throughput

For evaluations with bursty traffic model, the following performance metrics need to be considered:

- User perceived throughput (during active time), defined as the size of a burst divided by the time between the arrival of the first packet of a burst and the reception of the last packet of the burst
 - Average perceived throughput of a user defined as the average from all perceived throughput for all bursts intended for this user.
 - Tail perceived throughput defined as the worst 5% perceived throughput among all bursts intended for a user
- User perceived throughput CDF (average and/or tail user perceived throughput).
- Percentage of users with [1]% or more dropped packets.
- Median and 5% worst user perceived throughput (average and/or tail user perceived throughput).
- Overall average user throughput defined as average over all users perceived throughput.

For VoIP capacity evaluations, the following performance metrics need to be considered:

- VoIP system capacity in form of the maximum number of satisfied users supported per cell in downlink and uplink.
 - System capacity is defined as the number of users in the cell when more than [95%] of the users are satisfied.
 - A VoIP user is in outage (not satisfied) if [98%] radio interface tail latency of the user is greater than [50 ms]. This assumes an end-to-end delay below [200 ms] for mobile-to-mobile communications.

The following table should be included along with the simulation assumptions accompanying all results:

Are Throughput Values based solely on an assumption of a number of trials of independent placing of UEs?	Comments
Yes/No	If "Yes," then state the number of trials, i.e., placing of a group of UEs in cells used. If "No," either state the methodology by which confidence interval is achieved as well as confidence interval and confidence level, or justify the method of user placing in different trials.

A.2.1.5 Scheduling and resource allocation

Different scheduling approaches have impacts on performance and signalling requirements.

Evaluations should include a high-level description of the scheduling and resource allocation schemes simulated, including relevant parameter values. For frequency or carrier specific scheduling, and multipoint transmission schemes, any feedback approach, delay, and feedback error assumptions should also be indicated. For uplink queue-related scheduling, similar indications should be given for any buffer status feedback.

Evaluations should include fairness, as described in section A.2.1.4 above.

A.2.1.6 Antenna gain for a given bearing and downtilt angle

The orientation of the center cell hexagon is such that the main antenna lobe center direction either points to the flat side or the corner of the hexagon. The main antenna lobe center directions of the other 18-surrounding cell are parallel to those of the center cell.

Antenna downtilt is the angle between the main antenna lobe center and a line directed perpendicular from the antenna face. As the downtilt angle increases (positively) the antenna main lobe points increasingly toward the ground.

The Antenna gain that results for a given bearing and downtilt angle for a given cell/sector 'i' with respect to a mobile 'k' is characterized by the equations given below (B1,2). A geometric representation is given in Figure A.2.1.5-1 below.

$$\theta(i,k) = \gamma(i,k) - \xi(i) \quad (B1)$$

$$\phi(i,k) = \omega(i,k) - \zeta(i,k) \quad (B2)$$

where

$\theta(i,k)$ = angle between antenna main lobe center and line connecting cell 'i' and mobile 'k' in radians in horizontal plane.

$\phi(i,k)$ = angle between antenna main lobe center and line connecting cell 'i' and mobile 'k' in radians in vertical plane.

$\xi(i)$ = antenna bearing for cell 'i' in radians.

$h(i)$ = antenna height for cell 'i' in meters.

$\delta(i)$ = mechanical antenna downtilt in radians. Note that electrical downtilt is taken into account in the vertical antenna diagram.

$\zeta(i,k)$ = corrected downtilt angle for given horizontal offset angle ($\theta(i,k)$) in radians.
 $= \text{ATAN}(\text{COS}(\theta(i,k))\text{TAN}(\delta(i)))$

$\omega(i,k)$ = antenna-mobile line of sight angle in radians
 $= \text{ATAN}(h(i)/d(i,k))$

$d(i,k)$ = $(\text{mobile}(k)\text{\_ypos} - \text{cell}[i]\text{\_ypos})^2 + (\text{mobile}(k)\text{\_xpos} - \text{cell}[i]\text{\_xpos})^2$
 $= \text{distance}$

$\gamma(i,k)$ = mobile bearing is the angle between the line drawn between the cell and mobile and a line directed due east from the cell.
 $= \text{ATAN2}(\text{mobile}(k)\text{\_ypos} - \text{cell}[i]\text{\_ypos}, (\text{mobile}(k)\text{\_xpos} - \text{cell}[i]\text{\_xpos}))$

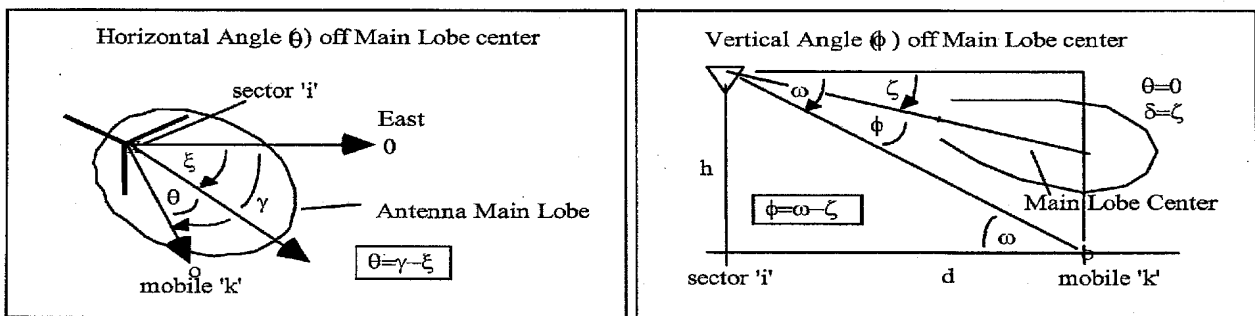


Figure A.2.1.5-1 Mobile Bearing orientation diagram example

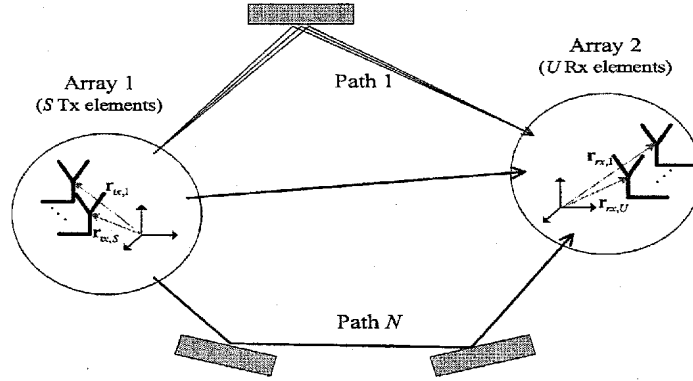
Annex B: Channel models (Informative)

The ITU-R IMT-Advanced channel model is a geometry-based stochastic model. It can also be called double directional channel model. It does not explicitly specify the locations of the scatters, but rather the directions of the rays, like the well-known spatial channel model (SCM) [B1]. Geometry-based modelling of the radio channel enables separation of propagation parameters and antennas.

The channel parameters for individual snapshots are determined stochastically based on statistical distributions extracted from channel measurements. Antenna geometries and radiation patterns can be defined properly by the user of the model. Channel realizations are generated through the application of the geometrical principle by summing contributions of rays (plane waves) with specific small-scale parameters like delay, power, angle-of-arrival (AoA) and angle-of-departure (AoD). Superposition results to correlation between antenna elements and temporal fading with geometry dependent Doppler spectrum.

A number of rays constitute a cluster. In the terminology of this document we equate the cluster with a propagation path diffused in space, either or both in delay and angle domains. Elements of the MIMO channel, e.g., antenna arrays at both link ends and propagation paths, are illustrated in Figure B-1. The generic MIMO channel model is applicable for all scenarios, e.g. indoor, urban and rural.

Figure B-1 The MIMO channel



The time variant impulse response matrix of the $U \times S$ MIMO channel is given by

$$\mathbf{H}(t; \tau) = \sum_{n=1}^N \mathbf{H}_n(t; \tau), \quad (3)$$

where t is time, τ is delay, N is the number of paths, and n is path index. It is composed of the antenna array response matrices $\mathbf{F}_{tx}$ and $\mathbf{F}_{rx}$ for the transmitter (Tx) and the receiver (Rx) respectively, and the dual-polarized propagation channel response matrix $\mathbf{h}_n$ for cluster n as follows

$$\mathbf{H}_n(t; \tau) = \iint \mathbf{F}_{rx}(\phi) \mathbf{h}_n(t; \tau, \phi, \varphi) \mathbf{F}_{tx}^T(\phi) d\phi d\varphi. \quad (4)$$

The channel from Tx antenna element s to Rx element u for cluster n is expressed as

$$\begin{aligned} H_{u,s,n}(t; \tau) = & \sum_{m=1}^M \begin{bmatrix} F_{rx,u,V}(\phi_{n,m}) \\ F_{rx,u,H}(\phi_{n,m}) \end{bmatrix}^T \begin{bmatrix} \alpha_{n,m,VV} & \alpha_{n,m,VH} \\ \alpha_{n,m,HV} & \alpha_{n,m,HH} \end{bmatrix} \begin{bmatrix} F_{tx,s,V}(\phi_{n,m}) \\ F_{tx,s,H}(\phi_{n,m}) \end{bmatrix} \\ & \times \exp(j2\pi\lambda_0^{-1}(\bar{\phi}_{n,m} \cdot \bar{r}_{rx,u})) \exp(j2\pi\lambda_0^{-1}(\bar{\phi}_{n,m} \cdot \bar{r}_{tx,s})) \\ & \times \exp(j2\pi\nu_{n,m}t) \delta(\tau - \tau_{n,m}) \end{aligned} \quad (5)$$

where $F_{rx,u,V}$ and $F_{rx,u,H}$ are the antenna element u field patterns for vertical and horizontal polarizations respectively, $\alpha_{n,m,VV}$ and $\alpha_{n,m,VH}$ are the complex gains of vertical-to-vertical and horizontal-to-vertical polarizations of ray n,m respectively, λ_0 is the wave length of the carrier frequency, $\bar{\phi}_{n,m}$ is the AoD unit vector, $\bar{\varphi}_{n,m}$ is the AoA unit vector, $\bar{r}_{tx,s}$ and $\bar{r}_{rx,u}$ are the location vectors of element s and u respectively, and $\nu_{n,m}$ is the Doppler frequency component of ray n,m . If the radio channel is modelled as dynamic, all the above mentioned small-scale parameters are time variant, i.e., they are functions of t [B8].

The IMT-Advanced channel model for the evaluation of IMT-Advanced candidate RITs consists of a Primary Module and an Extension Module. In this part, only the primary module is included, which is mandatory for IMT-Advanced evaluation. The Primary Module covers the mathematical framework, which is called *generic model*, a set of parameters as well as path loss models.

The generic channel model is a double-directional geometry-based stochastic model. It is a system level¹ model in the sense that is employed, e.g., in the SCM model [B1]. It can describe an unlimited number of propagation environment realizations for single or multiple radio links for all the defined scenarios and for arbitrary antenna configurations, with one mathematical framework by different parameter sets. The generic channel model is a stochastic model with two (or three) levels of randomness. First, large-scale (LS) parameters like shadow fading, delay, and angular spreads are drawn randomly from tabulated distribution functions. Next, small-scale (SS) parameters like delays, powers, and directions of

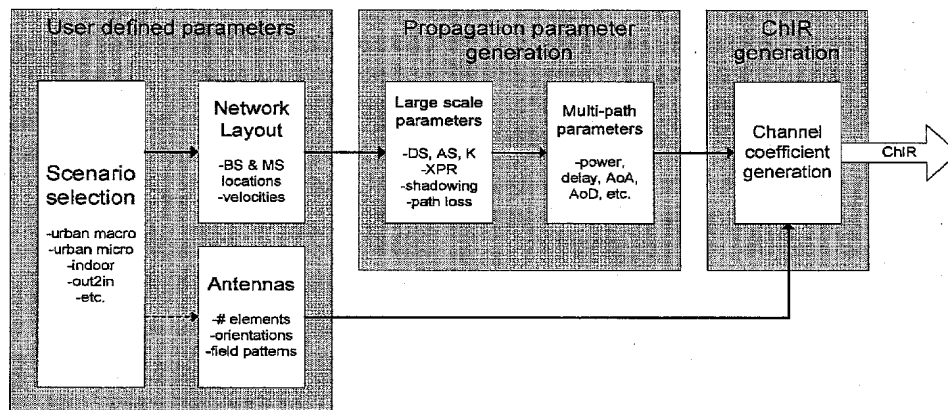
¹ The term system-level means here that the model is able to cover multiple links, cells and terminals.

arrival and departure are drawn randomly according to tabulated distribution functions and random LS parameters. At this stage the geometric setup is fixed and the only free variables are the random initial phases of the scatters. By picking (randomly) different initial phases, an infinite number of different realizations of the model can be generated. When the initial phases are also fixed, there is no further randomness left.

Figure B-2 shows the overview of the channel model creation. The first stage consists of two steps. First, the propagation scenario is selected. Then, the network layout and the antenna configuration are determined. In the second stage, large-scale and small-scale parameters are defined. In the third stage, channel impulse responses (ChIRs) are calculated.

The generic model is based on the drop concept. When using the generic model, the simulation of the system behaviour is carried out as a sequence of “drops”, where a “drop” is defined as one simulation run over a certain time period. A drop (or snapshot or channel segment) is a simulation entity where the random properties of the channel remain constant except for the fast fading caused by the changing phases of the rays. The constant properties during a single drop are, e.g., the powers, delays, and directions of the rays. In a simulation the number and the length of drops have to be selected properly by the evaluation requirements and the deployed scenario. The generic model allows the user to simulate over several drops to get statistically representative results. Consecutive drops are independent.

Figure B-2 Channel model creation process



B.1 Channel models

This section provides the reference channel model for each test environment. These test environments are intended to cover the range of IMT-Advanced operating environments.

The test operating environments are considered as a basic factor in the evaluation process of the candidate RITs. The reference models are used to estimate the critical aspects, such as the spectrum, coverage and power efficiencies.

B.1.2 Primary module

The following sections provide the details of the channel models, including the path loss models, for the terrestrial component. For terrestrial environments, the propagation effects are divided into three distinct types: These are the path loss, the slow variation due to shadowing and scattering, and the rapid variation in the signal due to multipath effects. The channel models are specified in the frequency range from 2 GHz to 6 GHz. For the rural macro-cell scenario (RMa), the channel model can be used for lower frequencies down to 450 MHz. The channel models also cover MIMO aspects as all desired dimensions (delay, AoA, AoD and polarisation) are considered. The channel models are targeted for up to 100 MHz RF bandwidth.

B.1.2.1 Path loss models

Path loss models for the various propagation scenarios have been developed based on measurement results carried out in [B2, B7, B9-B14], as well as results from the literature. The models can be applied in the frequency range of 2 – 6

GHz and for different antenna heights. The rural path-loss formula can be applied to the desired frequency range from 450 MHz to 6 GHz. The path loss models have been summarized in Table B1-2. Note that the distribution of the shadow fading is log-normal, and its standard deviation for each scenario is given in the table.

Table B1-2 Summary table of the primary module path loss models

Scenario		Path loss [dB] Note: f_c is given in GHz and distance in meters!	Shadow fading std [dB]	Applicability range, antenna height default values
Hotspot	LOS	$PL = 16.9\log_{10}(d) + 32.8 + 20\log_{10}(f_c)$	$\sigma = 3$	$3 \text{ m} < d < 100 \text{ m}$ $h_{BS} = 3\text{-}6 \text{ m}$ $h_{UT} = 1\text{-}2.5 \text{ m}$
	NLOS	$PL = 43.3\log_{10}(d) + 11.5 + 20\log_{10}(f_c)$	$\sigma = 4$	$10 \text{ m} < d < 150 \text{ m}$ $h_{BS} = 3\text{-}6 \text{ m}$ $h_{UT} = 1\text{-}2.5 \text{ m}$
Indoor (InH)	LOS	$PL = 22.0\log_{10}(d) + 28.0 + 20\log_{10}(f_c)$ $PL = 40\log_{10}(d_l) + 7.8 - 18\log_{10}(h'_{BS}) - 18\log_{10}(h'_{UT}) + 20\log_{10}(f_c)$	$\sigma = 3$ $\sigma = 3$	$10 \text{ m} < d_1 < d'_{BP}{}^{1)}$ $d'_{BP} < d_1 < 5000 \text{ m}^{1)}$ $h_{BS} = 10 \text{ m}^{1)}, h_{UT} = 1.5 \text{ m}^{1)}$
	NLOS	Manhattan grid layout: $PL = \min(PL(d_1, d_2), PL(d_2, d_1))$ where $PL(d_k, d_l) =$ $PL_{LOS}(d_k) + 17.9 - 12.5n_j + 10n_j \log_{10}(d_l) + 3\log_{10}(f_c)$ and $n_j = \max(2.8 - 0.0024d_k, 1.84)$ and PL_{LOS} is the path loss of scenario UMi LOS and $k, l \in \{1, 2\}$. Hexagonal cell layout: $PL = 36.7\log_{10}(d) + 22.7 + 26\log_{10}(f_c)$	$\sigma = 4$ $\sigma = 4$	$10 \text{ m} < d_1 + d_2 < 5\,000 \text{ m}$, $w/2 < \min(d_1, d_2) {}^{2)}$ $w = 20 \text{ m}$ (street width) $h_{BS} = 10 \text{ m}$, $h_{UT} = 1.5 \text{ m}$ When $0 < \min(d_1, d_2) < w/2$, the LOS PL is applied.
	O-to-I	$PL = PL_b + PL_{rw} + PL_{in}$ Manhattan grid layout (θ known): $\begin{cases} PL_b = PL_{B1}(d_{out} + d_{in}) \\ PL_{rw} = 14 + 15(1 - \cos(\theta))^2 \\ PL_{in} = 0.5d_{in} \end{cases}$ For hexagonal layout (θ unknown): $PL_{rw} = 20$, other values remain the same.	$\sigma = 7$	$10 \text{ m} < d_{out} + d_{in} < 1\,000 \text{ m}$, $0 \text{ m} < d_{in} < 25 \text{ m}$, $h_{BS} = 10 \text{ m}$, $h_{UT} = 3(n_{FI} - 1) + 1.5 \text{ m}$, $n_{FI} = 1$, Explanations: see ³⁾

Urban Macro (UMa)	LOS	$PL = 22.0 \log_{10}(d) + 28.0 + 20 \log_{10}(f_c)$ $PL = 40.0 \log_{10}(d_1) + 7.8 - 18.0 \log_{10}(h'_{BS}) - 18.0 \log_{10}(h'_{UT}) + 2.0 \log_{10}(f_c)$	$\sigma = 4$ $\sigma = 4$	$10 \text{ m} < d < d'_{BP}{}^{1)}$ $d'_{BP} < d < 5\,000 \text{ m}^{1)}$ $h_{BS} = 25 \text{ m}^{1)}, h_{UT} = 1.5 \text{ m}^{1)}$
	NLOS	$PL = 161.04 - 7.1 \log_{10}(W) + 7.5 \log_{10}(h) - (24.37 - 3.7(h/h_{BS})^2) \log_{10}(h_{BS}) + (43.42 - 3.1 \log_{10}(h_{BS})) (\log_{10}(d) - 3) + 20 \log_{10}(f_c) - (3.2 (\log_{10}(11.75 h_{UT}))^2 - 4.97)$	$\sigma = 6$	$10 \text{ m} < d < 5\,000 \text{ m}$ $h = \text{avg. building height}$ $W = \text{street width}$ $h_{BS} = 25 \text{ m}, h_{UT} = 1.5 \text{ m},$ $W = 20 \text{ m}, h = 20 \text{ m}$ The applicability ranges: $5 \text{ m} < h < 50 \text{ m}$ $5 \text{ m} < W < 50 \text{ m}$ $10 \text{ m} < h_{BS} < 150 \text{ m}$ $1 \text{ m} < h_{UT} < 10 \text{ m}$
Suburban Macro (SMa, optional)	LOS	$PL_1 = 20 \log_{10}(40\pi d f_c / 3) + \min(0.03 h^{1.72}, 10) \log_{10}(d) - \min(0.044 h^{1.72}, 14.77) + 0.002 \log_{10}(h) d$ $PL_2 = PL_1 (d_{BP}) + 40 \log_{10}(d/d_{BP})$	$\sigma = 4$ $\sigma = 6$	$10 \text{ m} < d < d_{BP}{}^{4)}$ $d_{BP} < d < 5\,000 \text{ m}$ $h_{BS} = 35 \text{ m}, h_{UT} = 1.5 \text{ m},$ $W = 20 \text{ m}, h = 10 \text{ m}$ (The applicability ranges of h, W, h_{BS}, h_{UT} are same as in UMa NLOS)
	NLOS	$PL = 161.04 - 7.1 \log_{10}(W) + 7.5 \log_{10}(h) - (24.37 - 3.7(h/h_{BS})^2) \log_{10}(h_{BS}) + (43.42 - 3.1 \log_{10}(h_{BS})) (\log_{10}(d) - 3) + 20 \log_{10}(f_c) - (3.2 (\log_{10}(11.75 h_{UT}))^2 - 4.97)$	$\sigma = 8$	$10 \text{ m} < d < 5\,000 \text{ m}$ $h_{BS} = 35 \text{ m}, h_{UT} = 1.5 \text{ m},$ $W = 20 \text{ m}, h = 10 \text{ m}$ (Applicability ranges of h, W, h_{BS}, h_{UT} are same as in UMa NLOS)
Rural Macro (RMa)	LOS	$PL_1 = 20 \log_{10}(40\pi d f_c / 3) + \min(0.03 h^{1.72}, 10) \log_{10}(d) - \min(0.044 h^{1.72}, 14.77) + 0.002 \log_{10}(h) d$ $PL_2 = PL_1 (d_{BP}) + 40 \log_{10}(d/d_{BP})$	$\sigma = 4$ $\sigma = 6$	$10 \text{ m} < d < d_{BP}{}^{4)}$ $d_{BP} < d < 10\,000 \text{ m},$ $h_{BS} = 35 \text{ m}, h_{UT} = 1.5 \text{ m},$ $W = 20 \text{ m}, h = 5 \text{ m}$ (Applicability ranges of h, W, h_{BS}, h_{UT} are same as UMa NLOS)

NLOS	$PL = 161.04 - 7.1 \log_{10}(W) + 7.5 \log_{10}(h) - (24.37 - 3.7(h/h_{BS})^2) \log_{10}(h_{BS}) + (43.42 - 3.1 \log_{10}(h_{BS})) (\log_{10}(d) - 3) + 20 \log_{10}(f_c) - (3.2 (\log_{10}(11.75 h_{UT}))^2 - 4.97)$	$\sigma = 8$	$10 \text{ m} < d < 5000 \text{ m},$ $h_{BS} = 35 \text{ m}, h_{UT} = 1.5 \text{ m},$ $W = 20 \text{ m}, h = 5 \text{ m}$ (The applicability ranges of h, W, h_{BS}, h_{UT} are same as UMa NLOS)
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- 1) Break point distance $d'_{BP} = 4 h'_{BS} h'_{UT} f_c / c$, where f_c is the centre frequency in Hz, $c = 3.0 \times 10^8$ m/s is the propagation velocity in free space, and h'_{BS} and h'_{UT} are the effective antenna heights at the BS and the UT, respectively. The effective antenna heights h'_{BS} and h'_{UT} are computed as follows: $h'_{BS} = h_{BS} - 1.0 \text{ m}$, $h'_{UT} = h_{UT} - 1.0 \text{ m}$, where h_{BS} and h_{UT} are the actual antenna heights, and the effective environment height in urban environments is assumed to be equal to 1.0 m.
- 2) The distances d_1 and d_2 are defined below in Figure A1-1.
- 3) PL_b = basic path-loss, PL_{BI} = Loss of UMi outdoor scenario, PL_{TW} = Loss through wall, PL_{in} = Loss inside, d_{out} = distance from BS to the wall next to UT location, d_{in} = perpendicular distance from wall to UT (assumed evenly distributed between 0 and 25 m), θ = angle between LOS to the wall and a unit vector normal to the wall.
- 4) Break point distance $d_{BP} = 2\pi h_{BS} h_{UT} f_c / c$, where f_c is the centre frequency in Hz, $c = 3.0 \times 10^8$ m/s is the propagation velocity in free space, and h_{BS} and h_{UT} are the antenna heights at the BS and the UT, respectively.

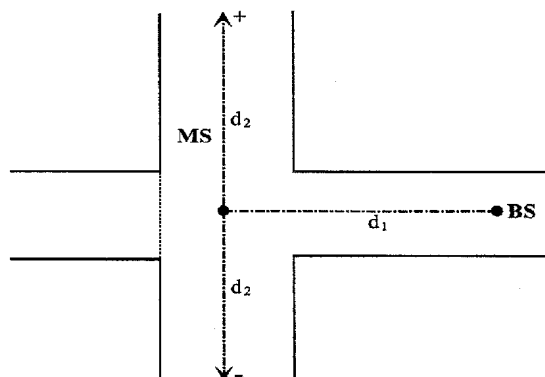
The line-of-sight (LOS) probabilities are given in Table B1-3. Note that probabilities are used only for system level simulations.

Table B1-3

Scenario	LOS probability as a function of distance d [m]
InH	$P_{LOS} = \begin{cases} 1, & d \leq 18 \\ \exp(-(d-18)/27), & 18 < d < 37 \\ 0.5, & d \geq 37 \end{cases}$
UMi	$P_{LOS} = \min(18/d, 1) \cdot (1 - \exp(-d/36)) + \exp(-d/36)$ (for outdoor users only)
UMa	$P_{LOS} = \min(18/d, 1) \cdot (1 - \exp(-d/63)) + \exp(-d/63)$
RMa	$P_{LOS} = \begin{cases} 1, & d \leq 10 \\ \exp\left(-\frac{d-10}{1000}\right), & d > 10 \end{cases}$

The NLOS path loss model for scenario UMi is dependent on two distances, d_1 and d_2 in the case of the Manhattan grid. These distances are defined with respect to a rectangular street grid, as illustrated in Figure B1-1, where the UT is shown moving along a street perpendicular to the street on which the BS is located (the LOS street). d_1 is the distance from the BS to the centre of the perpendicular street, and d_2 is the distance of the UT along the perpendicular street, measured from the centre of the LOS street.

Figure B1-1 Geometry for d_1 - d_2 path-loss model



B.1.2.1.1 Autocorrelation of shadow fading

The long-term (log-normal) fading in the logarithmic scale around the mean path loss PL (dB) is characterized by a Gaussian distribution with zero mean and standard deviation. Due to the slow fading process versus distance Δx , adjacent fading values are correlated. Its normalized autocorrelation function $R(\Delta x)$ can be described with sufficient accuracy by the exponential function [B6]

$$R(\Delta x) = e^{-\frac{|\Delta x|}{d_{cor}}} \quad (6)$$

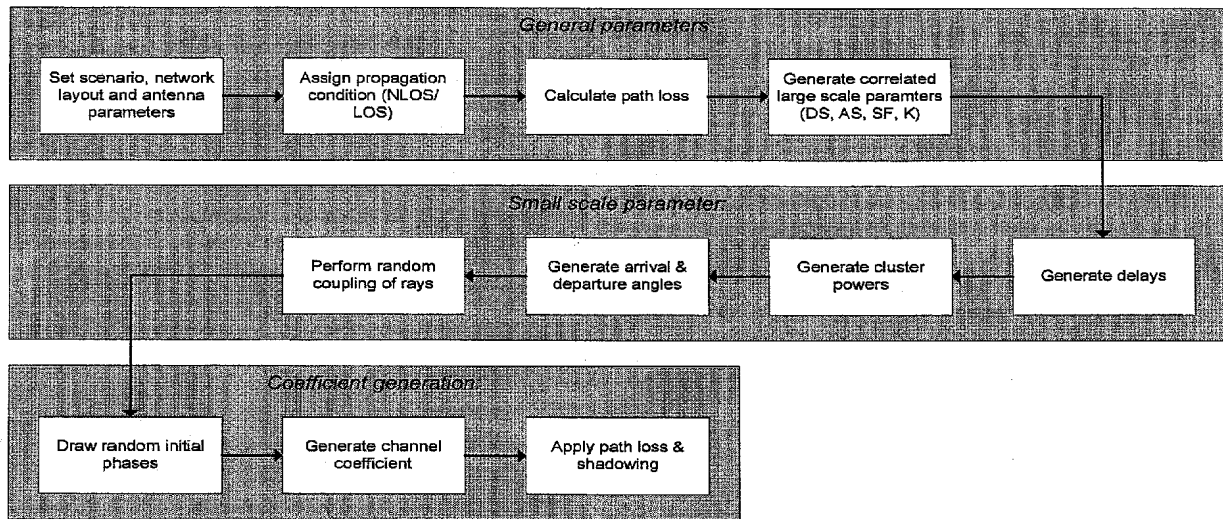
with the correlation length d_{cor} being dependent on the environment, see the correlation parameters for shadowing and other large scale parameters in Table B1-7 (Channel model parameters).

