

**IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TEXAS
TEXARKANA DIVISION**

PANTECH CORPORATION and PANTECH
WIRELESS, LLC

Plaintiffs,

v.

LG ELECTRONICS INC., and LG
ELECTRONICS U.S.A., INC.,

Defendants.

Case No.

JURY TRIAL DEMANDED

COMPLAINT FOR PATENT INFRINGEMENT

Plaintiffs Pantech Corporation (“Pantech Corp.”) and Pantech Wireless, LLC (“Pantech Wireless”) (collectively, “Plaintiffs” or “Pantech”), for their Complaint against Defendants LG Electronics Inc. (“LGE”) and LG Electronics U.S.A., Inc. (“LGEUS”) (collectively, “LG” or “Defendants”), allege the following:

NATURE OF THE ACTION

1. This is an action for patent infringement arising under the Patent Laws of the United States, 35 U.S.C. § 1, *et seq.*

THE PARTIES

2. Pantech Corp. is an entity organized under the laws of South Korea, with a place of business at 10F, 251, Gangnam-daero, Seocho-gu, Seoul 06735, Republic of Korea.

3. Pantech Wireless is the wholly owned subsidiary of Pantech Corp. Pantech Wireless is an entity organized under the laws of Texas, with a place of business at 3000 Polar Lane, #202, Cedar Park, TX 78613.

4. Defendant LG Electronics Inc. is a company under the laws of the Republic of Korea with its principal place of business at LG Twin Towers 20 Yoido-dong, Youngdungpo-gu, Seoul, South Korea.

5. Defendant LG Electronics U.S.A., Inc., is a Delaware corporation with a principal place of business at 111 Sylvan Avenue, North Building, Englewood Cliffs, New Jersey 07632. LGEUS is a wholly-owned subsidiary of LGE, and has regular and established places of business within this District at 2153-2155 Eagle Pkwy, Fort Worth, TX 76177 and 14901 Beach St, Fort Worth, TX 76177. LGEUS may be served with process through its Texas registered agent, United States Corporation Co., 211 East 7th Street, Suite 620, Austin, Texas 78701.

6. Defendants are or have been in the business of providing information and communication technology solutions. Specifically, Defendants have provided and made available for sale wireless telecommunications equipment, including smartphones and mobile devices.

JURISDICTION AND VENUE

7. This Court has subject matter jurisdiction over the subject matter of this action pursuant to 28 U.S.C. §§ 1331 and 1338(a) because the action arises under the patent laws of the United States, 35 U.S.C. § 271, *et seq.*

8. This Court has personal jurisdiction over Defendants pursuant to due process and/or the Texas Long Arm Statute because, inter alia, (i) Defendants have done and continue to do business in the United States, including in the State of Texas; (ii) Defendants have committed and continue to commit acts of patent infringement in the United States, including in the State of Texas, including making, using, offering to sell, and/or selling accused products in the United States and Texas, and/or importing accused products into the United States and Texas, including by Internet sales and sales via retail and wholesale stores, inducing others to commit acts of patent infringement in the United States and Texas, and/or committing a least a portion of any other

infringements alleged herein. LGEUS has maintained regular and established places of business within this District at 2153-2155 Eagle Pkwy, Fort Worth, TX 76177 and 14901 Beach St, Fort Worth, TX 76177. The address at 14901 Beach St, Fort Worth, TX 76177 is a distribution center. Defendants design, manufacture, distribute, import, offer for sale, and/or sell in the State of Texas and the Eastern District of Texas smartphones and tablets that infringe the Patents asserted in this matter. Further, Defendants have consented to jurisdiction for patent infringement actions wherein substantially the same accused devices are at issue, for example in *Spacetime3D, Inc. v. LG Electronics Inc. et al.*, No 2:22-cv-00049-RWS.

9. In addition, or in the alternative, this Court has personal jurisdiction over LGE pursuant to Fed. R. Civ. P. 4(k)(2).

10. Venue is proper in this district as to Defendants. LGEUS has maintained regular and established places of business within this District at 2153-2155 Eagle Pkwy, Fort Worth, TX 76177 and 14901 Beach St, Fort Worth, TX 76177. LGE is organized under the laws of South Korea. 28 U.S.C. § 1391(c)(3) provides that “a defendant not resident in the United States may be sued in any judicial district, and the joinder of such a defendant shall be disregarded in determining where the action may be brought with respect to other defendants.”

ACCUSED INSTRUMENTALITIES

11. Defendants make, use, sell and offer for sale, provide, and cause to be used, now and within the past six years, mobile phones, tablets, and certain other devices capable of operating on LTE and 5G cellular networks (the “Accused Instrumentalities”).

12. For example, Defendants advertise that the LG K22; LG K31; LG Arena 2; LG Aristo 3+; LG Aristo 3; LG Aristo 4+; LG Aristo 5; LG Dual Screen for LG VELVET 5G; LG Escape Plus; LG Fortune 2; LG Fortune 3; LG G5; LG G6; LG G6+; LG G7 fit; LG G7 ThinQ; LG G8 ThinQ; LG G8X ThinQ; LG G8X ThinQ Dual Screen; LG Harmony 3; LG Harmony 4;

LG Journey LTE; LG K20; LG K30; LG K31 Rebel; LG K40; LG K51; LG K8 (2018); LG K8+; LG K8S; LG K8X; LG K92 5G; LG Neon Plus; LG phoenix 4; LG Phoenix 5; LG Premier Pro LTE; LG Prime 2; LG Q7+; LG Q70; LG Rebel 4 LTE; LG Reflect; LG Risio 3; LG Risio 4; LG Solo LTE; LG Stylo 3 LTE (GSM); LG Stylo 3 Plus Titanium; LG Stylo 4; LG Stylo 4 Plus; LG Stylo 4+; LG Stylo 5; LG Stylo 5+; LG Stylo 5x; LG Stylo 6; LG Tribute Empire; LG Tribute Monarch; LG Tribute Royal; LG V20; LG V30; LG V30+; LG V35 ThinQ; LG V40 ThinQ; LG V50 ThinQ 5G; LG V60 ThinQ 5G; LG V60 ThinQ 5G Dual Screen; LG V60 ThinQ 5G UW; LG VELVET 5G; LG VELVET 5G UW; LG Wine 2; LG WING 5G; LG X venture; LG Xpression Plus; LG Xpression Plus 2; LG Xpression Plus 3, LG G Pad 5 10.1 FHD; LG G Pad F2 8.0; LG G Pad X II 8.0 PLUS; LG G Pad X II 10.1"; LG G Pad F 8.0" 2nd Gen; LG G Pad X 8.0"; LG G Pad F 8.0" 2nd Gen; LG G Pad F 8.0; LG G Pad X 10.1"; LG G Pad X 8.3; LG G Pad F7.0; LG G Pad 7.0 LTE; and LG G Pad 8.3 LTE devices are compliant with LTE and/or 5G cellular network standards. In addition, on information and belief, Defendants supply Telematic Control Unit ("TCU") products that are compliant with at least LTE network standards, including Gen10, Gen10A, Gen10AL, Gen10ALNB, Gen10B, Gen10BL, Gen10BLNB, Gen10BTBU, Gen10C, Gen10CL, Gen10CLNB, Gen10D, Gen10DL, Gen10DLNB, Gen10L, Gen10LNB, and Gen11NAN.

PATENTS-IN-SUIT

13. The Asserted Patents are U.S. Patent Nos. 9,136,924; 9,854,545; 10,869,247; 9,313,809; 9,065,486; 7,283,839; and 9,575,631.

14. U.S. Patent No. 9,136,924 (the "'924 Patent") is entitled "Transmitting device and a method of communicating therewith, and receiving device and a method of communicating

therewith.” On May 7, 2020 Pantech Corp. obtained full and complete ownership, title and interest in the ’924 Patent.¹

15. U.S. Patent No. 9,854,545 (the “’545 Patent”) is entitled “Apparatus and method for establishing uplink synchronization in a wireless communication system.” On May 7, 2020 Pantech Corp. obtained full and complete ownership, title and interest in the ’545 Patent.²

16. U.S. Patent No. 10,869,247 (the “’247 Patent”) is entitled “Supporting uplink transmissions.” On April 27, 2021, Pantech Wireless obtained full and complete ownership, title and interest in the ’247 Patent.³

17. U.S. Patent No. 9,313,809 (the “’809 Patent”) is entitled “Method and apparatus for terminating transmission of a message in an enhanced random access channel.” On April 27, 2021, Pantech Wireless obtained full and complete ownership, title and interest in the ’809 Patent.⁴

¹ The named inventor of the ’924 Patent is Kyoungmin Park. The U.S. patent application is the national stage entry of PCT/KR2011/004835, filed July 1, 2011, and the ’924 Patent issued on September 15, 2015. On December 28, 2012, the inventor assigned the application underlying the ’924 Patent to Pantech Co., Ltd. On July 6, 2016, Pantech Co., Ltd., transferred the interest to Pantech Inc. On Oct. 31, 2016, Pantech Inc. transferred the interest to Goldpeak Innovations Inc. On May 7, 2020, Goldpeak Innovations Inc. transferred the interest to Pantech Corp.

² The named inventors of the ’545 Patent are Kibum Kwon and Myungcheul Jung. The U.S. Patent application was filed on June 8, 2015, and the ’545 Patent issued on December 26, 2017. On August 10, 2012, the inventors assigned the application underlying the ’545 Patent to Pantech Co., Ltd. On July 6, 2016, Pantech Co., Ltd. transferred the interest to Pantech Inc. On Oct. 31, 2016, Pantech Inc. transferred the interest to Goldpeak Innovations Inc. On May 7, 2020, Goldpeak Innovations Inc. transferred the interest to Pantech Corp.

³ The named inventors of the ’247 Patent are Guodong Zhang, Sung-Hyuk Shin, Stephen E. Terry, James M. Miller, and Stephen G. Dick. The U.S. patent application was filed on August 31, 2020 and the ’247 Patent issued on December 15, 2020. On October 5, 2006, the inventors assigned the parent application, U.S. Patent App. No. 10/962,720 and any continuations thereto, including the application underlying the ’247 Patent, to InterDigital Technology Corporation. On October 11, 2013, InterDigital Technology Corporation transferred the interest to InterDigital Holdings, Inc., who transferred the interest to InterDigital, Inc., who transferred the interest to DST Holdings, Inc. On October 15, 2013, DST Holdings, Inc. (InterDigital Technology Corporation, InterDigital Holdings, Inc., InterDigital, Inc. and DST Holdings, Inc., collectively, “InterDigital”) transferred the interest to Signal Trust for Wireless Innovation (“Signal Trust”). On December 30, 2020, Signal Trust transferred the interest to RnB Wireless LLC (“RnB Wireless”). On April 27, 2021, RnB Wireless transferred the interest to Pantech Wireless.

⁴ The named inventors of the ’809 Patent are Benoit Pelletier, Diana Pani, Rocco DiGirolamo, Christopher R. Cave, Vincent Roy, Paul Marinier, and Eldad M. Zeira. The U.S. Patent Application was filed June 30, 2014, and the ’809 Patent issued on April 12, 2016. Between November 24, 2008 and December 5, 2008, the inventors assigned the application underlying the ’809 Patent to InterDigital Patent Holdings, Inc. On October 11, 2013, InterDigital Patent Holdings, Inc. transferred the interest to InterDigital Holdings, Inc., who transferred the interest to InterDigital Inc.,

18. U.S. Patent No. 9,065,486 (the “’486 Patent”) is entitled “Detection, avoidance and/or correction of problematic puncturing patterns in parity bit streams used when implementing turbo codes.” On April 27, 2021, Pantech Wireless obtained full and complete ownership, title and interest in the ’486 Patent.⁵

19. U.S. Patent No. 7,283,839 (the “’839 Patent”) is entitled “Wireless communicating terminal for providing integrated messaging service and method thereof.” On May 7, 2020 Pantech Corp. obtained full and complete ownership, title and interest in the ’839 Patent.⁶

20. U.S. Patent No. 9,575,631 (the “’631 Patent”) is entitled “Method for selecting and controlling second work process during first work process in multitasking mobile terminal.” On May 7, 2020 Pantech Corp. obtained full and complete ownership, title and interest in the ’631 Patent.⁷

who transferred the interest to DST Holdings. Inc. On October 15, 2013, DST Holdings, Inc. transferred the interest to Signal Trust. On December 30, 2020, Signal Trust transferred the interest to RnB Wireless. On April 27, 2021, RnB Wireless transferred the interest to Pantech Wireless.

⁵ The named inventors of the ’486 Patent are Philip J. Pietraski and Gregory S. Sternberg. The U.S. Patent Application was filed June 10, 2014, and the ’486 Patent issued on June 23, 2015. On April 28, 2004, the inventors assigned the application underlying the ’486 Patent to InterDigital Technology Corporation. On January 21, 2016, InterDigital Technology Corporation transferred the interest to InterDigital Holdings, Inc., who transferred the interest to InterDigital, Inc., who transferred the interest to DST Holdings. Inc. On February 9, 2016, DST Holdings, Inc. transferred the interest to Signal Trust. On March 17, 2016 Signal Trust transferred the interest to InterDigital Holdings, Inc., who transferred the interest to InterDigital, Inc., who transferred the interest to DST Holdings. Inc. On December 30, 2020, DST Holdings. Inc. transferred the interest to RnB Wireless. On April 27, 2021, RnB Wireless transferred the interest to Pantech Wireless.

⁶ The named inventors of the ’839 Patent are Jin-Woo You and SangWoo Suk. The U.S. Patent Application was filed April 13, 2005, and the ’839 Patent issued on October 16, 2007. On July 8, 2005, the inventors assigned the application underlying the ’839 Patent to Curitel Communications, Inc. On August 2, 2002, Curitel Communications Inc. changed its name to Pantech & Curitel Communications Inc. On December 30, 2009, Pantech & Curitel Communications Inc. transferred its interest to Pantech Co., Ltd. On October 22, 2015, Pantech Co., Ltd. transferred its interest to Pantech Inc. On Oct. 31, 2016, Pantech Inc. transferred the interest to Goldpeak Innovations Inc. On May 7, 2020, Goldpeak Innovations Inc. transferred the interest to Pantech Corp.

⁷ The named inventors of the ’631 Patent are Seul Ki Choi and Sang Jin Yoon. The U.S. Patent Application was filed January 29, 2016, and the ’631 Patent issued on February 21, 2017. On July 10, 2006, the inventors assigned the application underlying the ’631 Patent to Pantech & Curitel Communications Inc. On December 30, 2009, Pantech & Curitel Communications Inc. transferred its interest to Pantech Co., Ltd. On October 22, 2015, Pantech Co., Ltd. transferred its interest to Pantech Inc. On Oct. 31, 2016, Pantech Inc. transferred the interest to Goldpeak Innovations Inc. On May 7, 2020, Goldpeak Innovations Inc. transferred the interest to Pantech Corp.

21. Pantech Corp. is the rightful owner of the '924, '545, '839, and '631 Patents and holds the entire right, title and interest in the '924, '545, '839, and '631 Patents, including the right to collect for past damages.

22. Pantech Wireless is the rightful owner of the '247, '809, and '486 Patents and holds the entire right, title and interest in the '247, '809, and '486 Patents, including the right to collect for past damages.

BACKGROUND

Pantech Corp. and the Asserted Patents

23. Pantech Co., Ltd., the predecessor in interest to what is now Pantech Corp.,⁸ was originally founded in 1991 in Seoul, South Korea as a competitor in the wireless phone marketplace.

24. Throughout the 1990s and 2000s, Pantech rose to become a leading manufacturer of mobile phones. By 2012, Pantech had become the second best-selling Korean handset maker.

25. Pantech's products were sold in South Korea, the United States, Japan, China, Europe, Vietnam, and other countries around the world. Pantech launched operations in the United States in 2003.

26. Pantech's portfolio of intellectual property is broad and extensive, comprising thousands of worldwide patents and patent applications in the areas of telecommunications, "smart" devices, and Internet of Things products. Pantech's portfolio, in one aspect, covers wireless communication systems and devices and methods for using those communication systems. In the

⁸ Pantech Co., Ltd. was formed in 1991, and as the result of a restructuring and acquisition in 2015 became Pantech, Inc. Thereafter, Pantech Corporation was formed. Pantech, Inc. transferred its assets to Pantech Corp. as part of an asset sale in 2020 (these three entities are hereinafter referred to collectively as "Pantech").

wireless technology space alone, Pantech holds more than 200 U.S. patents and applications, many of which have been declared standard essential patents.

27. Pantech has invested heavily in research and development, investing, on average, over 10% of its annual revenue in research and development. Pantech's research and development efforts in network technology include, but are not limited to, technologies focused on LTE & 5G networks, WCDMA/CDMA, WiMAX, Wi-Fi, Near Field Communication (NFC), Visible Light Communication, Human Body Communication, Ultra-Wideband Communication and IP Mesh Network.

28. Over the last decade, Pantech has enthusiastically contributed to the 3rd Generation Partnership Project (3GPP) LTE/LTE-A standardization by submitting proposals to TSG RAN, RAN1, and RAN2. Indeed, Pantech secured numerous LTE Standard Essential Patents and patent applications (SEPs) in connection with its contributions. In 2014, National Applied Research Labs in Taiwan reported that Pantech held 1% of LTE-related SEPs, and that number has only increased since 2014.

29. Recognizing the value of its own portfolio and its potential role in the Fourth Industrial Revolution, Pantech has committed to making its intellectual property available in the marketplace, including to competitors. On its website, under the heading "IP Umbrella Services," Pantech offers to exchange intellectual property and technology, and collaborate with competitors and patent holders, through licenses, to enable the market to identify new technological ventures.

30. Pantech Corp. is the owner by assignment of a portfolio of patents, including the Asserted Patents described in paragraphs 14, 15, 19, and 20 and in detail in the counts below, that relate to mobile device user interface features and technology for cellular communications

networks, including variations or generations of cellular communication network technology such as, but not limited to LTE, as discussed herein.

Pantech Wireless and the Asserted Patents

31. InterDigital is a wireless research and development company that has, for decades, been a pioneer in the development of fundamental wireless technologies that are at the core of mobile devices, networks, and services worldwide. InterDigital has been one of the major contributors to worldwide wireless standards over the past 20 years.

32. In 2013, InterDigital established Signal Trust to monetize various patents and patent applications relating to cellular wireless technologies developed by InterDigital's engineers and researchers over more than a decade. Distributions from Signal Trust were earmarked to, among other things, support continued research related to cellular wireless technologies, as well as scholarly analysis of intellectual property rights and the technological, commercial, and creative innovations they facilitate.

33. A portion of the patent portfolio originally created by InterDigital and transferred to Signal Trust was thereafter transferred to RnB Wireless and then to Pantech Wireless.

34. Pantech Wireless is the owner by assignment of a portfolio of patents, including the Asserted Patents described in paragraphs 16-18 above and in the counts below, that relate to technologies used in cellular communications networks and associated devices, including, but not limited to 3G, 4G/LTE, and 5G technologies, as discussed herein.

Negotiations Between the Parties

35. Cellular communication network technology is used to provide data transmission across mobile cellular networks.

36. It is critical for cellular communication network technology to be standardized around the globe. Independent standard-setting organizations, like the European Telecommunications Standards Institute (ETSI), establish global standards for the telecommunication industries. ETSI, along with other standard-setting organizations, have made it possible to have global interoperability between networks, devices and network operators.

37. ETSI sets forth a policy in order to balance intellectual property protections against the need for an open standard by designating certain intellectual property rights (IPR) as “essential.” ETSI sets forth the following definition of “essential”:

“ESSENTIAL” as applied to IPR means that it is not possible on technical (but not commercial) grounds, taking into account normal technical practice and the state of the art generally available at the time of standardization, to make, sell, lease, otherwise dispose of, repair, use or operate EQUIPMENT or METHODS which comply with a STANDARD without infringing that IPR. For the avoidance of doubt in exceptional cases where a STANDARD can only be implemented by technical solutions, all of which are infringements of IPRs, all such IPRs shall be considered ESSENTIAL.

Clause 15.6 of the ETSI IPR Policy, <https://www.etsi.org/images/files/IPR/etsi-ipr-policy.pdf>.

38. Defendants are required to have a license to one or more essential patents owned by Pantech Corp. and Pantech Wireless including the Asserted Patents that are identified as essential.

39. On September 22, 2020, Pantech Corp. first sent a letter to LGE and LGEUS offering to license patents currently owned and/or managed by Pantech Corp., including those that are essential to cellular standards including LTE and LTE-Advanced. The correspondence identified Defendants’ products that were covered by claims of the offered patents, identified exemplary patents infringed by LG and its customers and users, including the asserted ’545 and ’839 Patents, and attached a list of Pantech’s patents. On January 27, 2021, Pantech Corp. provided LGE with follow-up correspondence offering again to license its patent portfolio. The

correspondence again identified exemplary patents infringed by LG and its customers and users, including the asserted '924 and '631 Patents, and set forth Pantech's FRAND offer.

40. Following the January 27, 2021 letter, Pantech Corp. engaged in additional communication with LGE through emails, letters, and meetings regarding licensing patents owned by Pantech Corp., including those that are essential to cellular standards including LTE and 5G. For example, Pantech Corp. provided additional details regarding its portfolio, exemplary patents, and or its licensing proposal to LGE on at least February 15, 2021, March 10, 2021, and June 23, 2021, at which time discussions were enlarged to also include Pantech Wireless's portfolio. As set forth in further detail below, such discussions did not lead to a license.

41. On February 27, 2015, Signal Trust first sent a letter to Mr. Joo Sup Kim, Vice President of Intellectual Property for LG Electronics, Inc., offering to license Signal Trust's wireless patent portfolio, a portion of which is now owned by Pantech Wireless and includes the asserted '247, '809, and '486 Patents. Signal Trust followed up with additional correspondence, dated April 22, 2015, to Jeongsu Kang of LGE, providing LGE with claim charts for exemplary patents and identifying exemplary infringing LGE products. The provided claim charts included claim charts for priority patents to each of the asserted '247 and '809 Patents. On April 29, 2016, Signal Trust provided additional claim charts to LGE, including one for the asserted '809 Patent. The parties thereafter exchanged correspondence and/or held meetings regarding these patents or their families on at least May 3, 2016, October 19, 2016; November 2, 2016; February 10, 2017; February 15, 2017 (on which date a claim chart for the '486 patent was provided to LGE); April 19, 2017; September 7, 2017 (on which date LGE was provided new claim chart for another priority patent to the '247 Patent and the parties discussed the '486 Patent); December 12, 2017; May 8, 2018; August 23, 2019 (on which date LGE was provided yet another priority patent to

the '247 Patent); November 20, 2019; January 29, 2020; February 6, 2020; and July 3, 2020. The parties held at least three additional meetings and exchanged extensive correspondence regarding licensing terms during this timeframe as well.

42. On May 6, 2021, Pantech Corp. followed up on Signal Trust's prior negotiations by sending an email notifying LGE that Pantech Wireless had acquired a portion of the Signal Trust portfolio of patents, including the asserted '247, '809, and '486 Patents. On July 12, 2021, Pantech Corp. sent another letter to Mr. Sehyun Steve Kim of LGE wherein it reiterated its prior notification that Pantech Wireless had acquired a portion of the Signal Trust portfolio of patents and provided a list of the acquired patents. In this correspondence, Pantech specifically identified the asserted '247 Patent as an exemplary infringed patent and made a licensing offer that included the Pantech Wireless patents.