B.1.2.2 Primary module channel model parameters

B.1.2.2.1 Generic model

The radio channels are created using the parameters listed in Table B1-7. The channel realizations are obtained by a step-wise procedure [B2] illustrated in Figure B1-2 and described below. It has to be noted that the geometric description covers arrival angles from the last bounce scatterers and respectively departure angles to the first scatterers interacted from the transmitting side. The propagation between the first and the last interaction is not defined. Thus, this approach can model also multiple interactions with the scattering media. This indicates also that e.g., the delay of a multipath component cannot be determined by the geometry. In the following steps, downlink is assumed. For uplink, arrival and departure parameters have to be swapped.

Figure B1-2 Channel coefficient generation procedure



General parameters:

Step 1: Set environment, network layout, and antenna array parameters

- Choose one of the scenarios (InH, UMi, ...)
- Give number of BS and UT
- Give locations of BS and UT, or equally distances of each BS and UT and relative directions and ϕ_{LOS} and ϕ_{LOS} of each BS and UT
- Give BS and UT antenna field patterns F_{rx} and F_{tx} and array geometries
- Give BS and UT array orientations with respect to north (reference) direction
- Give speed and direction of motion of UT
- Give system centre frequency

Large scale parameters:

Step 2: Assign propagation condition (LOS/NLOS).

Step 3: Calculate path loss with formulas of Table A1-2 for each BS-UT link to be modelled.

Step 4: Generate correlated large scale parameters, i.e. delay spread, angular spreads, Ricean K factor and shadow fading term like explained in [B2, section 3.3.1] (Correlations between large scale parameters). Limit random rms arrival and departure azimuth spread values to 104 degrees, i.e., $\sigma_\phi = \min(\sigma_\phi, 104^\circ)$.

Small scale parameters:

Step 5: Generate delays τ .

Delays are drawn randomly from the delay distribution defined in Table A1-7. With exponential delay distribution calculate

$$\tau_n' = -r_\tau \sigma_\tau \ln(X_n), \quad (7)$$

where r_τ is the delay distribution proportionality factor, $X_n \sim \text{Uni}(0,1)$, and cluster index $n = 1, \dots, N$. With uniform delay distribution the delay values τ_n' are drawn from the corresponding range. Normalise the delays by subtracting the minimum delay and sort the normalised delays to descending order:

$$\tau_n = \text{sort}(\tau_n' - \min(\tau_n')). \quad (8)$$

In the case of LOS condition, additional scaling of delays is required to compensate for the effect of LOS peak addition to the delay spread. The heuristically determined Ricean K-factor dependent scaling constant is

$$D = 0.7705 - 0.0433K + 0.0002K^2 + 0.000017K^3, \quad (9)$$

where K [dB] is the Ricean K-factor defined in Table A1-7. The scaled delays

$$\tau_n^{LOS} = \tau_n / D, \quad (10)$$

are not to be used in cluster power generation.

Step 6: Generate cluster powers P .

Cluster powers are calculated assuming a single slope exponential power delay profile. Power assignment depends on the delay distribution defined in Table A1-7. With exponential delay distribution the cluster powers are determined by

$$P'_n = \exp\left(-\tau_n \frac{r_r - 1}{r_r \sigma_r}\right) \cdot 10^{\frac{-Z_n}{10}} \quad (11)$$

where $Z_n \sim N(0, \zeta)$ is the per cluster shadowing term in [dB]. Average the power so that the sum power of all cluster powers is equal to one, i.e.,

$$P_n = \frac{P'_n}{\sum_{n=1}^N P'_n} \quad (12)$$

Assign the power of each ray within a cluster as P_n/M , where M is the number of rays per cluster.

Remove clusters with less than -25 dB power compared to the maximum cluster power.

Step 7: Generate arrival angles φ and departure angles ϕ .

As the composite PAS of all clusters is modelled as wrapped Gaussian (see Table A1-7), except indoor hotspot scenario (InH) as Laplacian, the AoAs are determined by applying the inverse Gaussian function (13) or inverse Laplacian function (14) with input parameters P_n and RMS angle spread σ_φ

$$\varphi'_n = \frac{2\sigma_{AoA} \sqrt{-\ln(P_n/\max(P_n))}}{C} \quad (13)$$

$$\varphi'_n = -\frac{\sigma_\varphi \ln(P_n/\max(P_n))}{C} \quad (14)$$

In the equation (13) $\sigma_{AoA} = \sigma_\varphi / 1.4$ is the standard deviation of the arrival angles (the factor 1.4 is the ratio of Gaussian std and the corresponding "RMS spread"). Constant C is a scaling factor related to total number of clusters and is given in the table below:

Table B1-4

# clusters	4	5	8	10	11	12	14	15	15 (InH)	16	19	19 (InH)	20
C	0.779	0.860	1.018	1.090	1.123	1.146	1.190	1.211	1.434	1.226	1.273	1.501	1.289

In the LOS case, constant C is dependent also on the Ricean K-factor. Constant C in (13) and (14) is substituted by C^{LOS} . Additional scaling of the angles is required to compensate for the effect of LOS peak addition to the angle spread. The heuristically determined Ricean K-factor dependent scaling constant is

$$C^{LOS} = C \cdot (1.1035 - 0.028K - 0.002K^2 + 0.0001K^3), \quad (15)$$

As for indoor hotspot scenario, the scaling constant is:

$$C^{LOS} = C \cdot (0.9275 + 0.0439K - 0.0071K^2 + 0.0002K^3) \quad (16)$$

where K [dB] is the Ricean K-factor defined in Table B1-7.

Assign positive or negative sign to the angles by multiplying with a random variable X_n with uniform distribution to the discrete set of $\{1, -1\}$, and add component $Y_n \sim N(0, \sigma_\varphi/7)$ to introduce random variation

$$\varphi_n = X_n \varphi_n' + Y_n + \varphi_{LOS}, \quad (17)$$

where φ_{LOS} is the LOS direction defined in the network layout description, see Step 1c.

In the LOS case, substitute (17) by (18) to enforce the first cluster to the LOS direction φ_{LOS}

$$\varphi_n = (X_n \varphi_n' + Y_n) - (X_1 \varphi_1' + Y_1 - \varphi_{LOS}). \quad (18)$$

Finally add offset angles α_m from Table B1-5 to the cluster angles

$$\varphi_{n,m} = \varphi_n + c_{AoA} \alpha_m, \quad (19)$$

where c_{AoA} is the cluster-wise rms azimuth spread of arrival angles (cluster ASA) in Table B1-7.

Table B1-5 Ray offset angles within a cluster, given for 1 rms angle spread

Ray number m	Basis vector of offset angles α_m
1,2	± 0.0447
3,4	± 0.1413
5,6	± 0.2492
7,8	± 0.3715
9,10	± 0.5129
11,12	± 0.6797
13,14	± 0.8844
15,16	± 1.1481
17,18	± 1.5195
19,20	± 2.1551

For departure angles ϕ_n the procedure is similar.

Step 8: Random coupling of rays within clusters.

Couple randomly departure ray angles $\phi_{n,m}$ to arrival ray angles $\varphi_{n,m}$ within a cluster n , or within a sub-cluster in the case of two strongest clusters (see Step 10a and Table A1-5).

Coefficient generation:

Step 9: Draw random initial phase $\{\Phi_{n,m}^{vv}, \Phi_{n,m}^{vh}, \Phi_{n,m}^{hv}, \Phi_{n,m}^{hh}\}$ for each ray m of each cluster n and for four different polarisation combinations (vv, vh, hv, hh). The distribution for initial phases is uniform within $(-\pi, \pi)$.

In the LOS case, draw also random initial phases $\{\Phi_{LOS}^{vv}, \Phi_{LOS}^{hh}\}$ for both VV and HH polarisations.

Step 10a: Generate channel coefficients for each cluster n and each receiver and transmitter element pair u, s .

For the $N - 2$ weakest clusters, say $n = 3, 4, \dots, N$, and uniform linear arrays (ULA), the channel coefficients are given by:

$$\mathbf{H}_{u,s,n}(t) = \sqrt{P_n} \sum_{m=1}^M \begin{bmatrix} F_{rx,u,V}(\phi_{n,m}) \\ F_{rx,u,H}(\phi_{n,m}) \end{bmatrix}^T \begin{bmatrix} \exp(j\Phi_{n,m}^{vv}) & \sqrt{\kappa^{-1}} \exp(j\Phi_{n,m}^{vh}) \\ \sqrt{\kappa^{-1}} \exp(j\Phi_{n,m}^{hv}) & \exp(j\Phi_{n,m}^{hh}) \end{bmatrix} \begin{bmatrix} F_{tx,s,V}(\phi_{n,m}) \\ F_{tx,s,H}(\phi_{n,m}) \end{bmatrix} \cdot \exp(jd_s 2\pi\lambda_0^{-1} \sin(\phi_{n,m})) \exp(jd_u 2\pi\lambda_0^{-1} \sin(\phi_{n,m})) \exp(j2\pi\nu_{n,m}t) \quad (20)$$

where $F_{rx,u,V}$ and $F_{rx,u,H}$ are the antenna element u field patterns for vertical and horizontal polarisations respectively, d_s and d_u are the uniform distances [m] between transmitter elements and receiver elements respectively, κ is the cross polarisation power ratio in linear scale, and λ_0 is the wavelength of the carrier frequency. If polarisation is not considered, the 2x2 polarisation matrix can be replaced by the scalar $\exp(j\Phi_{n,m})$ and only vertically polarised field patterns are applied.

The Doppler frequency component is calculated from the angle of arrival (downlink), UT speed v and direction of travel θ_v ,

$$\nu_{n,m} = \frac{\|v\| \cos(\phi_{n,m} - \theta_v)}{\lambda_0}, \quad (21)$$

For the two strongest clusters, say $n = 1$ and 2, rays are spread in delay to three sub-clusters (per cluster), with fixed delay offset $\{0, 5, 10\}$ ns (see Table B1-6). The delays of the sub-clusters are

$$\begin{aligned} \tau_{n,1} &= \tau_n + 0 \text{ ns} \\ \tau_{n,2} &= \tau_n + 5 \text{ ns} \\ \tau_{n,3} &= \tau_n + 10 \text{ ns} \end{aligned} \quad (22)$$

Twenty rays of a cluster are mapped to sub-clusters as presented in Table B1-6 below. The corresponding offset angles are taken from Table B1-5 with mapping of Table B1-6.

Table B1-6 Sub-cluster information for intra cluster delay spread clusters

sub-cluster #	mapping to rays	power	delay offset
1	1,2,3,4,5,6,7,8,19,20	10/20	0 ns
2	9,10,11,12,17,18	6/20	5 ns
3	13,14,15,16	4/20	10 ns

In the LOS case, define $\mathbf{H}'_{u,s,n} = \mathbf{H}_{u,s,n}$ and determine the channel coefficients by adding a single line-of-sight ray and scaling down the other channel coefficient generated by (20). The channel coefficients are given by:

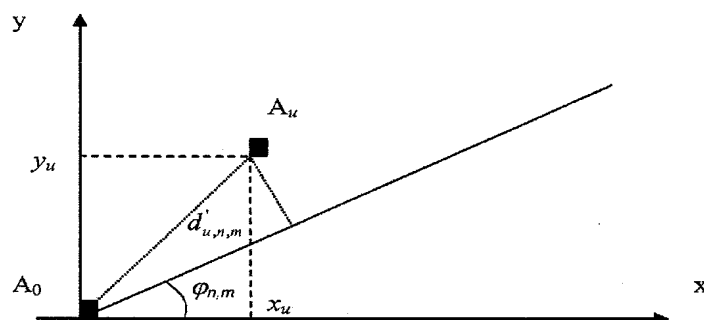
$$\begin{aligned} \mathbf{H}_{u,s,n}(t) &= \sqrt{\frac{1}{K_R + 1}} \mathbf{H}'_{u,s,n}(t) \\ &+ \delta(n-1) \sqrt{\frac{K_R}{K_R + 1}} \begin{bmatrix} F_{rx,u,V}(\phi_{LOS}) \\ F_{rx,u,H}(\phi_{LOS}) \end{bmatrix}^T \begin{bmatrix} \exp(j\Phi_{LOS}^{vv}) & 0 \\ 0 & \exp(j\Phi_{LOS}^{hh}) \end{bmatrix} \begin{bmatrix} F_{tx,s,V}(\phi_{LOS}) \\ F_{tx,s,H}(\phi_{LOS}) \end{bmatrix} \\ &\cdot \exp(jd_s 2\pi\lambda_0^{-1} \sin(\phi_{LOS})) \exp(jd_u 2\pi\lambda_0^{-1} \sin(\phi_{LOS})) \exp(j2\pi\nu_{LOS}t) \end{aligned} \quad (23)$$

where $\delta(\cdot)$ is the Dirac's delta function and K_R is the Ricean K-factor defined in Table A1-7 converted to linear scale.

If non-ULA arrays are used, the equations must be modified. For arbitrary array configurations on the horizontal plane, see Figure A1-3, the distance term d_u in equations (23) and (20) is replaced by:

$$d'_{u,n,m} = \frac{\sqrt{x_u^2 + y_u^2} \cos(\arctan(y_u/x_u) - \phi_{n,m})}{\sin \phi_{n,m}}, \quad (24)$$

where (x_u, y_u) are the co-ordinates of the u th element A_u and A_0 is the reference element.

Figure B1-3 Modified distance of antenna element u with non-ULA array

Step 10b: Generate channel coefficients for each cluster n and each receiver and transmitter element pair u,s . Alternatively to Step 10a channel coefficients can be generated by applying the so called correlation matrix based method. Temporal correlations (Doppler effect) are introduced either by filtering independent and identically distributed complex Gaussian sequences with a proper Doppler spectrum shaping filter or by applying some equivalent method. MIMO antenna correlations are introduced by performing a linear transformation to the temporally correlated sequences. Unique covariance matrices are determined for each drop and radio link based on the parameters defined in the previous steps. The MIMO covariance matrix can be composed of transmitter and receiver spatial correlation matrices, and by the polarization covariance matrices with the Kronecker product of matrices. Spatial correlation matrices can be derived for each cluster directly from the ChRs of Step 10a [B3, B4]. Alternatively, spatial correlation matrices and the polarization covariance matrices can be derived from the antenna configuration and the model parameters (AoA, AoD) determined in Step7 with XPR parameter from Table B1-7 [B5].

Step 11: Apply path loss and shadowing for the channel coefficients. This is valid only for system level simulations.

Table B1-7 Channel model parameters

- In the table below DS = rms delay spread, ASD = rms azimuth spread of departure angles, ASA = rms azimuth spread of arrival angles, SF = shadow fading, and K = Ricean K-factor.
- The sign of the shadow fading is defined so that positive SF means more received power at UT than predicted by the path loss model.

Scenarios		InH		UMi			UMa		RMa	
		LOS	NLOS	LOS	NLOS	O-to-I	LOS	NLOS	LOS	NLOS
Delay spread (DS)	μ	-7.70	-7.41	-7.19	-6.89	-6.62	-7.03	-6.44	-7.49	-7.43
	σ	0.18	0.14	0.40	0.54	0.32	0.66	0.39	0.55	0.48
AoD spread (ASD)	μ	1.60	1.62	1.20	1.41	1.25	1.15	1.41	0.90	0.95
	σ	0.18	0.25	0.43	0.17	0.42	0.28	0.28	0.38	0.45
AoA spread (ASA)	μ	1.62	1.77	1.75	1.84	1.76	1.81	1.87	1.52	1.52
	σ	0.22	0.16	0.19	0.15	0.16	0.20	0.11	0.24	0.13
Shadow fading (SF) [dB]	μ	3	4	3	4	7	4	6	4	8
	σ	4	N/A	5	N/A	N/A	3.5	N/A	4	N/A
Cross-Correlations *	ASD vs DS	0.6	0.4	0.5	0	0.4	0.4	0.4	0	-0.4
	ASA vs DS	0.8	0	0.8	0.4	0.4	0.8	0.6	0	0
	ASA vs SF	-0.5	-0.4	-0.4	-0.4	0	-0.5	0	0	0
	ASD vs SF	-0.4	0	-0.5	0	0.2	-0.5	-0.6	0	0.6
	DS vs SF	-0.8	-0.5	-0.4	-0.7	-0.5	-0.4	-0.4	-0.5	-0.5
	ASD vs ASA	0.4	0	0.4	0	0	0	0.4	0	0
	ASD vs K	0	N/A	-0.2	N/A	N/A	0	N/A	0	N/A
	ASA vs K	0	N/A	-0.3	N/A	N/A	-0.2	N/A	0	N/A
	DS vs K	-0.5	N/A	-0.7	N/A	N/A	-0.4	N/A	0	N/A
Delay distribution		Exp	Exp	Exp	Exp	Exp	Exp	Exp	Exp	Exp
AoD and AoA distribution		Laplacian		Wrapped Gaussian			Wrapped Gaussian		Wrapped Gaussian	
Delay scaling parameter r_r		3.6	3	3.2	3	2.2	2.5	2.3	3.8	1.7
XPR [dB]		11	10	9	8.0	9	8	7	12	7
Number of clusters		15	19	12	19	12	12	20	11	10
Number of rays per cluster		20	20	20	20	20	20	20	20	20
Cluster ASD		5	5	3	10	5	5	2	2	2
Cluster ASA		8	11	17	22	8	11	15	3	3
Per cluster shadowing std ζ [dB]		6	3	3	3	4	3	3	3	3
Correlation distance [m]	DS	8	5	7	10	10	30	40	50	36
	ASD	7	3	8	10	11	18	50	25	30
	ASA	5	3	8	9	17	15	50	35	40
	SF	10	6	10	13	7	37	50	37	120
	K	4	N/A	15	N/A	N/A	12	N/A	40	N/A

Table B1-8 Expectation (median) output values for large scale parameters

Scenario		DS (ns)	AS at BS (°)	AS at UT (°)
InH	LOS	20	40	42
	NLOS	39	42	59
UMi	LOS	65	16	56
	NLOS	129	26	69
	O-to-I	49	18	58
UMa	LOS	93	14	65
	NLOS	365	26	74
RMa	LOS	32	8	33
	NLOS	37	9	33

B.2 References

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Annex C: Change history

Table A.1: Draft History

Change history					
Date	TSG #	TSG Doc.	Subject/Comment	Old	New
	R1#54bis		Draft skeleton TR		0.1.0
			TP for clause 5,6,7,8 and 9 are captured		
	R1#55		TP for simulation models are captured		0.2.0
	R1#55bis	R1-090510	TP for wider bandwidth are captured		0.3.0
	R1#56	R1-091009	TP for UL scheme and channel models are captured		0.4.0
	R1#56	R1-091125	TP for UL/DL MIMO, DL RS, Relay are captured		1.0.0

4.2.3.5 MAC-ehs entity – UE Side

In the model below the MAC-ehs comprise the following entities:

- HARQ:
The HARQ entity is responsible for handling the HARQ protocol. There shall be one HARQ process per HS-DSCH per TTI for single stream transmission and two HARQ processes per HS-DSCH per TTI for dual stream transmission. There shall be one HARQ entity per HS-DSCH. The HARQ functional entity handles all the tasks that are required for hybrid ARQ. It is for example responsible for generating ACKs or NACKs. The detailed configuration of the hybrid ARQ protocol is provided by RRC over the MAC-Control SAP.
- Disassembly
The disassembly entity disassembles the MAC-ehs PDUs by removing the MAC-ehs header and possible padding.
- Reordering queue distribution
The reordering queue distribution function routes the received reordering PDUs to correct reordering queues based on the received logical channel identifier.
- Reordering & De-ciphering:
The reordering and deciphering entity is responsible for organising received reordering PDUs according to the received TSN and for de-ciphering for ciphered received reordering PDUs if dual cell HSDPA + MIMO is configured. Data blocks with consecutive TSNs are delivered to reassembly entity upon reception. A timer mechanism determines delivery of non-consecutive data blocks to higher layers. There is one reordering entity for each priority class. Details about ciphering can be found in [10].- Reassembly:
The reassembly entity reassembles segmented MAC-ehs SDUs (corresponding to either MAC-c or MAC-d PDUs) and forwards the MAC PDUs to LCH-ID demultiplexing entity.
- LCH-ID demultiplexing:
The demultiplexing entity routes the MAC-ehs SDUs to correct logical channel based on the received logical channel identifier.

The following is allowed:

The MAC-ehs SDUs included in a MAC-ehs PDU can have a different size and a different priority and can be mapped to different priority queues.

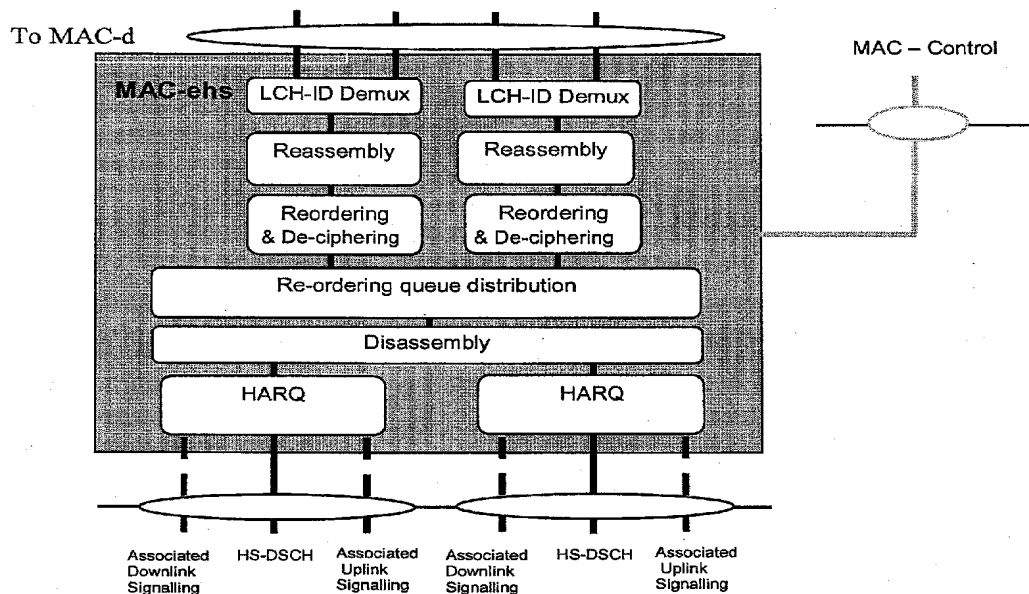


Figure 4.2.3.5-1: UE side MAC architecture/MAC-ehs details.

11.5 Ciphering (not dual-cell HSDPA + MIMO)

The ciphering function is performed in MAC (i.e. only in MAC-d) if a radio bearer is using the transparent RLC mode. The part of the MAC PDU that is ciphered is the MAC SDU and this is shown in Figure 11.5.1 below.

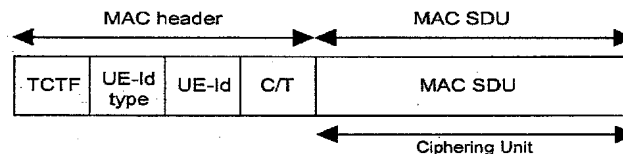


Figure 11.5.1: Ciphered part unit for a MAC PDU

In case a TTI contains multiple MAC PDUs for a given Transparent mode RB, the ciphering unit for this RB is the bitstring concatenation of all the MAC SDUs, resulting in the PLAINTEXT BLOCK, as defined in [15]. In case there is only one MAC PDU for a given Transparent mode RB, the ciphering unit is the MAC SDU, resulting in the PLAINTEXT BLOCK. The concatenation order is the same as the order of transmission of the Transport Blocks between MAC and Physical layer.

The KEYSTREAM BLOCK as defined in [10] is applied to the PLAINTEXT BLOCK, and the end result, CIPHERTEXT BLOCK, becomes the ciphered part for the MAC PDU, in case there is only one MAC PDU per RB. In case there is more than one MAC PDU per RB, the CIPHERTEXT BLOCK is split into the corresponding ciphered parts for each MAC PDU. The split order is the same as the order of transmission of the Transport Blocks between MAC and Physical layer.

The ciphering algorithm and key to be used are configured by upper layers [7] and the ciphering method shall be applied as specified in [10].

The parameters that are required by MAC for ciphering are defined in [10] and are input to the ciphering algorithm. The parameters required by MAC which are provided by upper layers [7] are listed below:

- MAC-d HFN (Hyper frame number for radio bearers that are mapped onto transparent mode RLC)

- BEARER defined as the radio bearer identifier in [10]. It will use the value RB identity -1 as in [7])
- CK (Ciphering Key)

If the TTI consists of more than one 10 ms radio frame, the CFN of the first radio frame in the TTI shall be used as input to the ciphering algorithm for all the data in the TTI.

11.5a Ciphering (dual-cell HSDPA + MIMO)

The ciphering function is performed in MAC (i.e. only in MAC-ehs) if dual cell HSDPA + MIMO is configured and radio bearers are using the unacknowledged or acknowledged RLC mode. The part of the MAC-ehs PDU that is ciphered is one or more reordering PDUs which consist one or more reordering SDUs belonging to the same priority queue and this is shown in Figure 11.5.1a below.

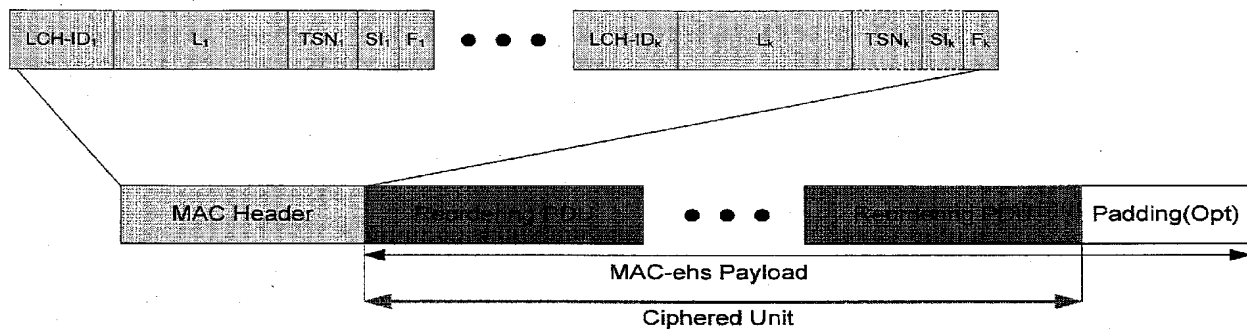


Figure 11.5.1a: Ciphered part unit for a MAC-ehs PDU

In case a TTI contains multiple reordering PDUs for a given each queue, the ciphering unit for this queue is the bitstring concatenation of all the reordering PDUs, resulting in the PLAINTEXT BLOCK, as defined in [15]. In case there is only one reordering PDU for a given queue, the ciphering unit is the reordering PDU, resulting in the PLAINTEXT BLOCK. The concatenation order is the same as the order of transmission of the Transport Blocks between MAC and Physical layer.

The KEYSTREAM BLOCK as defined in [10] is applied to the PLAINTEXT BLOCK, and the end result, CIPHERTEXT BLOCK, becomes the ciphered part for the MAC PDU, in case there is only one MAC PDU per RB. In case there is more than one MAC PDU per RB, the CIPHERTEXT BLOCK is split into the corresponding ciphered parts for each MAC PDU. The split order is the same as the order of transmission of the Transport Blocks between MAC and Physical layer.

The ciphering algorithm and key to be used are configured by upper layers [7] and the ciphering method shall be applied as specified in [10].

The parameters that are required by MAC for ciphering are defined in [10] and are input to the ciphering algorithm. The parameters required by MAC which are provided by upper layers [7] are listed below:

- MAC-ehs HFN (Hyper frame number for reordering queues that are mapped onto unacknowledged or acknowledged mode RLC)
- BEARER defined as the radio bearer identifier in [10]. It will use the value RB identity -1 as in [7])
- CK (Ciphering Key)

If the TTI consists of more than one 10 ms radio frame, the CFN of the first radio frame in the TTI shall be used as input to the ciphering algorithm for all the data in the TTI.

Reason for change:	⌘ A RRC Connection Request message is very short so that segmentation function and CRC attachment function are not needed for CCCH transmission in idle mode. When a RRC Connection Request message is sent, a network can estimate values in SI and a UE always triggers at the end of RRC Connection Request message once in SI with TEBS=0, HLBS=0. HLID = logical channel identifier for SRB #0.
Summary of change:	⌘ For CCCH transmission in idle mode, the UE does not perform segmentation function and attachment function of CRC checksum. In addition, for CCCH transmission in idle mode, scheduling information is not triggered
Consequences if not approved:	⌘ The MAC-i PDU size will be increased by 26 bits and unnecessary power consumption will be required due to the inclusion of the CRC and SI fields.

4.2.3.6 MAC-i/is entity – UE Side

The split between MAC-i and MAC-is in the UE is not detailed. In the model below the MAC-i/is comprises the following entities:

- HARQ:
The HARQ entity is responsible for handling the MAC functions relating to the HARQ protocol. It is responsible for storing MAC-i payloads and re-transmitting them. The detailed configuration of the hybrid ARQ protocol is provided by RRC over the MAC-Control SAP.
- For FDD: The HARQ entity provides the E-TFC, the retransmission sequence number (RSN), and the power offset to be used by L1. Redundancy version (RV) of the HARQ transmission is derived by L1 from RSN, CFN and in case of 2 ms TTI from the sub-frame number.
- For TDD: The HARQ entity provides the HARQ process identity, the E-TFC, the retransmission sequence number (RSN) and an indication of the power offset to be used by L1. The redundancy version (RV) of the HARQ transmission is derived by L1 from RSN. RRC signalling can also configure the L1 to use RV=0 for every transmission.
- Multiplexing and TSN setting:
The multiplexing and TSN setting entity is responsible for concatenating multiple MAC-d PDUs into MAC-is PDUs, and to multiplex one or multiple MAC-is PDUs into a single MAC-i PDU, to be transmitted in the next TTI, as instructed by the E-TFC selection function. It is also responsible for managing and setting the TSN per logical channel for each MAC-is PDU.
In FDD and 1.28 Mcps TDD, the multiplexing and TSN setting entity is responsible for multiplexing MAC-c PDUs or segments of MAC-c PDUs into a single MAC-is PDU, and for multiplexing MAC-is PDUs into a single MAC-i PDU, to be transmitted in the next TTI, as instructed by the E-TFC selection function. It is also responsible for managing and setting the TSN for the common control channel for each MAC-is PDU.
- Segmentation:
The segmentation function is responsible for segmenting MAC-d PDUs and MAC-c PDUs (FDD and 1.28 Mcps TDD only).
- CRC Attachment (FDD for CELL_FACH state and 1.28 Mcps TDD only):
If MAC segmentation is performed for MAC-c PDUs, a CRC is appended to the MAC-is SDU before this data (MAC-c PDU and CRC checksum) is segmented. The size of the CRC field is 8 bits and the CRC is calculated as specified in section 4.2.1.1 in [16] or [19]. In the CRC field, figure 9.1.5.4d, the LSB is the rightmost bit and the MSB is the leftmost bit.
- Add UE ID (FDD only):
In CELL_DCH state, no E-RNTI is included in the MAC-PDU header.
In CELL_FACH, the E-RNTI is added in all MAC-i PDUs for DCCH and DTCH transmission at the UE side until the UE receives an E-AGCH with its E-RNTI (through an E-RNTI-specific CRC attachment).
In CELL_FACH state and in Idle mode, no E-RNTI is added in MAC-i PDUs for CCCH data transmission.

- E-TFC selection:
This entity is responsible for E-TFC selection according to the scheduling information, Relative Grants (FDD only) and Absolute Grants, received from UTRAN via L1 and Serving Grant value signalled through RRC, and for arbitration among the different flows mapped on the E-DCH. The detailed configuration of the E-TFC entity is provided by RRC over the MAC-Control SAP. The E-TFC selection function controls the multiplexing function.
- ASC selection (FDD and 1.28 Mcps TDD only):
At the start of the Enhanced Uplink in CELL_FACH state and Idle mode, MAC-is/i applies the appropriate back-off parameter(s) associated with the given ASC. When sending an RRC CONNECTION REQUEST message, RRC will determine the ASC; in all other cases MAC-is/i selects the ASC.
- Scheduling Access Control (TDD only):
The Scheduling Access Control entity is responsible for routing associated uplink signalling via E-UCCH and MAC-e PDU (in the case that E-DCH resources are assigned) or via E-RUCCH (in the case that no E-DCH resources are assigned). It is also responsible for obtaining and formatting the appropriate information to be carried on E-UCCH/E-RUCCH.

NOTE: HARQ process ID and RSN are carried on E-UCCH.

4.2.4.7 MAC-is entity – UTRAN Side

For TDD, and for FDD in CELL_DCH and CELL_FACH, for each UE, there is one MAC-is entity in the SRNC. For FDD, for CCCH transmission in CELL_FACH state and Idle mode, there is one MAC-is entity per common E-DCH resource configured in the controlling RNC. For 1.28 Mcps TDD, for CCCH transmission in CELL_FACH state and Idle mode, there is one MAC-is entity per UE in the controlling RNC. When configured by the upper layers, the MAC-is sublayer handles E-DCH specific functionality, which is not covered in the MAC-i entity in Node B. In the model below, the MAC-is comprises the following entities:

- Disassembly:
The disassembly function is responsible for disassembly of MAC-is PDUs. When a MAC-is PDU is disassembled the MAC-is header is removed.
- Reordering Queue Distribution:
For DCCH and DTCH transmission, the reordering queue distribution function routes the MAC-is PDUs to the correct reordering buffer based on the SRNC configuration.
- Reordering:
This function reorders received MAC-is PDUs according to the received TSN and Node-B tagging i.e. (CFN, subframe number). MAC-is PDUs with consecutive TSNs are delivered to the disassembly function upon reception. Mechanisms for reordering MAC-is PDUs received out-of-order are left up to the implementation. There is one Re-ordering Process per logical channel.
- Macro diversity selection (FDD only):
The function is performed in the MAC-is, in case of soft handover with multiple Node-Bs (The soft combining for all the cells of a Node-B takes place in the Node-B). This means that the reordering function receives MAC-is PDUs from each Node-B in the E-DCH active set. The exact implementation is not specified. However the model below is based on one Reordering Queue Distribution entity receiving all the MAC-d flow from all the Node-Bs, and one MAC-is entity per UE.
- Reassembly:
For DTCH/DCCH transmission, the reassembly function reassembles segmented MAC-d PDUs, and delivers the MAC-d PDUs to the correct MAC-d entity. For CCCH transmission, the reassembly function reassembles segmented MAC-c PDUs, and delivers it to the CRC Error Correction function.
- CRC Error Correction (FDD and 1.28 Mcps TDD only):
When the MAC-c PDU is received correctly after reassembly is performed for CCCH in CELL_FACH state, then the CRC field is removed and the resulting data is delivered to the MAC-c. However, if a MAC-c PDU has been received with an incorrect CRC, the MAC-c PDU is discarded. The size of the CRC field is 8 bits and the CRC is calculated as specified in section 4.2.1.1 in [16] or [19].

9.2.4.3 MAC-is header parameters

- Transmission Sequence Number (TSN):
The TSN field provides the transmission sequence number for the MAC-is PDU. This information is used for reordering purposes to support in-sequence delivery to higher layers. The length of the TSN field is 6 bits.
- Segmentation Status (SS):
The Segmentation Status (SS) field provides indication of the segmentation status of the MAC SDU or segment of MAC SDU belonging to the logical channel identified by the LCH-ID field. The length of the SS field is 2 bits.

Table 9.2.4.3-1: Structure of the SS field

SS Field	Segmentation status
00	The first MAC-is SDU of the MAC-is PDU is a complete MAC-d PDU or MAC-c PDU. The last MAC-is SDU of the MAC-is PDU is a complete MAC-d PDU or MAC-c PDU. In case of CCCH transmission in idle mode, the MAC-is SDU of MAC-is PDU is a complete RRC Connection Request message.
01	If there are more than one MAC-is SDUs in the MAC-is PDU, the last MAC-is SDU of the MAC-is PDU is a complete MAC-d PDU or MAC-c PDU. The first MAC-is SDU of the MAC-is PDU is the last segment of a MAC-d PDU or MAC-c PDU.
10	If there are more than one MAC-is SDUs in the MAC-is PDU, the first MAC-is SDU of the MAC-is PDU is a complete MAC-d PDU or MAC-c PDU. The last MAC-is SDU of the MAC-is PDU is the first segment of a MAC-d PDU or MAC-c PDU.
11	If there are more than one MAC-is SDUs in the MAC-is PDU, the first MAC-is SDU of the MAC-is PDU is the last segment of a MAC-d PDU or MAC-c PDU and the last MAC-is SDU of MAC-is PDU is the first segment of a MAC-d PDU or MAC-c PDU. If there is only one MAC-is SDU in the MAC-is PDU, the MAC-is SDU is a middle segment of a MAC-d PDU or MAC-c PDU.

11.8.1.6 Scheduling Information reporting

Scheduling information reports will be triggered differently depending on the value of the variable `Serving_Grant` after the `Serving Grant Update` function. The triggering of a report shall be indicated to the E-TFC selection function at the first new transmission opportunity (this process may be delayed in case the HARQ processes are occupied with re-transmissions).

Even if multiple events are triggered by the time a new transmission can take place, only a single scheduling information header will be included in the payload.

In `CELL_DCH` state, the Scheduling Information shall not be transmitted if the TEBS is zero, even if it was triggered by one of the configured triggering mechanisms.

For FDD and for CCCH transmission in `CELL_FACH` state, the transmission of Scheduling Information shall only be triggered when TEBS becomes zero and the MAC-i PDU containing the last data is being transmitted. The SI is transmitted with the MAC-i PDU carrying the last data, given the serving grant is sufficient to carry the SI with the last remaining data. Otherwise, the empty buffer status report is transmitted separately with the next MAC-i PDU.

For FDD and for DTCH/DCCH transmission in `CELL_FACH` state, the transmission of Scheduling Information shall be triggered once, if the TEBS remains zero and no higher layer data remains in MAC to be transmitted for a period given by the E-DCH transmission continuation back off period unequal "infinity". For FDD and for DTCH/DCCH

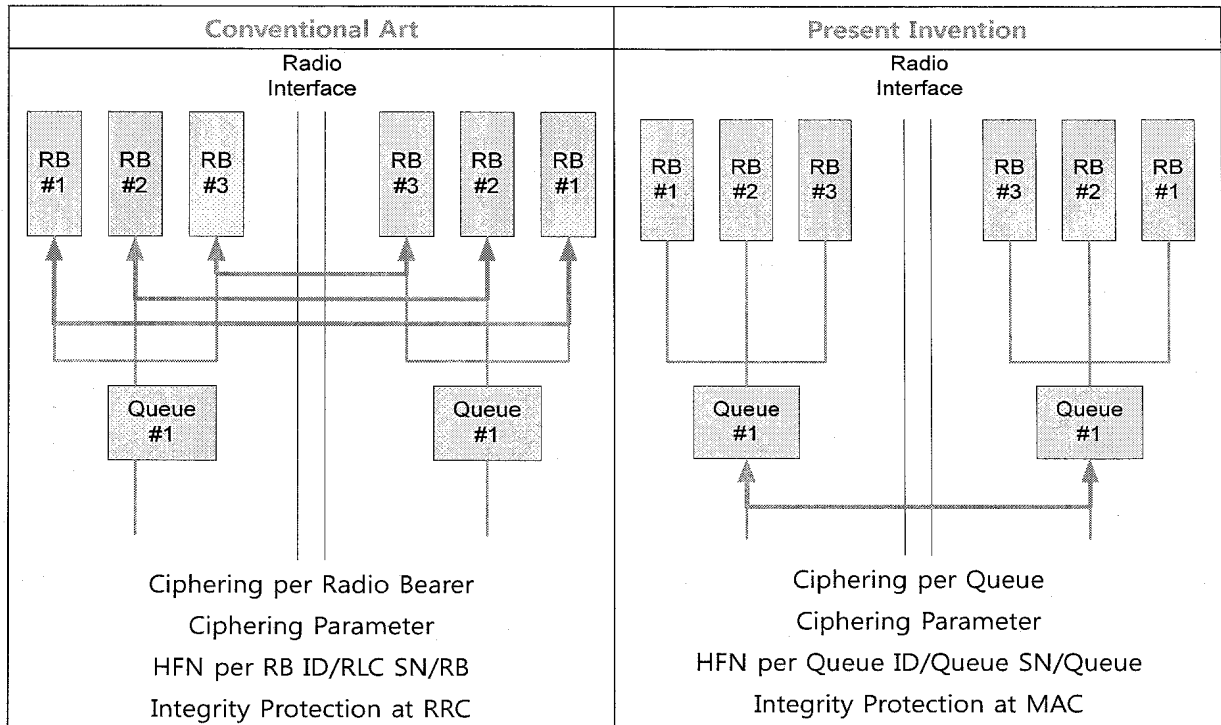
transmission in CELL_FACH state with E-DCH transmission continuation back off period set to "infinity" or "zero", the transmission of Scheduling Information shall be triggered each time when the TEBS becomes zero and no higher layer data remains in MAC to be transmitted after the transmission of the MAC-i PDU containing the scheduling information with the empty buffer status report.

If the Scheduling Information needs to be included in the MAC-e or MAC-i PDU according to subclause 9.2.4.2, it shall be transmitted regardless of TEBS status.

The transmission of Scheduling Information can take place on every HARQ process, even on those processes for which transmission is restricted according to RRC or deactivated by absolute grants, i.e. processes on which scheduled and/or non-scheduled transmission can not take place.

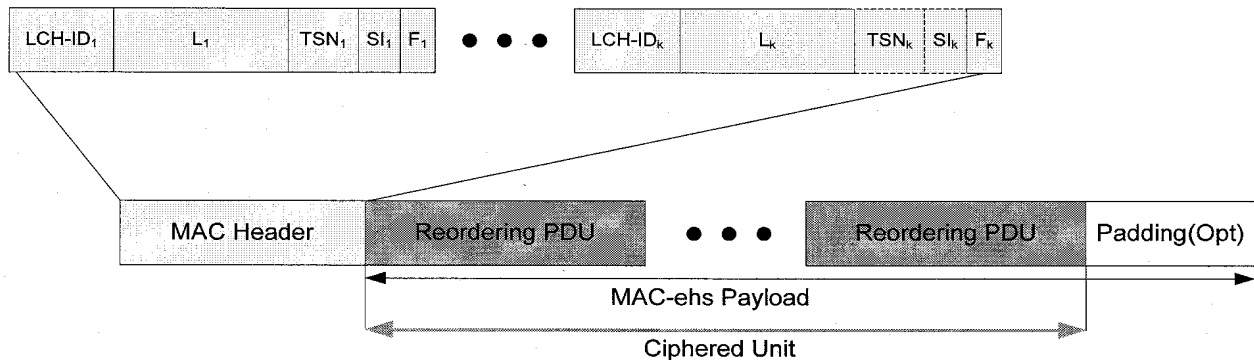
The description of the behaviour in the two cases is provided below.

Conventional Art



Present Invention

- Inform signaling parameter related to the ciphering not according to RB but according to Queue
 - Use the signaling values as HFN per Queue ID/Queue SN/Queue.
- Perform not only ciphering but also integrity at MAC.
 - Inform the signaling values per queue.
- Ciphering Unit



Integrity Unit

- 1. Perform integrity every reordering PDU
 - MAC-ehs PDU includes MAC-I as much as reordering queue.
 - Order of MAC-I attachment is the order of reordering PDU in the MAC-~~본~~.

- NodeB which is a transmitter in downlink selects TFRI by considering MAC-I.
- 2. Perform integrity every MAC-ehs PDU
 - Perform integrity with RB ID which corresponds to a first LoCH ID.
 - Perform integrity with a Queue ID which corresponds to a first Queue ID.
 - Attach MAC-I after last Reordering PDU.

Values for ciphering parameter and integrity is configured during MAC setup. These can be initialized after receiving messages such as Physical Channel Reconfiguration, Transport Channel Reconfiguration, Radio Bearer Setup, etc.

Advantageous Effect

- Control PDU (RLC Status PDU) which is feasible to the security can be ciphered.
- MBMS services which are feasible to the security can be ciphered.
- Processing time for layer 2 may be increased before re-ordering.

Problems

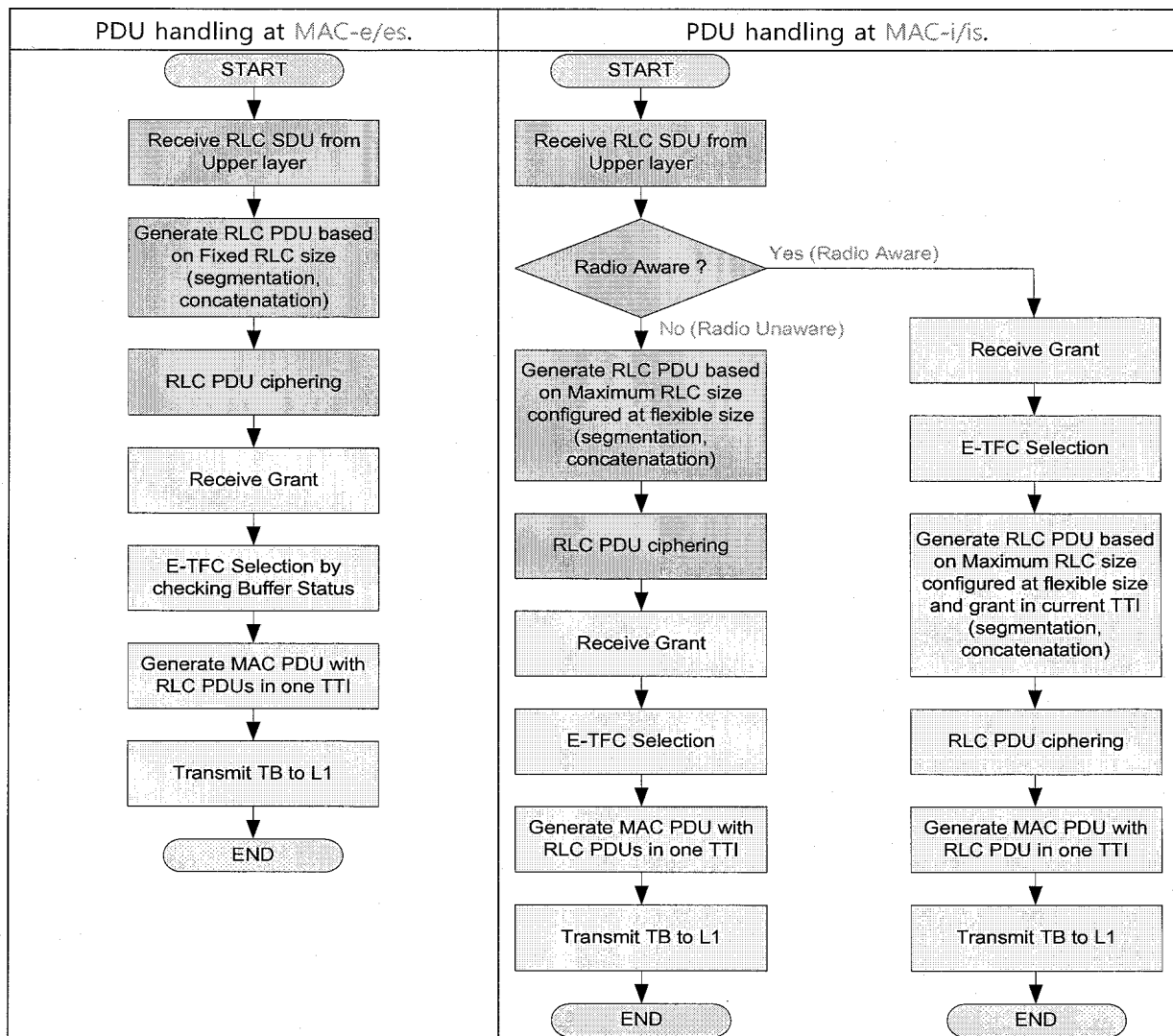
De-ciphering can be operated at RLC. RLC can de-cipher in sequence after re-ordering at MAC. However, peak rate of DC-HSDPA + MIMO can be increased as much as four times when maximum four carriers are used. It is possible for maximum 84Mbps transmission.

To decode more data during same interval, a technique to reduce the decoding time is needed.

Agreement

In DC-HSUPA, the use of MAC-i/is is approved, but the use of MAC-e/es is FFS.

Conventional Art



Present Invention

1. Use a scheme of radio unaware when DC-HSUPA and MAC-i/is are configured.

Problem

By employing DC-HSUPA, data rate is increased as much as two times. As a result, increased layer 2 processing time is required. A technique to reduce the layer 2 processing time is needed. Layer 2 processing time is an interval that L2 transfers MAC PDU to L1 after receiving grant from L1.

Change Request**9.2.2.9 Data field**

RLC SDUs or segments of RLC SDUs are mapped to this field in transparent, unacknowledged and acknowledged modes.

Transparent mode data:

- the length of RLC SDUs is not constrained to a multiple of 8 bits;
- if "Segmentation" is configured:
 - all the RLC PDUs carrying segments of a RLC SDU shall be sent in one TTI;
 - only RLC PDUs carrying segments from a single RLC SDU shall be sent in one TTI;
- otherwise (Segmentation is not configured):
 - TMD PDU size is fixed within a single TTI and is equal to the RLC SDU size.

Unacknowledged mode data and Acknowledged mode data:

- the length of RLC SDUs is constrained to a multiple of 8 bits;
- if "Fixed RLC PDU size" is configured:
 - the last segment of an RLC SDU shall be concatenated with the first segment of the next RLC SDU in order to fill the data field completely and avoid unnecessary padding unless otherwise specified in subclause 9.2.2.8 or subclause 11.2.2.2. The "Length Indicator" field is used to point the borders between RLC SDUs (see subclause 9.2.2.8).
- if "Flexible RLC PDU size" is configured:
 - in downlink, the last segment of an RLC SDU may be concatenated with the first segment of the next RLC SDU in order to fill the data field up to a maximum RLC PDU size. The "Length Indicator" field is used to point the borders between RLC SDUs (see subclause 9.2.2.8).
 - in uplink, the last segment of an RLC SDU shall be concatenated with the first segment of the next RLC SDU in order to fill the data field at least up to the Minimum UL RLC PDU size. It is allowed to concatenate up to the largest UL AMD PDU size for Acknowledged mode data and largest UMD PDU size for Unacknowledged mode data. The "Length Indicator" field is used to point the borders between RLC SDUs (see subclause 9.2.2.8). If data to be transmitted is not enough to create a UMD PDU of the minimum size, it is allowed to create a UMD PDU including all data to be transmitted, even if the resulting size is smaller than the Minimum UL RLC PDU size.
- in uplink, if MAC-i/is has been configured:
 - if the UE pre-generates RLC PDUs for transmission in a later TTI or Dual Cell-HSUPA is configured:
 - provided that the UE has sufficient amount of data available for transmission, the size of the data field of the RLC PDU shall be chosen so that each RLC PDU to be multiplexed to the MAC-i/is PDU matches the maximum amount of data allowed to be transmitted by the applicable current grants (scheduled or non-scheduled) for the current TTI.
 - RLC PDUs may only be pre-generated if the amount of data in outstanding pre-generated RLC PDUs for this logical channel is less than or equal to four times the maximum amount of data allowed to be transmitted by the applicable current grants (scheduled or non-scheduled) for the current TTI.
 - else:

- the size of the data field of the RLC PDU shall be chosen so that the RLC PDU size matches the data requested for this logical channel by the current E-TFC selection.
- if "Flexible RLC PDU size" is configured, the maximum size of the data field of the RLC PDU is 1503 octets.

Refer to the 25.322 v8.4.0

A Method of secondary cell activation/deactivation for DC-HSUPA

1. NB control : NB activate or deactivate secondary cell by using HS-SCCH order.
2. UE control : secondary cell is activated or deactivated by using a happy bit of secondary E-DPCCH
 - A. There are two E-DPCCHs in dual cell. When it is assumed that one happy bit is same as the happy bit of the primary E-DPCCH, another happy bit may be reused.

DC-HSDPA + MIMO

De-ciphering Accelerate Method

DC-HSDPA uses MAC-e-hs. This utilizes flexible RLC. Peak data rate for DC-HSDPA + MIMO is increased as much as four times compared with conventional method. It is possible for maximum 84Mbps transmission.

Conventional Art

RLC performs deciphering. No deciphering for control RLC PDU. Deciphering for data RLC PDU is only performed. RLC performs deciphering for received RLC PDU.

Title: MAC-i PDU format optimization for RRC Connection Request message

1. Background

Figure 1 shows a MAC-i PDU format when a RRC Connection Request message is sent.

LCH-ID (1110)	L	F	SS (00)	TSN	MAC-c PDU (RRC Connection Request)	CRC	SI
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Figure 1. MAC-i PDU format, when RRC Connection Request message is sent.

However, for a RRC Connection Request message, red marked values(SS, CRC and SI) in Figure 1 seem to be redundant.

First, the Segmentation Status (SS) field is used to segment MAC-d PDUs or MAC-c PDUs. However, there is no need to segment a MAC-c PDU since a RRC Connection Request message is very small.

Second, the CRC is used to detect correctly received a MAC-c PDU when a MAC segmentation is performed for a MAC-c PDU. If the MAC segmentation function is not used, there is no need to append the CRC checksum to the MAC-is SDU.

Finally, the Scheduling Information (SI) field is used to indicate to serving E-DCH Node-B the amount of resources a UE requires and to release the common E-DCH resource. However, the transmission of Scheduling Information is only triggered at the end of the RRC Connection Request message with TEBS=0(empty buffer status), HLBS=0, HLID = identifier of this logical channel.

Thus, in case of transmission of the RRC Connection Request message, we propose optimization of MAC-i PDU format.

2. Discussion

Typically, the size of RRC Connection Request message is very small. Therefore, removing CRC and SI fields in the RRC Connection Request message can bring much gain to UE power consumption and overall system capacity.

Let's see the RRC Connection Request message. This message size is usually between 150 and 200 bits. Then, the total size of MAC-i PDU containing the RRC Connection Request message would be between 200 and 250 bits considering MAC-i header (24bits), CRC (8bits), and SI (18bits).

When the UE is configured with E-TFCI table 0 and 2ms TTI, and TB size is between 200 bits and 250 bits, a mapping table of E-TFCI and TB size is shown below.

E-TFCI	14	15	16	17	18	19
TB size (bits)	192	199	206	214	222	230

If the TB size of the RRC Connection Request message including CRC and SI fields is 222 bits, then the E-TFCI would be 18. But if we remove the CRC and SI fields, the TB size would be reduced by 26 bits, which results in E-TFCI to 15. Therefore, unnecessary power consumption would be reduced by not transmitting CRC and SI fields.

3. Proposal

we propose optimization of MAC-i PDU format. The detailed CR is provided in [1].

LTE-Advance Carrier Aggregation

1 Introduction

For LTE-A, one of ITU requirements is to support 100MHz and it is possible by carrier aggregation (hereafter carrier aggregation is denoted as CA). Background on CA is given below which is copied from 3GPP TR 36.814.

5 Support of wider bandwidth

Editor's note: This section will capture means to support wider bandwidth as part of the evolution of E-UTRA

Carrier aggregation, where two or more component carriers are aggregated, is considered for LTE-Advanced in order to support wider transmission bandwidths e.g. up to 100MHz and for spectrum aggregation..

A terminal may simultaneously receive or transmit one or multiple component carriers depending on its capabilities:

- An LTE-Advanced terminal with reception and/or transmission capabilities for carrier aggregation can simultaneously receive and/or transmit on multiple component carriers.
- An LTE Rel-8 terminal can receive and transmit on a single component carrier only, provided that the structure of the component carrier follows the Rel-8 specifications.
 - It shall be possible to configure all component carriers LTE Release 8 compatible, at least when the aggregated numbers of component carriers in the UL and the DL are same. Consideration of non-backward-compatible configurations of LTE-A component carriers is not precluded

The L1 specification shall support carrier aggregation for both contiguous and non-contiguous component carriers with each component carrier limited to a maximum of 110 Resource Blocks using the Release 8 numerology

- For contiguous carrier aggregation, the needed frequency spacing between the contiguous component carriers will be studied by RAN WG4. This study should include the supported number of RBs per component carrier and the needed guard bands between and at the edges for a certain aggregation case.
- If possible, the same solution should be used in the L1 specifications for contiguous and non-contiguous aggregation.

It will be possible to configure a UE to aggregate a different number of component carriers of possibly different bandwidths in the UL and the DL. In typical TDD deployments, the number of component carriers and the bandwidth of each component carrier in UL and DL will be the same. RAN WG4 will study the supported combinations of aggregated component carrier and bandwidths.

5.1 MAC-PHY interface

From a UE perspective, there is one transport block (in absence of spatial multiplexing) and one hybrid-ARQ entity per scheduled component carrier. Each transport block is mapped to a single component carrier only. A UE may be scheduled over multiple component carriers simultaneously.

2 Discussion

Because from a UE point of view, there is one transport block and one HARQ entity per scheduled component carrier (hereafter component carrier is denoted as CC) and each transport block is mapped to a single CC only, the following DL/UL layer 2 architectures can be used.