43. Since advising LGE of the Signal Trust portfolio acquisition, Pantech Corp. (on behalf of itself and Pantech Wireless) continued to engage in negotiations with LGE regarding a license to the Pantech Corp. and Pantech Wireless portfolios. The parties exchanged additional emails and letters, and held additional meetings, on at least September 16, 2021, September 28, 2021, October 12, 2021, November 30, 2021, December 22, 2021, January 4, 2022, June 30, 2022, and July 28, 2022. At these meetings, the parties held technical discussions regarding exemplary patents and also discussed Pantech's FRAND offer.

44. Pantech (and Signal Trust before it) has continuously attempted to license to LG their patents—including the patents asserted herein—for years on fair, reasonable, and nondiscriminatory terms ("FRAND"), yet LG has still elected not to license Pantech's patents. Indeed, despite the amount of time that has passed since Pantech first reached out, LG has never provided Pantech a counter offer. The result is that LG is an unwilling licensee that has, for several

years, made, used, sold, and offered for sale, and continues today to make, use, sell and offer for sale Pantech's patented technology without license.

45. In accordance with ETSI's policy, Pantech Corp. and Pantech Wireless (through Pantech Corp.) provided Defendants with multiple license offers on terms that are FRAND for both the Pantech Corp. and Pantech Wireless patents. The United States Department of Justice, with the United States Patent and Trademark Office (USPTO) and the National Institute of Standards and Technology (NIST), have made clear that patent owners and potential licensees of essential patents should "engage in good-faith negotiations to reach F/RAND license terms" to "help reduce the costs and other burdens associated with litigation." 2019 Policy Statement on Remedies for SEPs Subject to Voluntary F/RAND Commitments, <https://www.justice.gov/atr/page/file/1228016/download> (December 19, 2019).

46. Pantech Corp. and Pantech Wireless have made continuous and good faith efforts to negotiate a FRAND license with Defendants, including but not limited to providing technical details regarding the Asserted Patents and their "standards essential" nature and offering to license the Asserted Patents and other offered patents on FRAND terms. However, Defendants have not engaged in good faith discussions or negotiations with Pantech Corp. or Pantech Wireless.

47. Defendants have been operating and continue to operate without a license to Plaintiffs' standards-essential and other patents. The parties' licensing negotiations to-date have been unsuccessful because Defendants refused to accept Plaintiffs' FRAND licensing offers.

COUNT I – INFRINGEMENT OF U.S. PATENT NO. 9,136,924

48. The allegations set forth in the foregoing paragraphs 1 through 47 are incorporated into this claim for relief.

49. On September 15, 2015, the '924 Patent, entitled "Transmitting device and a method of communicating therewith, and receiving device and a method of communicating

therewith” was duly and legally issued by the United States Patent and Trademark Office from U.S. Patent Application No. 13/807,706, which was the national stage entry of International Application No. PCT/KR2011/004835, filed on July 1, 2011. The ’924 Patent claims priority to KR 10-2010-0064573, filed on July 5, 2010. A true and correct copy of the ’924 Patent is attached as Exhibit 1.

50. Pantech Corp. is the assignee and owner of all right, title and interest in and to the ’924 Patent, including the right to assert all causes of action arising under said patent and the right to any remedies for its infringement.

51. The ’924 Patent discloses at least apparatuses and methods for receiving codebook restriction information in a wireless system to restrict precoding matrixes of precoding matrix groups and transmit precoding matrix information indicating selecting a precoding matrix based on codebook restricting information. Codebook restriction may improve communication in a wireless system by, for example, reducing inter-cell interference in advance, improve communication quality, and so on. This codebook restriction scheme, for example, generates a codebook including various precoding matrices, selects a precoding matrix to be used/not used in the codebook for each cell or each user equipment, and uses different codebooks for each cell or each user equipment based on codebook restricting information associated with a precoding matrix to be not used. For example, claims 17-19, 22-25, and 28 of the ’924 Patent recite elements of channel status information (CSI) reporting using a codebook restriction scheme mandated by the 5G standard, including at least 3GPP TS 38.214, TS 38.321, and TS 38.331. *See* 3GPP TS 38.214 v16.5.0 at 50, 55, 67-70, 164 (§§ 5.2.1.1, 5.2.1.4.2, 5.2.2.2.1, 8.5.3) (discussing CSI reporting configuration and codebook restriction); 3GPP TS 38.321 v16.5.0 at 80 (§ 5.18.3) (discussing aperiodic CSI trigger state subselection); 3GPP TS 38.331 v16.5.0 at 70-71, 374-75, 384-87, 401,

405-06, 409-13, (§§ 5.3.5.5, 6.3.2) (discussing cell group configuration, codebook configuration and restriction).

52. Upon information and belief, Defendants have and continue to directly infringe at least claims 17-19, 22-25, and 28 of the '924 Patent by making, using, selling, importing, offering to sell within the United States, importing into the United States, and providing to and within the United States, Accused Instrumentalities that practice at least claims 17-19, 22-25, and 28 of the '924 Patent (the "LG Accused '924 Instrumentalities"). Defendants also have and continue to directly infringe at least claims 17-19, 22-25, and 28 by practicing claims 17-19, 22-25, and 28 through the LG Accused '924 Instrumentalities, and by causing the LG Accused '924 Instrumentalities to practice the patented inventions.

53. LG Accused '924 Instrumentalities include, for example, the LG V60 ThinQ 5G and other 5G-compatible devices.

54. Defendants were made aware of the '924 Patent family and their infringement thereof at least as early as September 22, 2020, when the '924 Patent was identified in correspondence sent to Defendants by Pantech Corp.

55. Since at least as early as September 22, 2020, Defendants' infringement has been, and continues to be willful.

56. Upon information and belief, the LG Accused '924 Instrumentalities are used, marketed, provided to, and/or used by or for Defendants' partners, clients, customers/subscribers and end users across the country and in this district.

57. Upon information and belief, Defendants have induced and continue to induce others to infringe at least claims 17-19, 22-25, and 28 of the '924 Patent under 35 U.S.C. § 271(b) by, among other things, and with specific intent or willful blindness, actively aiding and abetting

others to infringe, including, but not limited to Defendants' partners, clients, customers/subscribers, and end users, whose use of the LG Accused '924 Instrumentalities constitutes direct infringement of at least claims 17-19, 22-25, and 28 of the '924 Patent. For example, Defendants advertise and have advertised the use of the LG Accused '924 Instrumentalities for 5G communications. *See* <https://www.lg.com/us/cell-phones/lg-lmv600amaattcb-att-v60-thinq-5g>.

58. In particular, Defendants' actions that aid and abet others such as their partners, customers/subscribers, clients, and end users to infringe include advertising and distributing the LG Accused '924 Instrumentalities, and providing instruction materials, training and services regarding the LG Accused '924 Instrumentalities.

59. Any party, including Defendants' partners, clients, customers/subscribers, and end users, using the LG Accused '924 Instrumentalities necessarily infringes the '924 Patent because the inventions of the '924 Patent are required to comply with the 5G cellular standard (3GPP TS 38.214, TS 38.321, and TS 38.331). Defendants advertise the LG Accused '924 Instrumentalities as compliant with 5G, which induces others to infringe the '924 Patent. Defendants have knowingly induced infringement since at least September 22, 2020, when Defendants were first made aware of the '924 Patent, as discussed above.

60. Upon information and belief, Defendants are liable as contributory infringers of the '924 Patent under 35 U.S.C. § 271(c) by offering to sell, selling and importing into the United States the LG Accused '924 Instrumentalities that infringe the patented inventions, to be especially made or adapted for use in an infringement of the '924 Patent. Each of the LG Accused '924 Instrumentalities is a material component for use in practicing the '924 Patent and is specifically made and not a staple article of commerce suitable for substantial non-infringing use. In particular,

each of the LG Accused '924 Instrumentalities is advertised to be compliant with the relevant standards and primarily used in compliance with such standards.

61. Pantech Corp. has been harmed by Defendants' infringing activities.

COUNT II – INFRINGEMENT OF U.S. PATENT NO. 9,854,545

62. The allegations set forth in the foregoing paragraphs 1 through 61 are incorporated into this claim for relief.

63. On December 26, 2017, the '545 Patent, entitled "Apparatus and method for establishing uplink synchronization in a wireless communication system" was duly and legally issued by the United States Patent and Trademark Office from U.S. Patent Application No. 14/733,068, filed on June 8, 2015. The '545 Patent claims priority to U.S. Patent Application No. 13/578,531, filed as PCT/KR2011/000909 on February 10, 2011, as well as Korean Patent Publication KR10-2010-0012564, filed February 10, 2010, Korean Patent Publication KR10-2010-0027230, filed March 26, 2010, and Korean Patent Publication KR10-2010-0008683, filed January 28, 2010. A true and correct copy of the '545 Patent is attached as Exhibit 2.

64. Pantech Corp. is the assignee and owner of all right, title and interest in and to the '545 Patent, including the right to assert all causes of action arising under said patent and the right to any remedies for their infringement.

65. The '545 Patent discloses at least apparatuses and methods for establishing uplink synchronization in a wireless communication with respect to at least one Component Carrier ("CC"), through the use of timing groups. For instance, a user equipment configures one or more uplink timing groups based on information received through Radio Resource Control (RRC) signaling, transmits a Random Access Preamble (RAP) through one or more CCs in a respective timing group, and receives in response a timing advance value to apply to uplink CCs in the timing group. For example, claims 2 and 3 of the '545 Patent recite elements of the carrier aggregation

functionality mandated by at least the LTE Advanced standard, including at least the following 3GPP technical specifications: TS 36.300, TS 36.321, TS 36.213, TS 36.211, and TS 36.331, Release 11 and higher. *See, e.g.*, 3GPP 36.331 v11.2.0 at 51 (§ 5.3.5.3), 64 (§ 5.3.10.0), 66 (5.3.10.4) (the UE receives, through RRC signaling, configuration information relating to secondary timing advance group sTAG for a secondary component carrier); 3GPP TS 36.300 v11.6.0 at 48 (§ 5.5), 60 (§ 7.5), 72 (§ 10.1.2.7) (specifying multiple timing advance capability and multiple timing advance groups; addition and configuration of secondary cells with uplink component carriers; and use of timing reference cells); *id.* at 72-75 (§ 10.1.5) (random access procedure used to obtain timing advance alignment for secondary timing advance group ("sTAG")); *id.* at 74-75 (§ 10.1.5.2) (specifying random access procedure steps performed by the UE including transmission of random access preamble and reception of random access response); 3GPP TS 36.321 v11.1.0 at 17-18 (§ 5.2), 43-44 (§ 6.1.5), 46 (§ 6.2.3) (MAC Random Access Responses include Timing Advance Command; UE applies Timing Advance Command upon receiving MAC); 3GPP TS 36.213 v11.1.0 at 9-10 (§ 4.2.3) (UE adjusts uplink transmission timing of sTAG upon reception of Timing Advance Command); 3GPP TS 36.211 v11.1.0 at 104 (§ 8.1) (specifying uplink-downlink frame timing). Compliance with these technical specifications, and thus with at least the LTE Advanced standard, requires the use of the invention recited in at least claims 2 and 3 of the '545 Patent, including the functionality described in this paragraph.

66. Furthermore, claims 2 and 3 of the '545 Patent also recite elements of the carrier aggregation and/or multi-radio dual connectivity functionality mandated by at least the 5G standard, including at least the following 3GPP technical specifications: TS 36.300, TS 36.213, TS 36.321, TS 36.211, TS, 36.331, TS 37.340, TS 38.300, TS 38.321, and TS 38.331, Release 16 and higher. *See, e.g.*, 3GPP TS 38.300 v16.0.0 at 8 (§ 1), 11-12 (§ 4.1), 24 (Section 5.4.1)

(specifying architecture including a gNB for providing NR connectivity interconnected with an eNB for providing EUTRA connectivity; specifying multiple timing advance capability and multiple timing advance groups); 3GPP TS 38.331 v16.0.0 at 55-56 (§ 5.3.5.1), 57 (§ 5.3.5.3), 62-66 (§ 5.3.5.5), 239-41 (§ 6.2.2), 605 (UE receives RRC signaling, including RRCReconfiguration with `mrdc-SecondaryCellGroupConfig`; specifying configuration of Master Cell Group and Secondary Cell Group, and configuration and addition of timing groups); 3GPP TS 38.321 v16.0.0 at 9 (§ 3.1) (timing advance group comprises a group of serving cells using the same timing reference cell and Timing Advance value); 3GPP TS 37.340 v16.2.0 at 7-12, 15 (§ 6.1), 27-28 (§ 10.2.2) (providing for Multi-Radio Dual Connectivity (“MR-DC”) and NR-E-UTRA Dual Connectivity; specifying Secondary Node Addition procedure including reception by the UE of a SN RRC reconfiguration message originating from the SN and relayed by the MN to the UE; MR-DC supports random access procedure and MAC entities); 3GPP TS 36.300 v16.0.0 at 116 (§ 10.1.2.7) (specifying that eNB maintains timing advance; disclosing multiple groups and use of timing reference cells); *id.* at 136-40 (§ 10.1.5) (random access procedure used to obtain timing advance alignment for secondary timing advance group (“sTAG”)); 3GPP TS 36.321 v16.0.0 at 31-32 (§ 5.2), 94 (§ 6.1.3.5), 110-11 (§ 6.1.5), 117 (§ 6.2.3) (MAC Random Access Responses include Timing Advance Command; UE applies Timing Advance Command upon receiving MAC); 3GPP TS 36.213 v16.0.0 at 12-13 (§ 4.2.3) (UE adjusts uplink transmission timing of sTAG upon reception of Timing Advance Command); 3GPP TS 36.211 v16.0.0 at 193 (§8.1) (specifying uplink-downlink frame timing); 3GPP 36.331 at 121-23 (§ 5.3.5.3) (the UE performs secondary cell group configuration in response to RRC signaling). Compliance with these technical specifications, and thus with at least the 5G standard, requires the use of the invention

recited in at least claims 2 and 3 of the '545 Patent, including the functionality described in this paragraph.

67. Upon information and belief, Defendants have and continue to directly infringe at least claims 2 and 3 of the '545 Patent by making, using, selling, importing, offering to sell within the United States, importing into the United States, and providing to and within the United States, Accused Instrumentalities that practice at least claims 2 and 3 of the '545 Patent (the "LG Accused '545 Instrumentalities"). Defendants also have and continue to directly infringe at least claims 2 and 3 by practicing claims 2 and 3 through the LG Accused '545 Instrumentalities, and by causing the LG Accused '545 Instrumentalities to practice the patented inventions.

68. LG Accused '545 Instrumentalities include, for example, the LG V60 ThinQ 5G and other LTE-compatible products that support LTE carrier aggregation and/or other 5G-compatible products that support carrier aggregation and/or multi-radio dual connectivity. On information and belief, each of the LG Accused '545 Instrumentalities incorporates at least one processor configured to comply with (1) LTE Advanced, including supporting LTE carrier aggregation, and thus including at least the following 3GPP technical specifications: TS 36.300, TS 36.321, TS 36.213, TS 36.211, and TS 36.331, each Release 11 and higher; and/or (2) 5G, including supporting carrier aggregation and/or multi-radio dual connectivity mandated by the 5G standard, and thus including at least the following 3GPP technical specifications: TS 36.300, TS 36.213, TS 36.321, TS 36.211, TS, 36.331, TS 37.340, TS 38.300, TS 38.321, and TS 38.331, Release 16 and higher.

69. LG Accused '545 Instrumentalities incorporate a chipset, application processor, SoC, or system-on-chip that, on information and belief, support (1) LTE carrier aggregation; and/or (2) 5G carrier aggregation and/or multi-radio dual connectivity. On information and belief,

each incorporated chipset, application processor, SoC, or system-on-chip complies with one or more of LTE Advanced cellular communication protocols (including at least 3GPP TS 36.300, TS 36.321, TS 36.213, TS 36.331, and TS 36.211, Release 11 or later) and 5G cellular communication protocols (including at least TS 36.300, TS 36.213, TS 36.321, TS 36.211, TS, 36.331, TS 37.340, TS 38.300, TS 38.321, and TS 38.331, Release 16 or later).

70. Defendants were made aware of the '545 Patent family and their infringement thereof at least as early as September 22, 2020, when the '545 Patent was identified in correspondence sent to Defendants by Pantech Corp.

71. Since at least as early as September 22, 2020, Defendants' infringement has been, and continues to be willful.

72. Upon information and belief, the LG Accused '545 Instrumentalities are used, marketed, provided to, and/or used by or for Defendants' partners, clients, customers/subscribers and end users across the country and in this district.

73. Upon information and belief, Defendants have induced and continue to induce others to infringe at least claims 2 and 3 of the '545 Patent under 35 U.S.C. § 271(b) by, among other things, and with specific intent or willful blindness, actively aiding and abetting others to infringe, including, but not limited to Defendants' partners, clients, customers/subscribers, and end users, whose use of the LG Accused '545 Instrumentalities constitutes direct infringement of at least claims 2 and 3 of the '545 Patent. For example, Defendants advertise and have advertised the use of the LG Accused '545 Instrumentalities for LTE and 5G communications. *See* <https://www.lg.com/us/cell-phones/lg-lmv600amaattcb-att-v60-thinq-5g>.

74. In particular, Defendants' actions that aid and abet others such as their partners, customers/subscribers, clients, and end users to infringe include advertising and distributing the

LG Accused '545 Instrumentalities, and providing instruction materials, training and services regarding the LG Accused '545 Instrumentalities.

75. Any party, including Defendants' partners, clients, customers/subscribers, and end users, using the LG Accused '545 Instrumentalities necessarily infringes the '545 Patent because the inventions of the '545 Patent are required to comply with the LTE and 5G cellular standards identified in the preceding paragraphs of this Count. Defendants advertise the LG Accused '545 Instrumentalities as compliant with LTE and 5G, which induces others to infringe the '545 Patent. Defendants have knowingly induced infringement since at least September 22, 2020, when Defendants were first made aware of the '545 Patent, as discussed above.

76. Upon information and belief, Defendants are liable as contributory infringers of the '545 Patent under 35 U.S.C. § 271(c) by offering to sell, selling and importing into the United States the LG Accused '545 Instrumentalities that infringe the patented inventions, to be especially made or adapted for use in an infringement of the '545 Patent. Each of the LG Accused '545 Instrumentalities is a material component for use in practicing the '545 Patent and is specifically made and not a staple article of commerce suitable for substantial non-infringing use. In particular, each of the LG Accused '545 Instrumentalities is advertised to be compliant with the relevant standards and primarily used in compliance with such standards.

77. Pantech Corp. has been harmed by Defendants' infringing activities.

COUNT III – INFRINGEMENT OF U.S. PATENT NO. 10,869,247

78. The allegations set forth in the foregoing paragraphs 1 through 77 are incorporated into this claim for relief.

79. On December 15, 2020, the '247 Patent, entitled "Supporting Uplink Transmissions," was duly and legally issued by the United States Patent and Trademark Office from U.S. Patent Application No. 17/008,439, filed on August 31, 2020. The '247 Patent claims

priority to at least provisional application No. 60/517,656, filed on November 5, 2003. A true and correct copy of the '247 Patent is attached as Exhibit 3.

80. Pantech Wireless is the assignee and owner of all right, title and interest in and to the '247 Patent, including the right to assert all causes of action arising under said patent and the right to any remedies for infringement of it.

81. The '247 Patent discloses at least a method and an apparatus for supporting uplink transmissions. For example, the '247 Patent discloses a method of transmitting a data block to a base station using a hybrid automatic repeat request (H-ARQ) process, receiving uplink scheduling information from the base station, and determining whether to retransmit the data block based on the received uplink scheduling information and not based on whether the UE has received a negative acknowledgment (NACK) from the base station. Compliance with 3GPP TS 38.212 and TS 38.321, as required by at least the 5G cellular standard, requires the use of the inventions recited in at least claims 1, 2, 8, 11, 12, and 18 of the '247 Patent, including the functionality described in this paragraph. *See* 3GPP TS 38.212 V15.8.0 at 74 (disclosing receiving uplink scheduling information) and TS 38.321 V15.8.0 at 28 (disclosing transmission of data to a base station using a HARQ process).

82. Upon information and belief, Defendants have and continue to directly infringe at least claims 1, 2, 8, 11, 12, and 18 of the '247 Patent by making, using, selling, importing, offering to sell within the United States, importing into the United States, and providing to and within the United States, Accused Instrumentalities that practice at least claims 1, 2, 8, 11, 12, and 18 of the '247 Patent (the "LG Accused '247 Instrumentalities"). Defendants also have and continue to directly infringe at least claims 1, 2, 8, 11, 12, and 18 by practicing claims 1, 2, 8, 11, 12, and 18

through the LG Accused '247 Instrumentalities, and by causing the LG Accused '247 Instrumentalities to practice the patented inventions.

83. LG Accused '247 Instrumentalities include, for example, the LG V60 ThinQ 5G and other 5G-compatible products that transmit data using a hybrid automatic repeat request (H-ARQ) in compliance with 3GPP TS 38.212 and TS 38.321. On information and belief, each of the LG Accused '247 Instrumentalities incorporates at least one processor configured to comply with one or more of 5G cellular communication protocols.

84. Defendants were made aware of the '247 Patent family and their infringement thereof at least as early as April 22, 2015, when a family member was identified in exemplary claim charts sent to LGE by Signal Trust. Pantech Corp., on behalf of itself and Pantech Wireless, followed up with additional correspondence identifying the '247 Patent and LGE's infringement thereof again on July 12, 2021.

85. Since at least July 12, 2021, when it was made aware of the '247 Patent by Pantech Corp. on behalf of Pantech Wireless, Defendants' infringement has been, and continues to be, willful.

86. Upon information and belief, the LG Accused '247 Instrumentalities are used, marketed, provided to, and/or used by or for Defendants' partners, clients, customers/subscribers and end users across the country and in this district.

87. Upon information and belief, Defendants have induced and continue to induce others to infringe at least claims 1, 2, 8, 11, 12, and 18 of the '247 Patent under 35 U.S.C. § 271(b) by, among other things, and with specific intent or willful blindness, actively aiding and abetting others to infringe, including, but not limited to Defendants' partners, clients, customers/subscribers, and end users, whose use of the LG Accused '247 Instrumentalities constitute direct infringement

of at least claims 1, 2, 8, 11, 12, and 18 of the '247 Patent. For example, LG advertises and has advertised the use of its devices for 5G communications. See <https://www.lg.com/us/cell-phones/lg-lmv600amaattcb-att-v60-thinq-5g>.

88. In particular, Defendants' actions that aid and abet others such as their partners, customers/subscribers, clients, and end users to infringe include advertising and distributing the LG Accused '247 Instrumentalities, and providing instruction materials, training and services regarding the LG Accused '247 Instrumentalities.