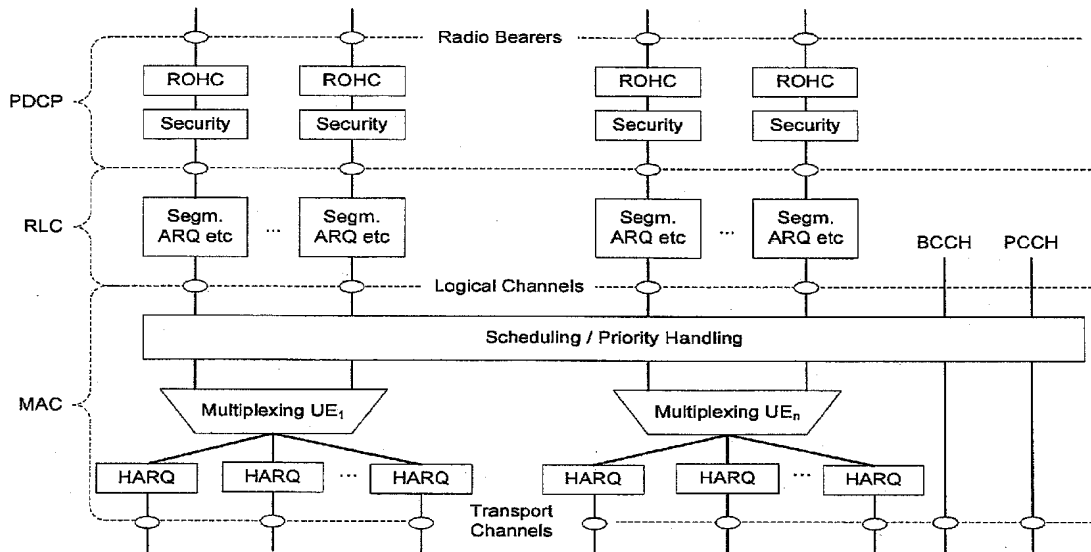


Figure 1: Layer 2 structure for LTE-A DL

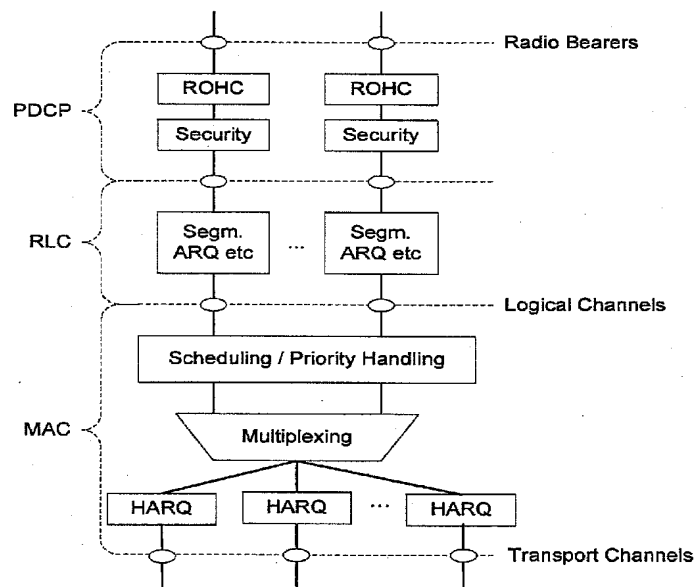


Figure 2: Layer 2 structure for LTE-A UL

2.1 Awareness of CA

If an eNB supports the carrier aggregation, it is questionable when a UE is aware of the carrier aggregation configuration.

There are two ways that the UE can be aware of it.

- Common control signalling and dedicated control signalling
- Only dedicated control signalling

Common control signalling and dedicated control signalling

In this way, firstly, the carrier aggregation configuration is informed to UEs in a cell via system information. Then, if multiple UL CCs are aggregated, the UE can use PRACH resources in all UL CCs. Then, the eNB after receiving information UE capability configures the UE to aggregate proper UL/DL CCs via the dedicated control signalling (e.g. PDCCH signalling, MAC control signalling or RRC signalling).

Only dedicated control signalling

In this way, the carrier aggregation configuration is not informed to UEs in a cell via common control signalling (e.g. system information). Only way to inform this to the UE is by the dedicated control signalling. It implies that only if there is RRC connection between UE and eNB, carrier aggregation is applicable. That is, Idle UE and UE before RRC connection or carrier aggregation configuration via dedicated control signalling are not aware of the carrier aggregation.

Alternative 1:

- All downlink component carriers serve the CA related system information.
- A UE can realize an existence of the carrier aggregation before initial access procedure.

Alternative 2:

- Only anchor component carrier serve the CA related system information
- A UE camped on the anchor component carrier can release existence of the carrier aggregation before initial access procedure.
- A UE camped on non-anchor component carrier can release existence of the carrier aggregation after initial access procedure. The eNB would inform information about carrier aggregation via, e.g. connection setup message.

2.2 CA configuration

...

2.3 HARQ operation

Because one of RAN1's decision is to have one HARQ entity per component carrier and the HARQ entity is responsible for handling the UL grant/DL assignment and HARQ feedback, we can conclude that there is DL assignment/UL grant/ HARQ feedback per component carrier.

Proposal 1: DL assignment per component carrier, UL grant per component carrier, UL/DL feedback per component carrier.

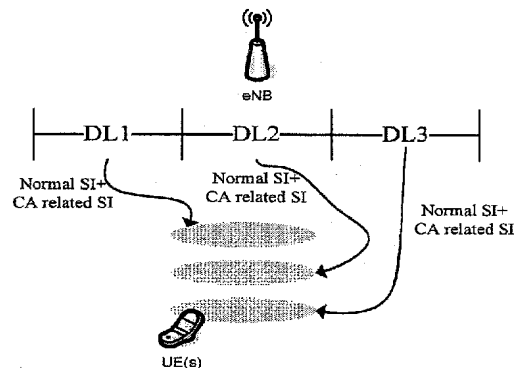
One of the component carriers can manage an UL grant and DL assignment for the other component carriers. That is, in DL, among several aggregated component carriers, one can be selected as an anchor carrier. The anchor carrier, DL assignment and UL grant receptions for all component carriers take place. In this architecture, we need to define a common HARQ entity. Then, the UE receives the uplink grant or downlink assignment of the each component carrier via the anchor carrier. Then, they are passed to the common HARQ entity. Based on the received grant and assignment, the common HARQ entity requests the corresponding a component carrier specific HARQ entity to transmit/receive data. Also, HARQ feedback of each component carrier is received/sent via the anchor component carrier. To do so, the UL grant, DL assignment and HARQ feedback should include an identification of the component carriers. For example, The UL grant including #1 UL component carrier identification is received via the anchor component carrier. Then it is passed to the common HARQ entity. Then the common HARQ entity identifies which component carrier the received uplink grant is targeting by using the identification included in the uplink grant.

Proposal 2: DL assignment, UL grant and HARQ feedback for all component carriers can be received/sent via an anchor component carrier. And they should have a component carrier identification.

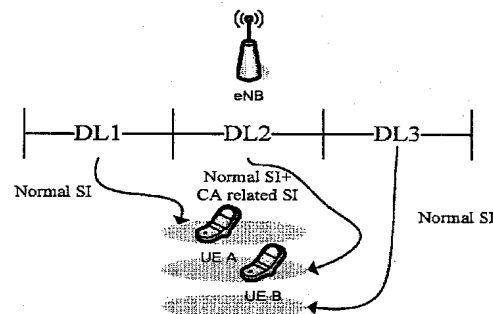
2.4 Acquisition of SI related to CA

In Rel-8, the UL bandwidth information can be obtained by a reception of SIB-2. It can be supposed that at least with CA, the paired UL component carrier should be known at that time because the backward compatibility should be supported.

So, the first question is when the UE can acquire the system information related to CA. Note that the system information related to CA would be e.g. configuration of the aggregated UL/DL component carriers.



In the above scenario, a UE can acquire the system information related to the carrier aggregation from all DL component carriers. It means that wherever the UE camps on, if multiple uplink component carriers are aggregated, the UE could use all PRACH resources when RRC connection establishment is performed.



In the above scenario, the system information related to the carrier aggregation is sent via only a specific DL component carrier (in this example, only DL2 component carrier serves it). Depending on which component carrier a UE camps on, the UE may or may not be aware of the carrier aggregation configuration.

In this case, the UE camped on the cell in which the system information related to the carrier aggregation is signalled, may not be aware of the carrier aggregation. The UE would think that there are only DL component carrier it camped on and the paired UL component carrier. So, from a random access procedure point of view, the UE would act as Rel-8 UE. Afterward, the UE is aware of the carrier aggregation.

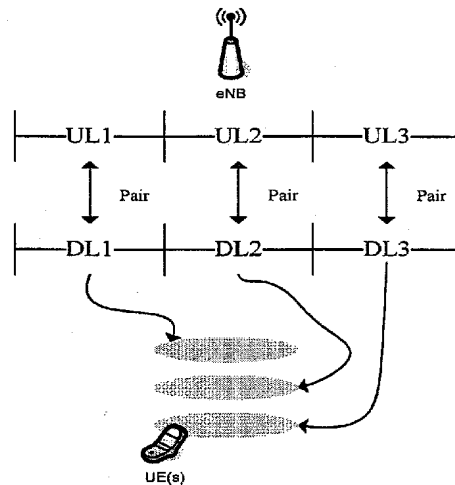
- Use Component ID to delete/add
- RLF
- Pathloss for Msg1?

2.5 Random access procedure

If a UE needs to perform a random access procedure before a carrier aggregation, e.g., at initial access case, depending on the deployment of the carrier aggregation, the procedure specified in LTE Rel-8 cannot be reused.

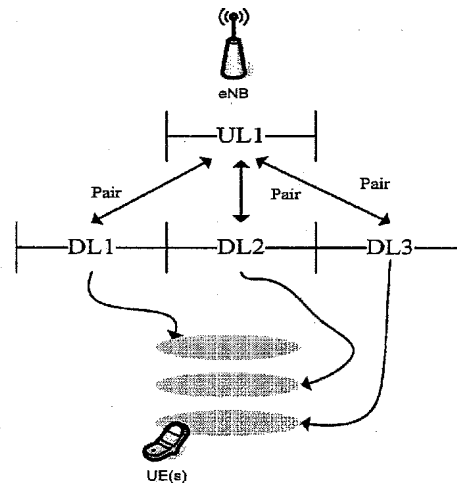
According to 3GPP TR 36.814, it is stated that it is possible to configure a UE to aggregate a different number of component carriers of possible different bandwidth in the UL and DL.

Firstly, assume a case where the same number of component carriers in the UL and DL are aggregated.



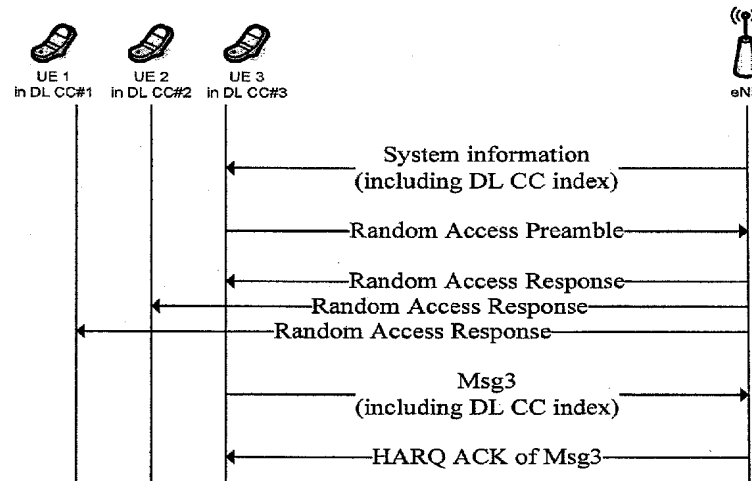
In this case, there would be no problem to reuse the LTE Rel-8 random access procedure. That is, by using the DL component carrier a UE is camping on and the paired UL component carrier, the UE sends Msg1 and Msg3 on that UL component carrier and LTE-A eNB sends Msg2/HARQ feedback of Msg3 and Msg4 on the paired DL component carrier. Thus, if the same number of component carriers are always aggregated, there is no impact to the random access procedure.

However, as stated above, there would be a case where a different number of component carriers in the UL and the DL are aggregated.



In this case, there would be some problems to reuse the LTE Rel-8 random access procedure. Because, as seen in the above figure, all DL component carriers are mapped on just one UL component carrier, when LTE-A eNB detects Msg1 via that UL component carrier, the LTE-A eNB does not know which DL component carrier the paired DL component carrier corresponding to the UL CC is. It would lead to the following alternatives.

- Alternative 1: use different RACH parameters between DL component carriers
 - E.g. there are three DL CCs and each DL CC serves different RACH parameters, e.g. preamble signature. Then, according to the cell a UE is camping on, the UE transmits Msg1 by using DL CC specific RACH parameters. So, upon a reception of Msg1, the eNB identifies the paired DL CC. So, the eNB sends Msg2 and others via that DL CC.
- Alternative 2: signal DL CC index included in Msg3



- Each DL CC serves its index via system information. E.g., if there are 3 DL CCs, 2 bits long index is used.
- A UE is camping on the DL3 CC and it identifies the DL3 CC index is "10" through the system information.
- The UE sends Msg1 via UL1 CC.
- The eNB may not know the paired DL CC corresponding to the UL1 CC Msg1 came from. So, the eNB may send Msg2 to all DL CCs.
- Because the UE is camping on the DL3 CC, it receives Msg2 on DL3 CC.
- When sending Msg3, the UE includes the DL3 CC index in Msg3.
- If DL3 CC index is identified by the eNB, the eNB now could send data to the UE via DL3 CC before the configuration of carrier aggregation.

2.6 Add/delete CC to/from aggregated CC list

If CC are aggregated, LTE-A UE is allowed to simultaneously receive/transmit data from/to each CC.

Because each CC should provide backward compatibility to LTE UE, different number of LTE UE would camp on the each CC. It implies that the load of each CC would be different.

For instance, assume that a UE is initially configured to aggregate 3 DL CCs and 2 UL CCs (hereafter assume that those CCs are included in the aggregated CC list). If one of DL CCs becomes loaded or if one of UL CCs become loaded, it would be worthwhile to delete those CCs from the aggregated CC list.

One of examples can be a case where a RACH is highly loaded. In this case, it would be beneficial for LTE-A UE not to use the overloaded CCs. On the contrary, if a specific CC becomes unloaded and it was deleted from the aggregated CC list, it would be also beneficial to ask UE to add the CC to the aggregated CC list.

2.7 Component carrier prioritization

...

2.8 Anchor carrier

...

3 Conclusion

c

4 Reference

D

LTE-Advance Relay

1 Introduction

For LTE-A, in order to extend a cell coverage, relaying functionality is used. The background on the relay is given below which is copied from 3GPP TR 36.814.

9 Relaying functionality

Editor's note: This section will capture techniques such as relaying, repeaters and self-backhauling

Relaying is considered for LTE-Advanced as a tool to improve e.g. the coverage of high data rates, group mobility, temporary network deployment, the cell-edge throughput and/or to provide coverage in new areas.

The relay node is wirelessly connected to radio-access network via a *donor cell*. The connection can be

- *inband*, in which case the network-to-relay link share the same band with direct network-to-UE links within the donor cell. Rel-8 UEs should be able to connect to the donor cell in this case.
- *outband*, in which case the network-to-relay link does not operate in the same band as direct network-to-UE links within the donor cell

With respect to the knowledge in the UE, relays can be classified into

- *transparent*, in which case the UE is not aware of whether or not it communicates with the network via the relay.
- *non-transparent*, in which case the UE is aware of whether or not it is communicating with the network via the relay.

Depending on the relaying strategy, a relay may

- be part of the donor cell
- control cells of its own

In the case the relay is part of the donor cell, the relay does not have a cell identity of its own (but may still have a relay ID). At least part of the RRM is controlled by the eNodeB to which the donor cell belongs, while parts of the RRM may be located in the relay. In this case, a relay should preferably support also LTE Rel-8 UEs. Smart repeaters, decode-and-forward relays and different types of L2 relays are examples of this type of relaying.

In the case the relay is in control of cells of its own, the relay controls one or several cells and a unique physical-layer cell identity is provided in each of the cells controlled by the relay. The same RRM mechanisms are available and from a UE perspective there is no difference in accessing cells controlled by a relay and cells controlled by a "normal" eNodeB. The cells controlled by the relay should support also LTE Rel-8 UEs. Self-backhauling (L3 relay) and "type 1 relay nodes" uses this type of relaying.

At least "Type 1" relay nodes are part of LTE-Advanced. A "type 1" relay node is an inband relaying node characterized by the following:

- It control cells, each of which appears to a UE as a separate cell distinct from the donor cell
- The cells shall have its own Physical Cell ID (defined in LTE Rel-8) and the relay node shall transmit its own synchronization channels, reference symbols, ...
- In the context of single-cell operation, the UE shall receive scheduling information and HARQ feedback directly from the relay node and send its control channels (SR/CQI/ACK) to the relay node
- It shall appear as a Rel-8 eNodeB to Rel-8 UEs (i.e. be backwards compatible)
- To LTE-Advanced UEs, it should be possible for a type 1 relay node to appear differently than Rel-8 eNodeB to allow for further performance enhancement.

9.1 Relay-eNodeB link

9.1.1 Resource partitioning for relay-eNodeB link

In order to allow inband backhauling of the relay traffic on the relay-eNodeB link, some resources in the time-frequency space are set aside for this link and cannot be used for the access link on the respective node. At least the following scheme will be supported for this resource partitioning:

General principle for resource partitioning at the relay:

- eNB → RN and RN → UE links are time division multiplexed in a single frequency band (only one is active at any time)
- RN → eNB and UE → RN links are time division multiplexed in a single frequency band (only one is active at any time)

Multiplexing of backhaul links in FDD:

- eNB → RN transmissions are done in the DL frequency band
- RN → eNB transmissions are done in the UL frequency band

Multiplexing of backhaul links in TDD:

- eNB → RN transmissions are done in the DL subframes of the eNB and RN
- RN → eNB transmissions are done in the UL subframes of the eNB and RN

9.1.2 Backward compatible backhaul partitioning

For inband relaying, the eNodeB-to-relay link operates in the same frequency spectrum as the relay-to-UE link. Due to the relay transmitter causing interference to its own receiver, simultaneous eNodeB-to-relay and relay-to-UE transmissions on the same frequency resource may not be feasible unless sufficient isolation of the outgoing and incoming signals is provided e.g. by means of specific, well separated and well insulated antenna structures. Similarly, at the relay it may not be possible to receive UE transmissions simultaneously with the relay transmitting to the eNodeB.

One possibility to handle the interference problem is to operate the relay such that the relay is not transmitting to terminals when it is supposed to receive data from the donor eNodeB, i.e. to create “gaps” in the relay-to-UE transmission. These “gaps” during which terminals (including Rel-8 terminals) are not supposed to expect any relay transmission can be created by configuring MBSFN subframes as exemplified in Figure 9.1. Relay-to-eNodeB transmissions can be facilitated by not allowing any terminal-to-relay transmissions in some subframes.

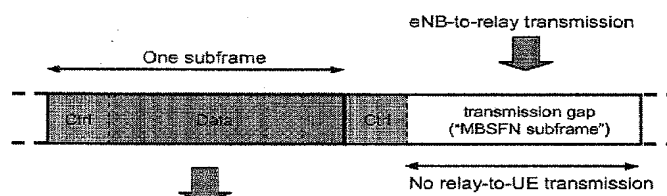


Figure 9.1: Example of relay-to-UE communication using normal subframes (left) and eNodeB-to-relay communication using MBSFN subframes (right).

2 Discussion

Following initial agreements are made in RAN2.

Agreements (“Type-1 relays”):

Definitions:

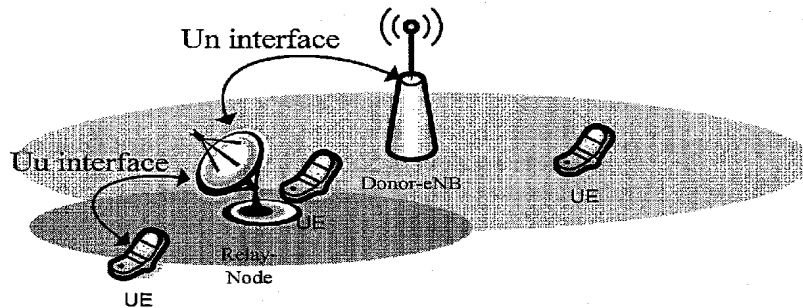
- Nodes: UE, Relay-Node, Donor-eNB
- Interface: Uu: between UE and Relay-Node
Un: between Relay-Node and Donor-eNB

- 1) On Uu interface, all AS control plane protocols are terminated in the Relay-Node
- 2) On Uu interface, all AS user plane protocols are terminated in the Relay-Node

* 1) and 2) are conditional on that SA3 can agree to this.

- 3) Un should be standardised i.e. open interface
- 4) Un user plane will have MAC, RLC and PDCP.
 - FFS if they are exactly identical to Uu MAC, RLC and PDCP.

Control plane structure for Un is still FFS.



Relay Architecture

2.1 Random Access via Un interface

Because one or more UEs belong to a cell of Relay-Node and the data from a number of UEs in the cell should be forwarded to the Donor-eNB through Relay-Node, there should be enough uplink resource (hereafter, the resources used to send data from Relay-Node to Donor-eNB is defined as uplink resources).

Also because data of a lot of UEs would be queued in Relay-Node, delays to get uplink resources from Relay-Node point of view would cause bad experiences of UEs in the cell.

Therefore, it is important that uplink resources to Relay-Node are given with reasonable amounts and delays.

To do so, static uplink resources allocation and/or dedicated scheduling request would be mainly used. However, because Relay-Node initially needs a connection to Donor-eNB and also mobility of Relay-Node is supported, Relay-Node also needs to perform a random access procedure. However, with the assumptions above, the random access procedure used in LTE would not be enough in terms of amount of resource and a delay.

In LTE, there are two random access procedures. One is a contention based random access procedure and the other one is a non-contention based random access procedure.

Given the assumption the delay should be kept reasonable, the contention based random access procedure would not be applicable because there would be an existence of the collision. So, if there is a need to get uplink resources or obtain time-synchronization, the UE should do at least non-contention based random access procedure. So, we can summarize as below.

- Uplink resources to Relay-Node should be given with reasonable amount and delays.
- Static uplink resources allocation and dedicated scheduling request should be mainly used.
- To support initial access and mobility, a random access procedure is supported.
- The random access procedure should be non-contention based.

As known in LTE, use cases of the random access procedure are 1) initial access 2) HO/RL failure 3) HO 4) UL data arrival 5) DL data arrival.

For case 3), because Donor-eNB can specially handle mobility of Relay-Node, in all HO cases, dedicated preamble are always given to Relay-Node. Also, because targets Donor-eNB also knows the dedicated preamble used by Relay-Node, it can allocate enough uplink resources.

For case 4), because Relay-Node would have static uplink resources and/or dedicated scheduling request, case 4 is not foreseen in LTE-A system.

For case 5), Because Relay-Node is special compared to the UE, the Relay-Node would be always time-synchronized. Therefore, case 5) is not foreseen in LTE-A system.

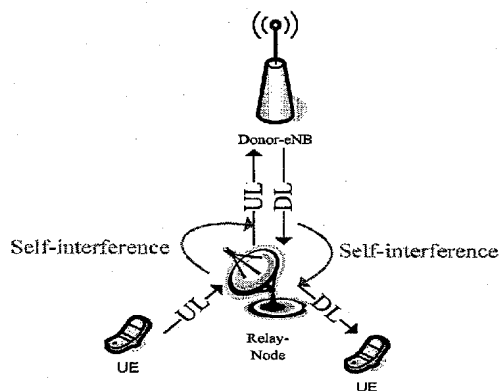
So, main question is how does the Relay-Node do the non-contention based random access procedure in case 1) and 2).

In 1) and 2) cases, because there is no connection between Relay-Node and Donor-eNB, it is not possible to give any dedicated resources and dedicated scheduling request. So, following ways could be foreseen.

- Alternative 1:

2.2 Mitigation of self-interference

There would be self-interference between communications between UE and Relay-Node and between Relay-Node and Donor-eNB.



In case of in-band relaying, the same frequency are used for Uu interface and Un interface, it would not be possible that while a Relay-Node is transmitting to Donor-eNB, it can not receive from the UE and vice versa,

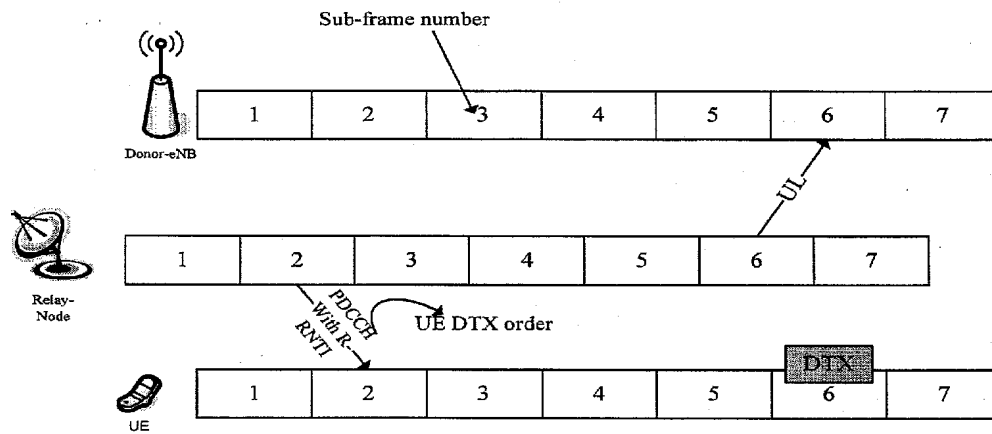
In DL case, because the data to be transmitted from Relay to UE is entirely scheduled by Relay-Node, while the Relay-Node is receiving from Donor-eNB, it would not schedule any data to UEs.

However, in UL case, if there are pre-configured resources allocated to UEs and those resources are overlapped with the time when the Relay-Node is transmitting to Donor-eNB, there is an occurrence of self-interference and it would need to be controlled in order for the UE not to transmit to Relay-Node.

To do so, the following alternative solutions are proposed.

Alternative 1: UE DTX order on PDCCH

When the Relay-Node is ready to transmit to Donor-eNB, it asks the UEs in the cell to do DTX through PDCCH. And this PDCCH is addressed to common RNTI, e.g. R-RNTI (Relay-Node-RNTI). There is one R-RNTI per cell which belongs to Relay-Node. From UE point of view, if the PDCCH for R-RNTI is detected, in the corresponding TTI, the UE does DTX regardless of whether or not the UE has data to be transmitted at that time. The corresponding TTI would be 4ms after a reception of the PDCCH for R-RNTI.

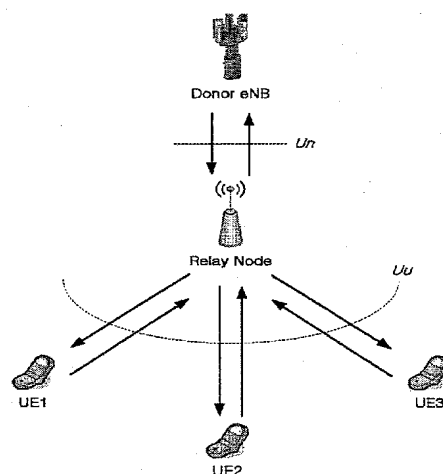


Alternative 2:

Title: Bearer Mapping in Relay Node

Current Status

In LTE-Advanced study, the concept of “Relay Node” (hereafter it is called RN) is introduced. By using RN, the Donor eNB (hereafter it is called DeNB) can extend its coverage. The RN is connected to the DeNB through wireless Backhaul link where the radio resource is shared with Access link (i.e. self-backhauling). The interface between RN and DeNB is called “Un”, while the interface between RN and UE is still called “Uu”. The concept of RN is graphically shown in Fig.1.



[Fig.1] Relay Node

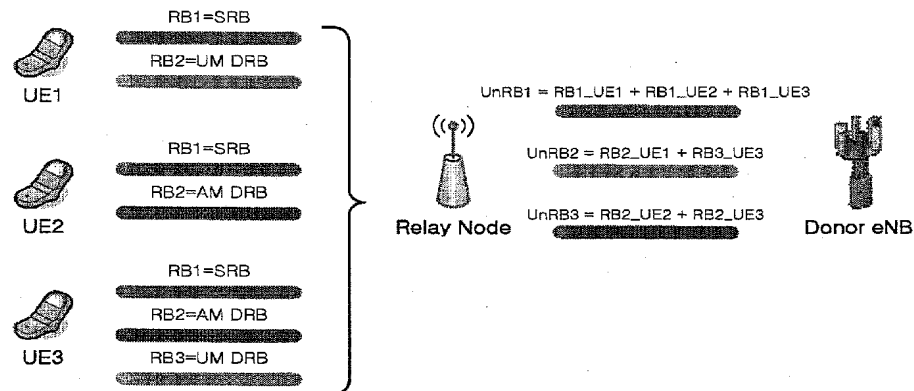
Problems

RN transmits/receives data to/from multiple UEs, and also transmits/receives data to/from the DeNB. However, how to multiplex/demultiplex multiple data streams of UEs to/from a single data stream of DeNB is not decided yet. Therefore, a new protocol architecture supporting multiplexing/demultiplexing of multiple UE's Radio Bearers (hereafter it is called RB) is required. In addition, efficient transmission scheme in Un interface is also required.

Invention

Between Un interface, a new Radio Bearer called “UnRB” is defined. The UnRB is established between RN and DeNB. One UnRB is mapped to multiple RBs of multiple UEs based on the QoS characteristics of each RB. The QoS characteristic of RB is provided by DeNB or core network (e.g. by QCI, QoS Characteristic Indicator) at RB setup, and with this information, the RN can map the RBs to UnRB. For the bearer mapping, the RN considers only the characteristic of RB regardless of which UE the RB belongs to.