89. Any party, including Defendants' partners, clients, customers/subscribers, and end users, using the LG Accused '247 Instrumentalities necessarily infringes the '247 Patent because the inventions of the '247 Patent are required to comply with the 5G cellular standard (3GPP TS 38.212 and TS 38.321). Defendants advertise the LG Accused '247 Instrumentalities as compliant with 5G, which induces others to infringe the '247 Patent. Defendants have knowingly induced infringement since at least as early as July 12, 2021.

90. Upon information and belief, Defendants are liable as contributory infringers of the '247 Patent under 35 U.S.C. § 271(c) by offering to sell, selling and importing into the United States the LG Accused '247 Instrumentalities that infringe the patented inventions, to be especially made or adapted for use in an infringement of the '247 Patent. Each of the LG Accused '247 Instrumentalities is a material component for use in practicing the '247 Patent and is specifically made and not a staple article of commerce suitable for substantial non-infringing use. In particular, each of the LG Accused '247 Instrumentalities is advertised to be compliant with the relevant standards and primarily used in compliance with such standards.

91. Pantech Wireless has been harmed by Defendants' infringing activities.

COUNT IV – INFRINGEMENT OF U.S. PATENT NO. 9,313,809

92. The allegations set forth in the foregoing paragraphs 1 through 91 are incorporated into this claim for relief.

93. On April 12, 2016, the '809 Patent, entitled "Method and apparatus for terminating transmission of a message in an enhanced random access channel" was duly and legally issued by the United States Patent and Trademark Office from U.S. Patent Application No. 14/319,608, filed on June 30, 2014. The '809 Patent claims priority to U.S. Patent Application No. 12/238,910, filed on September 26, 2008, U.S. Provisional Patent Application No. 60/975,985, filed on September 28, 2007, U.S. Provisional Patent Application No. 60/982,528, filed on October 25, 2007, U.S. Provisional Patent Application No. 61/018,999, filed on January 4, 2008, U.S. Provisional Patent Application No. 61/025,441, filed on February 1, 2008, U.S. Provisional Patent Application No. 61/038,576, filed on March 21, 2008, U.S. Provisional Patent Application No. 61/074,288, filed on June 20, 2008, and U.S. Provisional Patent Application No. 61/083,409, filed on July 24, 2008. A true and correct copy of the '809 Patent is attached as Exhibit 4.

94. Pantech Wireless is the assignee and owner of all right, title and interest in and to the '809 Patent, including the right to assert all causes of action arising under said patent and the right to any remedies for their infringement.

95. The '809 Patent discloses at least apparatuses and methods for communicating with a base station using an enhanced dedicated channel (E-DCH) resource while in a cell forward access channel (CELL_FACH) state. If a E-DCH buffer is empty, then the WTRU transmits scheduling information (SI) including a total E-DCH buffer status (TEBS) equal to zero to the bases station. The WTRU also determines if a hybrid automatic repeat request (HARQ) buffer is empty and releases the E-DCH resource when the transmission of the SI with the TEBS equal to zero and the HARQ buffer is empty. For example, claims 1-10 of the '809 Patent recite elements

required for compliance with at least WDCMA standards, including at least 3GPP TS 25.211, TS 25.214, and TS 25.321. *See* 3GPP TS 25.211 v 9.2.0 at 38 (§ 5.3.3.7) (showing the relationship between E-DCH and AICH); TS 25.214 v 9.8.0 at 41-42 (§ 6.1A) (Physical random access procedure for Enhanced Uplink in CELL_FACH state); and TS 25.321 v 9.9.0 at 10, 16, 94, 104, 108, 109-110, 153-154, 156, (§§ 3.1.2.1, 4.2.3, 9.2.5.3.2, 11.2.2A, 11.8.1) (the UE is configured to release the common E-DCH resource when the empty buffer status (TEBS=0) has been reported, and no MAC PDU is left in a HARQ process for transmission or retransmission).

96. Upon information and belief, Defendants have and continue to directly infringe at least claims 1-10 of the '809 Patent by making, using, selling, importing, offering to sell within the United States, importing into the United States, and providing to and within the United States, Accused Instrumentalities that practice at least claims 1-10 of the '809 Patent (the "LG Accused '809 Instrumentalities"). Defendants also have and continue to directly infringe at least claims 1-10 by practicing claims 1-10 through the LG Accused '809 Instrumentalities, and by causing the LG Accused '809 Instrumentalities to practice the patented inventions.

97. LG Accused '809 Instrumentalities include, for example, the LG G7 ThinQ and other WDCMA-compatible devices that support the request and receipt of enhanced uplink resources from a wireless network in compliance with 3GPP TS 25.211, TS 25.214, and TS 25.321.

98. Defendants were made aware of the '809 Patent family and their infringement thereof at least as early as April 22, 2015, when a family member was identified in exemplary claim charts sent to LGE by Signal Trust. Signal Trust followed up with additional correspondence specifically identifying the '809 Patent and LGE's infringement thereof again on April 29, 2016.

99. Since at least as early as April 29, 2016, Defendants' infringement has been, and continues to be willful.

100. Upon information and belief, the LG Accused '809 Instrumentalities are used, marketed, provided to, and/or used by or for Defendants' partners, clients, customers/subscribers and end users across the country and in this district.

101. Upon information and belief, Defendants have induced and continue to induce others to infringe at least claims 1-10 of the '809 Patent under 35 U.S.C. § 271(b) by, among other things, and with specific intent or willful blindness, actively aiding and abetting others to infringe, including, but not limited to Defendants' partners, clients, customers/subscribers, and end users, whose use of the LG Accused '809 Instrumentalities constitutes direct infringement of at least claims 1-10 of the '809 Patent. For example, Defendants advertise and have advertised the use of the LG Accused '809 Instrumentalities for WDCMA communications. *See* <https://www.lg.com/us/cell-phones/lg-LMG710TM-g7-thinq-tmobile>.

102. In particular, Defendants' actions that aid and abet others such as their partners, customers/subscribers, clients, and end users to infringe include advertising and distributing the LG Accused '809 Instrumentalities, and providing instruction materials, training and services regarding the LG Accused '809 Instrumentalities.

103. Any party, including Defendants' partners, clients, customers/subscribers, and end users, using the LG Accused '809 Instrumentalities necessarily infringes the '809 Patent because the inventions of the '809 Patent are required to comply with the WDCMA cellular standards (3GPP TS 25.211, TS 25.214, and TS 25.321). Defendants advertise the LG Accused '809 Instrumentalities as compliant with WDCMA, which induces others to infringe the '809 Patent. Defendants have knowingly induced infringement since at least April 30, 2016, when Defendants were first made aware of the '809 Patent, as discussed above.

104. Upon information and belief, Defendants are liable as contributory infringers of the '809 Patent under 35 U.S.C. § 271(c) by offering to sell, selling and importing into the United States the LG Accused '809 Instrumentalities that infringe the patented inventions, to be especially made or adapted for use in an infringement of the '809 Patent. Each of the LG Accused '809 Instrumentalities is a material component for use in practicing the '809 Patent and is specifically made and not a staple article of commerce suitable for substantial non-infringing use. In particular, each of the LG Accused '809 Instrumentalities is advertised to be compliant with the relevant standards and primarily used in compliance with such standards.

105. Pantech Corp. has been harmed by Defendants' infringing activities.

COUNT V – INFRINGEMENT OF U.S. PATENT NO. 9,065,486

106. The allegations set forth in the foregoing paragraphs 1 through 105 are incorporated into this claim for relief.

107. On June 23, 2015, the '486 Patent, entitled "Detection, avoidance and/or correction of problematic puncturing patterns in parity bit streams used when implementing turbo codes" was duly and legally issued by the United States Patent and Trademark Office from U.S. Patent Application No. 14/300,734, filed on June 10, 2014. The '486 Patent claims priority to U.S. Patent Application No. 13/744,984, filed on January 18, 2013, U.S. Patent Application No. 13/309,962, filed on December 2, 2011, U.S. Patent Application No. 11/974,381, filed on October 12, 2007, U.S. Patent Application No. 10/725,779, filed on December 2, 2003, U.S. Provisional Patent Application No. 60/434,232, filed on December 16, 2002, U.S. Provisional Patent Application No. 60/444,068, filed on January 30, 2003, U.S. Provisional Patent Application No. 60/470,921, filed on May 15, 2003, and U.S. Provisional Patent Application No. 60/494,404, filed on August 11, 2003. A true and correct copy of the '486 Patent is attached as Exhibit 5.

108. Pantech Wireless is the assignee and owner of all right, title and interest in and to the '486 Patent, including the right to assert all causes of action arising under said patent and the right to any remedies for their infringement.

109. The '486 Patent discloses at least apparatuses and methods for detecting and correcting performance degradation in punctured Turbo codes using a Turbo encoder. A puncturing pattern which approximates a particular code is identified, and a value for anticipated degradation is adjusted in accordance with a matching of the puncturing pattern and the particular code rate. For example, claims 3-4 of the '486 Patent recite elements of detecting and correcting problematic puncturing patterns in parity bit streams when implementing punctured Turbo codes as mandated by the LTE standard, including at least 3GPP TS 36.212. *See* 3GPP TS 36.212 v 10.0.0 at 15 (§ 5.1.4.1) (showing the rate matching for turbo coded transport channels).

110. Upon information and belief, Defendants have and continue to directly infringe at least claims 3-4 of the '486 Patent by making, using, selling, importing, offering to sell within the United States, importing into the United States, and providing to and within the United States, Accused Instrumentalities that practice at least claims 3-4 of the '486 Patent (the "LG Accused '486 Instrumentalities"). Defendants also have and continue to directly infringe at least claims 3-4 by practicing claims 3-4 through the LG Accused '486 Instrumentalities, and by causing the LG Accused '486 Instrumentalities to practice the patented inventions.

111. LG Accused '486 Instrumentalities include, for example, the LG G7 ThinQ and other LTE-compatible devices.

112. Defendants were made aware of the '486 Patent and their infringement thereof at least as early as February 15, 2017, when the '486 Patent was identified in exemplary claim charts sent to LGE by Signal Trust.

113. Since at least as early as February 15, 2017, Defendants' infringement has been, and continues to be willful.

114. Upon information and belief, the LG Accused '486 Instrumentalities are used, marketed, provided to, and/or used by or for Defendants' partners, clients, customers/subscribers and end users across the country and in this district.

115. Upon information and belief, Defendants have induced and continue to induce others to infringe at least claims 3-4 of the '486 Patent under 35 U.S.C. § 271(b) by, among other things, and with specific intent or willful blindness, actively aiding and abetting others to infringe, including, but not limited to Defendants' partners, clients, customers/subscribers, and end users, whose use of the LG Accused '486 Instrumentalities constitutes direct infringement of at least claims 3-4 of the '486 Patent. For example, Defendants advertise and have advertised the use of the LG Accused '486 Instrumentalities for LTE communications. See <https://www.lg.com/us/cell-phones/lg-LMG710TM-g7-thinq-tmobile>.

116. In particular, Defendants' actions that aid and abet others such as their partners, customers/subscribers, clients, and end users to infringe include advertising and distributing the LG Accused '486 Instrumentalities, and providing instruction materials, training and services regarding the LG Accused '486 Instrumentalities.

117. Any party, including Defendants' partners, clients, customers/subscribers, and end users, using the LG Accused '486 Instrumentalities necessarily infringes the '486 Patent because the inventions of the '486 Patent are required to comply with the LTE cellular standards (3GPP TS 36.212). Defendants advertise the LG Accused '486 Instrumentalities as compliant with LTE, which induces others to infringe the '486 Patent. Defendants have knowingly induced infringement

since at least September 7, 2017, when Defendants were first made aware of the '486 Patent, as discussed above.

118. Upon information and belief, Defendants are liable as contributory infringers of the '486 Patent under 35 U.S.C. § 271(c) by offering to sell, selling and importing into the United States the LG Accused '486 Instrumentalities that infringe the patented inventions, to be especially made or adapted for use in an infringement of the '486 Patent. Each of the LG Accused '486 Instrumentalities is a material component for use in practicing the '486 Patent and is specifically made and not a staple article of commerce suitable for substantial non-infringing use. In particular, each of the LG Accused '486 Instrumentalities is advertised to be compliant with the relevant standards and primarily used in compliance with such standards.

119. Pantech Corp. has been harmed by Defendants' infringing activities.

COUNT VI – INFRINGEMENT OF U.S. PATENT NO. 7,283,839

120. The allegations set forth in the foregoing paragraphs 1 through 119 are incorporated into this claim for relief.

121. On October 16, 2007, the '839 Patent, entitled "Wireless communicating terminal for providing integrated messaging service and method thereof" was duly and legally issued by the United States Patent and Trademark Office from U.S. Patent Application No. 11/106,160, filed on April 13, 2005. The '839 Patent claims priority to KR 10-2004-0025882, filed on April 14, 2004, and KR 10-2004-0083073, filed on October 18, 2004. A true and correct copy of the '839 Patent is attached as Exhibit 6.

122. Pantech Corp. is the assignee and owner of all right, title and interest in and to the '839 Patent, including the right to assert all causes of action arising under said patent and the right to any remedies for infringement of it.

123. The '839 Patent discloses a wireless communication terminal having a function providing and integrated messaging service.

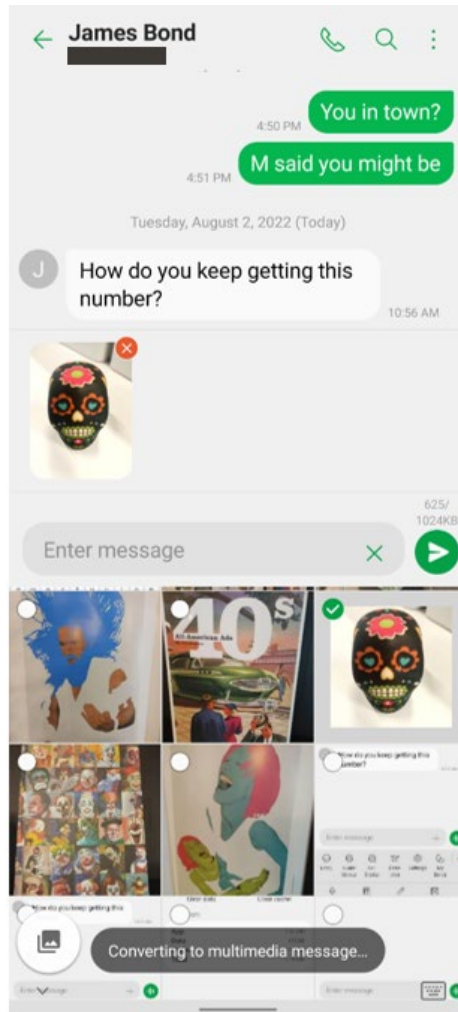
124. At the time of the '839 Patent (which claims priority to April 14, 2004), conventional message services provided different interfaces for text messages and multimedia messages. In some instances, a user would need to access separate applications for text and multimedia applications. Further, conventional wireless communication terminals managed incoming and outgoing messages using an in-box and an out-box, analogizing the messages to a traditional letter. This approach provides a late response in comparison to an Internet messenger. *See* '839 Patent at 1:32-50.

125. The '839 Patent solved this problem by providing an integrated messaging service. In one example, the integrated messaging service receives message content and a menu selecting signal in the integrated user interface. The integrated user interface also displays the message content and description data. The wireless communication terminal determines the kind of message to be transmitted which is inputted into the integrated user interface, generates an outgoing message which includes identification data corresponding to the message kind, and transmitting the outgoing message. The integrated user interface displays the outgoing message content and the description data. The wireless communication terminal also determines a message kind of a received message, divides the message into message content and description data, and displays the message content and the description data in the integrated user interface. *See* '839 Patent at 4:6-5:19, 5:20-62, FIG. 2, FIG. 3. By integrating the user interface of text messages and multimedia messages, the technique provides a single application or service thereby increasing usability and simplicity for the user. *See id.* at 1:32-44. As an additional benefit, the integrated user interface increases speed by avoiding delays due to analogizing messages to letters. *Id.* at 1:45-50.

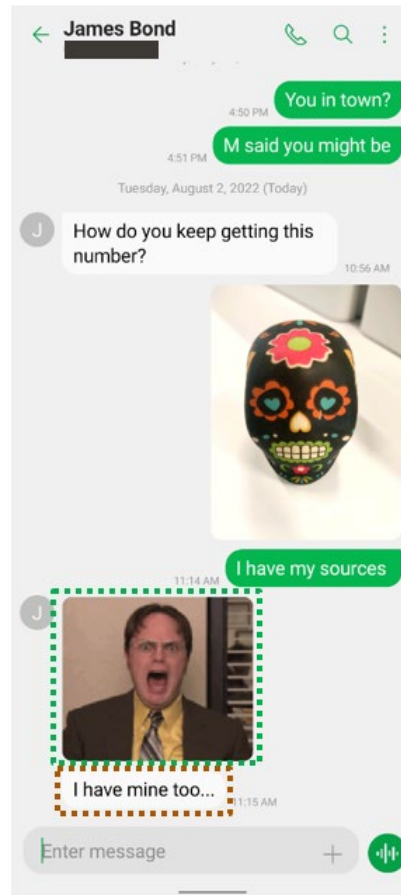
126. Upon information and belief, Defendants have and continue to directly infringe at least claims 1-5 of the '839 Patent by making, using, selling, importing, offering to sell within the United States, importing into the United States, and providing to and within the United States, Accused Instrumentalities that practice at least claims 1-5 of the '839 Patent (the "LG Accused '839 Instrumentalities"). Defendants also have and continue to directly infringe at least claims 1-5 by practicing claims 1-5 through the LG Accused '839 Instrumentalities, and by causing the LG Accused '839 Instrumentalities to practice the patented inventions.

127. LG Accused '839 Instrumentalities include, for example, the LG V60 ThinQ 5G and other products that incorporate at least one processor, touchscreen, and include software functionality such as described below.

128. For example, the LG V60 ThinQ 5G is a wireless communication terminal having a function of providing an integrated messaging service. As one example, the LG V60 ThinQ 5G includes an integrated user interface for sending and receiving both text messages and multimedia messages. The LG V60 ThinQ 5G determines the type of message to be transmitted, generates an outgoing message, transmits the outgoing message, and displays the message content and the description data in the integrated user interface. The LG V60 ThinQ 5G also determines a type of received message, divides the message into message content and description data, and displays the message content and the description data in the integrated user interface.



LG V60 ThinQ 5G Screenshot showing outgoing message



Annotated LG V60 ThinQ 5G Screenshot showing received message

129. Defendants were made aware of the '839 Patent and their infringement thereof at least as early as September 22, 2020, when the '839 Patent was identified in correspondence sent to Defendants by Pantech Corp.

130. Since at least as early as September 22, 2020, when Defendants were made aware of the '839 Patent, Defendants' infringement has been, and continues to be willful.

131. Upon information and belief, the LG Accused '839 Instrumentalities are used, marketed, provided to, and/or used by or for Defendants' partners, clients, customers/subscribers and end users across the country and in this district.

132. Upon information and belief, Defendants have induced and continue to induce others to infringe at least claims 1-5 of the '839 Patent under 35 U.S.C. § 271(b) by, among other

things, and with specific intent or willful blindness, actively aiding and abetting others to infringe, including, but not limited to Defendants' partners, clients, customers/subscribers, and end users, whose use of the LG Accused '839 Instrumentalities constitute direct infringement of at least claims 1-5 of the '839 Patent. For example, Defendants' user manual for the LG V60 ThinQ 5G shows users how to "Specify a recipient and crates a message," "attach files, and "send the message."

133. In particular, Defendants' actions that aid and abet others such as their partners, customers/subscribers, clients, and end users to infringe include advertising and distributing the LG Accused '839 Instrumentalities, and providing instruction materials, training and services regarding the LG Accused '839 Instrumentalities.

134. Any party, including Defendants' partners, clients, customers/subscribers, and end users, using the preinstalled Messages application of the LG Accused '839 Instrumentalities infringes the '839 Patent. Defendants have knowingly induced infringement since at least September 22, 2020, when Defendants were first made aware of the '839 Patent.

135. Upon information and belief, Defendants are liable as contributory infringers of the '839 Patent under 35 U.S.C. § 271(c) by offering to sell, selling and importing into the United States the LG Accused '839 Instrumentalities that infringe the patented inventions, to be especially made or adapted for use in an infringement of the '839 Patent. Each of the LG Accused '839 Instrumentalities is a material component for use in practicing the '839 Patent and is specifically made and not a staple article of commerce suitable for substantial non-infringing use. For example, the software associated with implementing the LG Accused '839 Instrumentalities is not suitable for substantial non-infringing use.

136. Pantech Corp. has been harmed by Defendants' infringing activities.

COUNT VII – INFRINGEMENT OF U.S. PATENT NO. 9,575,631

137. The allegations set forth in the foregoing paragraphs 1 through 136 are incorporated into this claim for relief.

138. On February 21, 2017, the '631 Patent, entitled "Method for selecting and controlling second work process during first work process in multitasking mobile terminal" was duly and legally issued by the United States Patent and Trademark Office from U.S. Patent Application No. 15/010,629, filed on January 29, 2016. The '631 Patent claims priority to U.S. Patent Application No. 14/840,844, filed on August 31, 2015, U.S. Patent Application No. 11/495,863, filed on July 28, 2006, KR 10-2005-0073877, filed on August 11, 2005, and KR 10-2005-0102198, filed on October 28, 2005. A true and correct copy of the '631 Patent is attached as Exhibit 7.

139. Pantech Corp. is the assignee and owner of all right, title and interest in and to the '631 Patent, including the right to assert all causes of action arising under said patent and the right to any remedies for infringement of it.

140. The '631 Patent discloses a method for controlling a predetermined function of a second work process during a first work process in a multitasking mobile terminal that performs the first work process and the second work process.

141. At the time of the '631 Patent (which claims priority to August 11, 2005), conventional methods for multitasking in a mobile terminal meant that when a user wanted to change from one process to another, the previous process would be terminated. '631 Patent at 1:61-64; FIG. 2. As one example, a user had to terminate a text message creation process in order to control music or audio playback. *Id.* at 2:40-44. Upon returning to the text message creation, the user would be faced with the inconvenience of recreating any progress previously discarded or forced to seek out the incomplete message stored in a temporary mailbox. *Id.* at 2:44-51.

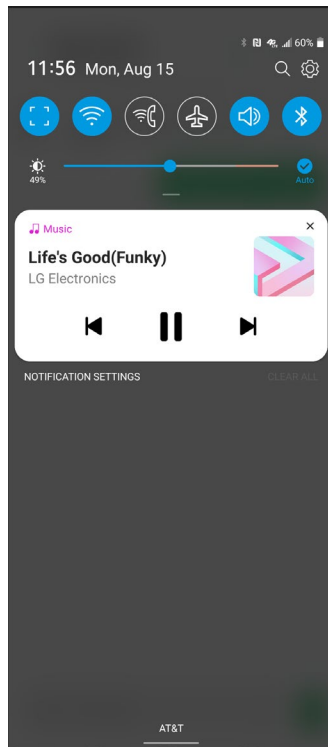
142. The '631 Patent solved this problem by providing a technique for controlling a predetermined function of a second work process in a multitasking mobile terminal that performs the first work process and the second work process. In one example, an icon is displayed which corresponds to a first work process. If the icon is selected, then a screen for the first work process is displayed. '631 Patent at 5:40-45. Multiple icons, including an icon corresponding to a second work process, are displayed when a command is received to sequentially display icons. The icon corresponding to the second work process can be selected and a corresponding screen is displayed. From this screen, a control menu can be activated for controlling the first work process and commands can be input for controlling the first work process. *Id.* at 5:50-58.

143. Upon information and belief, Defendants have and continue to directly infringe at least claims 1-4, 8, and 9 of the '631 Patent by making, using, selling, importing, offering to sell within the United States, importing into the United States, and providing to and within the United States, Accused Instrumentalities that practice at least claims 1-4, 8, and 9 of the '631 Patent (the "LG Accused '631 Instrumentalities"). Defendants also have and continue to directly infringe at least claims 1-4, 8, and 9 by practicing claims 1-4, 8, and 9 through the LG Accused '631 Instrumentalities, and by causing the LG Accused '631 Instrumentalities to practice the patented inventions.

144. The LG Accused '631 Instrumentalities include, for example, the LG V60 ThinQ 5G and other products that incorporate at least one processor, touchscreen, and include software functionality such as described below.

145. For example, the LG V60 ThinQ 5G performs a method for controlling a predetermined function of a second work process in a multitasking mobile terminal that performs the first work process and the second work process. As one example, the LG V60 ThinQ 5G

displays an icon corresponding to an audio player, which can be used to play music. The LG V60 ThinQ 5G also displays an icon for the Messages application. The LG V60 ThinQ 5G can concurrently display the Messages work process while playing music. In response to a swipe down, a control menu is displayed which allows for control of the audio player.



LG V60 ThinQ 5G Screenshot showing control menu

146. Defendants were made aware of the '631 Patent and their infringement thereof at least as early as January 27, 2021, when the '631 Patent was identified in correspondence sent to Defendants by Pantech Corp.

147. Since at least January 27, 2021, when Defendants were made aware of the '631 Patent, Defendants' infringement has been, and continues to be willful.

148. Upon information and belief, the LG Accused '631 Instrumentalities are used, marketed, provided to, and/or used by or for Defendants' partners, clients, customers/subscribers and end users across the country and in this district.

149. Upon information and belief, Defendants have induced and continue to induce others to infringe at least claims 1-4, 8, and 9 of the '631 Patent under 35 U.S.C. § 271(b) by, among other things, and with specific intent or willful blindness, actively aiding and abetting others to infringe, including, but not limited to Defendants' partners, clients, customers/subscribers, and end users, whose use of the LG Accused '631 Instrumentalities constitute direct infringement of at least claims 1-4, 8, and 9 of the '631 Patent. For example, Defendants' user manual for the LG V60 ThinQ 5G instructs users to "open multiple apps on the screen and easily switch between them at any time."

150. In particular, Defendants' actions that aid and abet others such as their partners, customers/subscribers, clients, and end users to infringe include advertising and distributing the LG Accused '631 Instrumentalities, and providing instruction materials, training and services regarding the LG Accused '631 Instrumentalities.

151. Any party, including Defendants' partners, clients, customers/subscribers, and end users, using multitasking functions for music control of the LG Accused '631 Instrumentalities infringes the '631 Patent. Defendants have knowingly induced infringement since least January 27, 2021, when Defendants were first made aware of the '631 Patent.

152. Upon information and belief, Defendants are liable as contributory infringers of the '631 Patent under 35 U.S.C. § 271(c) by offering to sell, selling and importing into the United States the LG Accused '631 Instrumentalities that infringe the patented inventions, to be especially made or adapted for use in an infringement of the '631 Patent. Each of the LG Accused '631 Instrumentalities is a material component for use in practicing the '631 Patent and is specifically made and not a staple article of commerce suitable for substantial non-infringing use. For example,

the software associated with implementing the LG Accused '631 Instrumentalities is not suitable for substantial non-infringing use.

153. Pantech Corp. has been harmed by Defendants' infringing activities.

DAMAGES

As a result of Defendants' acts of infringement, Pantech has suffered actual and consequential damages. To the fullest extent permitted by law, Pantech seeks recovery of damages at least in the form of reasonable royalties.

JURY DEMAND

Pursuant to Rule 38 of the Federal Rules of Civil Procedure, Plaintiffs demand a trial by jury on all issues triable as such.

PRAYER FOR RELIEF

WHEREFORE, Plaintiffs demands judgment for itself and against Defendants as follows:

- A. An adjudication that Defendants have infringed U.S. Patent Nos. 9,136,924; 9,854,545; 10,869,247; 9,313,809; 9,065,486; 7,283,839; and 9,575,631;
- B. An award of damages to be paid by Defendants adequate to compensate Plaintiffs for Defendants' past infringement of the Asserted Patents, and any continuing or future infringement through the date such judgment is entered, including interest, costs, expenses and an accounting of all infringing acts including, but not limited to, those acts not presented at trial;
- C. A declaration that this case is exceptional under 35 U.S.C. § 285, and an award of Plaintiffs' reasonable attorneys' fees; and
- D. An award to Plaintiffs of such further relief at law or in equity as the Court deems just and proper.

Dated: September 2, 2022 <i>Of counsel:</i> James A. Fussell, III Jamie B. Beaber Saqib J. Siddiqui Tiffany A. Miller Baldine Paul* Clark S. Bakewell Seth W. Bruneel* MAYER BROWN LLP 1999 K Street, N.W. Washington D.C. 20006 (202) 263-3000 jbeaber@mayerbrown.com jfussell@mayerbrown.com ssiddiqui@mayerbrown.com tmiller@mayerbrown.com bpaul@mayerbrown.com cbakewell@mayerbrown.com sbruneel@mayerbrown.com Graham M. Buccigross* MAYER BROWN LLP Two Palo Alto Square, Suite 300 3000 El Camino Real Palo Alto, CA 94306 (650) 331-2000 gbuccigross@mayerbrown.com Gregory J. Apgar* MAYER BROWN LLP 1221 Avenue of the Americas New York, NY 10020 (212) 506-2500 gapgar@mayerbrown.com Luiz Miranda* MAYER BROWN LLP 71 S. Wacker Drive Chicago, IL 60606 (312) 782-0600 lmiranda@mayerbrown.com (* <i>pro hac vice</i> application to be filed)	Respectfully submitted, <u>/s/ Geoffrey Culbertson</u> Geoffrey Culbertson Kelly Tidwell PATTON TIDWELL & CULBERTSON, LLP 2800 Texas Blvd. (75503) Post Office Box 5398 Texarkana, TX 75505-5398 (P) (903) 792-7080 (F) (903) 792-8233 gpc@texarkanalaw.com kbt@texarkanalaw.com <i>Counsel for Plaintiffs Pantech Corporation and Pantech Wireless, LLC</i>
--	--

JS 44 (Rev. 04/21)

CIVIL COVER SHEET

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

I. (a) PLAINTIFFS

PANTECH CORPORATION and
PANTECH WIRELESS. LLC

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

(c) Attorneys (Firm Name, Address, and Telephone Number)

Geoff Culbertson, Patton, Tidwell & Culbertson, LLP
2800 Texas Blvd., Texarkana, Texas 75503

DEFENDANTS

LG ELECTRONICS INC., AND LG ELECTRONICS U.S.A.,
INC.

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

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

Attorneys (If Known)

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

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

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

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

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

Click here for: [Nature of Suit Code Descriptions.](#)

CONTRACT	TORTS	FORFEITURE/PENALTY	BANKRUPTCY	OTHER STATUTES
☐ 110 Insurance ☐ 120 Marine ☐ 130 Miller Act ☐ 140 Negotiable Instrument ☐ 150 Recovery of Overpayment & Enforcement of Judgment ☐ 151 Medicare Act ☐ 152 Recovery of Defaulted Student Loans (Excludes Veterans) ☐ 153 Recovery of Overpayment of Veteran's Benefits ☐ 160 Stockholders' Suits ☐ 190 Other Contract ☐ 195 Contract Product Liability ☐ 196 Franchise	PERSONAL INJURY ☐ 310 Airplane ☐ 315 Airplane Product Liability ☐ 320 Assault, Libel & Slander ☐ 330 Federal Employers' Liability ☐ 340 Marine ☐ 345 Marine Product Liability ☐ 350 Motor Vehicle ☐ 355 Motor Vehicle Product Liability ☐ 360 Other Personal Injury ☐ 362 Personal Injury - Medical Malpractice	PERSONAL INJURY ☐ 365 Personal Injury - Product Liability ☐ 367 Health Care/Pharmaceutical Personal Injury Product Liability ☐ 368 Asbestos Personal Injury Product Liability LABOR ☐ 370 Other Fraud ☐ 371 Truth in Lending ☐ 380 Other Personal Property Damage ☐ 385 Property Damage Product Liability	☐ 625 Drug Related Seizure of Property 21 USC 881 ☐ 690 Other ☐ 422 Appeal 28 USC 158 ☐ 423 Withdrawal 28 USC 157 INTELLECTUAL PROPERTY RIGHTS ☐ 820 Copyrights ☒ 830 Patent ☐ 835 Patent - Abbreviated New Drug Application ☐ 840 Trademark ☐ 880 Defend Trade Secrets Act of 2016 SOCIAL SECURITY ☐ 861 HIA (1395ff) ☐ 862 Black Lung (923) ☐ 863 DIWC/DIWW (405(g)) ☐ 864 SSID Title XVI ☐ 865 RSI (405(g)) FEDERAL TAX SUITS ☐ 870 Taxes (U.S. Plaintiff or Defendant) ☐ 871 IRS—Third Party 26 USC 7609	☐ 375 False Claims Act ☐ 376 Qui Tam (31 USC 3729(a)) ☐ 400 State Reapportionment ☐ 410 Antitrust ☐ 430 Banks and Banking ☐ 450 Commerce ☐ 460 Deportation ☐ 470 Racketeer Influenced and Corrupt Organizations ☐ 480 Consumer Credit (15 USC 1681 or 1692) ☐ 485 Telephone Consumer Protection Act ☐ 490 Cable/Sat TV ☐ 850 Securities/Commodities/Exchange ☐ 890 Other Statutory Actions ☐ 891 Agricultural Acts ☐ 893 Environmental Matters ☐ 895 Freedom of Information Act ☐ 896 Arbitration ☐ 899 Administrative Procedure Act/Review or Appeal of Agency Decision ☐ 950 Constitutionality of State Statutes
REAL PROPERTY ☐ 210 Land Condemnation ☐ 220 Foreclosure ☐ 230 Rent Lease & Ejectment ☐ 240 Torts to Land ☐ 245 Tort Product Liability ☐ 290 All Other Real Property	CIVIL RIGHTS ☐ 440 Other Civil Rights ☐ 441 Voting ☐ 442 Employment ☐ 443 Housing/Accommodations ☐ 445 Amer. w/Disabilities - Employment ☐ 446 Amer. w/Disabilities - Other ☐ 448 Education	PRISONER PETITIONS Habeas Corpus: ☐ 463 Alien Detainee ☐ 510 Motions to Vacate Sentence ☐ 530 General ☐ 535 Death Penalty Other: ☐ 540 Mandamus & Other ☐ 550 Civil Rights ☐ 555 Prison Condition ☐ 560 Civil Detainee - Conditions of Confinement	☐ 710 Fair Labor Standards Act ☐ 720 Labor/Management Relations ☐ 740 Railway Labor Act ☐ 751 Family and Medical Leave Act ☐ 790 Other Labor Litigation ☐ 791 Employee Retirement Income Security Act IMMIGRATION ☐ 462 Naturalization Application ☐ 465 Other Immigration Actions	

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

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

Cite the U.S. Civil Statute under which you are filing (Do not cite jurisdictional statutes unless diversity):

35 U.S.C. § 271, et seq.

VI. CAUSE OF ACTION

Brief description of cause:
Patent Infringement

VII. REQUESTED IN COMPLAINT:

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

DEMAND \$

CHECK YES only if demanded in complaint:

JURY DEMAND: ☒ Yes ☐ No

VIII. RELATED CASE(S) IF ANY

(See instructions):

JUDGE

DOCKET NUMBER

DATE

9/2/2022

SIGNATURE OF ATTORNEY OF RECORD

/s/Geoff Culbertson

FOR OFFICE USE ONLY

RECEIPT #

AMOUNT

APPLYING IFP

JUDGE

MAG. JUDGE

EXHIBIT 1



US009136924B2

(12) **United States Patent**
Park

(10) **Patent No.:** **US 9,136,924 B2**
(45) **Date of Patent:** **Sep. 15, 2015**

(54) **TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH**

H04B 7/0634; H04B 7/0413; H04B 7/0452;
H04B 7/0626

See application file for complete search history.

(75) Inventor: **Kyoungmin Park**, Seoul (KR)

(56) **References Cited**

(73) Assignee: **Pantech Co., Ltd.**, Seoul (KR)

U.S. PATENT DOCUMENTS

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 94 days.

2009/0257383	A1	10/2009	Lee et al.	
2010/0048233	A1	2/2010	Kim et al.	
2010/0322176	A1 *	12/2010	Chen et al.	370/329
2011/0032839	A1 *	2/2011	Chen et al.	370/252
2011/0034192	A1 *	2/2011	Lim et al.	455/501
2011/0116563	A1	5/2011	Vitthaladevuni et al.	
2011/0206024	A1 *	8/2011	Lee et al.	370/338
2011/0249713	A1 *	10/2011	Hammarwall et al.	375/220
2011/0268068	A1 *	11/2011	Jian et al.	370/329
2011/0274188	A1 *	11/2011	Sayana et al.	375/260
2011/0305263	A1 *	12/2011	Jongren et al.	375/219
2012/0003945	A1 *	1/2012	Liu et al.	455/115.1
2012/0127948	A1 *	5/2012	Chung et al.	370/329

(21) Appl. No.: **13/807,706**

(22) PCT Filed: **Jul. 1, 2011**

(86) PCT No.: **PCT/KR2011/004835**

§ 371 (c)(1),
(2), (4) Date: **Dec. 28, 2012**

FOREIGN PATENT DOCUMENTS

(87) PCT Pub. No.: **WO2012/005476**

WO 2009-125956 10/2009

PCT Pub. Date: **Jan. 12, 2012**

OTHER PUBLICATIONS

(65) **Prior Publication Data**

US 2013/0114763 A1 May 9, 2013

International Search Report dated Dec. 28, 2011 issued for related International Application No. PCT/KR2011/004835.

(30) **Foreign Application Priority Data**

Jul. 5, 2010 (KR) 10-2010-0064573

* cited by examiner

(51) **Int. Cl.**

H04B 7/02 (2006.01)

H04B 7/04 (2006.01)

H04B 7/06 (2006.01)

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

CPC **H04B 7/0456** (2013.01); **H04B 7/0413** (2013.01); **H04B 7/0469** (2013.01); **H04B 7/0626** (2013.01)

(58) **Field of Classification Search**

CPC .. H04B 7/0639; H04B 7/0456; H04B 7/0469;

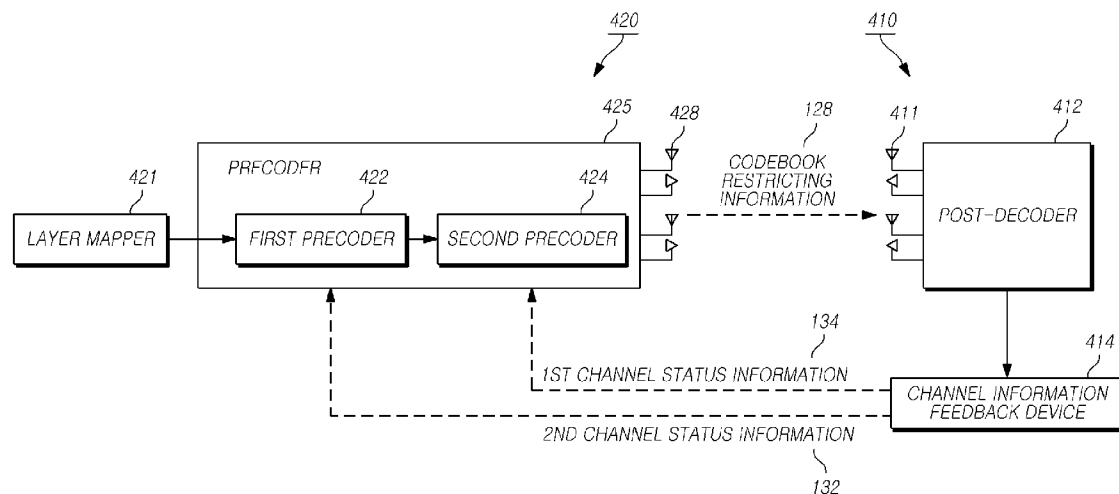
Primary Examiner — Kenneth Lam

(74) *Attorney, Agent, or Firm* — H.C. Park & Associates, PLC

(57) **ABSTRACT**

An embodiment of the present invention relates to a wireless communication system, and more specifically relates to a wireless communication system using multi-input and multi-output (MIMO) antennas in all transmission and reception terminals.

28 Claims, 10 Drawing Sheets



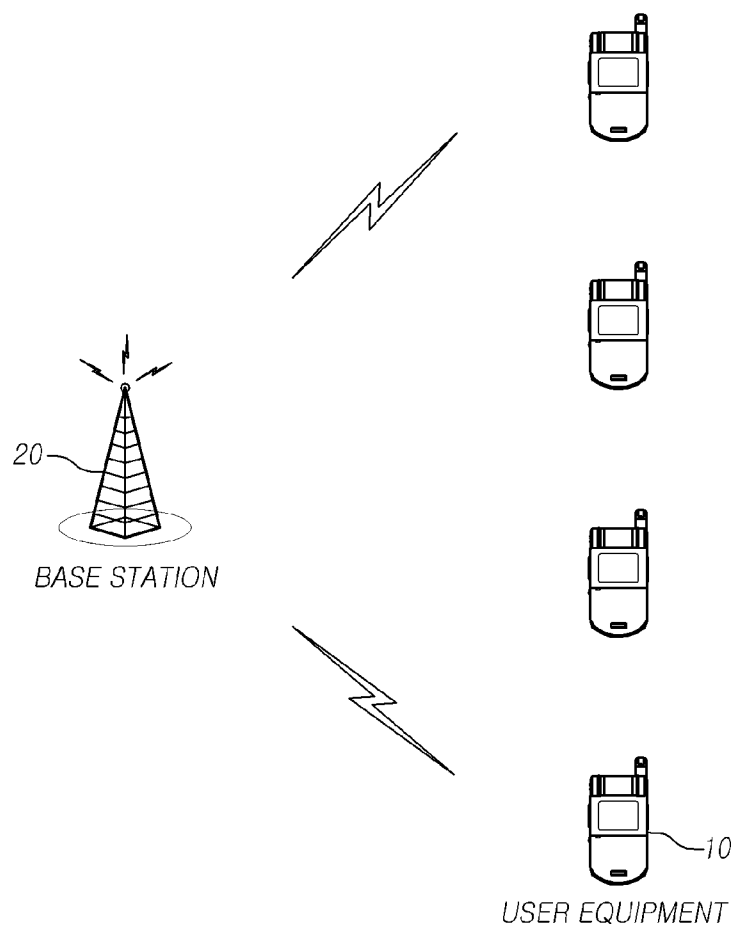
U.S. Patent

Sep. 15, 2015

Sheet 1 of 10

US 9,136,924 B2

FIG. 1



U.S. Patent

Sep. 15, 2015

Sheet 2 of 10

US 9,136,924 B2

FIG. 2

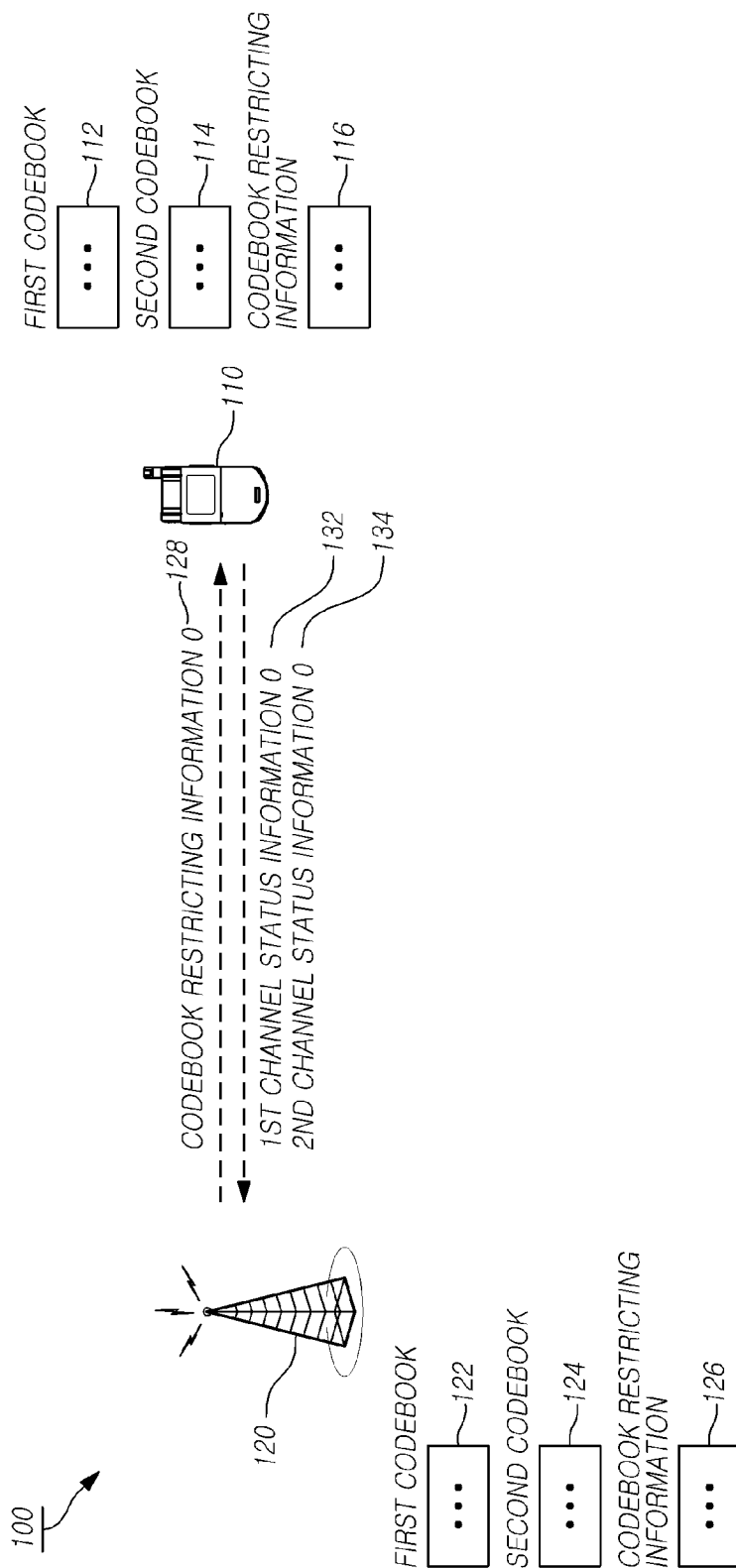
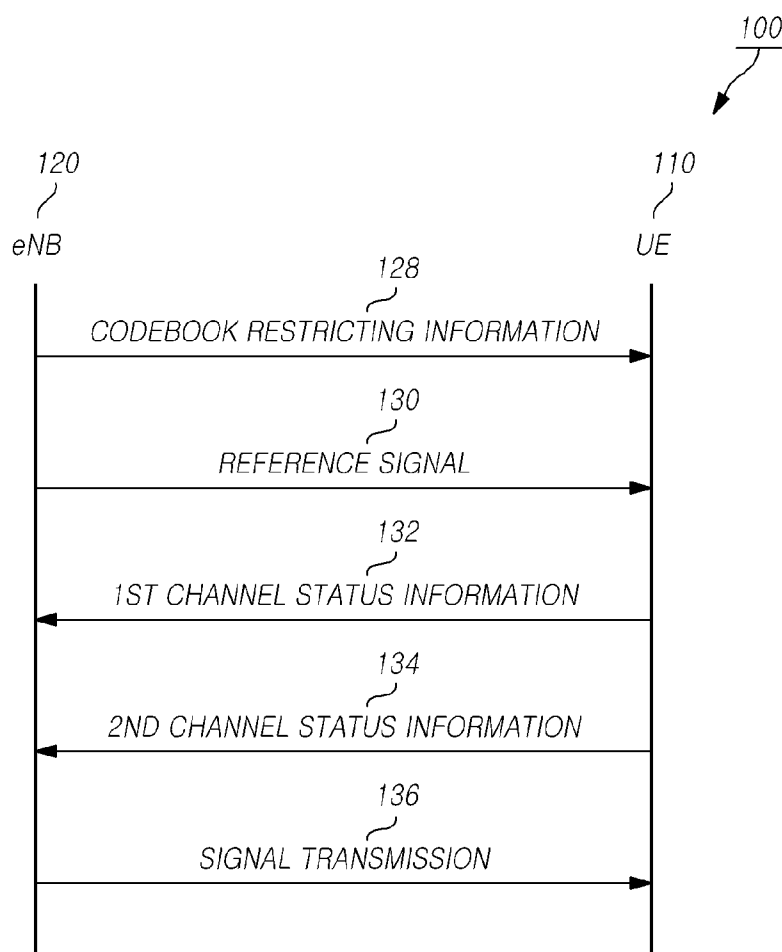