An example of bearer mapping is shown in Fig.2. In the figure, the direction of RBs and UnRBs can be either DL or UL, but all RBs and UnRBs should be in the same direction.



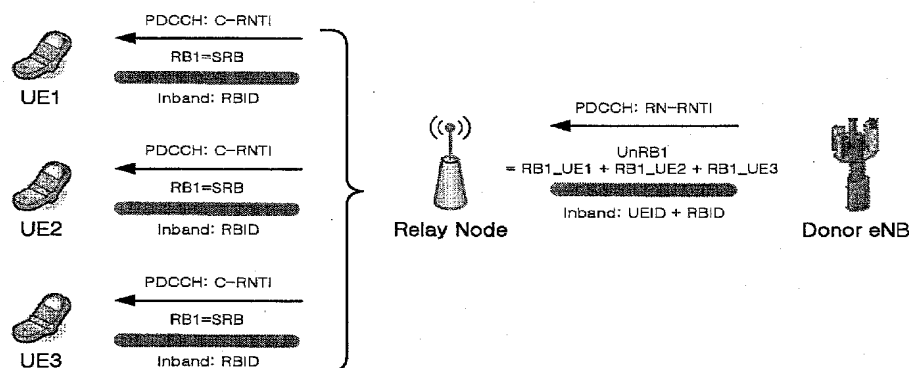
[Fig.2] Bearer mapping in Relay Node

In Fig.2, the followings are assumed.

- UE: two RBs
 - RB1: Signalling RB (SRB)
 - RB2: Data RB (DRB) using RLC UM, e.g. VoIP
- UE2: two RBs
 - RB1: Signalling RB (SRB)
 - RB2: Data RB (DRB) using RLC AM, e.g. Web browsing
- UE3: three RBs
 - RB1: Signalling RB (SRB)
 - RB2: Data RB (DRB) using RLC AM, e.g. Web browsing
 - RB3: Data RB (DRB) using RLC UM, e.g. VoIP

In Uu interface, RBs are established per UE. Therefore, the number of RBs is proportional to the number of UEs. If the RN establishes the same number of UnRBs in Un interface, it may suffer from lack of radio resource or running out of protocol processor.

Considering that some RBs in Uu interface have similar QoS characteristics, it is possible for RN to multiplex them into the single UnRB. For example, as shown in Fig.2, the SRBs of each UE can be multiplexed into UnRB1. As a consequence, total 3 UnRBs can serve total 7 RBs in Fig.2.



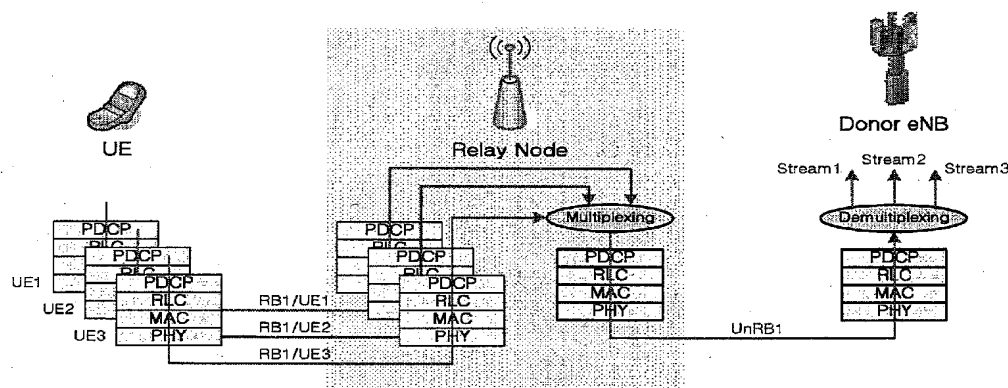
[Fig.3] PDCCH addressing and inband signalling

For UE's UL/DL transmission, it first receives UL grant or DL assignment from RN through PDCCH, where the PDCCH is addressed on UE's C-RNTI. Then, the UE can transmit/receive UL/DL data on the allocated resource.

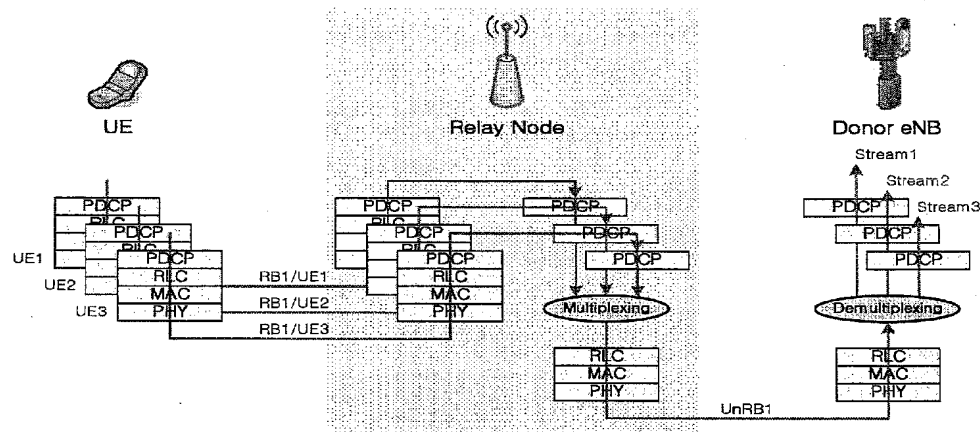
Likewise in Uu interface, the RN should first receive UL grant or DL assignment from DeNB through PDCCH. For the RN to identify that the PDCCH is targeted for him, a temporary identifier similar to UE's C-RNTI should be introduced. Here the "RN-RNTI" is introduced, by which the DeNB addresses the RN on PDCCH. Similar to C-RNTI, the RN-RNTI is allocated by DeNB each time RRC connection is established with DeNB.

When the RN receives PDCCH on RN-RNTI, it can transmit/receive data blocks of UnRB. The difference in data transmission between Uu and Un interface is that since UnRB multiplexes RBs of multiple UEs, an identifier should be included in each data block in Un interface to uniquely identify the UE and the RB of the UE. For example, the UEID (e.g. C-RNTI) as well as the RBID are included in the data block in Un interface.

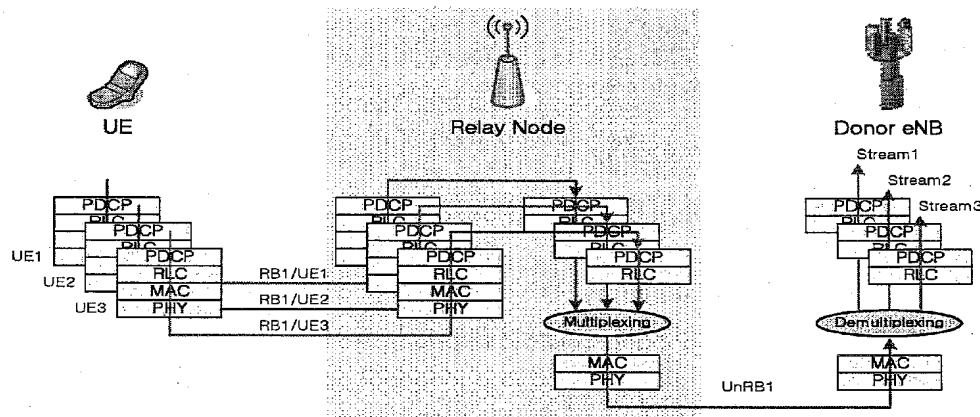
If another identifier like GTP-ID uniquely identifies the UE and the RB of the UE, then the GTP-ID can be used instead of the UEID + RBID in Un interface. Since the GTP-ID is used in S1 bearer (the bearer between DeNB and core network, and has one-to-one correspondence with RB), it can be used for identification of the data blocks in Un interface. But in this case, the RN should know the mapping relationship between GTP-ID and the UEID/RBID pair beforehand. This information is provided by DeNB to RN at RB setup.



(a) PDCP SDU (=IP packet) multiplexing



(b) RLC SDU (=PDCP PDU) multiplexing



(c) MAC SDU (=RLC PDU) multiplexing

[Fig.4] Relay Node protocol architecture – UL flow example

To multiplex/demultiplex RBs to/from a UnRB, multiplexing and demultiplexing functions are included in the RN protocol. There are several ways to achieve this functionality in RN protocol as shown in Fig.4. Note that though Fig.4 shows only UL data flow, the same approach can be applied to DL data flow, by switching “Multiplexing” and “Demultiplexing” blocks.

- PDCP SDU (=IP packet) multiplexing/demultiplexing
- RLC SDU (=PDCP PDU) multiplexing/demultiplexing
- MAC SDU (=RLC PDU) multiplexing/demultiplexing

Though not shown in the figure, it's also possible to multiplex/demultiplex MAC PDUs between PHY and MAC layers.

The multiplexing/demultiplexing block can be either separate functional block from radio protocols (PHY/MAC/RLC/PDCP) or incorporated into the radio protocols.

The important feature of multiplexing/demultiplexing function is that when multiplexing/demultiplexing data blocks of RBs, the RN adds/removes unique identifier to/from a data block of UnRB. The unique identifier is the identifier that identifies the UE and the RB of the UE, as already explained before. That is, the unique identifier is UEID + RBID, or GTP-ID, for example.

So, for UL transmission, when the multiplexing block receives a data block from a RB, it adds a unique identifier to the data block (possibly in the header), and transmits it over the Un interface. Similarly for DL transmission, when the demultiplexing block receives a data block from a UnRB, it removes the unique identifier from the data block, and transmits it over the Uu interface.

To support multiplexing/demultiplexing functionality in RN, the DeNB should also have same functionality. For UL transmission, DeNB demultiplexes the data block received via UnRB, where the unique identifier is removed, and delivers it to correct UE stream. For DL transmission, DeNB multiplexes the data blocks received from multiple streams, where the unique identifier is added, and transmits it to Un interface.

Title : component carrier aggregation

Minimum (Default) aggregation of component carriers

The figure 1 shows an example of component carrier aggregation. In downlink, D1, D2 and D3 component carriers are aggregated. In uplink, U1, U2 and U3 component carriers are aggregated. One eNB manages D1, D2 and D3 and U1, U2 and U3 together.

In FDD mode, D_i and U_i are paired ($i = 1, 2, 3$). D_i is a downlink frequency band on a paired band. U_i is a uplink frequency band on a paired band.

In TDD mode, D_i and U_i are placed on an unpaired band ($i = 1, 2, 3$). D_i is a downlink time slot and U_i is a uplink time slot on the same unpaired band.

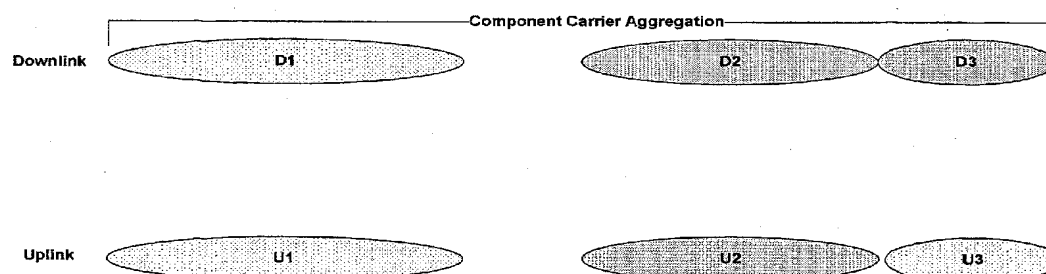


Figure 1. Example of Component Carrier Aggregation

UE may be incapable of receiving or transmitting all component carriers i.e. may not support 100 Mhz BW in maximum. So, when UE performs random access on U2 in uplink, eNB does not know if UE can support all of D1, D2 and D3 or not.

Thus, D1, D2 and D3 broadcast minimum aggregation of component carriers in their BCCH respectively e.g. default aggregation of component carriers. The minimum aggregation of component carriers would not go beyond 20 Mhz which is a minimum bandwidth of R8 UE. Thus, all UEs in Release 10 or beyond can support the minimum aggregation of component carriers.

Before eNB knows UE's capability of aggregation of component carriers and configures downlink component carriers for the UE, eNB transmits downlink signalling or data on the minimum aggregation of component carriers only. In addition, before eNB knows UE's capability of aggregation of component carriers and configures uplink component carriers for the UE, if UE transmits uplink signalling or data on a uplink component carrier, eNB receives uplink signalling or data only from the uplink component carrier that the UE transmit uplink signalling or data before.

For example, D2 broadcasts the information that D2 and D3 are minimum aggregation of component carriers. When UE camps on D2, the UE knows that D2 and D3 are the minimum aggregation of component carriers while UE is camping on D2. Thus, before eNB knows UE's capability of aggregation of component carriers and configures downlink component carriers for the UE, eNB transmits downlink signalling or data on D2 or D3 only excluding D1. While UE is camping on D2, if UE accesses D2, UE may transmit uplink signalling or data on one of uplink component carriers e.g. U2 in figure 1. In this case, before eNB knows UE's capability of aggregation of component carriers and configures uplink component carriers for the UE, eNB receives uplink signalling or data only e.g. from U2 in figure 1.

After eNB knows UE's capability of aggregation of component carriers, eNB can configure downlink and/or uplink component carriers for the UE. eNB may configure aggregation of component carriers for the UE by sending RRCConnectionSetup message, RRCConnectionReconfiguration message or RRCConnectionReestablishment message. If UE can support wider BW than all of D1, D2 and D3, eNB may configure D1, D2 and D3 in downlink for the UE. If UE can support wider BW than both of U2 and U3, eNB may configure U2 and U3 in uplink for the UE. Afterwards, UE can receive downlink signalling or data in the configured downlink carriers and transmit uplink signalling or data in the configured uplink carriers.

UE in Release 10 or beyond may include UE's capability of aggregation of component carriers in RRCConnectionRequest message, RRCConnectionSetupComplete message, RRCConnectionReconfigurationComplete message or RRCConnectionReestablishmentComplete message.

Scheduling across component carriers

During data transmission from/to UE in Release 10 or beyond, eNB may dynamically schedule data transmission across uplink or downlink on one of uplink or downlink component carriers. In this case, eNB could indicate to UE which uplink or downlink component carrier is used for scheduled data transmission for data transmission in a certain time by sending PDCCH or MAC Control Element. If such dynamic scheduling is not needed across component carriers, eNB may configure aggregation of component carriers for the UE by sending one of RRC messages such as RRCConnectionSetup message, RRCConnectionReconfiguration message or RRCConnectionReestablishment message.

In summary, regarding scheduling across aggregated component carriers in UL/DL

- Cross-scheduling between DL carriers is possible?
 - No...RRC configures DL carrier where UE stays
 - for pre-release UE with RRC re-configuration procedure i.e. normal handover
 - Yes...One carrier dynamically or semi-statically schedules across DL carriers by using PDCCH or MAC CE or RRC
 - R10 UE can be dynamically scheduled across DL carriers not by normal handover but by e.g. PDCCH or MAC CE or RRC
- Cross-scheduling between UL carriers is possible?
 - No impact on pre-release UE
 - No...RRC configures UL carrier where UE stays
 - DL carrier also moves with UL carrier ??
 - Yes...R10 UE can be dynamically scheduled across UL carriers by e.g. PDCCH or MAC CE or RRC

RLF handling

While UE is camping on one of aggregated component carriers, if radio link failure (RLF) occurs, the UE prioritizes another aggregated component carrier to perform RRC connection re-establishment procedure. That means a cell corresponding to aggregated component carrier is always prepared i.e. the cell has a valid UE context.

eNB may signal a priority of component carriers to the UE by DCCH, CCCH or BCCH. In this case, the UE will perform RRC connection re-establishment procedure according to the priority.

If UE fails to perform RRC connection re-establishment procedure on all aggregated component carriers, UE will perform RRC connection re-establishment procedure on one of non-aggregated component carriers.

RRC connection re-establishment message during this RRC connection re-establishment procedure (or RRC connection setup message) could re-locate UE from one carrier to another carrier.

For example, in figure 1, if UE camps on D2 and then RLF occurs on D2, UE in RRC Connected mode tries to perform RRC connection re-establishment procedure on another aggregated component carrier i.e. D3 or D1. Then, if the procedure is not successful on D3 and D1, UE will perform RRC connection re-establishment procedure on one of non-aggregated component carriers.

eNB may indicate to the UE that D3 has a higher priority than D1 e.g. for the UE. In this case, the UE will perform RRC connection re-establishment procedure on D3 at first.

Access Control [FFS]

In case UE gets information on an aggregation of component carriers, if UE considers a cell belonging to the aggregation of component carriers not barred, the UE shall not consider another cell belonging to the same aggregation of component carriers barred at the same time.

For example, in figure 1, if UE considers D2 not barred, the UE shall not consider D1 and D3 barred at the same time.

In case UE gets information on an aggregation of component carriers, if UE considers a cell belonging to the aggregation of component carriers barred, the UE shall consider another cell belonging to the same aggregation of component carriers barred at the same time. [FFS]

In case UE gets information on an aggregation of component carriers, if UE considers a cell belonging to the aggregation of component carriers barred, the UE shall not consider another cell belonging to the same aggregation of component carriers barred at the same time. [FFS]

Title: Method for access/connection control in congested hybrid cells

Objective of Invention

- When hybrid cell is congested, it might be needed to differentiate access prioritization over CSG and non-CSG UEs which are attempting to establish connection or being already connected, such that non-CSG UEs are steered to other cells, possibly on other frequency, than the congested hybrid cell. The congested cell then needs to be excluded from the candidate for further mobility target

Method of Invention

General

- An indicator is introduced, which tells the UE that the current cell(serving cell or the cell for which access is tried) and/or the frequency of the cell shall be considered as barred/deprioritized
- The indicator can be applied for idle UE which is making attempt to establish a connection. This indicator can be also applied for connected UE.
- The indicator generally can work in a way that non-CSG UE is not likely to stay in the cell (e.g., hybrid cells), in a congested situation to favor CSG UEs.
- It is proposed that the indicator be included in connection release/connection reject/handover message, when needed.

UE Aspect

For connected UEs: non-handover

- Upon the reception of **RRCConnectionRelease** including the indicator, UE shall deprioritize the cell and/or frequency of the cell to which UE has been connected, by performing:
 - UE shall consider **the cell** as barred; and/or
 - UE shall consider **the frequency** on which the serving cell was lying as barred; and/or
 - UE shall consider the priority of the frequency of the cell as having **the lowest priority**.
- The indicator can specify which barring/deprioritization in the above shall be performed by the UE.
- If a cell/frequency is considered as barred/deprioritized, it needs to determine how long such assumption shall be applied. So it is also proposed that:

- For each behavior described above for barring/deprioritizing cell/frequency, timer is introduced to determine how long such barring/deprioritization shall be applied
- The timer starts upon reception of the message including the indicator set to be TRUE.
- The barring/deprioritization described above shall be withdrawn at the following cases:
 - ◆ Upon the expiry of the timer; or
 - ◆ Upon entering RRC_CONNECTED; or
 - ◆ a PLMN selection is performed
- Upon the reception of **RRCConnectionRelease** including the indicator set to be disabled, or upon the reception of **RRCConnectionRelease** not including the indicator
 - No change in subsequent UE behaviors from UE behaviors without this invention
- The indicator can be implicitly signaled in **RRCConnectionRelease** message.

For connected UEs: handover

- Upon the reception of **handover message** including the indicator, UE shall bar/deprioritize the cell(serving cell which sent handover message) and/or frequency of the cell, in case of handover failure, by performing:
 - UE shall consider **the cell** as barred; and/or
 - UE shall consider **the frequency** on which the serving cell was lying as barred; and/or
 - UE shall consider the priority of the frequency of the cell as having **the lowest priority**.
- The indicator can specify which barring/deprioritization in the above shall be performed by the UE.
- If a cell/frequency is considered as barred/deprioritized, it needs to determine how long such assumption shall be applied. So it is also proposed that:
 - For each behavior described above for barring/deprioritizing cell/frequency, timer is introduced to determine how long such barring/deprioritization shall be applied
 - The timer starts upon recovery from handover failure is initiated.
 - The barring/deprioritization described above shall be withdrawn at the following cases:
 - ◆ Upon the expiry of the timer; or
 - ◆ Upon entering RRC_CONNECTED; or
 - ◆ a PLMN selection is performed
- Upon the reception of **handover message** including the indicator set to be disabled, or upon the reception of **handover message** not including the indicator
 - No change in subsequent UE behaviors from UE behaviors without this invention
- The indicator can be implicitly signaled in handover message.

For idle UEs

- Mostly the same as the UE behaviors for connected UEs, with the exception that **RRCCConnectionReject** is used instead of **RRCCConnectionRelease**
- If the **RRCCConnectionReject** includes an indication which mandates UE not to perform intra frequency reselection, then the UE applied the barring/deprioritization for the frequency for which access is tried.
- The indicator can be implicitly signaled in **RRCCConnectionReject** message.

Network Aspect

- Network shall select UEs to be steered to other cells possibly on other frequencies. Following rule is proposed for how to select such UEs.

Priority ordering

- Priorities among UEs are defined to select which UEs are first selected in the barring/deprioritization policy.
 - ◆ Allowed CSG UEs shall be assumed to have higher priority than non-CSG UEs
 - ◆ Connected UE shall be assumed to have higher priority than UEs attempting to make a connection.
 - ◆ UEs with lower priority shall be first selected for barring/deprioritization.
 - As an example of priority ordering, 'non-CSG UEs attempting to make a connection < For a non-CSG UEs to be connected < CSG UE attempting to make a connection < CSG UE that are connected' can be suggested.

UL interference ordering

- If network allows the UE, which is barred/deprioritized by the network, to perform intra frequency reselection, UL interference is also considered.
 - ◆ Network(e.g.,eNB) estimates UL interference level from the UE to itself
 - ◆ If the UE is thought to be able to cause UL interference level that is higher than **UL_INT_A**, then the network decides to mandate the UE not to perform intra-frequency reselection.
 - ◆ If the UE is thought to be able to cause UL interference that is lower than **UL_INT_A**, then the network decides to allow the UE not to perform intra-frequency reselection.
- When UE is ordered by using UL interference ordering and priority ordering, both ordering rule can be weighted in a configurable way. Thus one extreme is to use priority ordering only, and the other extreme is to use UL interference ordering only. In general, some in-between ordering is applied for the best interference and access control management.
- Based on the ordering, network determines how to perform access/connection control management.
 - ◆ Network redirects the UE to other cell; or

- ◆ Network rejects the attempt to make a connection; or
- ◆ Network hands the UE over the other cell
- Redirection information and/or intra-frequency reselection indication can be included in the RRC message for access/connection control.

Reason for change: ⌘	In the current specification, when one or two padding byte is required, MAC subheader corresponding to Padding is included at the beginning of MAC PDU. However, the meaning of "padding is required" is ambiguous: - Alt.1: The actual amount of 'not useful data' in the actually transmitted MAC PDU. I.e., the sum of "padding (at the very end of PDU)" and "subheader for padding" in the finally composed MAC PDU. - Alt.2: The amount of left space in the allocated radio resource after logical channel prioritization. In case, the intention of the specification is read as alternative 1, the UE may not construct a valid MAC PDU. See the discussion in R2-09xxxx
Summary of change: ⌘	It is clarified that: - 'one or two padding is required' means the 'one or two byte padding is required after logical channel prioritization' - padding subheader is Isolated Impact Analysis: Functionality corrected: Multiplexing If a UE which has not been implemented according to the intention of this CR does not implement this CR: - The UE may not compose a MAC PDU and If a UE which has been implemented according to the intention of this CR does not implement this CR, no impact is foreseen. No eNB impact is foreseen.
Consequences if not approved:	⌘ There is a possibility that some UE may not have been implemented according to the intention of the specification. For example, if the UE is implemented according to the alternative 1, the UE may be stuck so that it can not make a valid MAC PDU and cannot transmit a MAC PDU over the allocated resources.

6.1.2 MAC PDU (DL-SCH and UL-SCH except transparent MAC and Random Access Response)

A MAC PDU consists of a MAC header, zero or more MAC Service Data Units (MAC SDU), zero, or more MAC control elements, and optionally padding; as described in Figure 6.1.2-3.

Both the MAC header and the MAC SDUs are of variable sizes.

A MAC PDU header consists of one or more MAC PDU subheaders; each subheader corresponds to either a MAC SDU, a MAC control element or padding.

A MAC PDU subheader consists of the six header fields R/R/E/LCID/F/L but for the last subheader in the MAC PDU and for fixed sized MAC control elements. The last subheader in the MAC PDU and subheaders for fixed sized MAC control elements consist solely of the four header fields R/R/E/LCID. A MAC PDU subheader corresponding to padding consists of the four header fields R/R/E/LCID.

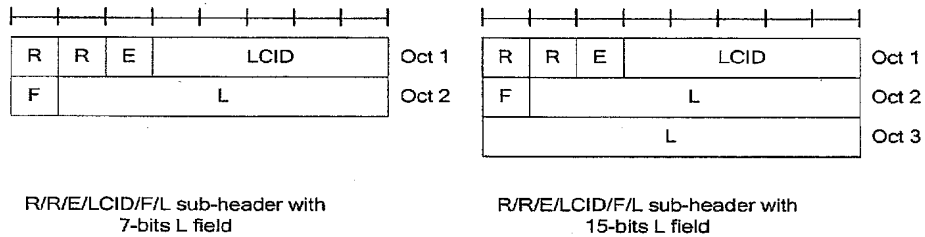


Figure 6.1.2-1: R/R/E/LCID/F/L MAC subheader

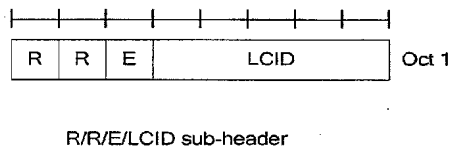


Figure 6.1.2-2: R/R/E/LCID MAC subheader

MAC PDU subheaders have the same order as the corresponding MAC SDUs, MAC control elements and padding.

MAC control elements are always placed before any MAC SDU.

Padding occurs at the end of the MAC PDU, except when single-byte or two-byte padding is required after logical channel prioritization. Padding may have any value and the UE shall ignore it.

When single-byte or two-byte padding is required after logical channel prioritization, one or two MAC PDU padding subheaders are placed at the beginning of the MAC PDU before any other MAC PDU subheader.

A maximum of one MAC PDU can be transmitted per TB per UE.

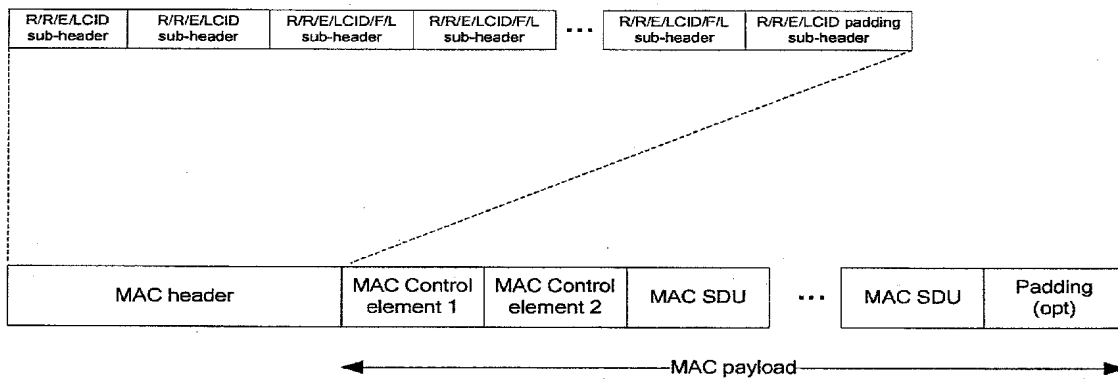


Figure 6.1.2-3: Example of MAC PDU consisting of MAC header, MAC control elements, MAC SDUs and padding

Title: Discussion on LTE-A

1. Introduction

Agreements ("Type-1 relays"):

Definitions:

- Nodes: UE, Relay-Node, Donor-eNB
- Interface: Uu: between UE and Relay-Node
Un: between Relay-Node and Donor-eNB

- 1) On Uu interface, all AS control plane protocols are terminated in the Relay-Node
- 2) On Uu interface, all AS user plane protocols are terminated in the Relay-Node

* 1) and 2) are conditional on that SA3 can agree to this.

3) Un should be standardised i.e. open interface

4) Un user plane will have MAC, RLC and PDCP.

- FFS if they are exactly identical to Uu MAC, RLC and PDCP.

Control plane structure for Un is still FFS.

Open issues on control plane architecture:

Radio interface reNB<->asNB:

- CP:
 - reNB has own IMSI/NAS to request EPS bearers ? If reNB-NAS, how is EPS bearer rate increases/decreases handled ?
 - Other solutions ?
 - Is (updated) Rel-9 RRC used or new RRC ?
- UP
 - optimisations or just full S1-UP ?
- => Will study fixed, nomadic and mobile Relay-Nodes.
- => Priority in the study will be given to fixed Relay-Nodes, i.e. Relay-Nodes that are not moving.

LTE-A.

How to authenticate a ReNB?

How DeNB can authenticate ReNB?