FIG. 3

U.S. Patent

Sep. 15, 2015

Sheet 4 of 10

US 9,136,924 B2

FIG. 4

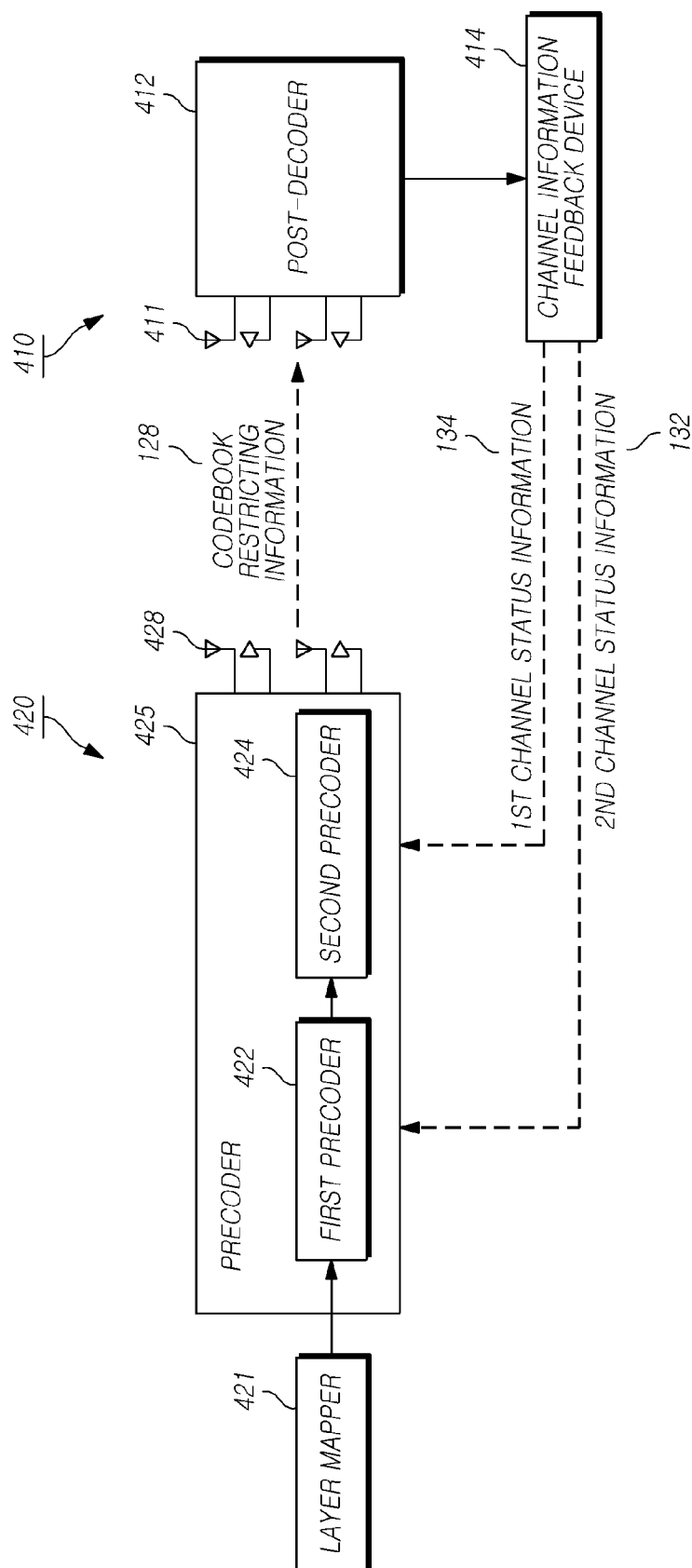
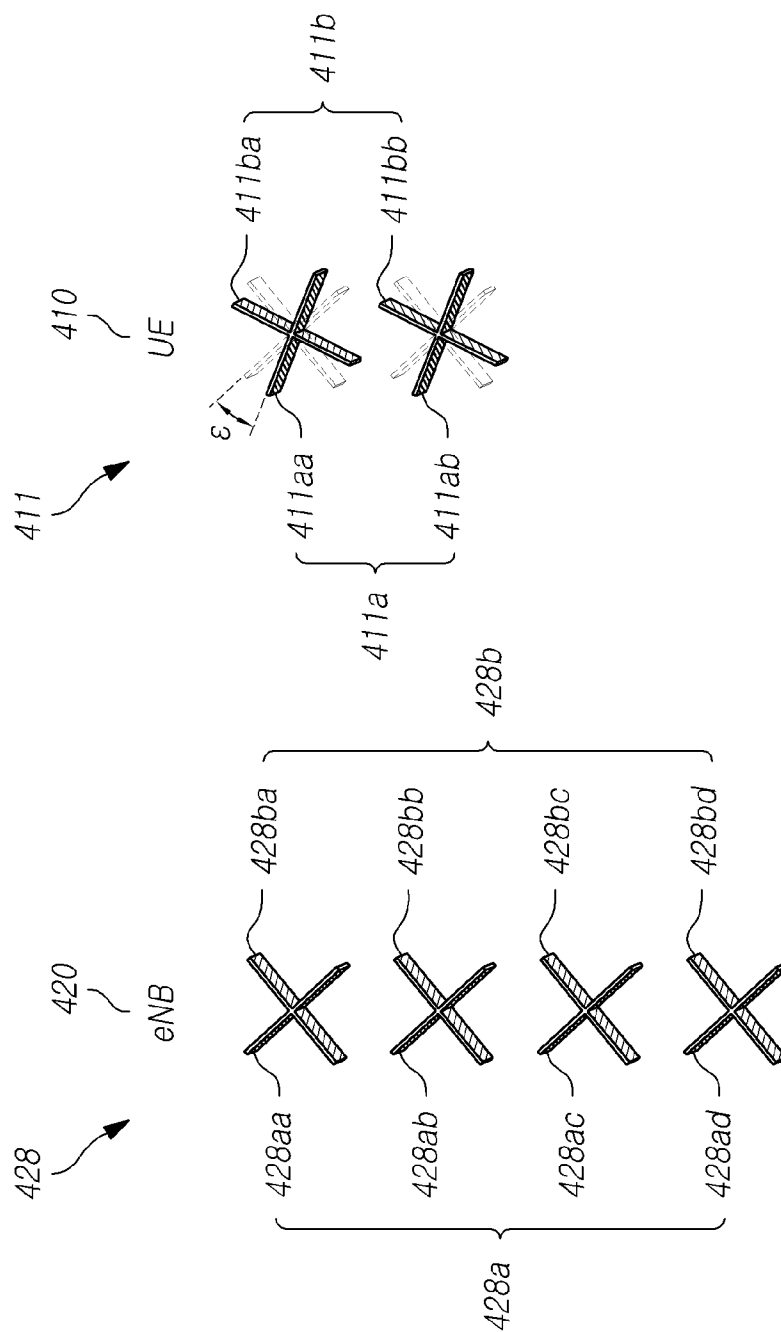


FIG. 5

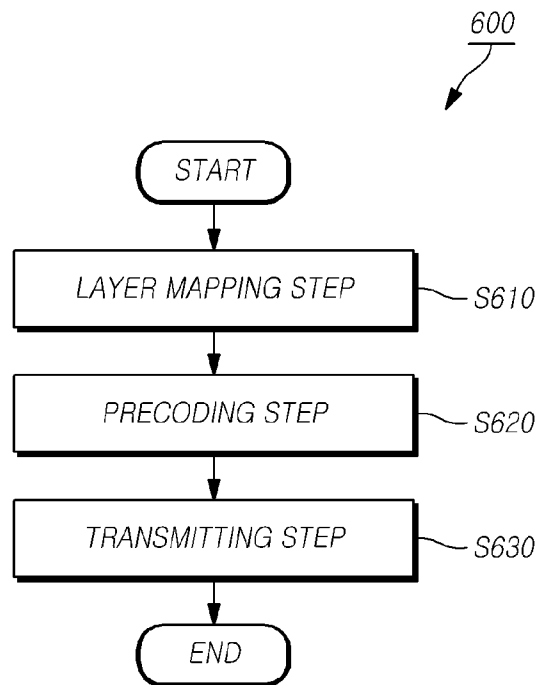
U.S. Patent

Sep. 15, 2015

Sheet 6 of 10

US 9,136,924 B2

FIG. 6



U.S. Patent

Sep. 15, 2015

Sheet 7 of 10

US 9,136,924 B2

FIG. 7

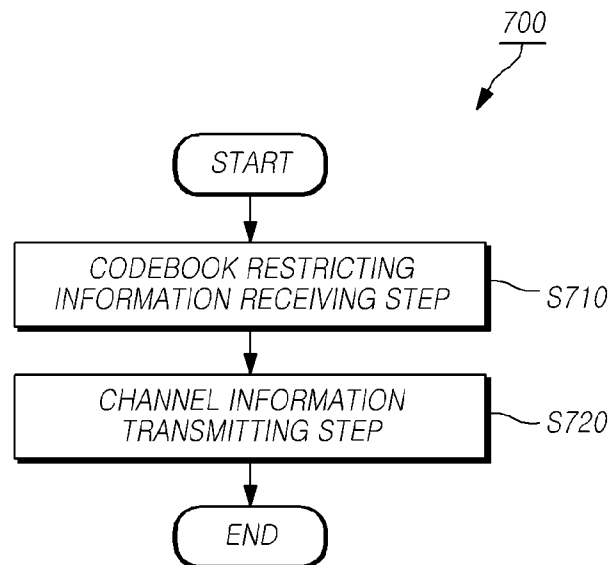


FIG. 8

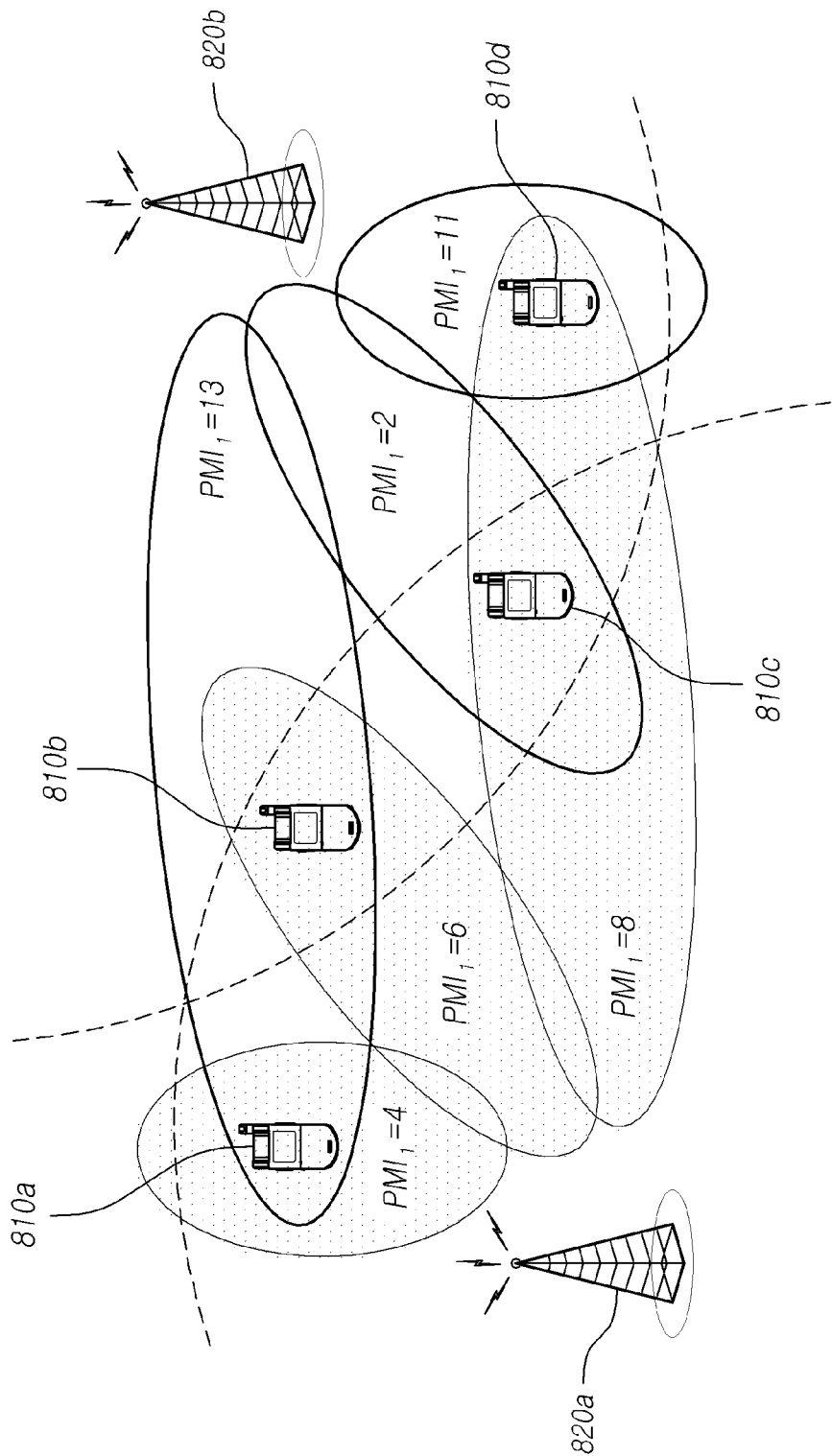


FIG. 9

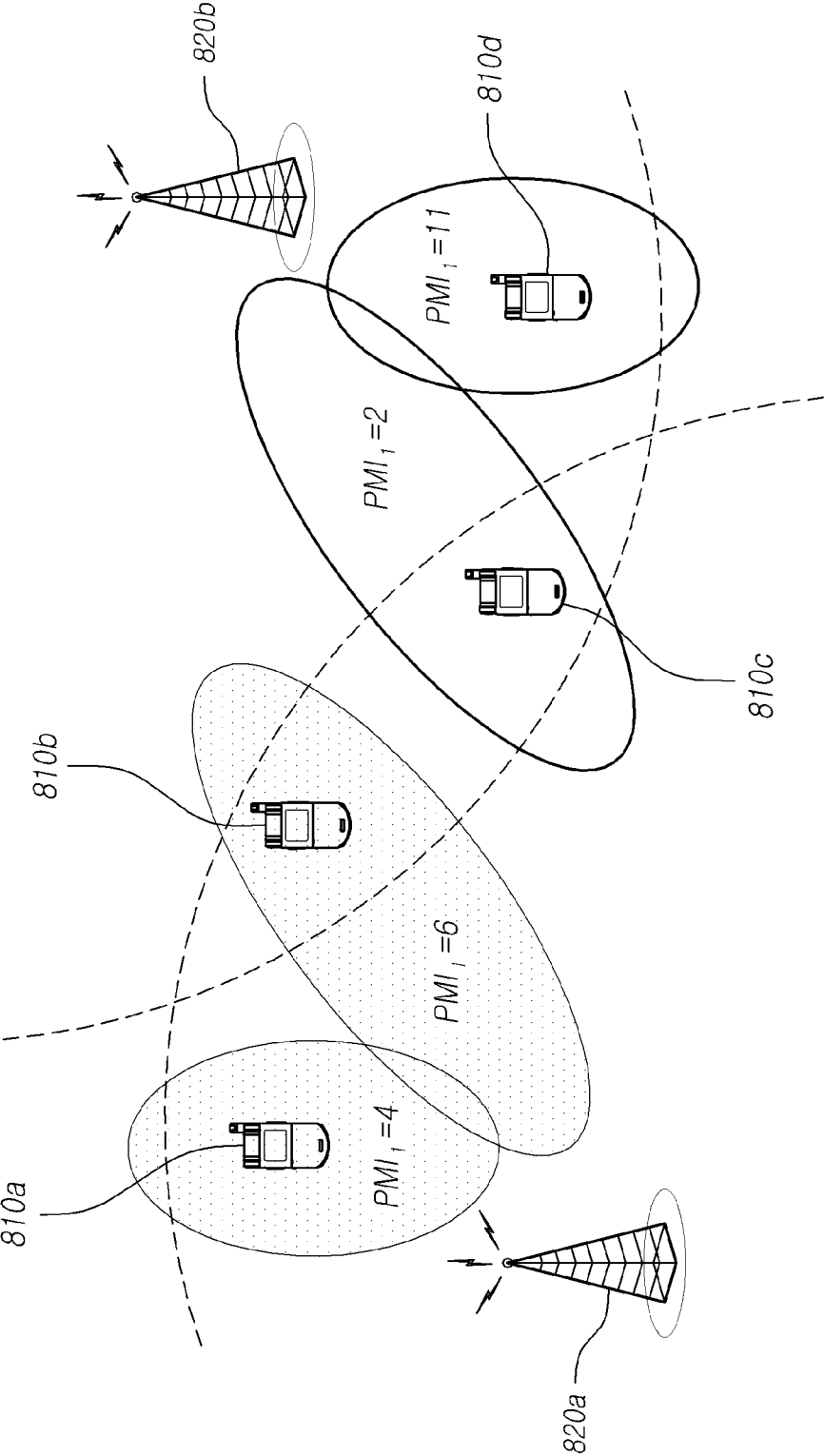
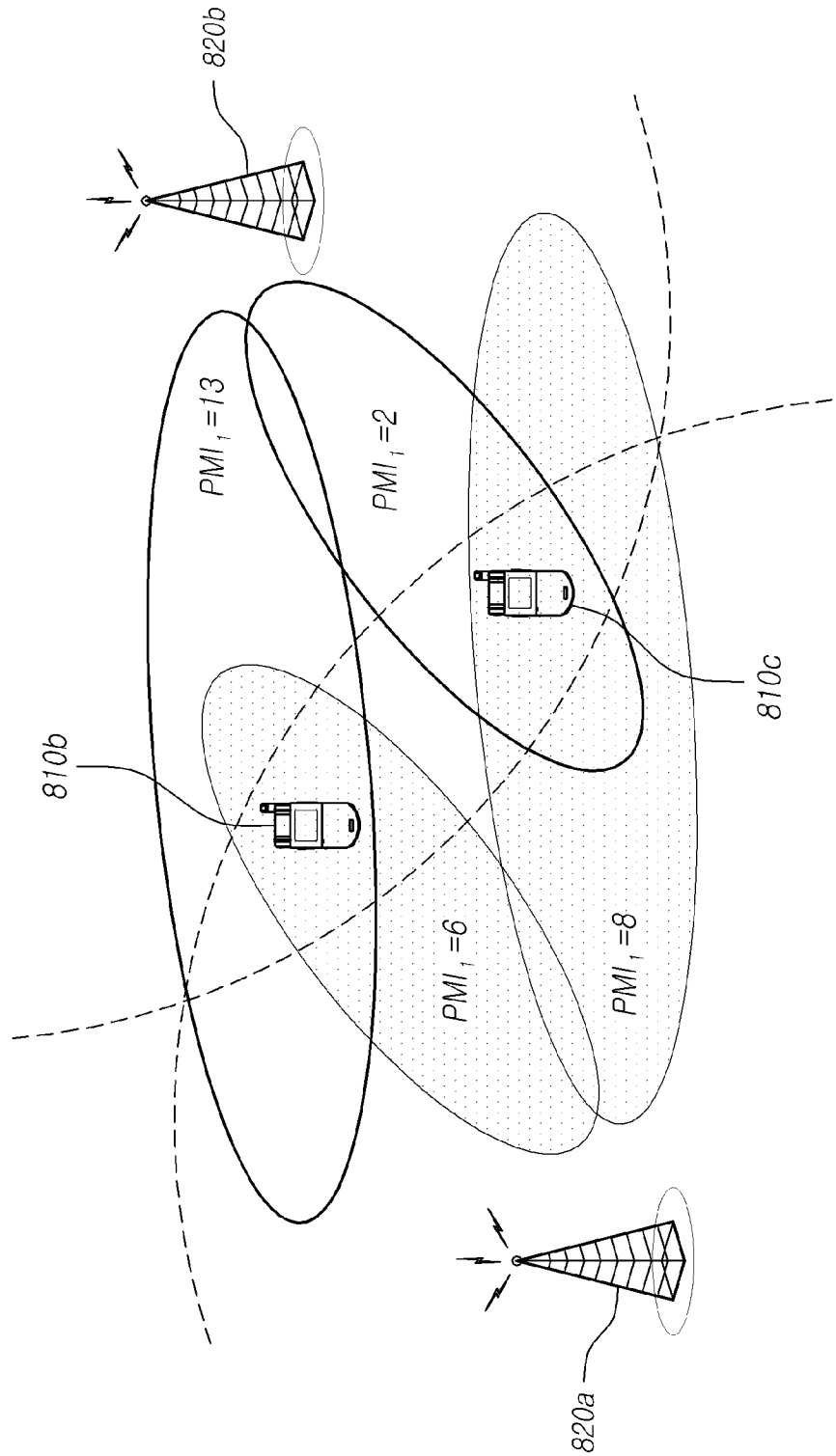


FIG. 10



US 9,136,924 B2

1

TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH

CROSS-REFERENCE TO RELATED APPLICATION

This application is the National Stage Entry of International Application No. PCT/KR2011/004835, filed on Jul. 1, 2011, and claims priority from and the benefit of Korean Patent Application No. 10-2010-0064573, filed on Jul. 5, 2010, all of which are hereby incorporated by reference for all purposes as if fully set forth herein.