How ReNB is allocated with CGI/TA-ID(Sib contents) from core for SIB transmission?

ReNB(mobile?nomadic) needs to perform measurement reporting?

Who performs admission control?

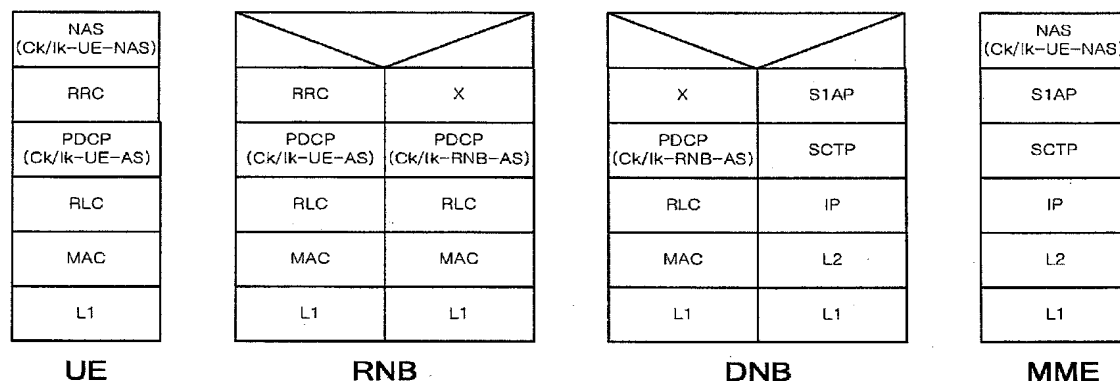
What is RRC-un look like?

- configuration of sib
- cac? (dNB has a right to decide the amount of resources for RNB?)

Need for rlc-tm/um/am for Un interface..

2. Discussion

2.1 Security



Ck: ciphering key

CK-UE-AS : ciphering key used for a specific UE in AS level

CK-UE-NAS : ciphering key used for a specific UE in NAS level

CK-RNB-AS : ciphering key used for a specific RNB in AS level

Ik-> Integrity Key,

IK-UE-AS : Integrity key used for a specific UE in AS level

IK-UE-NAS : Integrity key used for a specific UE in NAS level

IK-RNB-AS : Integrity key used for a specific RNB in AS level

In each case, the transmit ciphers/integrity-protects the transmitted PdU with configured keys.

In each case, the receiver de-ciphers/integrity-checks the received PdU with configured keys.

2.1 Call setup

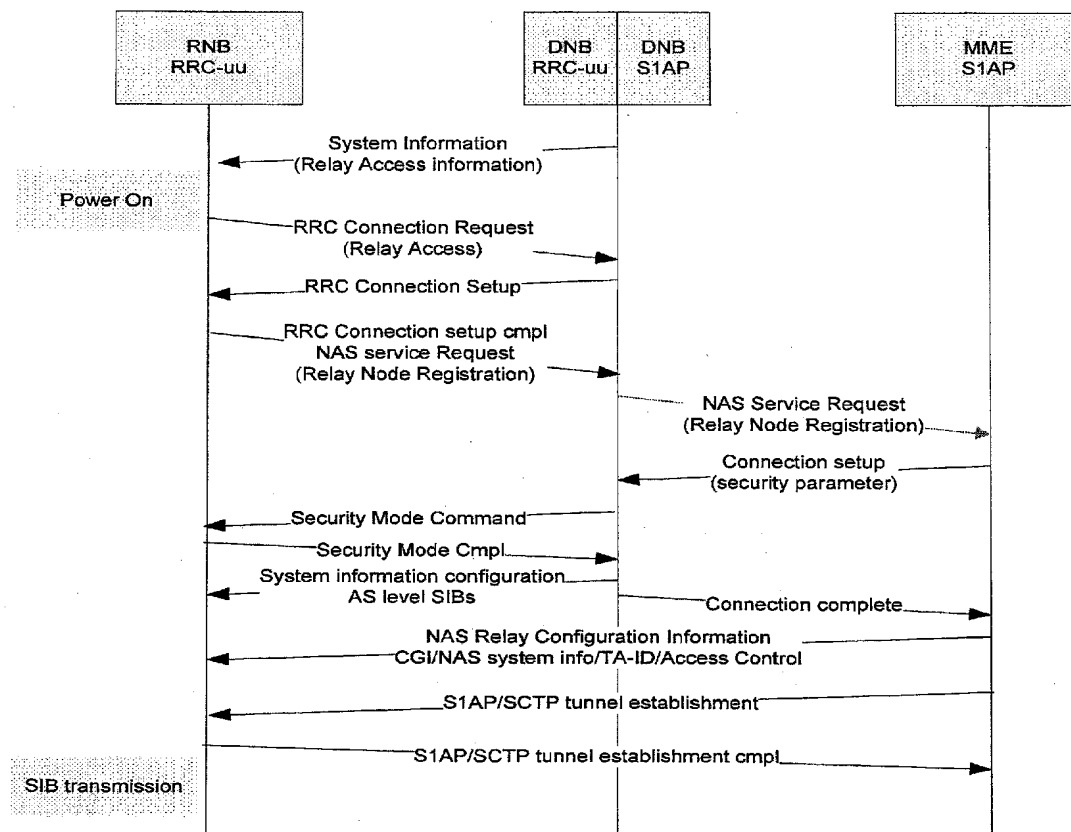
UE -> RNB : RRC request

RNB->DNB: RRC request allowed? (or, DNB has already given the RNB regarding the number of max RRC UE that RNB is allowed)

DNB->RNB: RRC accept

RNB->UE: RRC setup

Following figure shows the relay setup:

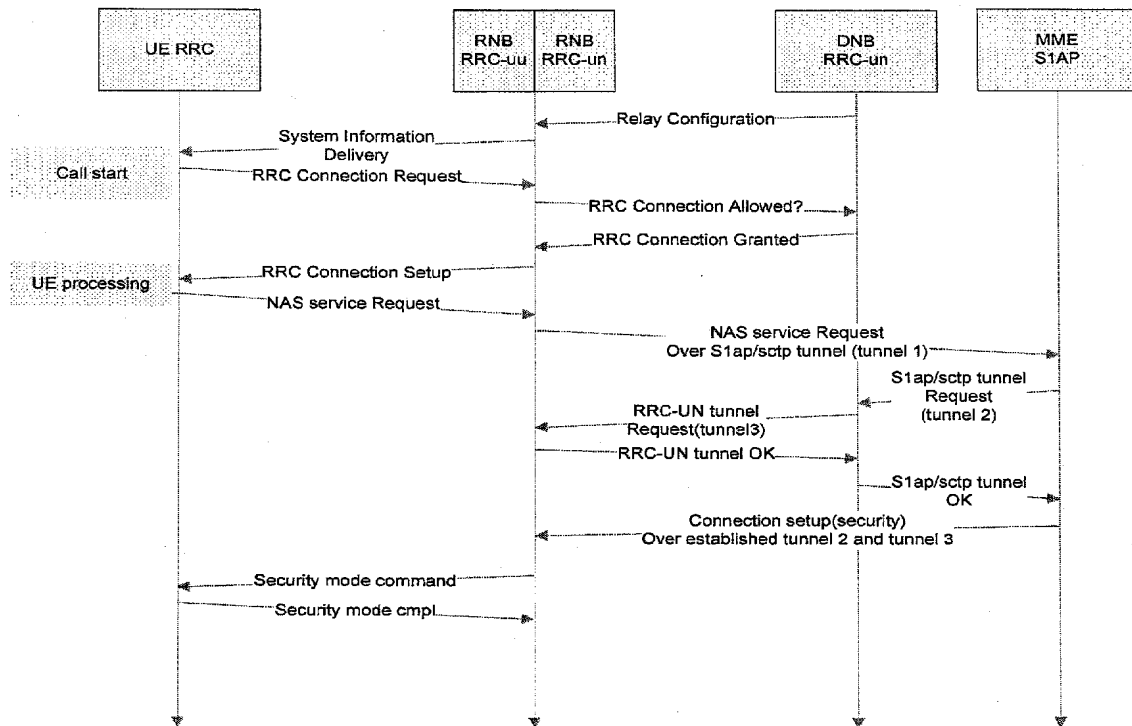


- 1.DNB(Doner NB) broadcast system information. In this system information, DNB tells whether it supports RNB(Relay NB) or not.This system information is delivered over Uu interface. When this system information indicates that it supports RNB RNB can access this DNB.
- 2.RNB transmit RRC Connection Request as normal Rel-8 UE. But, in this RRC Connection Request, the RNB indicates that it is Relay NB. Relay NB can access DNB only when DNB allows the access.
- 3.DNB transmit RRC Connection setup. If necessary, DNB can establish another SRB dedicated to Un interface.
- 4.RNB transmit NAS service Request message. In this NAS message, Relay NB registers itself to MME or EPS. In this NAS message, the identify of RNB is included and RNB indicates to MME/EPS that it functions as RNB and request CGI/TA-ID etc.
- 5.DNB forward this NAS message to MME/EPS.
- 6.MME/EPS process the received NAS message. If it decides to grant access of the RNB, it established S1 link. Also, MME/EPs delivers security related information to the DNB.
- 7.Based on the security information, DNB establish security context with RNB.
- 8.If necessary RNB delivers to necessary information related to system information or other configuration information. This information can be delivered either RRC-uu interface or RRC-un interface..
- 9.After successful security setup, DNB informs this to MME/EPS
10. MME/EPS delivered CGI/TA-ID/access restriction related information, etc. to RNB.

11. MME/EPS establishes another tunnel between MME/EPS and RNB(tunnel 1). This tunnel is regarded as normal RAB to DNB. I.e., the message over this tunnel is transparent to dNB. This tunnel 1 acts like S1-MME between RNB and MME/EPS.

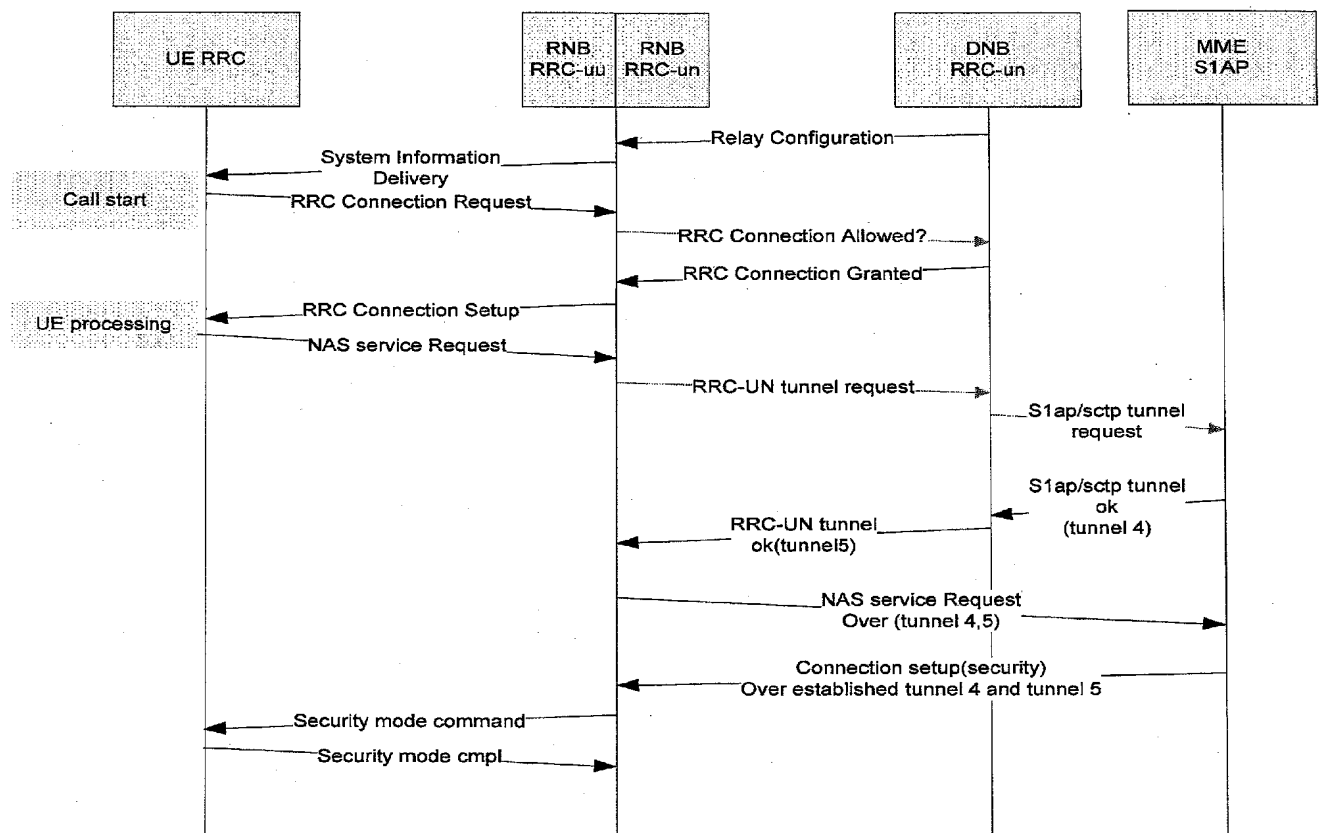
In above, Uu interface can be replace with Un interface. For all the message that is not used for UE, the message can be called as transmitted over Un interface.

Following figure shows the Call setup.



1. UE reads system information from RNB
2. UE transmit RRC Connection Request to RNB
3. RNB checks whether the UE can access or not. I.e, it performs Call Admission Control. For example, if there is limit to the number of connected that RNB is allowed to handle/established, the RNB checks whether the limited is reached or not.

4. Or, the RNB forwards information from the UE to DNB. Then, DNB decides whether to grant a RRC connection to this UE or not
5. If RNB or DNB decides to grant a access for this UE, the RNB transmit RRC Connection Setup to this UE.
6. The UE transmit NAS Service Request
7. RNB forward necessary information to MME/EPS. In this case, the information is delivered over the set-up tunnel (tunnel 1).
8. If MME decides to setup a call with this UE, the MME/EPS establishes tunnel 2 and tunnel 3. The mapping information between tunnel 2 and tunnel 3 is also delivered to DNB. Thus, the DNB connects the tunnel 2 and tunnel 3. The number of tunnel 2 is same as the required number of S1 connection between UE and MME/GW/EPS. The number of tunnel 3 is same as the required number of S1 connection between UE and MME/GW/EPS. This setup applies to both c-plane and u-plane bearer
9. When tunnels are setup, the RNB establish security context with UE using the information from MME/EPS



1. UE reads system information from RNB
2. UE transmit RRC Connection Request to RNB
3. RNB checks whether the UE can access or not. I.e, it performs Call Admission Control. For example, if there is limit to the number of connected that RNB is allowed to handle/established, the RNB checks whether the limited is reached or not.
4. Or, the RNB forwards information from the UE to DNB. Then, DNB decides whether to grant a RRC connection to this UE or not

- 5.If RNB or DNB decides to grant a access for this UE, the RNB transmit RRC Connection Setup to this UE.
- 6.The UE transmit NAS Service Request
- 7.RNB request establishment of tunnel 4 and tunnel 5. Tunnel 5 is bearer between RNB and DNB and tunnel 4 is bearer between DNB and MME. In this case MME information is delivered from RNB to DNB based on the information from the UE. For fast setup, the NAS service request message can be also delivered to DNB and this NAS message can be delivered to MME when tunnel 4 is established.
8. When tunnel 4 and tunnel 5 is successfully established,
- 9.Over the tunnel 4 and tunnel 5, NAS service request message is delivered.
10. If mme/eps decides to grant a connection for the UE, security information is delivered to UE.
11. Additional bearer like tunnel 4 and tunnel 5 can be established and each corresponds to the bearer between UE and RNB. The mapping information between tunnel 4 and tunnel 5 is also kept in DNB. Thus, the DNB connects the tunnel 4 and tunnel 5. The number of tunnel 4 is same as the required number of S1 connection between UE and MME/GW/EPS. The number of tunnel 5 is same as the required number of S1 connection between UE and MME/GW/EPS. This setup applies to both c-plane and u-plane bearer

Proposal 1:

a.

3. Proposal

It is proposed that:

4. Reference

[1] R2-092aaa, aaa, aaa

5. Annex

RNB is allocated with multiple D-SR channels. Different D-SR can be mapped to different RBs or different RB groups or different QoS/QCIs. When a condition is met for each D-SR, each D-SR channel is set or triggered. The triggering condition for each D-SR channel can be configured separately. For example, RNB can be allocated with D-SR 1 and D-SR 2 and D-SR 1 is mapped to RB group1 and D-SR 2 is mapped to RB group 2. When there is a data for RB group 1 or a triggering condition is met for RB group 1 or when a BSR(Buffer status report) is triggered for RB group 1, D-SR 1 is triggered and set. When there is a data for RB group 2 or a triggering condition is met for RB group 2 or when a BSR (Buffer status report) is triggered for RB group 2, D-SR 2 is triggered and set.

In above, D-SR channel is similar to D-SR of LTE Rel-8. Or, it can be one-bit channel.

RNB report buffer status report to DNB.

In this buffer status report, RNB report the amount of data in its buffer. Or, in this buffer status report, RNB report the total sum of buffer status report from UE. For example, let's assume the RNB has received BSR 1 from UE 1 and BSR 2

from UE 2. And further assume that BSR 1 says that UE 1 has 1 MB data to transmit and BSR 2 says that UE 2 has 2 MB data to transmit. Then, RNB report that the amount of data expected is 3 MB to DNB. This report can inform the expected amount of data per UE. This report may also inform the time when each BSR report from UE is received. In the above report, RNB may exclude the amount of data that it already has received from UE.

DNB report buffer status report to RNB.

In DL, RNB buffer for DL data may be short. Thus, to manage buffer, RNB has to know the amount of data it expect to receive from DNB. Thus, periodically, or event-based, DNB has to inform RNB of the amount of DL data that the DNB has. The DNB can configure RNB so that the amount buffer that should be reserved for DL in RNB is set.

RNB report its Buffer capability to DNB. This buffer capability information can be separately delivered per DL/UL.

When DL buffer of RNB is full or above some threshold (percent, or configured absolute value), the RNB report this to DNB. For example, if the DL buffer of RNB is 1 MB and if it is full, the RNB report this to DNB. Then, DNB may stop sending DL data to RNB. When, this situation is over, the RNB report that the end of situation.

Or, the above mechanism can be used also for UL. I.e., when UL buffer(i.e, the data received from UEs) of RNB is also full or above some configured threshold, then RNB report this to DNB.

Or, above method can be used for total sum of DL/UL buffer.

In above method, MAC CE(control element) or PDCP report or RLC report can be used. OR, RRC report can be used. Or, one-bit channel over physical resources such as D-SR channel can be used. I.e, eNB can configure a physical channel and when above condition is met, the UE informs the event by using the physical channel.

For example, when DL buffer of RNB is full, 1 bit channel is set and when buffer of RNB is not full, the 1 bit channel is not set.

Each data has delay limit. When there is a data that a delay limit is almost reached in the RNBs buffer, the RNB indicates this event to DNB. This can be done by control PDU over RLC/MAC/RRC/PDCP level or physical channel, 1 bit channel such as D-SR..

RNB can use SPS(Semi persistent scheduling). RNB can inform DNB:

- The number of user for which SPS is configured or required
 - The bitrate required to support the service over SPS
 - The number of voice service user
 - The optimized(required) number of bits or the amount of radio resource per each SPS interval/occasion
- I.e, the RNB can request DNB to allocate SPS resource and the SPS configuration such as interval and amount of resources.

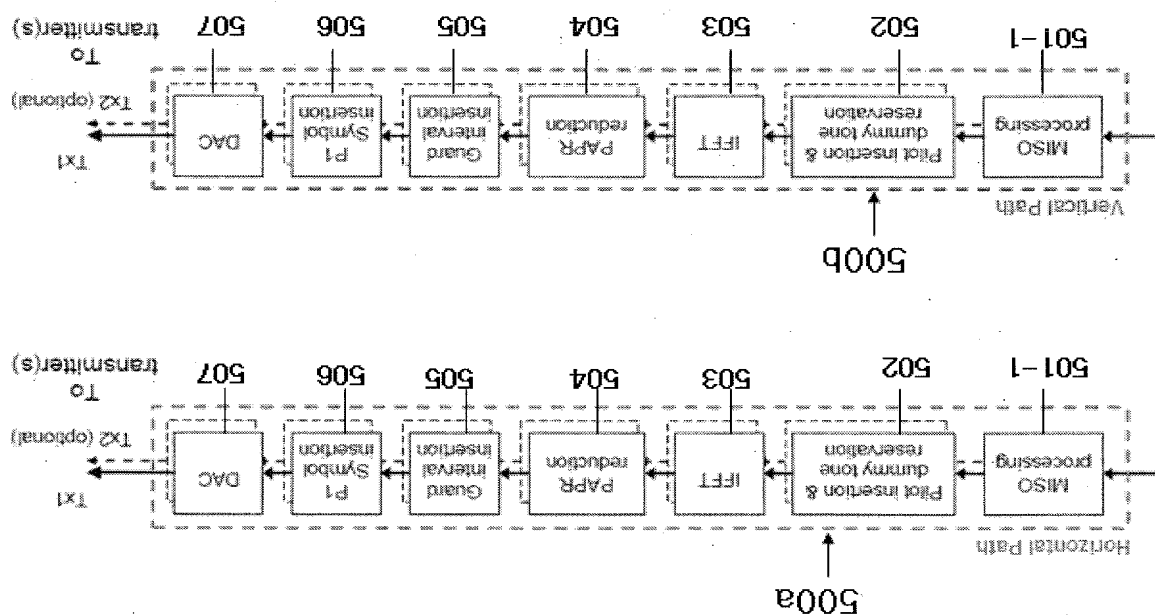
To optimize dl resource allocation for RNB, DNB can use/allocate several RNTIs to RNB.

Each RNTI that RNB uses is associated RBs/RB groups/QoS/QCIs. The RBs are radio bearer between RNB and DNB or the radio bearer between DNB and RNB. Optionally, radio bearer between DNB and RNB may include multiple radio bearer between UE and RNBs.

DNB/RNB may configure which RNTI is associated with RB/rb groups/qcis/qos..etc. Thus, when a grant for a specific RNTI is received, the RNB uses that RNTI for the transmission of data only from the associated RB/RB group/QCIS/Qos...

One of the RNTIs can be used for general purpose. When a grant is received for this RNTI, the grant can be used to transmit any kind of data.

When a separate group or additional group/rb/qos/qci needs to be defined, a RNB can request allocation of additional RNTIs.



【 17 】

Title: Discussion on MBMS Impact on MAC

1. Introduction

In this contribution, we discuss what kind of impact on MAC are foreseen by the introduction of MBMS

2. Discussion

(connected mode/idle mode)

2.1 Requirement.

At this moment, it is not clear whether MBMS is mandatory feature for Rel-9 UE or not. Even if MBMS is optional feature, there should be minimum requirement for the MBMS capable UE. If mandatory, it is not clear what is the requirement for the connected mode. Ue.

Or sps.

For example, if measurement gap collides with mbsfn reception, what is the desired behavior? Ue should inform eNB of the service it receives? Or the UE can skip?

Or separate harq process? This is not impacted by mac reset?

Separate mac reconfiguration procedure? separate mac reset?

Impact on drx section.. exclude mbsfn frame?

From the analysis, it seems better to use separate MCH/RNTI for MCCH.

2. Proposal

It is proposed to discuss whether both options need to be supported. If only one option needs to be supported for simplification, it is further proposed to change the following bullet of section 15.3.5:

- The MCCH-MBSFN area is not necessarily the same as the MTCH-MBSFN area i.e. MCCH can be either on a different MCH than the MCH carrying "advertised" MTCH, or multiplexed on the same MCH as the one carrying "advertised" MTCH.

3. Reference

[1] R2-092706, MBMS baseline CR to 36.300 after RAN2#65bis, MBMS Rapporteur

3. ANNEX

There are two LCID tables. One is used for non-mbms traffic/control and the other table is used for MBMS traffic/control

The UE knows about the mbms related RNTIs.(MCH RNTIs or MCCH RNTIs, MICH RNTI MTCH RNTIs..etc) The UE knows about the non mbms related RNTIs.(C-RNTI, RA-RNTI, T-C_RNTI, SPS-C-RNTI, P-RNTI, SI-RNTI..etc)

Thus, when a MAC PDU is received using MBMS related RNTIs, the UE applies LCID tables related to MBMS. And when a MAC PDU is received using non MBMS related RNTIs, the UE applies LCID tables related to non-MBMS traffic/control

And the other [1] R2-092706, MBMS baseline CR to 36.300 after RAN2#65bis, MBMS Rapporteur

One of R bit of MAC Subheader is used to indicate whether this subframe is the last subframe among the subframes indicated to be used for the transmission for some specific MTCH(MBMS service). I.e., each MAC PDU that includes the data for a MBMS service, there is one bit indicator that is used whether there is no more data for this MBMS service until next occasion where MBMS scheduling info is delivered or until the end subframe where the unsuccessfully received scheduling info may have indicated.

I.e., when the UE fail to receive scheduling info at the subframe where the scheduling info is expected, ue continues to receive the MCH. And when above situation occurs, the UE can stop receiving.

One of R bit of MAC subheader is used to indicate whether the related MAC SDu includes a RLC header or not.

Title: Discussion on Multiplexing of MCCH/MTCH

1. Introduction

In Rel-9 MBMS, it was agreed that a cell can belong to only one MBSFN area.

Thus, some text of TS36.300, which was included before this agreement was made, needs to be revisited.

In this document, following statements found in section 15.3.3 of TS36.300 is discussed:

Whether there is a 1-to-1 mapping between MCH and MBSFN Area is FFS.

2. Discussion

2.1 MCCH

MCCH is used to inform UE of necessary information for the reception of MBMS services. Thus, to receive a MBMS service, a MBMS-joined UE should read MCCH.

In section 15.3.5 of [1] following is stated:

15.3.5 MCCH Structure

The following principles govern the MCCH structure:

- BCCH indicates the scheduling of the MCCH for multi-cell transmission on MCH.
- BCCH only points to the resources where the MCCH(s) can be found i.e. it does not indicate the availability of the services.
- The MCCH is sent on MCH.
- The MCCH-MBSFN area is not necessarily the same as the MTCH-MBSFN area i.e. MCCH can be either on a different MCH than the MCH carrying "advertised" MTCH, or multiplexed on the same MCH as the one carrying "advertised" MTCH.

According to the first two bullets, what the UE can know from the BCCH is the time when MCCH can be transmitted. I.e., the UE does not know exact the time when MCCH is transmitted. It means that the UE has to check the existence of MCCH at each subframe where MBSFN resources are allocated.

Regarding how the UE know the existence of MCCH at a certain subframe, following two methods are foreseen:

Option 1: Using separate MCH/RNTI

In this approach, one MCH is dedicated to a MCCH and a separate RNTI for MCCH is used to indicate the MCH. Thus, when a UE needs to read MCCH, a UE checks the existence of the specific MCH/RNTI at each subframe where MBSFN resource is allocated. If the MCH/RNTI is found, the UE reads the MCH at the subframe.

Pros:

Because the UE needs to process only one specific MCH, burden on UE processing would be relaxed.

Because there is one-to-one mapping between MCH and MCCH, there might be no need to include MAC header.

Application of different QoS (e.g. HARQ) between MCCH/MTCH may be possible.

Option 2: Using MAC PDU multiplexing

In this approach, there is no MCH dedicated to a MCCH. Because each MCH has the possible to transport a MCCH, the identification of MCCH is performed by checking the MAC PDU header. Though currently it is not clear what MAC PDU structure will be for MCH, the easiest approach is to reserve one code point of the field similar to LCID.

Pros:

Because MCCH and MTCH can be transmitted within same MAC PDU, there will be some multiplexing gain.

Cons:

Because each MAC PDU transported over MCH can include MCCH, a UE has to receive and process all the MAC PDUs at the subframe where a MBSFN resource is allocated. If there are many MCHs in one subframe, this will be huge burden for the UE.

From the analysis, it seems better to use separate MCH/RNTI for MCCH.

Proposal 1:

For the transmission of MCCH, use dedicated MCH.

2.2 MTCH

For each MBMS service, separate radio bearer or MTCH will be setup between UE and eNB and separate bearer will be setup between eNB and MGW (MBMS GateWay).

In this case, if all the MTCH are multiplexed into same MCH, a single loss of one data block for one MTCH will block the transmission of data blocks for other MTCHs. For example, let's assume there are MTCH 1 and MTCH 2. And further assume that, MTCH 1 and MTCH 2 are transmitted at the same TTI over same MCH. If a data block for MTCH 1 for subframe X is received and a data block for MTCH 2 for subframe X is not received, eNB cannot transmit even data block for MTCH 2 which is successfully received from MGW.

In addition, in a subframe where MBSFN resource is allocated, the data that one user is interested will occupy only a fraction of the allocated resource. Then, to require the UE to process whole MBSFN resources or to require the UE to process other MTCHs that the user has not subscribed to will be burden to the UE.