BACKGROUND

1. Field

The present invention relates to a wireless communication system, and more particularly, to a wireless communication system that uses multiple input multiple output (MIMO) in both a transmitting end and a receiving end.

2. Discussion of the Background

As communication systems have developed, various wireless terminals have been utilized by consumers, such as companies and individuals.

A current mobile communication system, such as 3GPP, LTE (Long Term Evolution), LTE-A (LTE Advanced), and the like, may be a high capacity communication system capable of transmitting and receiving various data such as image data, wireless data, and the like, beyond providing a sound-based service. Accordingly, there is a desire for a technology that transmits high capacity data, which is comparable with a wired communication network. Also, the system is required to minimize loss of information and increase transmission efficiency of the system so as to enhance performance of the system.

SUMMARY

In accordance with an aspect of the present invention, there is provided a communication method of a transmitting device including a first precoder and a second precoder, the method including: determining first information to restrict a precoding matrix from being used as a first precoding matrix of the first precoder, and second information to restrict a precoding matrix from being used as a second precoding matrix of the second precoder in a corresponding codebook with respect to each layer; and transmitting, to a receiving device, codebook restricting information including at least one of the determined first information and second information.

In accordance with another aspect of the present invention, there is provided a transmitting device, the device including: a layer mapper to map a codeword to a layer; a precoder including a first precoder and a second precoder that performs precoding on a data symbol corresponding to the codeword mapped to the layer by the layer mapper, using a first precoding matrix and a second precoding matrix selected from a corresponding codebook; and an antenna array to transmit signals output from the precoder, and the codeword includes at least one of first information to restrict a precoding matrix from being used as the first precoding matrix and second information to restrict a precoding matrix from being used as the second precoding matrix in the corresponding codebook with respect to each layer.

In accordance with another aspect of the present invention, there is provided a communication method of a receiving

2

device in a wireless communication system, the method including: receiving codebook restricting information including at least one of first information to restrict a precoding matrix from being used as a first precoding matrix and second information to restrict a precoding matrix from being used as a second precoding matrix for each layer; and transmitting, to a transmitting device, 1st channel status information indicating a first precoding matrix and 2nd channel status information indicating a second precoding matrix, the first precoding matrix and the second precoding matrix being selected, based on the codebook restricting information, from among precoding matrices that are not restricted from being used as the first precoding matrix or the second precoding matrix in a codebook.

In accordance with another aspect of the present invention, there is provided a receiving device in a wireless communication system, the device including: an antenna array to receive, as codebook restricting information, at least one of first information to restrict a precoding matrix from being used as a first precoding matrix and first information to restrict a precoding matrix from being used as a second precoding matrix with respect to each layer; and a channel information feedback device to transmit, to a transmitting device, 1st channel status information indicating a first precoding matrix and 2nd channel status information indicating a second precoding matrix, the first precoding matrix and the second precoding matrix being selected, based on the codebook restricting information, from among precoding matrices that are not restricted from being used as the first precoding matrix of the second precoding matrix in a codebook.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram illustrating a wireless communication system according to embodiments of the present invention;

FIG. 2 is a diagram illustrating a wireless communication system in which a base station and a user equipment exchange codebook restricting information and channel status information in a case of codebook restriction;

FIG. 3 is a flowchart further illustrating a reference signal and signal transmission in the wireless communication system that exchanges codebook restricting information and channel status information of FIG. 2;

FIG. 4 is a block diagram illustrating a base station and a user equipment in a MIMO wireless communication system according to an embodiment of the present invention;

FIG. 5 is a diagram illustrating a channel between a base station and a user equipment that use a polarized antenna array of FIG. 4;

FIG. 6 is a flowchart illustrating a communication method of a transmitting device according to another embodiment of the present invention; and

FIG. 7 is a flowchart illustrating a communication method of a receiving device according to another embodiment of the present invention.

FIGS. 8 through 10 are conceptual diagrams illustrating a process of controlling inter-cell interference using a codebook restriction scheme in a wireless communication system according to embodiments of the present invention.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

Hereinafter, exemplary embodiments of the present invention will be described with reference to the accompanying drawings. In the following description, the same elements

US 9,136,924 B2

3

will be designated by the same reference numerals although they are shown in different drawings. Further, in the following description of the present invention, a detailed description of known functions and configurations incorporated herein will be omitted when it may make the subject matter of the present invention rather unclear.

FIG. 1 is a block diagram illustrating a wireless communication system according to embodiments of the present invention.

The wireless communication system may be widely installed so as to provide various communication services such as voice data, packet data, and the like.

Referring to FIG. 1, the wireless communication system may include a user equipment (UE) 10 and a base station (BS) 20.

The user equipment 10 may be an inclusive concept indicating a user terminal utilized in a wireless communication, including a UE (User Equipment) in WCDMA, LTE, HSPA, and the like, and an MS (Mobile Station), a UT (User Terminal), an SS (Subscriber Station), a wireless device and the like in GSM.

The base station 20 or a cell may generally refer to a station where communication with the user equipment 10 is performed, and may also be referred to as a Node-B, an eNB (evolved Node-B), a BTS (Base Transceiver System), an access point, a relay node, and the like.

In the specifications, the user equipment 10 and the base station 20 are used as two inclusive transceiving subjects to embody the technology and technical concepts described in the specifications, and may not be limited to a predetermined term or word.

An embodiment of the present invention may be applicable to an asynchronous wireless communication scheme that is advanced through GSM, WCDMA, and HSPA, to be LTE (Long Term Evolution) and LTE-advanced, and may be applicable to a synchronous wireless communication scheme that is advanced through CDMA and CDMA-2000, to be UMB. Embodiments of the present invention may not be limited to a specific wireless communication scheme, and may be applicable to all technical fields to which a technical idea of the present invention is applicable.

The wireless communication system according to embodiments of the present invention may support an uplink and/or downlink HARQ (Hybrid Automatic Repeat request), and may use a CQI (channel quality indicator) for link adaptation. Also, a multiple access scheme for downlink transmission and a multiple access scheme for uplink transmission may be different from each other. For example, a downlink may use OFDMA (Orthogonal Frequency Division Multiple Access) and an uplink may use SC-FDMA (Single Carrier-Frequency Division Multiple Access).

To support high-speed information transmission for the user, the wireless communication system may consider using a Multiple Input Multiple Output (MIMO) scheme that transfers information through the same band using an antenna array including a multi-antenna.

To embody an effective MIMO system, a MIMO wireless communication system may need to provide, to a transmitting device, information associated with a propagation channel or information associated with a precoder or a precoding matrix (hereinafter referred to as a precoding matrix) appropriate for a propagation channel, to increase transmission capacity. In this example, the former requires a large amount of feedback overhead, whereas the latter requires a relatively small amount of feedback overhead.

In the latter case, each of the user equipment 10 and the base station 20 stores a codebook that defines N available

4

precoding matrices, and expresses an index or an indicator indicating or indexing (corresponding to) each precoding matrix, and identification. Each user equipment 10 selects a precoding matrix appropriate for a propagation channel, and transmits an index indexing the selected precoding matrix to the base station 20. The base station 20 receives precoding matrix indices from each user equipment 10, and selects a MIMO mode or a user equipment or performs precoding based on the received precoding matrix indices.

In this example, as a size of a codebook becomes larger since a number of available precoding matrices is large, the precoding performance of the base station 20 increases. However, an amount of feedback overhead of the user equipment 10 required for reporting the precoding matrices or corresponding indices to the base station 20 may be increased. Therefore, when a large size codebook is used, a codebook restriction or a codebook subset restriction that restricts at least one precoding matrix in a codebook may need to be used for more effective precoding.

The codebook restriction is a scheme that generates a codebook including various precoding matrices, selects a precoding matrix to be used/not used in the codebook for each cell or each user equipment, and uses different codebooks for each cell or each user equipment based on codebook restricting information (hereinafter referred to as "codebook restricting information") associated with a precoding matrix to be not used. When the codebook restriction scheme is used, the whole wireless communication system has a large size codebook, but a codebook that is used by each cell or each user equipment is configured of subsets of the codebook, and has a small size, and is configured of only precoding matrices appropriate for a given environment and thus, a precoding gain may be increased.

For example, when downlink MIMO transmission between the base station 20 and the user equipment 10 simultaneously performs transmission with respect to up to 4 layers, the user equipment 10 may transfer, to the base station 20 using a rank indicator (RI), a number of layers that the user equipment 10 is capable of receiving. In this example, 16 precoding matrices may be designated for each rank during the downlink MIMO transmission between the base station 20 and the user equipment 10, and a total of 64 precoding matrices may be configured as shown in Table 1.

TABLE 1

RI	PMI				
	0	1	2	...	15
1	a0	a1	a2	...	a15
2	a16	a17	a18	...	a31
3	a32	a33	a34	...	a47
4	a48	a49	a50	...	a63

In a case in which the codebook restriction is used, when whether a precoding matrix is to be used is determined for each of the 64 precoding matrices and codebook restricting information is transmitted based on a bitmap format that designates whether each precoding matrix is to be used using 1 bit, a total of 64 bits may be required. For example, a corresponding order of an available precoding matrix is expressed to be 1, and a corresponding order of an unavailable precoding matrix is expressed to be 0, as shown in [001010010 ... 010].

The user equipment 10 may report, to the base station 20 as channel status information, 64 indices corresponding to the total of 64 precoding matrices using a total of 6 bits. In this

US 9,136,924 B2

5

example, when a codebook restriction that restricts the use of 32 precoding matrices from among the 64 precoding matrices is used, a number of information to be distinguished by 6 bits may be decreased from 64 to 32 and thus, a degree of reliability of a feedback signal may be increased. The user equipment **10** may decrease a number of bits that expresses the indices corresponding to the precoding matrices to 5 bits so as to reduce an amount of feedback overhead of the channel status information.

In addition, the use of precoding matrices that are predicted to cause inter-cell interference may be restricted by the codebook restriction and thus, the inter-cell interference may be prevented in advance. In particular, when a beamforming like precoding that is based on a location of each user equipment is performed, a user equipment located in a cell edge may cause serious inter-cell interference. To prevent the inter-cell interference in advance, a codebook restriction may be performed for each cell and thus, the inter-cell interference may be controlled.

The base station **20** may use a multistage precoder including at least two precoders. The codebook restriction that restricts a precoding matrix to be used for each precoder may also be applicable, when the multistage precoder is used. In this example, a number of precoding matrices is generally increased and a number of bits to be used for codebook restricting information for the codebook restriction may also be increased.

In particular, a high signaling and feedback overhead may be required to support high speed information transmission in an uplink or a downlink and thus, a number of bits that the base station **20** uses to inform each user equipment **10** of the codebook restriction may need to be reduced.

The wireless communication system according to embodiments of the present invention has been described. Hereinafter, with reference to FIGS. **2** and **3**, a process will be described in which a base station and a user equipment exchange codebook restricting information and channel status information in a wireless communication system when a multistage precoder is used in a case of codebook restriction.

FIG. **2** illustrates a wireless communication system in which a base station and a user equipment exchange codebook restricting information and channel status information in a case of codebook restriction.

Referring to FIG. **2**, a wireless communication system **100** may include the base station **120** and may include at least one user equipment existing in the wireless communication system **100**, for example, *n* user equipments **110**, like the wireless communication system of FIG. **1**. Although the user equipments **110** may correspond to user equipments that are currently being connected or that attempt additional connection, a single user equipment is illustrated in FIG. **2** for ease of descriptions.

The base station **120** includes a multistage precoder including at least two precoders, that is, first and second precoders. The base station **120** stores a first codebook **122** that expresses *N* first precoding matrices to be used for the first precoder and first indices indexing the first precoding matrices and a second codebook **124** that expresses *M* second precoding matrices to be used for the second precoder and second indices indexing the second precoding matrices.

The base station stores a restriction book **126** including ranks and an index (hereinafter referred to as a restriction index) corresponding to each pair of a first index and a second index with respect to each rank. The base station **120** determines a precoding matrix to be used/not used for each cell or for each user equipment, and may transmit, to the user equipment **110**, codebook restricting information **128** associated

6

with the precoding matrix to be not used. In this example, the codebook restricting information **128** includes first information that restricts a precoding matrix from being used as a first precoding matrix and second information that restricts a precoding matrix from being used as a second precoding matrix in the first and second codebooks **122** and **124** with respect to each layer.

FIG. **3** is a flowchart further illustrating a reference signal and signal transmission in the wireless communication system that exchanges codebook restricting information and channel status information of FIG. **2**.

Referring to FIG. **3**, for transmission and reception of data between the user equipment **110** and the base station **120**, the base station **120** at a transmitter side transmits a reference signal **130** as further illustrated in FIG. **3**, and the user equipment **110** at a receiver side estimates a channel using the reference signal **130**. For example, in a case of downlink transmission, the user equipment **110** may estimate a downlink channel. In particular, in a case of OFDM transmission, the user equipment **110** may estimate a channel of each sub-carrier. Conversely, in a case of uplink transmission, the base station **120** may estimate an uplink channel.

For the channel estimation, a predetermined signal or symbol may be inserted into a frequency-domain grid at regular or irregular intervals. In this example, the predetermined signal or symbol may be referred to as a reference signal or a reference symbol, a pilot symbol, and the like. In the specifications, the predetermined signal or symbol is referred to as a reference signal, but this may not be limited thereto. The reference signal **130** may not be used for only the estimation of the frequency-domain channel, but may be used for estimation of a location required for wireless communication between a user equipment and a base station, transmission and reception of control information, transmission and reception of scheduling information, transmission and reception of feedback information, and the like.

There may be various types of reference signals for downlink or uplink transmission, and new reference signals for various purposes have been defined and discussed. For example, reference signals for the uplink transmission may include a DM-RS (Demodulation RS), an SRS (Sounding RS), and the like. Reference signals for the downlink transmission may include a DM-RS (Demodulation RS), CRS (Cell-specific RS), an MBSFN RS, a UE-specific RS, and the like. Also, a CSI-RS is used as a reference signal that a base station transmits to obtain channel status information (CSI) of a center cell or adjacent cells from the user equipment **110** in a case of downlink transmission. The CSI-RS may be used for reporting a CQI (Channel Quality Indicator)/PMI (Precoder Matrix Indicator)/RI (Rank Indicator), and the like. The CSI-RS may be cell-specific so as to be distinguished for each cell included in a base station that transmits the CSI-RS, and may need to be sufficiently scattered in a frequency and a time for a low overhead.

Referring again to FIG. **2**, the user equipment **110** stores a first codebook **112** that expresses *N* first precoding matrices used for a first precoder and first indices indexing the first precoding matrices and a second codebook **114** that expresses *M* second precoding matrices used for a second precoder and second indices indexing the second precoding matrices. The first codebook **112** and the second codebook **114** may be identical to the first codebook **122** and the second codebook **124** stored in the base station **120**, respectively.

The user equipment **110** stores a restriction book **116**, which will be described with reference to Table 4, including ranks and a plurality of indices (hereinafter referred to as a restriction index) corresponding to each pair of a first index

US 9,136,924 B2

7

and a second index included in each rank. The restriction book 116 stored in each user equipment 110 may be identical to the restriction book 126 stored in the base station 120.

The user equipment 110 may receive codebook restricting information 128 from the base station 120. The codebook restricting information 128 includes at least one of first information that restricts a precoding matrix from being used as a first precoding matrix and second information that restricts a precoding matrix from being used as a second precoding matrix in first and second codebooks for each layer.

The user equipment 110 determines, based on the first information included in the codebook restricting information 128, a first precoding matrix excluding precoding matrices that are restricted from being used as a first precoding matrix, and reports/feeds back 1st channel status information 132 associated with the determined precoding matrix to the base station 120. Also, each user equipment 110 determines, based on the second information included in the codebook restricting information 128, a second precoding matrix excluding precoding matrices that are restricted from being used as a second precoding matrix, and reports/feeds back 2nd channel status information 134 associated with the determined second precoding matrix to the base station 120.

The base station 120 determines precoding matrices of the first precoder and the second precoder from the first codebook 122 and the second codebook 124 based on the channel status information 132 and 134 reported from each user equipment 110, and performs precoding of data symbols using the precoding matrices.

Referring again to FIG. 3, the base station 120 transmits a precoded signal 136 to the user equipment 110 as illustrated in FIG. 3. Conversely, the user equipment 110 receives the signal 136 and decodes the signal into original data.

The process has been described in which a base station and a user equipment exchange codebook restricting information and channel status information in the wireless communication system when a multistage precoder is used in a case of codebook restriction. Hereinafter, a MIMO wireless communication system that transmits and receives codebook restricting information and the channel status information will be described.

FIG. 4 is a block diagram illustrating a base station and a user equipment in a MIMO wireless communication system according to an embodiment of the present invention. FIG. 5 illustrates a channel between a base station and a user equipment that uses a polarized antenna array of FIG. 4.

Referring to FIG. 4, a MIMO wireless communication system may include a user equipment 410 and a base station 420.

The user equipment 410 includes an antenna array 411 to receive a signal through a downlink channel, a post-decoder 412 to process a received signal and to decode the received signal into original data using a precoding matrix, and a channel information feedback device 414.

The antenna array 411 may use a plurality of antennas. In this example, the antenna array 411 may form a polarized antenna array. The array may be embodied as a dual polarized antenna array in which two antennas having different polarities intersect each other so as to arrange a larger number of antennas in a limited space.

Referring to FIG. 5, when “+” indicates a direction polarizing to the right from the vertical direction and “-” indicates a direction polarizing to the left from the vertical direction, the user equipment 410 includes a polarized antenna array 411 including two pairs of antennas in which antennas 411aa and 411ab polarized at 45 degrees from the vertical direction and antennas 411ba and 411bb polarized at -45 degrees from

8

the vertical direction intersect to each other, respectively. In this example, the antennas 411aa and 411ab polarized at +45 degrees may be referred to as a first domain 411a or a first subset of a transmitting side, and the antennas 411ba and 411bb polarized at -45 degrees may be referred to as a second domain 411b or a second subset of the transmitting side.

Referring again to FIG. 4, the post-decoder 412 may correspond to a first precoder 422 and a second precoder 424 of the base station 420. The post-decoder may transfer a received reference signal to the channel information feedback device 414.

The channel information feedback device 414 may receive a reference signal and may estimate a channel using the reference signal. The channel information feedback device 414 may generate channel information including 1st channel status information and 2nd channel status information. The channel information feedback device 414 may feed back the channel information to the base station 420.

The base station 420 may include a layer mapper 421 to map a codeword to a layer, a precoder 425 to perform precoding of data symbols obtained through the layer mapping using a precoding matrix, and an antenna array 428 to transmit a precoded signal on air. The precoder 425 may include the first precoder 422 and the second precoder 424 to perform precoding of data symbols. In this example, the first precoder 422 and the second precoder 424 may perform precoding of data symbols using a corresponding first precoding matrix and a corresponding second precoding matrix, respectively.

The antenna array 428 of the base station 420 may use a plurality of antennas. In this example, the antenna array 428 may form a polarized antenna array. An array may be embodied as a dual polarized antenna array in which two antennas having different polarities intersect each other so as to arrange a larger number of antennas in a limited space in a wireless communication system. In this example, although it is described that the antenna arrays 411 and 428 use a dual polarized antenna array, this may not be limited thereto.

Referring to FIG. 5, the base station 420 includes a polarized antenna array 428 including four pairs of antennas in which antennas 428aa through 428ad polarized at 45 degrees from the vertical direction and antennas 428ba through 428bd polarized at -45 degrees intersect each other, respectively. In this example, the antennas 428aa through 428ad polarized at +45 degrees are referred to as a first domain 428a or a first subset of a receiving side, and the antennas 428ba through 428bd polarized at -45 degrees are referred to as a second domain 428b or a second subset of a receiving side.

When a phase mismatch does not exist between polarized antennas of the user equipment 410 and the base station 420, an overall channel H may be expressed as shown in Equation 1.

$$H = \begin{bmatrix} H_h & 0 \\ 0 & H_v \end{bmatrix} \quad \text{Equation 1}$$

In this example, H_h denotes a channel between the first subset or the first domain 411a of the user equipment 410 and the first subset or the first domain 428a of the base station 420, and H_v denotes a channel between the second subset or the second domain 411b and the second subset or the second domain 428b of the base station 420.

As shown in Equation 1, when antennas polarized to different directions intersect each other and have no phase mismatch, the antennas may not affect each other. Therefore, only H_h and H_v may be estimated and thus, a channel may be

US 9,136,924 B2

9

recognized. When a distance d between adjacent polarized antennas is shorter than a signal wavelength λ , a correlation between antennas may be high. In this example, H_h and H_v may be determined based on a distance d between antennas and an incident angle θ of signal propagation that arrives at the user equipment **410**.

When a phase mismatch exists between polarized antennas of the user equipment **410** and the base station **420**, for example, when pairs of antennas of the user equipment **410** are tilted to the left by ϵ , signals transmitted from each polarized domain of the base station **420** may be received by two polarized domains of the user equipment **410** and thus, inter-domain interference may occur due to a phase mismatch between the domains. Therefore, a channel may be affected by a degree of a phase error or a phase mismatch between polarized antennas of the user equipment **410** and the base station **420**, that is, by ϵ , and thus, the overall channel H may be expressed by Equation 2.

$$H = \begin{bmatrix} H_h \cos \epsilon & -H_v \sin \epsilon \\ H_h \sin \epsilon & H_v \cos \epsilon \end{bmatrix} \quad \text{Equation 2}$$

Referring again to FIG. 4, the second precoder **424** may correct a phase mismatch to remove an effect from a phase error or a phase mismatch between polarized domains formed by the antenna array **428** including antennas intersecting in a horizontal direction and a vertical direction, and the first precoder may perform intra-domain precoding.

When a dual polarized domain is configured based on a scheme of arranging two antennas at the same location, each polarized domain may have an identical spatial channel characteristic. That is, each domain may be precoded based on an identical precoding matrix ($H_h = H_v = R_0$), and a signal transmitted through each polarized domain may have a different phase and size when arriving at the user equipment **410**. In this example, a first precoding matrix and a second precoding matrix used in the first precoder **422** and the second precoder **424** may be expressed by Equation 3.

$$W = \begin{pmatrix} R_0 & 0 \\ 0 & R_0 \end{pmatrix} \begin{pmatrix} I \\ \Lambda \end{pmatrix} \quad \text{Equation 4}$$

$w_1 \quad w_2$

In Equation 3, R_0 denotes a value determined by a precoding gain when the first is domain and the second domain have an identical spatial channel status, I denotes a unit matrix, and Λ denotes a phase mismatch correction value between the first domain and the second domain.