Thus, it should be allowed that different MTCHs are transmitted over different MCHs within one MBSFN area.

Proposal 2:

In one MBSFN area, multiple MCHs can be setup for MTCHs.

3. Proposal

It is proposed that:

- Proposal 0: One MBSFN area can have multiple MCHs.
- Proposal 1: For the transmission of MCCH, use dedicated MCH.
- Proposal 2: In one MBSFN area, multiple MCHs can be setup for MTCHs.

4. Reference

[1] R2-092706, MBMS baseline CR to 36.300 after RAN2#65bis, MBMS Rapporteur

5. Annex

BCCH includes MCH information.

MCH information includes information for all the MCHs setup in the cell(MBSFN area)

For MCH information for each MCH, it includes:

- The used RNTI for the MCH
- A Indicator whether the used RNTI is for one specific MTCH or for multiple MTCHs
- In case the used RNTI is for multiple MTCHs, it further includes the MBMS service IDs or MTCH IDs.
- In case the used RNTI is for one MTCHs, it further includes the MBMS service ID or MTCH ID.
 - In case the used RNTI is for one specific MTCH, if the RNTI is found over the physical channel at a certain subframe, only the subscribed UE for the service will received over the indicated radio resource.
 - In case the used RNTI is for multiple MTCHs, if the RNTI is found over the physical channel at a certain subframe, the UE whose subscribed MTCH/service ID matchs any one of the MTCH/service id for the MCH will received over the indicated radio resource.
 -

For MCCH transmission

BCCH includes a information for a RNTI that is used for MCH dedicated to MCCH.

BCCH indicates whether a MCCH is delivered or dedicated MCH or shared MCH. Dedicated MCH is a MCH that only transport MCCH. Shared MCH is a MCH that transport not only MCCH but also some MTCHs.

In case dedicated MCH is used for MCCH, and when a UE needs to read MCCH, if the RNTI for MCH dedicated for MCCH is received, UE further receives the indicated resources. In case dedicated MCH is used for MCCH, and when a UE does not need to read MCCH, if the RNTI for MCH dedicated for MCCH is received, UE does not receive the indicated resources.

On the other hand, in case shared MCH is used for MCCH, if the RNTI for MCH shared for MCCH is received, UE further receives the indicated resources.

When a MCH is shared between MCCH and MTCH, MCCH is the first element included into the MAC PDU over the MCH. I.e., the MCCH data is included before other MTCH data.

In a MAC PDU, MCCH uses specific, pre-assigned, fixed LCID value.

The list of available MBMS service is included into the MCCh?

MCCH or BCCH includes which MBMS services belong to which MCH. And the m-RNTI of the mCH.

UE receives MSCH to know at which subframes data for a specific MBMS service is delivered.

When, the UE fails to receive a mbMS service data at the subframe indicated by MSCH, the UE regards that there is a missing data or Missing Pdu at the subframe. Based on this, the UE disassemble using RLC PDUs received before the missing PdUs and using RLC Pds received after the missing PdUs.

One of R field in the mac header is used to indicate for the related logical about:

- Whether the related rlc pdu(mac sdu) includes header or not
- Whether the related rlc pdu(mac sdu) includes sequence number or not
- Whether the related rlc pdu(mac sdu) includes framing information or not
- Whether the related rlc pdu(mac sdu) includes only one complete rlc sdu
- Whether the related rlc pdu(mac sdu) includes complete rlc sdus

-

-

Title: Discussion on Padding

1. Introduction

At the RAN2#65, CR324 was agreed so that subheader for 1 or 2 byte padding is always placed before any other subheader. The related discussion paper is in [1].

6.1.2 MAC PDU (DL-SCH and UL-SCH except transparent MAC and Random Access Response)

Padding occurs at the end of the MAC PDU, except when single-byte or two-byte padding is required. Padding may have any value and the UE shall ignore it.

When single-byte or two-byte padding is required, one or two MAC PDU subheaders corresponding to padding are placed at the beginning of the MAC PDU before any other MAC PDU subheader.

According to the current section 6.1.2, a problem occurs in following figure 1:

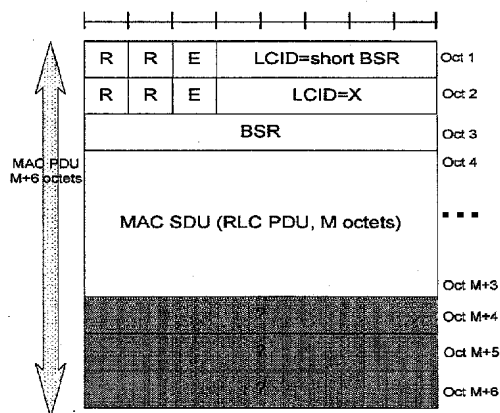


Fig. 1 Example 1

In above figure 1, the MAC PDU size is $M+6$ octets and the MAC SDU size is M octets. To fill the 3 remaining octets, following options in figure 2 may be possible.

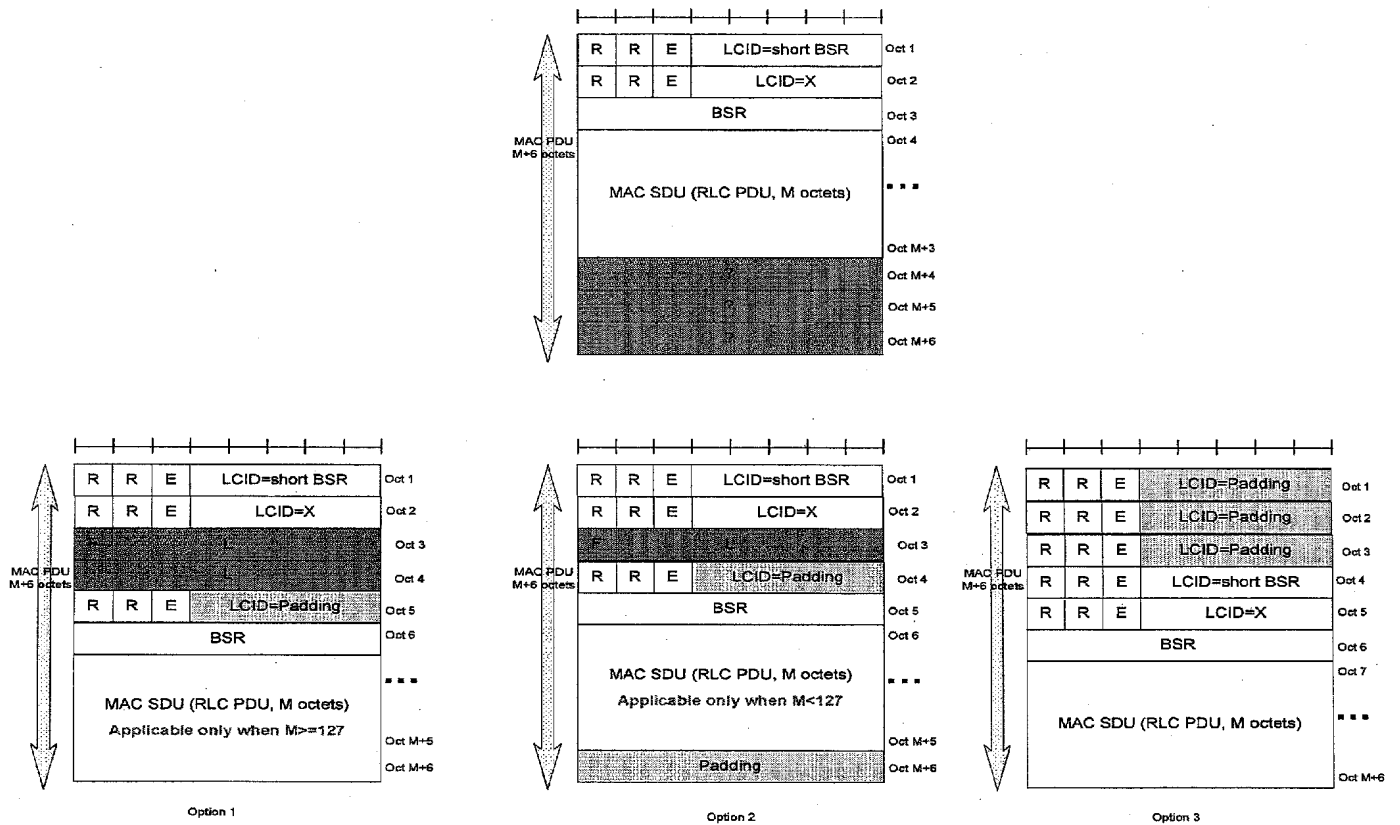


Fig. 2 Option set 1

Option 1 and 2 violates the agreement of the CR324. I.e., one or two byte padding should be at the beginning of the MAC PDU. And option 3 violates the current specification in that 3 byte padding is placed at the beginning of the MAC PDU.

There are other options as shown in the following figure 3:

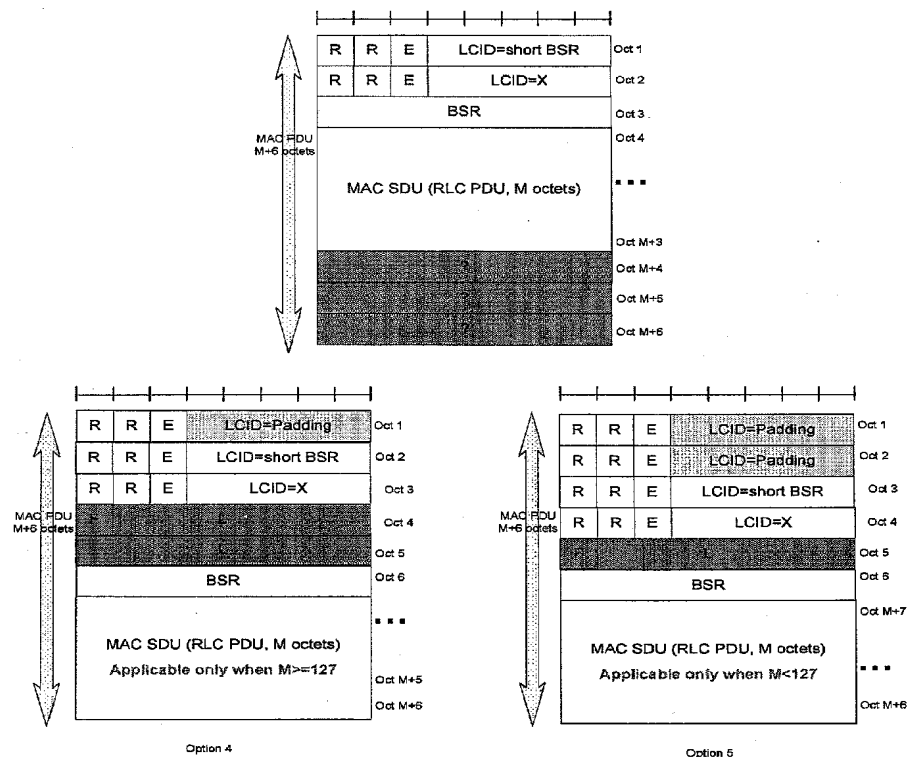


Fig. 3 Option set 2

However, above option 4 and option 5 also violates current specification because the last MAC Subheader cannot include "F/L" fields.

6.1.2 MAC PDU (DL-SCH and UL-SCH except transparent MAC and Random Access Response)

A MAC PDU subheader consists of the six header fields R/R/E/LCID/F/L but for the last subheader in the MAC PDU and for fixed sized MAC control elements. The last subheader in the MAC PDU and subheaders for fixed sized MAC control elements consist solely of the four header fields R/R/E/LCID. A MAC PDU subheader corresponding to padding consists of the four header fields R/R/E/LCID.

2. Discussion

To root of the problem described in the section 1 is that it is not clear what is meant by "when single-byte or two-byte padding is required"

Regarding the interpretation of "when single-byte or two-byte padding is required", there are two alternatives:

- Alt.1: The actual amount of 'not useful data' in the actually transmitted MAC PDU. I.e., the sum of "padding (at the very end of PDU)" and "subheader for padding" in the finally composed MAC PDU.
- Alt.2: The amount of left space in the allocated radio resource after logical channel prioritization.

During the offline discussion, it was a common understanding that “when single-byte or two-byte padding is required” should be interpreted according to alternative 2.

This means, the number of required padding byte is the number of padding space after logical channel prioritization. In this logical channel prioritization, padding BSR is included and the normal MAC subheader is assumed. Here, normal MAC subheader means that the last MAC subheader does not include ‘F/L’ field.

With above clarification, for figure 1, 3 bytes padding is required. Thus, option 1 and option 2 is allowed.

3. Proposal

It was proposed to clarify the meaning of the ‘when single-byte or two-byte padding is required’. The draft CR is in [2].

3. Reference

- [1] R2-090087, MAC PDU subheaders corresponding to padding, Panasonic, Fujitsu
- [2] R2-09xxxx, Proposed CR correction on MAC Padding

Title: Discussion on RLC UM for MTCH

1. Introduction

At the last meeting RAN2#65bis, it was agreed that RLC UM is used for MTCH.

In Rel-9, only MCH is used for MBMS. Because MCH does not support HARQ and eNB cannot perform quick-repeat on a data from GW, it is obvious that there is no possibility of out-of-delivery from lower layer. This means that re-ordering functionality is not needed for MTCH. Due to the agreement from the last meeting that *"Will only make changes to RLC-UM if really necessary."*, the only way to disable re-ordering functionality is to apply '0ms' as a timer value for T-Reordering timer.

2. Discussion

When T-Reordering timer value is set to '0ms' or very short value, a problem occurs when a UE falls into out-of-service for a short period. For example, when T-Reordering timer value is set to '0ms', VR(UH) and VR(UR) is always set to same value. Thus, all the received RLC PDUs with SN within Receiving Window are discarded because there are regarded as duplicates. This is shown in the following example figure where SN length is 2bit.

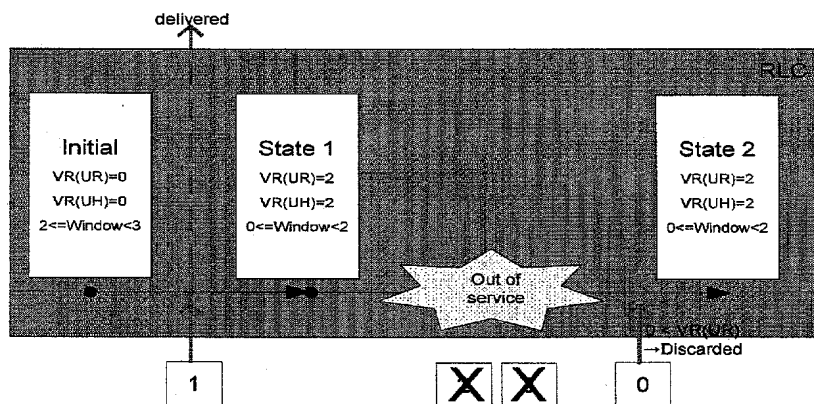


Fig. 1 Too short timer value

To avoid above problem, one can argue to use long timer value. However, this can cause unnecessary delay, considering that there is no duplicate/no retransmission.

Furthermore, when the T-Reordering value is set to longer value, this can cause data corruption.

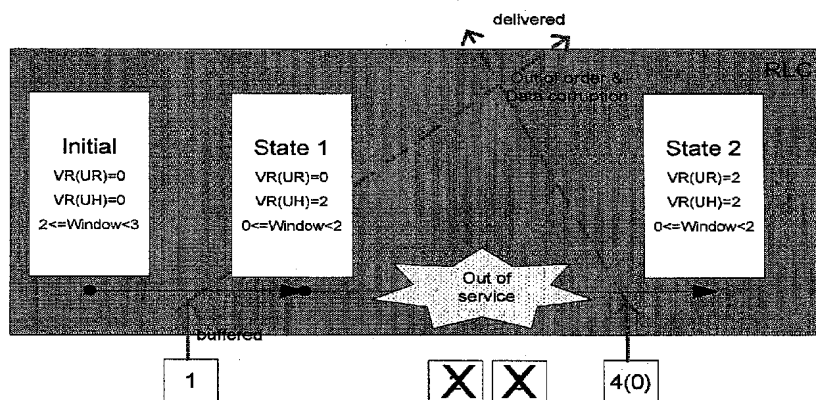


Fig. 2 Too long timer value

In above figure 2, when PDU 1 is received, this is put in the reordering buffer. If the re-ordering timer has not expired until the UE comes into in-service area, the newly received PDU 0 is regarded as the PDU that the reordering function has waited for. This leads to the data corruption and out-of-order delivery.

In case of Uni-cast data service, UE is in RRC connected mode and HARQ ACK/NACK channel is activated. Thus, eNB can detect whether a problematic situation such as SN-wrap-around has occurred or not.

However, in case of MBMS, there is no feedback channel and most of the UE will be in RRC-Idle mode. Thus, the erroneous situation is hard to detect.

3. Proposal

Option 1:

The simplest solution may be for the UE to re-establish RLC UM entity used for MTCH as soon as it comes back from out-of-service state.

Option 2:

Flush timer is defined. When a new PDU is received, this timer is started. When the timer expires, the PDU in the buffer is flushed or the RLC UM entity is re-established.

3. Reference

[1] R2-092706, MBMS baseline CR to 36.300 after RAN2#65bis, MBMS Rapporteur

Title: Discussion on Service Continuity

1. Discussion

There are several scenarios for mobility regarding MBSFN area:

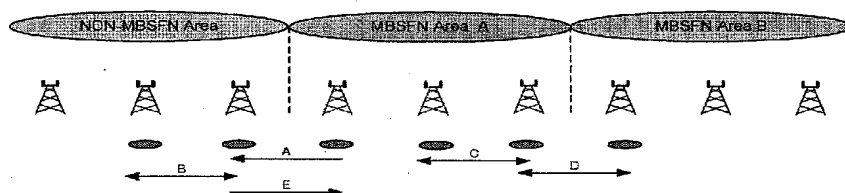


Fig.1 Mobility scenario

I.e., there are following 5 scenarios:

Scenario A: Mobility from a MBSFN cell to a Non-MBSFN cell.

Scenario B: Mobility between Non-MBSFN cells.

Scenario C: Mobility between MBSFN cells of same MBSFN area.

Scenario D: Mobility between MBSFN cells of different MBSFN area.

Scenario E: Mobility from a Non-MBSFN cell to a MBSFN cell.

At the last meeting RAN2#65bis, following was agreed for MBMS

- Agreement 5): No AS level mechanism for service continuity will be defined for mobility outside cells belonging to the MBSFN area.
- Agreement 6): MBMS does not affect unicast mobility procedures.
- Agreement 7): No information is provided to help the UE in switching reception between MBSFNs. Going from one MBSFN area to another is left up to UE implementation.

However, it is not clear to which scenario these agreements apply to. And, in previous meeting, all scenarios have not been considered.

2.1 Scenario A: Mobility from a MBSFN cell to a Non-MBSFN cell.

Basically, the agreement 5) seems not to target this scenario. In this scenario, there are 4 sub cases:

	Ongoing MBMS service	No Ongoing MBMS Service
Connected Mode UE	Because eNB is in control of mobility, there will be nothing AS can do.(agreement 6))	Because eNB is in control of mobility, there will be nothing AS can do. (agreement 6))
Idle Mode UE	The UE cannot receive any further data upon cell-reselection.	The UE does not experience any MBMS service interruption.

In Rel-9, MBMS is provided only by MBSFN. If a cell does not belong to MBSFN, it means that MBMS is not supported in the cell. Thus, it cannot be expected that Non-MBSFN cell will deliver any MBMS related information. In this sense, any eNB based solution may not work.

By the way, in this scenario A, when there is an ongoing MBMS service, the UE cannot receive any further data for the MBMS service as soon as the UE enters into a new cell. However, this scenario is different from the scenario where MBMS service stops due to the end of the MBMS program. If a user knows that he cannot receive any MBMS service due to out-of-MBSFN area, he may try to select other RATs.

In this case, a notification to NAS regarding whether current cell provides MBMS service is beneficial.

Proposal 1:

When serving cell changes, the AS informs NAS whether the new cell supports MBMS or not.

2.2 Scenario B: Mobility between Non-MBSFN cells.

The intention of the agreement 5) seems to target this scenario. However, it is ambiguous whether there will be neither "AS-NAS interaction" nor "NAS level mechanism". Though "NAS level mechanism" is not the scope of RAN WG2, "AS-NAS interaction" can be scope of RAN WG2.

One possibility for "AS-NAS interaction" is notification to NAS regarding whether current cell provides MBMS service or not. Proposal 1 seems also applicable here.

2.3 Scenario C: Mobility between MBSFN cells of same MBSFN area.

2.4 Scenario D: Mobility between MBSFN cells of different MBSFN area.

For the Connected Mode UE, the UE can do nothing because eNB is in control of mobility. However, eNB can do smart things if it has some information of the UE regarding MBMS. For example, if serving eNB knows that the UE has subscribed to a MBMS service, the eNB can put more weight to the MBSFN cell than to the Non-MBSFN cell for handover decision.

Proposal 2:

For connected mode UE, serving eNB has the MBMS context information. This context information comes from EPS and includes information such as whether the UE subscribes to MBMS or joined service list (details FFS).

For scenario C, all the cells within same MBSFN area will transmit identical PDCP/RLC PDU. Also, the RB configuration information will be same. Thus, there is no need for the UE to re-establish PDCP/RLC.

Proposal 3:

For the serving cell change between cells of same MBSFN area, RLC/PDCP for MTCH/MCCH is not re-established.

However, even for same MBMS service, cells of different MBSFN area may apply different configuration for the same MTCH/MCCH. In this case, RLC/PDCP should be re-established. Then, a mechanism is needed to differentiate scenario C from scenario D.

In addition to that, the identification whether the new cell belongs to the same MBSFN area as the last cell should be done fast. Otherwise, the interruption of MBMS service will be long.

One simple method for these goals is to include information such as MBSFN area ID into System Information. Because the first information that UE reads from a new cell is System information, the UE entering a new cell can easily identify whether the new cell and the old cell belongs to the same MBSFN. If MBSFN area ID information is included into SIB 1, it is even possible that UE starts receive MBMS service data even before acquiring other system information.

Proposal 3:

For the cell which supports MBSFN, MBSFN ID information is broadcast over system information such as SIB 1.

2.4 Scenario E: Mobility from a Non-MBSFN cell to a MBSFN cell.

In this case, there is nothing the Non-MBSFN cell can do for a UE. A UE entering a MBSFN area should identify the availability of MBMS service itself by finding MCCH.

3. Proposal

Xxxx

3. Reference

[1] R2-092706, MBMS baseline CR to 36.300 after RAN2#65bis, MBMS Rapporteur

Title: Discussion on Service Continuity

1. Discussion

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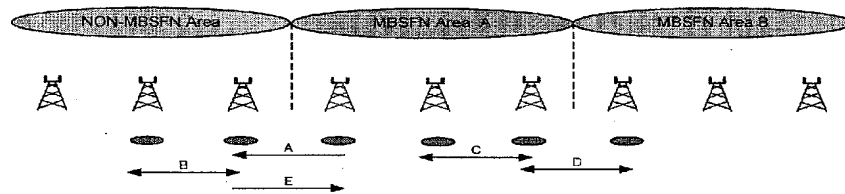


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Proposal 2:

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In this case, there is nothing the Non-MBSFN cell can do for a UE. A UE entering a MBSFN area should identify the availability of MBMS service itself by first finding MCCH.

3. Proposal

Xxxx

3. Reference

[1] R2-092706, MBMS baseline CR to 36.300 after RAN2#65bis, MBMS Rapporteur

3. ANNEX

SIB includes the list of PCIs. This PCI indicates the PCI of neighbouring cell which belong to the same MBSFN area as the current serving cell. Thus, when the UE changes serving cell, if the PCI of the new cell was included in the list of PCIs received in the previous cell, the UE consider that the new cell and the old cell belong to the same MBSFN. In this case, the UE can optimize reception of MBMS. I.e, the UE can skip the re-establishment of the PDCP/RLC/MAC for the MBMS service.

In the handover command (RRC Re-configuration) message), one bit indicator is included to notify UE whether it can continue the reception of MBMS service. I.e., this bit indicates whether the target cell and serving cell belong to the same MBSFN area or not. If this indication is set, the UE which was receiving MBMs in the serving cell can continue the reception of MBMS service using the configuration (which was used in the serving cell) also in the target cell. In this case, the UE can continue/start the MBMS reception even before accessing target cell, or before completion of handover or before the reception of MCCH/BCCH in the new cell.

DESCRIPTION OF THE RELATED ART

[0001] Universal mobile telecommunications system (UMTS) is a 3rd Generation (3G) asynchronous mobile communication system operating in wideband code division multiple access (WCDMA) based on European systems, global system for mobile communications (GSM) and general packet radio services (GPRS). The long-term evolution (LTE) of UMTS is under discussion by the 3rd generation partnership project (3GPP) that standardized UMTS.

[0002] The 3GPP LTE is a technology for enabling high-speed packet communications. Many schemes have been proposed for the LTE objective including those that aim to reduce user and provider costs, improve service quality, and expand and improve coverage and system capacity. The 3G LTE requires reduced cost per bit, increased service availability, flexible use of a frequency band, a simple structure, an open interface, and adequate power consumption of a terminal as an upper-level requirement.

[0003] FIG. 1 is a block diagram illustrating network structure of an evolved universal mobile telecommunication system (E-UMTS). The E-UMTS may be also referred to as an LTE system. The communication network is widely deployed to provide a variety of communication services such as voice and packet data.

[0004] As illustrated in FIG. 1, the E-UMTS network includes an evolved UMTS terrestrial radio access network (E-UTRAN), an Evolved Packet Core (EPC) and one or more user equipment. The E-UTRAN may include one or more evolved NodeB (eNodeB) 20, and a plurality of user equipment (UE) 10 may be located in one cell. One or more E-UTRAN mobility management entity (MME)/system architecture evolution (SAE) gateways 30 may be positioned at the end of the network and connected to an external network.

[0005] As used herein, “downlink” refers to communication from eNodeB 20 to UE 10, and “uplink” refers to communication from the UE to an eNodeB. UE 10 refers to communication equipment carried by a user and may be also be referred to as a mobile station (MS), a user terminal (UT), a subscriber station (SS) or a wireless device.

[0006] An eNodeB 20 provides end points of a user plane and a control plane to the UE 10. MME/SAE gateway 30 provides an end point of a session and mobility management function for UE 10. The eNodeB and MME/SAE gateway may be connected via an S1 interface.

[0007] The eNodeB 20 is generally a fixed station that communicates with a UE 10, and may also be referred to as a base station (BS) or an access point. One eNodeB 20 may be deployed per cell. An interface for transmitting user traffic or control traffic may be used between eNodeBs 20.

[0008] The MME provides various functions including distribution of paging messages to eNodeBs 20, security control, idle state mobility control, SAE bearer control, and ciphering and integrity protection of non-access stratum (NAS) signaling. The SAE gateway host provides assorted functions including termination of U-plane packets for paging reasons, and switching of the U-plane to support UE mobility. For clarity MME/SAE gateway 30 will be referred to herein simply as a "gateway," but it is understood that this entity includes both an MME and an SAE gateway.

[0009] A plurality of nodes may be connected between eNodeB 20 and gateway 30 via the S1 interface. The eNodeBs 20 may be connected to each other via an X2 interface and neighboring eNodeBs may have a meshed network structure that has the X2 interface.

[0010] FIG. 2 is a block diagram depicting architecture of a typical E-UTRAN and a typical EPC. As illustrated, eNodeB 20 may perform functions of selection for gateway 30, routing toward the gateway during a Radio Resource Control (RRC) activation, scheduling and transmitting of paging messages, scheduling and transmitting of Broadcast Channel (BCCH) information, dynamic allocation of resources to UEs 10 in both uplink and downlink, configuration and provisioning of eNodeB measurements, radio bearer control, radio admission control (RAC), and connection mobility control in LTE_ACTIVE state. In the EPC, and as noted above, gateway 30 may perform functions of paging origination, LTE-IDLE state management, ciphering of the user plane, System Architecture Evolution (SAE) bearer control, and ciphering and integrity protection of Non-Access Stratum (NAS) signaling.

[0011] FIGS. 3(a) and 3(b) are block diagrams depicting the user-plane protocol and the control-plane protocol stack for the E-UMTS. As illustrated, the protocol layers may be divided into a first layer (L1), a second layer (L2) and a third layer (L3) based upon the three lower layers of an open system interconnection (OSI) standard model that is well known in the art of communication systems.

[0012] The physical layer, the first layer (L1), provides an information transmission service to an upper layer by using a physical channel. The physical layer is connected with a medium access control (MAC) layer located at a higher level through a transport channel, and data between the MAC layer and the physical layer is transferred via the transport channel. Between different physical layers, namely, between physical layers of a transmission side and a reception side, data is transferred via the physical channel.