A size of a signal received in each domain may be determined by a precoding gain of R_0 of a first precoding matrix W_1 , a second precoding matrix W_2 corrects a phase mismatch between signals received in respective domains. When an operation proceeds in this manner, a first index PMI_1 for setting the first precoding matrix W_1 and a second index PMI_2 for setting the second precoding matrix W_2 may be independently selected.

As shown in Equation 3, the precoder **425** is a precoder configured of a first precoding matrix that performs precoding using R_0 determined by a precoding gain in each of the

10

two domains (a polarized domain or a subset of antennas) and a second precoding matrix that performs phase mismatch correction (co-phasing) between domains. Therefore, each of the two independent domains may be precoded by R_0 determined by a precoding gain, and one of the domains may be phase-corrected by Λ and may be transmitted.

In the precoder **425**, the second precoding matrix corresponds to a precoding matrix that corrects signal attenuation caused by a phase error between polarized domains in polarized antennas. Also, the second precoding matrix may correspond to a precoding matrix to correct signal attenuation caused by a phase error between polarized domains, or may correspond to a precoding matrix to correct a phase mismatch that naturally occurs between polarized antennas. The base station **420** stores a first codebook that expresses N (N is a natural number greater than or equal to 1) first precoding matrices used for the first precoder **422** and first indices indexing the first precoding matrices, and a second codebook that expresses M (M is a natural number greater than or equal to 1) second precoding matrices and second indices indexing the second precoding matrices.

Table 2 and Table 3 correspond to examples of the first codebook and the second codebook that use 16 precoding matrices and 4 precoding matrices for each rank, respectively, when the antenna array **428**, including 8 dual polarized antennas **428a** and **428b**, simultaneously transmits a total of 8 layers.

TABLE 2

RI	PMI_1				
	0	1	2	...	15
1	b0	b1	b2	...	b15
2	b16	b17	b18	...	b31
...	...	...	...	...	...
8	b112	b113	b114	...	b127

TABLE 3

RI	PMI_2			
	0	1	2	3
1	c0	c1	c2	c3
2	c4	c5	c6	c7
...	...	...	...	...
8	c28	c29	c30	c31

The base station **420** stores a restriction book including ranks and an index (hereinafter referred to as a restriction index) corresponding to each pair of a first index and a second index for each rank. Table 4 corresponds to a restriction book that uses 16 precoding matrices and 4 precoding matrices for each rank when the antenna array **428**, including 8 dual polarized antennas **428a** and **428b**, simultaneously transmits a total of 8 layers.

US 9,136,924 B2

11

TABLE 4

RI	(PMI ₁ , PMI ₂)									
	(0,0)	(0,1)	(0,2)	(0,3)	(1,0)	(1,1)	...	(15,1)	(15,2)	(15,3)
1	a0	a1	a2	a3	a4	a5	...	a61	a62	a63
2	a64	a65	a66	a67	a68	a69	...	a125	a126	a127
...	...	...	...	...	...	...	...	...	...	...
8	a448	a449	a450	a451	a452	a453	...	a509	a510	a511

In a case of codebook restriction, when codebook restricting information is transmitted based on a bitmap format that designates whether each precoding matrix is to be used using one bit, a total of $16 \times 4 \times 8 = 512$ bits may be required for the ranks and pairs of a first index and a second index for respective ranks.

However, as described in the foregoing, a first index PMI₁ for setting a first precoding matrix W₁ and a second index PMI₂ for setting a second precoding matrix W₂ may be independently selected and thus, a codebook may be restricted independently with respect to each precoding matrix, for each rank and for each of the first precoder and the second precoder. Table 5 expresses precoders that are restricted in a restriction book when codebook restriction is determined with respect to the first index=0 (PMI₁=0) and the second index=1 (PMI₂=1) in a rank 1.

TABLE 6

RI	(PMI ₁ , PMI ₂)									
	(0,0)	(0,1)	(0,2)	(0,3)	(1,0)	(1,1)	...	(15,1)	(15,2)	(15,3)
1	a0	a1	a2	a3	a4	a5	...	a61	a62	a63
2	a64	a65	a66	a67	a68	a69	...	a125	a126	a127
...	...	...	...	...	...	...	...	...	...	...
8	a448	a449	a450	a451	a452	a453	...	a509	a510	a511

Although not illustrated in Table 5, a codebook restriction may be independently performed on a first precoding matrix and a second precoding matrix with respect to 8 ranks, in the same manner as the codebook restriction performed on the rank 1.

The base station 420 determines a precoding matrix to be used/not used for each cell or for each user equipment, and transmits codebook restricting information associated with the precoding matrix to be not used to the user equipment 410. In this example, the codebook restricting information may include first information that restricts a precoding matrix from being used as a first precoding and second information that restricts a precoding matrix from being used as a second precoding matrix in the first and second codebooks for each layer.

As shown in Table 5, when codebook restriction on a first index=0 (PMI₁=0) and a second index=1 (PMI₂=1) is determined with respect to the rank 1, codebook restricting information may include [0111111111111111] corresponding to first information and corresponding to second information in a bitmap format. As described in the foregoing, a corresponding order of an available precoding matrix is expressed to be 1, and a corresponding order of a precoding matrix not to be used is expressed to be 0. Accordingly, a codebook may be generally restricted with respect to second indices that make pairs with the first index=0 (PMI₁=0), for example, (PMI₁, PMI₂)=(0,1), (0,1), (0,2), (0,3) in Table 5. Also, a codebook

12

may be generally restricted with respect to the first indices that make pairs with the second index=1 (PMI₂=1), for example, (PMI₁, PMI₂)=(0,1), (1,1), ..., (14,1), (15,1) in table 5.

When a codebook restriction on a first index=1 (PMI₁=1) and a second index=2 (PMI₂=2) is determined with respect to a rank 2, codebook restricting information may include [1011111111111111] corresponding to first information and [1101] corresponding to second information. Accordingly, a codebook may be generally restricted with respect to second indices that make pairs with the first index=1 (PMI₁=1), for example, (PMI₁, PMI₂)=(1,1), (1,1), (1,2), (1,3) in Table 5. Also, a codebook may be generally restricted with respect to the first indices that make pairs with the second index=2 (PMI₂=2), for example, (PMI₁, PMI₂)=(0,2), (1,2), ..., (14,2), (15,2) in table 5.

When a codebook restriction on a first index=0 (PMI₁=0) and a second index=3 (PMI₂=3) is determined with respect to a rank 8, codebook restricting information may include [0111111111111111] corresponding to first information and [1110] corresponding to second information. Accordingly, a codebook may be generally restricted with respect to second indices that make pairs with the first index=0 (PMI₁=0), for example, (PMI₁, PMI₂)=(0,1), (0,1), (0,2), (0,3) in Table 5. Also, a codebook may be generally restricted with respect to the first indices that make pairs with the second index=3 (PMI₂=3), for example, (PMI₁, PMI₂)=(0,3), (1,3), ..., (14,3), (15,3) in table 5.

In other words, the codebook restricting information includes the first information and the second information. Accordingly, when a first precoding matrix is restricted from being used as a first precoding matrix based on the first information, the use of second precoding matrices that make pairs with the restricted first precoding matrix may be restricted. When a second precoding matrix is restricted from being used as a second precoding matrix based on the second information, the use of first precoding matrices that make pairs with the restricted second precoding matrix may be restricted.

In the same manner, codebook restricting information with respect to each of a rank 3 through a rank 7 may include first information and second information in a bitmap format. In this example, although the codebook restricting information including the first information and the second information is provided in a bitmap format, this is merely an example and may not be limited thereto.

In the same manner described in the foregoing, when the rank 1 through rank 8 transmit codebook restricting information based on the same bitmap format, a total number of bits of the codebook restricting information that independently restricts a first precoding matrix and a second precoding matrix with respect to a total of 8 ranks may be $(16+4) \times 8 = 160$.

The base station 420 may transmit, to the user equipment 410, codebook restricting information that expresses codebook restriction based on a bitmap format using 20 bits for

US 9,136,924 B2

13

each rank, that is, a total of 160 bits for the rank 1 through the rank 8. The codebook restricting information may be transmitted as downlink control information, for example, an RRC signal, from the base station 420 to the user equipment 410 through a Physical Downlink Shared Channel (PDSCH). In this example, the codebook restricting information may be transmitted from the base station 420 to the user equipment 410 through a Physical Downlink Control Channel (PDCCH) in addition to the PDSCH. In this example, the codebook restricting information may sequentially include first information and second information for each rank. For example, the codebook restricting information may include first information and second information associated with the rank 1, first information and second information associated with the rank 2, . . . , and first information and second information associated with the rank 8, sequentially.

The codebook restricting information may sequentially include first information for each rank, and then may sequentially include second information for each rank. For example, the codebook restricting information may sequentially include first information associated with the rank 1 through the rank 8, and then may sequentially include second information associated with the rank 1 through the rank 8. The first information and the second information included in the codebook restricting information may be independently transmitted for each rank from the base station 420 to the user equipment 410. When a codebook is not restricted for a predetermined rank, codebook restricting information associated with the predetermined codebook may not be included.

Accordingly, when a pair of a first index and a second index is restricted, codebook restricting information of a total of 512 bits is required. However, when restriction on a first index and a second index is independently determined and transmitted, an amount of feedback overhead of the codebook restriction may be significantly reduced.

When the first precoder 422 performs intra-domain precoding using a first precoding matrix, for example, in a case where a codebook is restricted so that precoding matrices expressed to be a first index=7 ($PMI_1=7$) are not to be used since an intra-domain precoding gain is small, any precoding matrix that is expressed to be $PMI_1=7$ when the second precoder 424 performs phase mismatch correction using a second precoding matrix may not obtain an excellent precoding gain.

That is, determining restriction on a first precoding matrix that performs intra-domain precoding may take precedence over determining restriction on a second precoding matrix that performs phase mismatch correction. Therefore, when a codebook restriction is performed, only the first precoding matrix may be restricted. In this example, the codebook restricting information includes only first information that restricts the first precoding matrix and thus, a total of $16 \times 8 = 128$ bits may be required.

When inter-domain phase mismatch interference takes precedence in a condition of the same inter-domain interference, only the second precoding matrix may be restricted. In this example, the codebook restricting information includes only second information that restricts the second precoding matrix and thus, a total of $4 \times 8 = 32$ bits may be required.

As described in the foregoing, a scheme that restricts both the first precoding matrix and the second precoding matrix, independently, a scheme that restricts only the first precoding matrix, and a scheme that restricts only the second precoding matrix may be selectively used. In this example, the base station 420 may transmit, to the user equipment 410, a restriction mode indicator of a total of 2 bits that indicates a restriction mode.

14

The channel information feedback device 414 of the user equipment 410 determines a first precoding matrix excluding precoding matrices that are restricted from being used as a first precoding matrix based on first information included in codebook restricting information, and reports/feeds back, to the base station 420, 1st channel status information associated with the first precoding matrix. In the example provided in the foregoing, when [01111111111111] corresponding to first information of a bitmap format that restricts a codebook with respect to a first index=0 ($PMI_1=0$) in a rank 1 is received, the channel information feedback device 414 determines a first precoding matrix from among precoding matrices corresponding to indices excluding the first index=0 ($PMI_1=0$), that is, from among precoding matrices excluding precoding matrices corresponding to the first index=0, and reports/feeds back 1st channel status information associated with the first precoding matrix to the base station. Also, each user equipment 410 determines a second precoding matrix excluding matrices that are restricted from being used as a second precoding matrix based on second information included in codebook restricting information, and reports/feeds back, to the base station 420, 2nd channel status information associated with the second precoding matrix. In the example provided in the foregoing, when [1011] corresponding to second information of a bitmap format that restricts a codebook with respect to a second index=1 ($PMI_2=1$) in a rank 2 is received, the channel information feedback device 414 determines a second precoding matrix from among precoding matrices corresponding to indices excluding the second index=1 ($PMI_2=1$), that is, from among precoding matrices excluding precoding matrices corresponding to the second index=1, and reports/feeds back 2nd channel status information associated with the second precoding matrix to the base station.

When [1011111111111111] corresponding to first information and [1101] corresponding to second information of a bitmap format that restrict a codebook with respect to a first index=1 ($PMI_1=1$) and a second index=2 ($PMI_2=2$) in the rank 2 are received, the channel information feedback device 414 determines a first precoding matrix and a second precoding matrix excluding precoding matrices corresponding to the first index=1 ($PMI_1=1$) and the second index=2 ($PMI_2=2$) with respect to the rank 2 as shown in Table 5, and reports/feeds back, to the base station, the associated 1st channel status information and 2nd channel status information. In the same manner, the channel information feedback device 414 may determine a first precoding matrix and a second precoding matrix excluding precoding matrices designated by first information and second information, with respect to the rank 3 through the rank 8.

As described in the foregoing, a scheme that restricts both the first precoding matrix and the second precoding matrix, independently, a scheme that restricts only the first precoding matrix, and a scheme that restricts only the second precoding matrix may be selectively used. When the base station 420 transmits, to the user equipment 410, a restriction mode indicator of a total of 2 bits that indicates a restriction mode, the channel information feedback device 414 of the user equipment 410 may determine a first precoding matrix and a second precoding matrix based on the restriction mode, and generates and reports 1st channel status information and 2nd channel status information.

A feedback period or interval of the 1st channel status information and the 2nd channel status information may be different from each other. For example, the 1st channel status information may be fed back to the base station 420 based on a short term, and the 2nd channel status information may be fed back to the base station 420 based on a long term. In other

US 9,136,924 B2

15

words, a long period/long term and a short period/short term are relative terms, and the long period/long term indicates a period that is longer than the short period/short term.

The first precoder 422 and the second precoder 424 of the base station 420 determine first and second precoding matrices based on/using channel status information reported from each user equipment 410, and perform precoding of data symbols using the precoding matrices.

The MIMO wireless communication system that transmits and receives codebook restricting information and channel status information according to another embodiment of the present invention has been described. Hereinafter, a communication method of a transmitting device according to another embodiment of the present invention will be described.

FIG. 6 is a flowchart illustrating a communication method of a transmitting device according to another embodiment of the present invention.

Referring to FIG. 6, a communication method 600 of a transmitting device according to another embodiment of the present invention includes a layer mapping step S610 to map a codeword to a layer, a precoding step S620 to perform precoding of symbols, and a transmitting step S630 to propagate a precoded symbol into air through two or more antennas. The layer mapping step S610, the precoding step S620, and the transmitting step S630 are identical as described in the foregoing and thus, detailed descriptions thereof will be omitted.

A communication method 600 of a base station according to another embodiment of the present invention independently performs codebook restriction on a first precoding matrix of Table 3 and a second precoding matrix of Table 4 with respect to each rank by referring to Table 5, and transmits, to the user equipment 410, codebook restricting information that expresses codebook restriction in a bitmap format using 20 bits for each rank, that is, a total of 160 bits from a rank 1 through a rank 8. The codebook restricting information may be transmitted as downlink control information, for example, an RRC signal, from the base station 420 to the user equipment 410 through a Physical Downlink Shared Channel (PDSCH). In this example, the codebook restricting information may be transmitted from the base station 420 to the user equipment 410 through another channel such as a Physical Downlink Control Channel (PDCCH) in addition to the PDSCH.

In the layer mapping step S610, the codebook restricting information may be mapped to a layer as a downlink control signal.

The base station 420 determines a precoding matrix to be used/not to be used for each cell or each user equipment, and transmits codebook restricting information associated with the precoding matrix to the user equipment 410. In this example, the codebook restricting information includes first information to restrict a precoding matrix from being used as a first precoding matrix and second information to restrict a precoding matrix from being used as a second precoding matrix in first and second codebooks for each layer.

As shown in Table 5, when codebook restriction is determined with respect to a first index=0 ($PMI_1=0$) and a second index=1 ($PMI_2=1$) in a rank 1, codebook restricting information may include [0111111111111111] corresponding to first information and [1011] corresponding to second information in a bitmap format.

The precoding step S620 may perform precoding of a data symbol obtained through layer mapping, using a first precoding matrix and a second precoding matrix selected from a corresponding codebook. In this example, the precoding step S620 may perform precoding of data symbols using a first

16

precoding matrix and a second precoding matrix corresponding to a first index and a second index received from a receiving device such as a user equipment. In this example, the first index and the second index received from the receiving device may correspond to indices associated with precoding matrices selected from precoding matrices excluding precoding matrices that are restricted based on the codebook restricting information in the first codebook of Table 3 and the second codebook of Table 4.

As described in the foregoing, the transmitting device such as a base station may include at least one antenna pair in which at least one antenna polarized in one direction and at least one antenna polarized in another direction intersect each other.

In this example, as described with reference to Equation 3, a first precoding matrix performs precoding between one antenna and another antenna that intersect each other, and a second precoding matrix performs phase mismatch correction between one antenna and another antenna.

The communication method of the transmitting device has been described. Hereinafter, a communication method of a receiving device will be described.

FIG. 7 is a flowchart illustrating a communication method of a receiving device according to another embodiment of the present invention.

A communication method 700 of a receiving device may include a codebook restricting information receiving step S710 to receive codebook restricting information from a transmitting device, and a channel information transmitting step S720 to transmit 1st channel status information and 2nd channel status information to the transmitting device.

The codebook restricting information receiving step S710 may receive first information to restrict a precoding matrix from being used as a first precoding matrix and second information to restrict a precoding matrix from being used as a second precoding matrix for each layer. In this example, the codebook restricting information includes first information to restrict a precoding matrix from being used as a first precoding matrix and second information to restrict a precoding matrix from being used as a second precoding matrix in a first codebook and a second codebook for each layer. The channel information transmitting step S720 transmits, to the transmitting device, 1st channel status information indicating a first precoding matrix and 2nd channel status information indicating a second precoding matrix, the first precoding matrix and the second precoding matrix being selected, based on codebook restricting information, from precoding matrices that are not restricted from being used as a first precoding matrix or a second precoding matrix in a codebook.

Step S710 and step S720 will be described in detail in the following. When the receiving device receives [0111111111111111] corresponding to first information and [1011] corresponding to second information in a bitmap format that restrict a codebook with respect to a first index=0 ($PMI_1=0$) in a rank 1 in step S710, the receiving device determines a first precoding matrix from among precoding matrices corresponding to indices excluding the first index=0 ($PMI_1=0$), that is, from among precoding matrices excluding precoding matrices corresponding to the first index=0, as shown in Table 5, and reports/feeds back associated 1st channel status information to a base station, and determines a second precoding matrix from among precoding matrices corresponding to indices excluding the second index=1 ($PMI_2=1$), that is, from among precoding matrices excluding precoding matrices corresponding to the second index=1, and reports/feeds back associated 2nd channel status information to the base station in step S720.

US 9,136,924 B2

17

Accordingly, a codebook may be generally restricted with respect to second indices that make pairs with the first index=0 ($\text{PMI}_1=0$), for example, $(\text{PMI}_1, \text{PMI}_2)=(0,1), (0,1), (0,2), (0,3)$ in Table 5. Also, a codebook may be generally restricted with respect to the first indices that make pairs with the second index=1 ($\text{PMI}_2=1$), for example, $(\text{PMI}_1, \text{PMI}_2)=(0,1), (1,1), \dots, (14,1), (15,1)$ in table 5.

When the receiving device receives [10111111111111] corresponding to first information and [1101] corresponding to second information of a bitmap format that restrict a codebook with respect to a first index=1 ($\text{PMI}_1=1$) and a second index=2 ($\text{PMI}_2=2$) in a rank 2 in step S710, the receiving device determines a first precoding matrix and a second precoding matrix excluding precoding matrices corresponding to the first index=1 ($\text{PMI}_1=1$) and the second index=2 ($\text{PMI}_2=2$) for the rank 2 as shown in Table 5, and reports/feeds back is associated 1st channel status information and associated 2nd channel status information to the base station in step S720.

Accordingly, a codebook may be generally restricted with respect to second indices that make pairs with the first index=1 ($\text{PMI}_1=1$), for example, $(\text{PMI}_1, \text{PMI}_2)=(1,1), (1,1), (1,2), (1,3)$ in Table 5. Also, a codebook may be generally restricted with respect to the first indices that make pairs with the second index=2 ($\text{PMI}_2=2$), for example, $(\text{PMI}_1, \text{PMI}_2)=(0,2), (1,2), \dots, (14,2), (15,2)$ in table 5.

In other words, the codebook restricting information includes the first information and the second information. Accordingly, when a first precoding matrix is restricted from being used as a first precoding matrix based on the first information, the use of second precoding matrices that make pairs with the restricted first precoding matrix may be restricted. When a second precoding matrix is restricted from being used as a second precoding matrix based on the second information, the use of first precoding matrices that make pairs with the restricted second precoding matrix may be restricted.

In the same manner, the receiving device may determine a first precoding matrix and a second precoding matrix for each of a rank 3 through a rank 8, excluding precoding matrices designated by first information and second information.

The process in which a base station and a user equipment exchange codebook restricting information and channel status information in a wireless communication system when a codebook is restricted in a case where a multistage precoder is used, a MIMO wireless communication system that transmits and receives codebook restricting information and channel status information, and the transceiving method or communication method of the transmitting device and the receiving device in the wireless communication system have been described.

According to the embodiments of the present invention, information to restrict precoding matrices is determined for each multistage precoder, and codebook restricting information including the determined information is transmitted and thus, an amount of transmission overhead of the codebook restricting information may be reduced. According to the embodiments of the present invention, the wireless communication system uses the codebook restriction scheme and thus, inter-cell interference may be controlled.

According to a definition of a precoding matrix as described with reference to Equation 3, a precoding gain in each domain or a subset of an antenna is determined by a first precoding matrix. That is, an overall precoding gain is determined by a gain associated with the first precoding matrix and a coding gain of a second precoder matrix that performs phase mismatch correction (co-phasing) between domains or sub-

18

sets. In this example, the second precoding matrix performs phase mismatch correction (co-phasing) between domains or subsets and thus, a maximum precoding gain that each user equipment is able to obtain may be determined by the first precoding matrix. In other words, power or receivable maximum power of a signal that each user equipment receives is determined by a first precoder or a first precoding matrix, and a second precoder or a second precoding matrix performs only phase correction of a signal received by each domain or subset of an antenna. Interference by multiple-access may be significantly affected by a first precoder or a first precoding matrix.

FIGS. 8 through 10 are conceptual diagrams illustrating a process of controlling inter-cell interference using a codebook restriction scheme in a wireless communication system according to embodiments of the present invention.

Referring to FIG. 8, inter-cell interference may occur among cell edge user equipments 810a through 810d during beamforming. For example, user equipments 810a and 810b exist in a coverage of a first base station and a second base station as shown in FIG. 8 and thus, when a signal is transmitted that is precoded based on a first precoding matrix associated with a $\text{PMI}_1=4$ or $\text{PMI}_1=6$ of the first base station of a first cell 820a, transmission of a signal that is precoded based on a first precoding matrix associated with a $\text{PMI}_1=13$ of the second base station or a second cell 820b may cause interference.