[0013] The MAC layer of Layer 2 (L2) provides services to a radio link control (RLC) layer (which is a higher layer) via a logical channel. The RLC layer of Layer 2 (L2) supports the transmission of data with reliability. It should be noted that the RLC layer illustrated in FIGS. 3(a) and 3(b) is depicted because if the RLC functions are implemented in and performed by the MAC layer, the RLC layer itself is not required. The PDCP layer of Layer 2 (L2) performs a header compression function that reduces unnecessary control information such that data being transmitted by employing Internet protocol (IP) packets, such as IPv4 or IPv6, can be efficiently sent over a radio (wireless) interface that has a relatively small bandwidth.

[0014] A radio resource control (RRC) layer located at the lowest portion of the third layer (L3) is only defined in the control plane and controls logical channels, transport channels and the physical channels in relation to the configuration, reconfiguration, and release of the radio bearers (RBs). Here, the RB signifies a service provided by the second layer (L2) for data transmission between the terminal and the UTRAN.

[0015] As illustrated in FIG. 3(a), the RLC and MAC layers (terminated in an eNodeB 20 on the network side) may perform functions such as Scheduling, Automatic Repeat Request (ARQ), and Hybrid Automatic Repeat Request (HARQ). The PDCP

layer (terminated in eNodeB 20 on the network side) may perform the user plane functions such as header compression, integrity protection, and ciphering.

[0016] As illustrated in FIG. 3(b), the RLC and MAC layers (terminated in an eNodeB 20 on the network side) perform the same functions as for the control plane. As illustrated, the RRC layer (terminated in an eNodeB 20 on the network side) may perform functions such as broadcasting, paging, RRC connection management, Radio Bearer (RB) control, mobility functions, and UE measurement reporting and controlling. The NAS control protocol (terminated in the MME of gateway 30 on the network side) may perform functions such as a SAE bearer management, authentication, LTE_IDLE mobility handling, paging origination in LTE_IDLE, and security control for the signaling between the gateway and UE 10.

[0017] The NAS control protocol may use three different states; first, a LTE_DETACHED state if there is no RRC entity; second, a LTE_IDLE state if there is no RRC connection while storing minimal UE information; and third, an LTE_ACTIVE state if the RRC connection is established. Also, the RRC state may be divided into two different states such as a RRC_IDLE and a RRC_CONNECTED.

[0018] In RRC_IDLE state, the UE 10 may receive broadcasts of system information and paging information while the UE specifies a Discontinuous Reception (DRX) configured by NAS, and the UE has been allocated an identification (ID) which uniquely identifies the UE in a tracking area. Also, in RRC-IDLE state, no RRC context is stored in the eNodeB.

[0019] In RRC_CONNECTED state, the UE 10 has an E-UTRAN RRC connection and a context in the E-UTRAN, such that transmitting and/or receiving data to/from the network (eNodeB) becomes possible. Also, the UE 10 can report channel quality information and feedback information to the eNodeB.

[0020] In RRC_CONNECTED state, the E-UTRAN knows the cell to which the UE 10 belongs. Therefore, the network can transmit and/or receive data to/from UE 10, the network can control mobility (handover) of the UE, and the network can perform cell measurements for a neighboring cell.

[0021] In RRC_IDLE mode, the UE 10 specifies the paging DRX (Discontinuous Reception) cycle. Specifically, the UE 10 monitors a paging signal at a specific paging occasion of every UE specific paging DRX cycle.

[0022] The paging occasion is a time interval during which a paging signal is transmitted. The UE 10 has its own paging occasion.

[0023] A paging message is transmitted over all cells belonging to the same tracking area. If the UE 10 moves from one tracking area to another tracking area, the UE will send a tracking area update message to the network to update its location.

[0024] A physical channel transfers signaling and data between layer L1 of a UE and eNB. As illustrated in FIG. 4, the physical channel transfers the signaling and data with a radio resource, which consists of one or more sub-carriers in frequency and one more symbols in time.

[0025] One sub-frame, which is 1.0 ms. in length, consists of several symbols. The particular symbol(s) of the sub-frame, such as the first symbol of the sub-frame, can be used for the L1 / L2 control channel. The L1 / L2 control channel carries L1 / L2 control information, such as signaling.

[0026] A transport channel transfers signaling and data between the L1 and MAC layers. A physical channel is mapped to a transport channel.

[0027] Downlink transport channel types include a Broadcast Channel (BCH), a Downlink Shared Channel (DL-SCH), a Paging Channel (PCH) and a Multicast Channel (MCH). The BCH is used for transmitting system information. The DL-SCH supports HARQ, dynamic link adaptation by varying the modulation, coding and transmit power, and both dynamic and semi-static resource allocation. The DL-SCH also may enable broadcast in the entire cell and the use of beamforming. The PCH is used for paging a UE. The MCH is used for multicast or broadcast service transmission.

[0028] Uplink transport channel types include an Uplink Shared Channel (UL-SCH) and Random Access Channel(s) (RACH). The UL-SCH supports HARQ and dynamic link adaptation by varying the transmit power and potentially modulation and coding. The UL-SCH also may enable the use of beamforming. The RACH is normally used for initial access to a cell.

[0029] The MAC sublayer provides data transfer services on logical channels. A set of logical channel types is defined for different data transfer services offered by MAC. Each logical channel type is defined according to the type of information transferred.

[0030] Logical channels are generally classified into two groups. The two groups are control channels for the transfer of control plane information and traffic channels for the transfer of user plane information.

[0031] Control channels are used for transfer of control plane information only. The control channels provided by MAC include a Broadcast Control Channel (BCCH), a Paging Control Channel (PCCH), a Common Control Channel (CCCH), a Multicast Control Channel (MCCH) and a Dedicated Control Channel (DCCH). The BCCH is a downlink channel for broadcasting system control information. The PCCH is a downlink channel that transfers paging information and is used when the network does not know the location cell of a UE. The CCCH is used by UEs having no RRC connection with the network. The MCCH is a point-to-multipoint downlink channel used for transmitting MBMS control information from the network to a UE. The DCCH is a point-to-point bi-directional channel used by UEs having an RRC connection that transmits dedicated control information between a UE and the network.

[0032] Traffic channels are used for the transfer of user plane information only. The traffic channels provided by MAC include a Dedicated Traffic Channel (DTCH) and a Multicast Traffic Channel (MTCH). The DTCH is a point-to-point channel, dedicated to one UE for the transfer of user information and can exist in both uplink and downlink. The MTCH is a point-to-multipoint downlink channel for transmitting traffic data from the network to the UE.

[0033] Uplink connections between logical channels and transport channels include a DCCH that can be mapped to UL-SCH and a DTCH that can be mapped to UL-SCH. Downlink connections between logical channels and transport channels include a BCCH that can be mapped to BCH, a PCCH that can be mapped to PCH, a DCCH that can be mapped to DL-SCH, and a DTCH that can be mapped to DL-SCH.

[0034] It is known that different cause values may be mapped on the signature sequence used to send messages between a UE and eNB and that either Channel Quality Indicator (CQI) or path loss and cause or message size are candidates for

inclusion in the initial preamble. FIG. 5 illustrates different messages exchanged between a UE and eNB during initial access.

[0035] When a UE wishes to access the network and determines a message to be transmitted, the message may be linked to a purpose and a cause value may be determined. The size of the ideal message number 3 illustrated in FIG. 5 may also be determined by identifying all optional information and different alternative sizes, such as by removing optional information, or an alternative "scheduling request" message may be used.

[0036] The UE acquires necessary information for the transmission of the preamble, UL interference, Pilot Transmit power and required Signal-to-Noise Ratio (SNR) for the preamble detection at the receiver or combinations thereof. This information must allow the calculation of the initial transmit power of the preamble. It is beneficial to transmit the uplink message in the vicinity of the preamble from a frequency point of view in order to ensure that the same channel is used for the transmission of the message.

[0037] The UE should take into account the uplink interference and the uplink path loss in order to ensure that the network receives the preamble with a minimum SNR. The uplink interference can be determined only in the ENodeB and, therefore, must be broadcast by the ENodeB and received by the UE prior to the transmission of the preamble. The uplink path loss can be considered to be similar to the downlink path loss and can be estimated by the UE from the received Rx (receiver) signal strength when the transmit power of some pilot sequence of the cell is known to the UE.

[0038] The required uplink SNR for the detection of the preamble would typically depend on the NodeB configuration, such as a number of Rx antennas and receiver performance. There may be advantages to transmitting the rather static Transmit power of the pilot and the necessary uplink SNR separately from the varying uplink interference and possibly the power offset required between the preamble and the message.

[0039] The initial transmission power of the preamble can be roughly calculated according to the following formula:

[0040] $\text{Transmit power} = \text{TransmitPilot} - \text{RxPilot} + \text{ULInterference} + \text{Offset} + \text{SNRRequired}$.

[0041] Therefore, any combination of SNRRequired, ULInterference, TransmitPilot and Offset can be broadcast. In principle, only one value must be broadcast. This is essentially the method in current UMTS systems, although the UL interference in LTE will mainly be neighboring cell interference that is probably more constant than in UMTS.

[0042] The UE determines the initial uplink transmit power for the transmission of the preamble as explained above. The receiver in the eNB is able to estimate the absolute received power as well as the relative received power compared to the interference in the cell. The eNB will consider a preamble detected if the received signal power compared to the interference is above an eNB known threshold.

[0043] The UE performs power ramping in order to ensure that a UE can be detected even if the initially estimated transmission power for the preamble is not adequate. Another preamble will most likely be transmitted if no acknowledgement or a negative acknowledgement is received by the UE before the next random access attempt. The transmit power of the preamble can be increased, and / or the preamble can be transmitted on a different uplink frequency in order to increase the probability of detection. Therefore, the actual transmit power of the preamble that will be detected does not necessarily correspond to the initial transmit power of the preamble as initially calculated by the UE.

[0044] The UE must determine the possible uplink transport format. The transport format, which may include Modulation and Coding Scheme (MCS) and a number of resource blocks that should be used by the UE, depends mainly on two parameters, specifically the SNR at the eNB and the required size of the message to be transmitted.

[0045] In practice, a maximum UE message size, or payload, and a required minimum SNR correspond to each transport format. In UMTS, the UE determines before the transmission of the preamble whether a transport format can be chosen for the transmission according to the estimated initial preamble transmit power, the required offset between preamble and the transport block, the maximum allowed or available UE

transmit power, a fixed offset and additional margin. The preamble in UMTS need not contain any information regarding the transport format selected by the UE since the network does not need to reserve time and frequency resources and, therefore, the transport format is indicated together with the transmitted message.

[0046] The eNB must be aware of the size of the message that the UE intends to transmit and the SNR achievable by the UE in order to select the correct transport format upon reception of the preamble and then reserve the necessary time and frequency resources. Therefore, the eNB cannot estimate the SNR achievable by the UE according to the received preamble because the UE transmit power compared to the maximum allowed or possible UE transmit power is not known to the eNB, given that the UE will most likely consider the measured path loss in the downlink or some equivalent measure for the determination of the initial preamble transmission power.

[0047] The eNB could calculate a difference between the path loss estimated in the downlink compared and the path loss of the uplink. However, this calculation is not possible if power ramping is used and the UE transmit power for the preamble does not correspond to the initially calculated UE transmit power. Furthermore, the precision of the actual UE transmit power and the transmit power at which the UE is intended to transmit is very low. Therefore, it has been proposed to code the path loss or CQI estimation of the downlink and the message size or the cause value in the uplink in the signature.

BRIEF DESCRIPTION OF THE DRAWINGS

[0048] FIG. 1 illustrates a block diagram illustrating network structure of an evolved universal mobile telecommunication system (E-UMTS).

[0049] FIG. 2 illustrates a block diagram depicting architecture of a typical E-UTRAN and a typical EPC.

[0050] FIG. 3(a) illustrates the user-plane protocol for the E-UMTS.

[0051] FIG. 3(b) illustrates the control-plane protocol stack for the E-UMTS

[0052] FIG. 4 illustrates a Structure of the physical channel.

[0053] FIG. 5 illustrates a Random Access procedure for E-UTRAN initial access.

[0054] FIG. 6 illustrates a block diagram of a mobile station (MS) or access terminal (AT) according to the present invention.

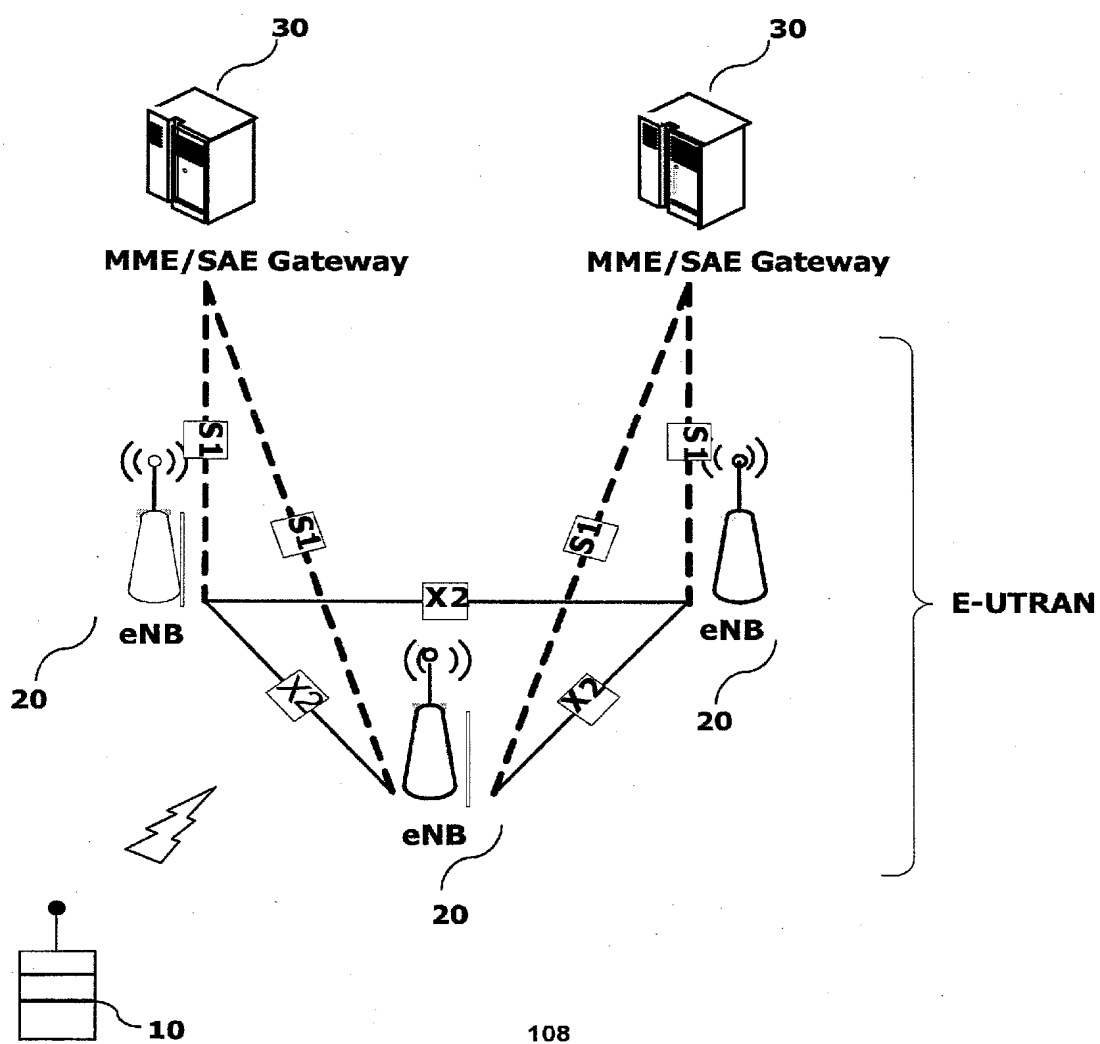
Fig. 1

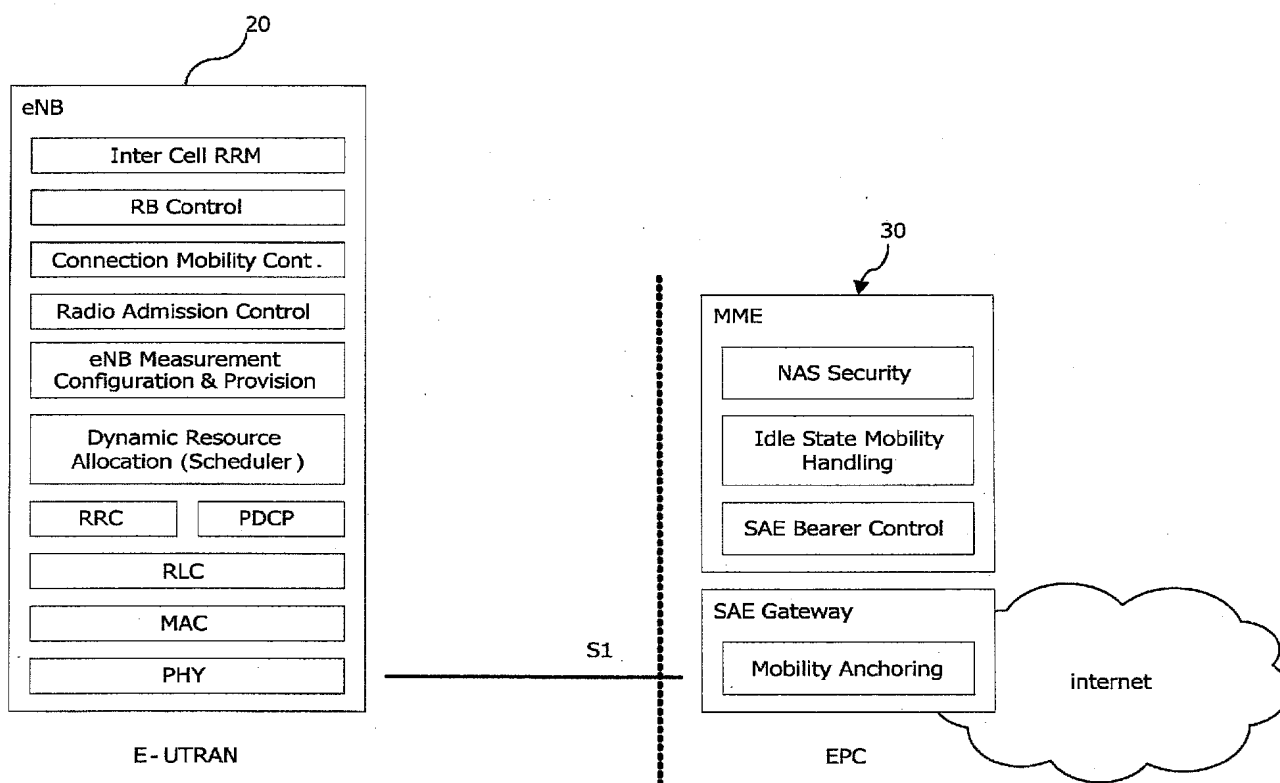
Fig. 2

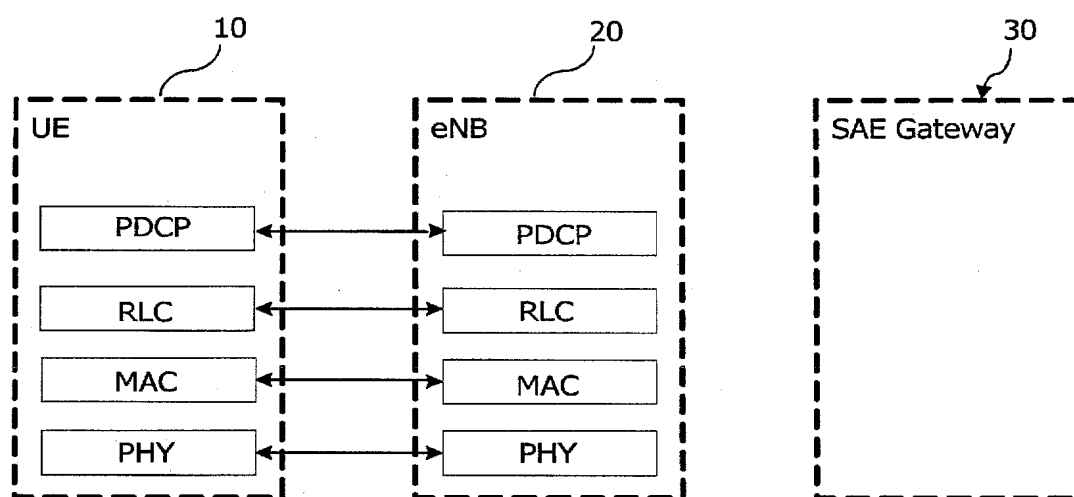
Fig. 3(a)

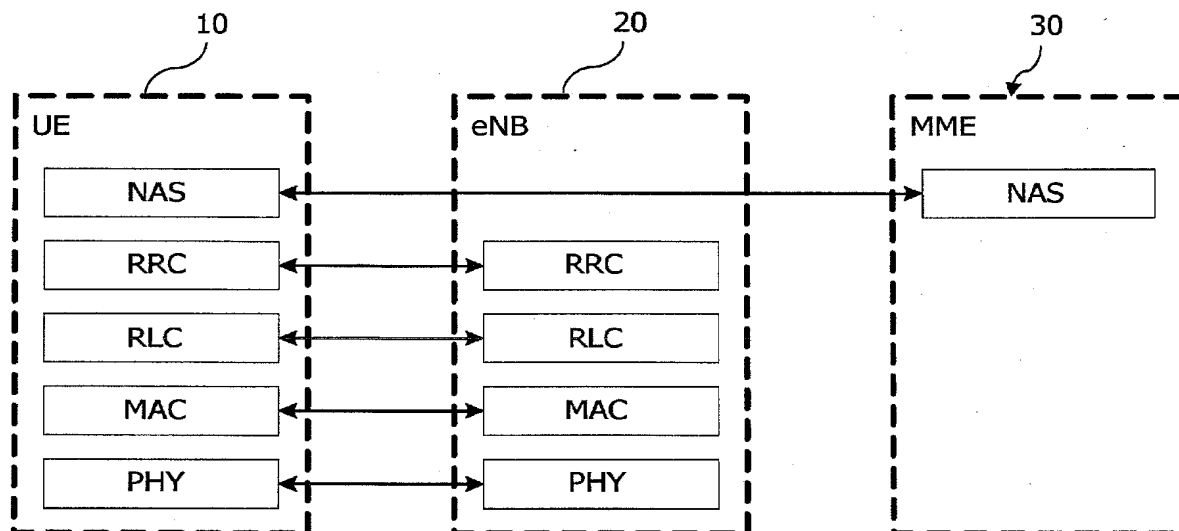
Fig. 3(b)

Fig. 4
Structure of the physical channel

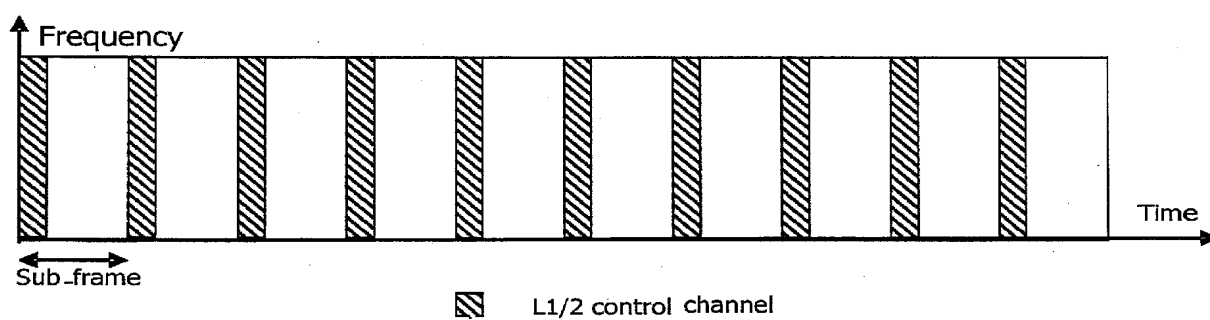


Fig. 5
Random Access procedure for E-UTRAN initial access

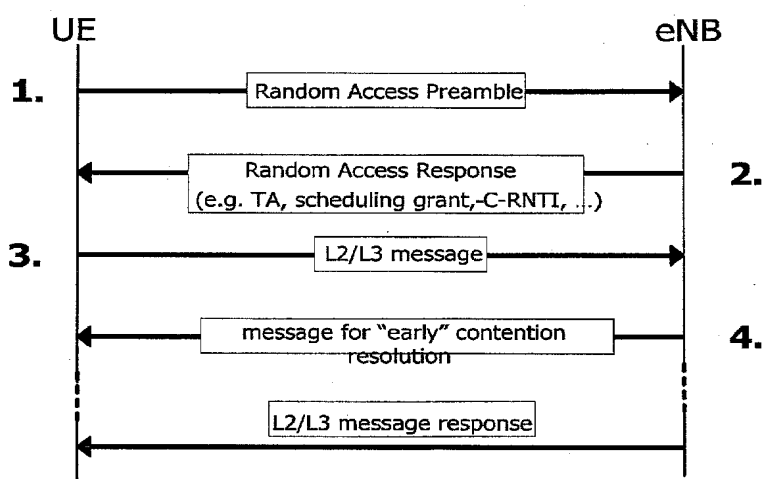
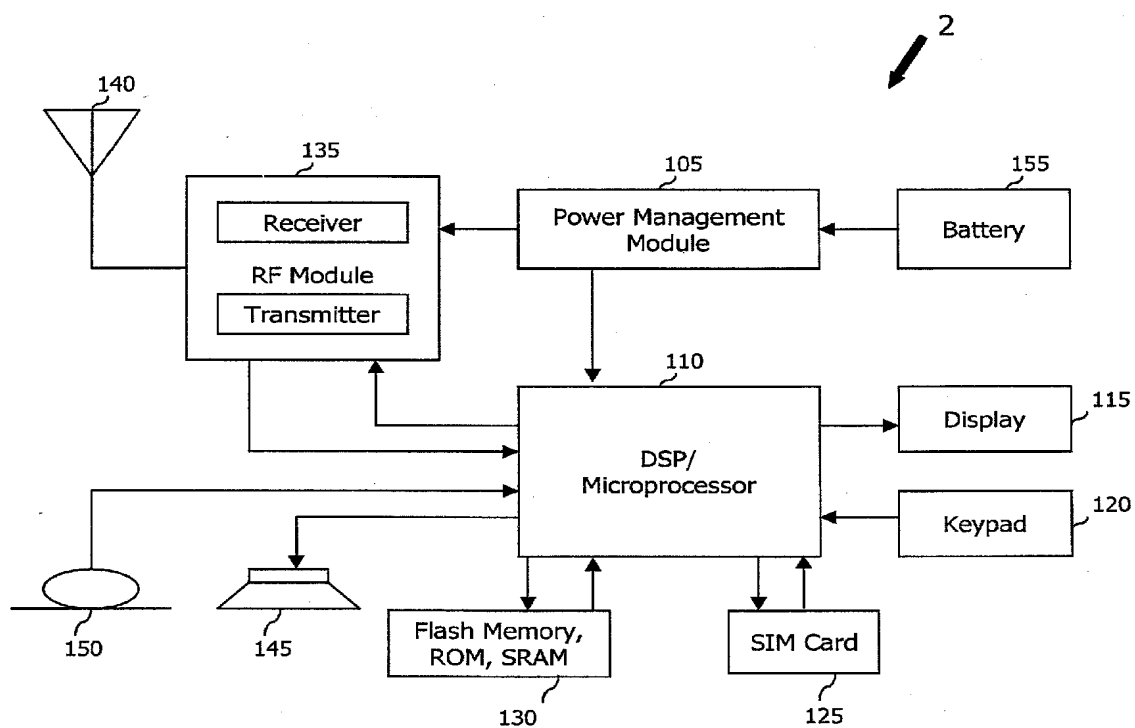


Fig. 6
MOBILE STATION/ACCESS TERMINAL



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Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		UT09556_T.pdf	12266420 1460faf2e36c79170bf8f745e5cad5cb0834e343	yes	116

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Docket No.: UT09-0556
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Seung June YI, et al.

Application No.: 61/171,440

Confirmation No.: 7472

Filed: April 21, 2009

Art Unit:

For: BEARER MAPPING IN RELAY NODE

Examiner:

**REPLY TO LETTER RE NON-ENGLISH LANGUAGE
APPLICATION PAPERS IN A PROVISIONAL APPLICATION**

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Examiner:

In response to the Letter re Non-English Language Application Papers in a Provisional Application forwarded with the Official Filing Receipt dated April 28, 2009, for the above-identified Provisional application, and in accordance with 37 C.F.R. 1.78(a)(5), enclosed are:

1. An English Translation of the Specification; and
2. A statement of Verification dated April 19, 2010.

Respectfully submitted,

Dated: April 19, 2010
Customer No. 67487

By: 

Andrew S. PARK
Registration No.: 47,841
KBK & Associates

VERIFICATION

I, Hyunjung KIM(Name of translator), residing at 10F., Songam Bldg., #642-10, Yeoksam-dong, Gangnam-gu, Seoul, Republic of Korea state that the attached document is a true and complete translation to the best of my knowledge of the Korean and English languages and that the writings contained in the following pages are a correct English translation of the specification of United States Provisional Application No. 61/171,440 filed on April 21, 2009.

Date: April 19, 2010

Signature of translator: KZM. Hyunjung