In other words, the user equipments 810a and 810b receive both the transmitted signal that is precoded based on the first precoding matrix associated with the $\text{PMI}_1=4$ or $\text{PMI}_1=6$ of the first base station or the first cell 820a and the transmitted signal that is precoded based on the first precoding matrix associated with a $\text{PMI}_1=13$ of the second base station or the second cell 820b and thus, interference may occur.

Also, user equipments 810c and 810d exist in a coverage of the first base station and the second base station as shown in FIG. 8 and thus, when a signal is transmitted that is precoded based on a first precoding matrix associated with a $\text{PMI}_1=8$ of the first base station 820a, transmission of a signal that is precoded based on a first precoding matrix associated with a $\text{PMI}_1=2$ or a $\text{PMI}_1=11$ of the second base station 820b may cause interference.

The descriptions may be specifically provided using the user equipment 810b as an example as follows. The user equipment 810b receives a signal from both the first base station 820a and the second base station 820b as shown in FIG. 8. The first base station 820a transmits a signal using the first precoding matrix corresponding to the $\text{PMI}_1=6$ to transmit a signal to the user equipment 810b, and the second base station 820b uses the first precoder matrix corresponding to the $\text{PMI}_1=13$ to transmit a signal to the user equipment 810b. Accordingly, as illustrated in FIG. 8, when the second base station 820b transmits a signal to the user equipment 810b using the $\text{PMI}_1=13$, another user equipment 810a may receive multiple-access interference by the signal transmitted to the user equipment 810b.

When the second base station 820b restricts a codebook so that the first precoder matrix corresponding to the $\text{PMI}_1=13$ is not to be used, the user equipment 810b receives a signal from only the first base station 820a and thus, inter-cell interference due to multiple-interference may be prevented in advance.

Other user equipments 810c and 810d may receive multiple-access interference due to inter-cell interference, like the user equipments 810a and 810b.

When the first base station 820a restricts a codebook so that the first precoder matrix corresponding to the $\text{PMI}_1=8$ is not

US 9,136,924 B2

19

to be used, user equipments **810c** and **810d** receive a signal from only the second base station **820b** and thus, inter-cell interference due to multiple-interference may be prevented in advance.

FIG. 9 conceptually illustrates a case in which a first precoding matrix or an associated index that is expected to cause inter-cell interference is restricted by performing a codebook restriction based on the above-mentioned scheme, and a downlink MIMO is performed based on the restriction.

Referring to FIG. 9, when each base station **820a** and **820b** performs a $\text{PMI}_1=13$ based codebook restriction that restricts the use of a first precoding matrix corresponding to a $\text{PMI}_1=13$ or a $\text{PMI}_1=8$, occurrence of inter-cell interference may be avoided or reduced as illustrated in FIG. 9. Therefore, when a codebook restriction is applied to only a PMI_1 and is not applied to a PMI_2 , inter-cell interference may be removed.

Referring to FIG. 10, the user equipment **810b** receives signals precoded based on a first precoding matrix associated with a $\text{PMI}_1=6$ of a first base station and a first precoding matrix associated with a $\text{PMI}_1=13$ of a second base station and thus, interference may occur. The user equipment **810c** receives signals precoded based on a first precoding matrix associated with a $\text{PMI}_1=8$ of the first base station and a first precoding matrix associated with a $\text{PMI}_1=2$ of the second base station and thus, interference may occur. In this example, the first base station may allow the use of the $\text{PMI}_1=6$ and may restrict the use of the $\text{PMI}_1=2$, and conversely, the second base station may allow the use of the $\text{PMI}_1=2$ and may restrict the use of the $\text{PMI}_1=6$ and thus, interference between user equipments may be removed.

As another example, to remove interference between user equipments, the first base station may allow the use of the $\text{PMI}_1=8$ and may restrict the use of the $\text{PMI}_1=13$, and conversely, the second base station may allow the use of the $\text{PMI}_1=13$ and may restrict the use of the $\text{PMI}_1=8$.

As another example, to remove interference between user equipments, the first base station may allow the use of the $\text{PMI}_1=6$ and the $\text{PMI}_1=8$ and the second base station may restrict the use of the $\text{PMI}_1=6$ and the $\text{PMI}_1=8$. Conversely, the first base station may restrict the use of the $\text{PMI}_1=6$ and the $\text{PMI}_1=8$ and the second base station may allow the use of the $\text{PMI}_1=6$ and the $\text{PMI}_1=8$.

As described in the foregoing, when each base station **820a** and **820b** performs the PMI_1 based codebook restriction, occurrence of inter-cell interference may be avoided or reduced.

Also, when codebook restriction is applied with respect to only the PMI_2 , there is an advantage in that a codebook is restricted by a small number of bits. Also, no restriction is applied to the PMI_1 that directly controls a precoding gain and thus, more precise precoding is available and a size of a codebook may be reduced.

Although the embodiments of the present invention have been described in detail, the present invention may not be limited thereto.

The embodiments of the present invention may be applied to an up/downlink MIMO system, and may be applied to all up/downlink MIMO systems such as a Coordinated multi-point transmission/reception system (CoMP), a heterogeneous network, and the like, in addition to a single cell environment.

Although a preferred embodiment of the present invention has been described for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims. Therefore, the embodiments disclosed in the

20

present invention are intended to illustrate the scope of the technical idea of the present invention, and the scope of the present invention is not limited by the embodiment. The scope of the present invention shall be construed on the basis of the accompanying claims in such a manner that all of the technical ideas included within the scope equivalent to the claims belong to the present invention.

The invention claimed is:

1. A communication method of a transmitting device including a first precoder and a second precoder, the method comprising:

determining a first bit sequence to restrict at least one precoding matrix from a first precoding matrix group, each bit of the first bit sequence corresponding to one precoding matrix of the first precoding matrix group, respectively, and the at least one precoding matrix of the first precoding matrix group being restricted from being used as a precoding matrix of the first precoder;

determining a second bit sequence to restrict at least one precoding matrix from a second precoding matrix group, each bit of the second bit sequence corresponding to one precoding matrix of the second precoding matrix group, respectively, and the at least one precoding matrix of the second precoding matrix group being restricted from being used as a precoding matrix of the second precoder; and

transmitting, to a receiving device, codebook restricting information including at least one of the first bit sequence and the second bit sequence,

receiving, from the receiving device, information relating to the precoding matrix of the first precoder and information relating to the precoding matrix of the second precoder, and

wherein a period of receiving the information relating to the precoding matrix of the first precoder and a period of receiving the information relating to the precoding matrix of the second precoder are different from each other.

2. The method of claim 1, further comprising:

precoding data symbols through the first precoder and the second precoder using the precoding matrix of the first precoder and the precoding matrix of the second precoder; and

transmitting the precoded data symbols,

wherein the information relating to the precoding matrix of the first precoder and the information relating to the precoding matrix of the second precoder correspond to channel status information.

3. The method of claim 1, wherein the first matrix group includes N precoding matrices, and the first bit sequence is an N-bit sequence, where N is an integer.

4. The method of claim 1, wherein the use of precoding matrices for the second precoder that make pairs with restricted precoding matrices of the first matrix group is restricted based on the first bit sequence, and the use of precoding matrices for the first precoder that make pairs with restricted precoding matrices of the second matrix group is restricted based on the second bit sequence.

5. The method of claim 1, wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and

the precoding matrix of the first precoder performs precoding on the first domain and the second domain, separately, and the precoding matrix of the second precoder

US 9,136,924 B2

21

performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

6. The method of claim 5, wherein the precoding matrix of the first precoder corresponds to W1 in the following Equation, and the precoding matrix of the second precoder corresponds to W2 in the following Equation:

$$W = \begin{pmatrix} R_0 & 0 \\ 0 & R_0 \end{pmatrix} \begin{pmatrix} I \\ \Lambda \end{pmatrix},$$

$w_1 \quad w_2$

wherein R_0 denotes a value determined by a precoding gain when the first domain and the second domain have an identical spatial channel status, I denotes a unit matrix, and Λ denotes a phase mismatch correction value between the first domain and the second domain.

7. The method of claim 5, wherein a number of the antenna pairs corresponds to 4.

8. The method of claim 1, wherein the period of receiving the information relating to the precoding matrix of the first precoder is longer than the period of receiving the information relating to the precoding matrix of the second precoder.

9. A transmitting device, the device comprising:

a layer mapper to map a codeword to a layer;

a precoder configured to precode a data symbol corresponding to the codeword mapped to the layer by the layer mapper, the precoder precoding the data symbol using a precoding matrix of a first precoder and a precoding matrix of a second precoder selected from corresponding codebooks; and

an antenna array to transmit, to a receiving device, at least one of a first bit sequence and a second bit sequence, to receive, from the receiving device, information relating to the precoding matrix of the first precoder and information relating to the precoding matrix of the second precoder, and to transmit signals output from the precoder,

wherein the first bit sequence restricts at least one precoding matrix from a first precoding matrix group, the at least one precoding matrix of the first precoding matrix group being restricted from being used as the precoding matrix of the first precoder,

wherein the second bit sequence restricts at least one precoding matrix from a second precoding matrix group, the at least one precoding matrix of the second precoding matrix group being restricted from being used as the precoding matrix of the second precoder,

wherein each bit of the first bit sequence corresponds to one precoding matrix of the first precoding matrix group, respectively, and each bit of the second bit sequence corresponds to one precoding matrix of the second precoding matrix group, respectively, and

wherein a period of receiving the information relating to the precoding matrix of the first precoder and a period of receiving the information relating to the precoding matrix of the second precoder are different from each other.

10. The device of claim 9, wherein the information relating to the precoding matrix of the first precoder and the information relating to the precoding matrix of the second precoder correspond to channel status information.

11. The device of claim 9, wherein the first matrix group includes N precoding matrices, and the first bit sequence is an N-bit sequence, where N is an integer.

22

12. The device of claim 9, wherein the use of precoding matrices for the second precoder that make pairs with restricted precoding matrices of the first matrix group is restricted based on the first bit sequence, and the use of precoding matrices for the first precoder that make pairs with restricted precoding matrices of the second matrix group is restricted based on the second bit sequence.

13. The device of claim 9, wherein the antenna array includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and

the precoding matrix of the first precoder performs precoding on the first domain and the second domain, separately, and the precoding matrix of the second precoder performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

14. The device of claim 13, wherein the precoding matrix of the first precoder corresponds to W1 in the following Equation, and the precoding matrix of the second precoder corresponds to W2 in the following Equation:

$$W = \begin{pmatrix} R_0 & 0 \\ 0 & R_0 \end{pmatrix} \begin{pmatrix} I \\ \Lambda \end{pmatrix},$$

$w_1 \quad w_2$

wherein R_0 denotes a value determined by a precoding gain when the first domain and the second domain have an identical spatial channel status, I denotes a unit matrix, and Λ denotes a phase mismatch correction value between the first domain and the second domain.

15. The device of claim 13, wherein the first domain and the second domain intersect each other.

16. The device of claim 13, wherein a number of the antenna pairs corresponds to 4.

17. A communication method of a receiving device in a wireless communication system, the method comprising:

receiving codebook restricting information including at least one of a first bit sequence to restrict at least one precoding matrix from a first precoding matrix group and a second bit sequence to restrict at least one precoding matrix from a second precoding matrix group, each bit of the first bit sequence corresponding to one precoding matrix of the first precoding matrix group, respectively, the at least one precoding matrix of the first precoding matrix group being restricted from being used as a precoding matrix of a first precoder, each bit of the second bit sequence corresponding to one precoding matrix of the second precoding matrix group, respectively, and the at least one precoding matrix of the second precoding matrix group being restricted from being used as a precoding matrix of a second precoder; and

transmitting, to a transmitting device, 1st channel status information indicating the precoding matrix of the first precoder and 2nd channel status information indicating the precoding matrix of the second precoder, the precoding matrix of the first precoder and the precoding matrix of the second precoder being selected, based on the codebook restricting information, from among precoding matrices that are not restricted,

wherein a period of transmitting the information relating to the precoding matrix of the first precoder and a period of

US 9,136,924 B2

23

transmitting the information relating to the precoding matrix of the second precoder are different from each other.

18. The method of claim 17, wherein the first matrix group includes N precoding matrices, and the first bit sequence is an N-bit sequence, where N is an integer.

19. The method of claim 17, wherein the use of precoding matrices for the second precoder that make pairs with restricted precoding matrices of the first matrix group is restricted based on the first bit sequence, and the use of precoding matrices for the first precoder that make pairs with restricted precoding matrices of the second matrix group is restricted based on the second bit sequence.

20. The method of claim 17, wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and

the precoding matrix of the first precoder performs precoding on the first domain and the second domain, separately, and the precoding matrix of the second precoder performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

21. The method of claim 20, wherein the precoding matrix of the first precoder corresponds to W1 in the following Equation and the precoding matrix of the second precoder corresponds to W2 in the following Equation:

$$W = \begin{pmatrix} R_0 & 0 \\ 0 & R_0 \end{pmatrix} \begin{pmatrix} I \\ \Lambda \end{pmatrix},$$

$\frac{w_1}{w_2}$

wherein R_0 denotes a value determined by a precoding gain when the first domain and the second domain have an identical spatial channel status, I denotes a unit matrix, and Λ denotes a phase mismatch correction value between the first domain and the second domain.

22. The method of claim 17, wherein the period of transmitting the information relating to the precoding matrix of the first precoder is longer than the period of transmitting the information relating to the precoding matrix of the second precoder.

23. A receiving device in a wireless communication system, the receiving device comprising:

an antenna array to receive, as codebook restricting information, at least one of a first bit sequence to restrict at least one precoding matrix from a first precoding matrix group and a second bit sequence to restrict at least one precoding matrix from a second precoding matrix group, each bit of the first bit sequence corresponding to one precoding matrix of the first precoding matrix group, respectively, the at least one precoding matrix of the first precoding matrix group being restricted from being used as a precoding matrix of a first precoder, each bit of the second bit sequence corresponding to one precoding matrix of the second precoding matrix group, respectively, and the at least one precoding matrix of the

24

second precoding matrix group being restricted from being used as a precoding matrix of a second precoder; and

a channel information feedback device to transmit, to a transmitting device, information relating to the precoding matrix of the first precoder and information relating to the precoding matrix of the second precoder, the precoding matrix of the first precoder and the precoding matrix of the second precoder being selected, based on the codebook restricting information, from among precoding matrices that are not restricted,

wherein a period of transmitting the information relating to the precoding matrix of the first precoder and a period of transmitting the information relating to the precoding matrix of the second precoder are different from each other.

24. The device of claim 23, wherein the first matrix group includes N precoding matrices, and the first bit sequence is an N-bit sequence, where N is an integer.

25. The device of claim 23, wherein the use of precoding matrices for the second precoder that make pairs with restricted precoding matrices of the first matrix group is restricted based on the first bit sequence, and the use of precoding matrices for the second precoder that make pairs with restricted precoding matrices of the second matrix group is restricted based on the second bit sequence.

26. The device of claim 23, wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and

the precoding matrix of the first precoder performs precoding on the first domain and the second domain, separately, and the precoding matrix of the second precoder performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

27. The device of claim 26, wherein the precoding matrix of the first precoder corresponds to W1 in the following Equation, and the precoding matrix of the second precoder corresponds to W2 in the following Equation:

$$W = \begin{pmatrix} R_0 & 0 \\ 0 & R_0 \end{pmatrix} \begin{pmatrix} I \\ \Lambda \end{pmatrix},$$

$\frac{w_1}{w_2}$

wherein R_0 denotes a value determined by a precoding gain when the first domain and the second domain have an identical spatial channel status, I denotes a unit matrix, and Λ denotes a phase mismatch correction value between the first domain and the second domain.

28. The device of claim 23, wherein the period of transmitting the information relating to the precoding matrix of the first precoder is longer than the period of transmitting the information relating to the precoding matrix of the second precoder.

* * * * *

EXHIBIT 2



US009854545B2

(12) **United States Patent**
Kwon et al.

(10) **Patent No.:** **US 9,854,545 B2**
(45) **Date of Patent:** **Dec. 26, 2017**

(54) **APPARATUS AND METHOD FOR ESTABLISHING UPLINK SYNCHRONIZATION IN A WIRELESS COMMUNICATION SYSTEM**

(58) **Field of Classification Search**

CPC H04W 56/00; H04W 74/002; H04W 74/0833; H04W 72/04; H04Q 7/20; H04J 3/00

See application file for complete search history.

(71) Applicant: **GOLDPEAK INNOVATIONS INC.**,
Seoul (KR)

(56) **References Cited**

U.S. PATENT DOCUMENTS

(72) Inventors: **Kibum Kwon**, Seoul (KR);
Myungcheul Jung, Seoul (KR)

8,606,336 B2 12/2013 Womack et al.
2008/0002660 A1* 1/2008 Jeong H04B 7/2681
370/350

(73) Assignee: **GOLDPEAK INNOVATIONS INC.**,
Seoul (KR)

(Continued)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 54 days.

FOREIGN PATENT DOCUMENTS

(21) Appl. No.: **14/733,068**

JP 2010-254386 A 11/2010
JP 2013-516917 5/2013

(Continued)

(22) Filed: **Jun. 8, 2015**

(65) **Prior Publication Data**

US 2015/0271770 A1 Sep. 24, 2015

Related U.S. Application Data

(63) Continuation of application No. 13/578,531, filed as application No. PCT/KR2011/000909 on Feb. 10, 2011, now Pat. No. 9,054,835.

OTHER PUBLICATIONS

Qualcomm Incorporated, "Supporting multiple timing advance groups", 3GPP TSG-RAN WG2 meeting#68bis, Jan. 18-22, 2010, R2-100423, Valencia, Spain.

(Continued)

(30) **Foreign Application Priority Data**

Feb. 10, 2010 (KR) 10-2010-0012564
Mar. 26, 2010 (KR) 10-2010-0027230
Jan. 28, 2011 (KR) 10-2011-0008683

Primary Examiner — Ricky Ngo

Assistant Examiner — Lan Huong Truong

(74) *Attorney, Agent, or Firm* — Lex IP Meister, PLLC

(51) **Int. Cl.**

H04J 3/06 (2006.01)
H04W 56/00 (2009.01)

(Continued)

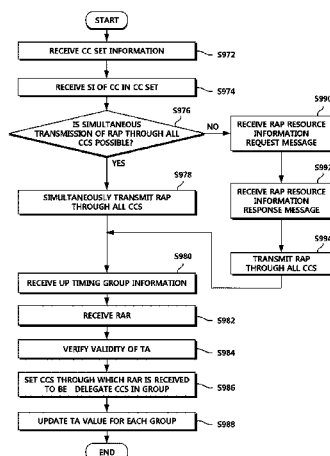
(52) **U.S. Cl.**

CPC **H04W 56/0005** (2013.01); **H04L 5/001**
(2013.01); **H04W 56/0045** (2013.01);
(Continued)

(57) **ABSTRACT**

Uplink synchronization establishment in a base station which operates a plurality of component carriers according to one embodiment of the present description, is performed in that the base station is connected to a user equipment, sets component carrier aggregation information, generates an uplink timing groups in the set component carrier aggregation, and transmits information on the thus-generated uplink timing groups to the user equipment.

3 Claims, 11 Drawing Sheets



US 9,854,545 B2

Page 2

- (51) **Int. Cl.**
H04W 74/00 (2009.01)
H04W 76/04 (2009.01)
H04L 5/00 (2006.01)
H04W 88/08 (2009.01)
H04W 92/10 (2009.01)
H04B 1/7087 (2011.01)
- 2010/0323744 A1 12/2010 Kim et al.
 2011/0170495 A1 7/2011 Earnshaw et al.
 2012/0008600 A1* 1/2012 Marinier H04L 5/001
 370/336

FOREIGN PATENT DOCUMENTS

- (52) **U.S. Cl.**
 CPC *H04W 74/004* (2013.01); *H04W 76/046*
 (2013.01); *H04B 1/7087* (2013.01); *H04L*
5/0007 (2013.01); *H04W 88/08* (2013.01);
H04W 92/10 (2013.01)

KR 10-2008-0063023 7/2008
 KR 10-2008-0079961 9/2008
 KR 10-2009-0115913 11/2009
 WO 2009/113815 9/2009

OTHER PUBLICATIONS

(56) **References Cited**

U.S. PATENT DOCUMENTS

2008/0188219 A1* 8/2008 Fischer H04W 74/0866
 455/434
 2008/0268850 A1* 10/2008 Narasimha H04W 36/0072
 455/437
 2009/0116434 A1 5/2009 Lohr et al.
 2009/0270094 A1 10/2009 Ito et al.
 2009/0274120 A1 11/2009 Chou
 2009/0279495 A1* 11/2009 Yoo H04L 5/0078
 370/329
 2009/0316642 A1 12/2009 Yamada et al.
 2009/0318175 A1 12/2009 Sandberg
 2010/0041399 A1 2/2010 Kim et al.
 2010/0086065 A1 4/2010 Higuchi et al.
 2010/0111005 A1 5/2010 Ahn et al.
 2010/0118720 A1 5/2010 Gauvreau et al.
 2010/0142485 A1* 6/2010 Lee H04W 36/02
 370/331
 2010/0177747 A1* 7/2010 Chun H04W 56/009
 370/336
 2010/0238857 A1 9/2010 Zhang et al.
 2010/0238872 A1* 9/2010 Kim H04W 74/008
 370/329

ITRI, "Time Alignment Timer for different TA", 3GPP TSG-RAN WG2 meeting#68bis, Jan. 18-22, 2010, R2-100560, Valencia, Spain.
 NTT Docomo, Inc., "TA maintenance for CA", 3GPP TSG-RAN2#68bis, Jan. 18-22, 2010, R2-100472, Valencia, Spain.
 Huawei, "Different Timing Advance Impact on Carrier Aggregation", 3GPP TSG RAN WG2 meeting#67bis, Oct. 12-16, 2009, R2-095815, Miyazaki, Japan.
 International Search Report of PCT/KR2011/000909 dated Dec. 7, 2011.
 Non Final Office Action issued on Jul. 16, 2014, in U.S. Appl. No. 13/578,531.
 Notice of Allowance issued on Feb. 4, 2015, in U.S. Appl. No. 13/578,531.
 Catt, "L3 Anchor Carrier", 3GPP TSG-RAN WG2 Meeting #67, R2-094322, Aug. 24-28, 2009, 2 pages, Shenzhen, China.
 Nokia Corporation, Nokia Siemens Networks, "RACH and carrier aggregation", 3GPP TSG-RAN WG2 Meeting #67bis, Oct. 12-16, 2009, 3 pages, Miyazaki, Japan.
 Office Action issued by JPO on Jun. 13, 2017 for the corresponding JP Application No. 2015-154385.
 Office Action issued by KIPO on Dec. 21, 2016 for the corresponding KR Application No. 10-2011-0008683.
 Nokia Corporation et al, 3GPP TSG-RAN WG2 Meeting #67bis, R2-095898, "RACH and carrier aggregation", Miyazaki, Japan dated Oct. 12-16, 2009.

* cited by examiner

U.S. Patent

Dec. 26, 2017

Sheet 1 of 11

US 9,854,545 B2

FIG. 1

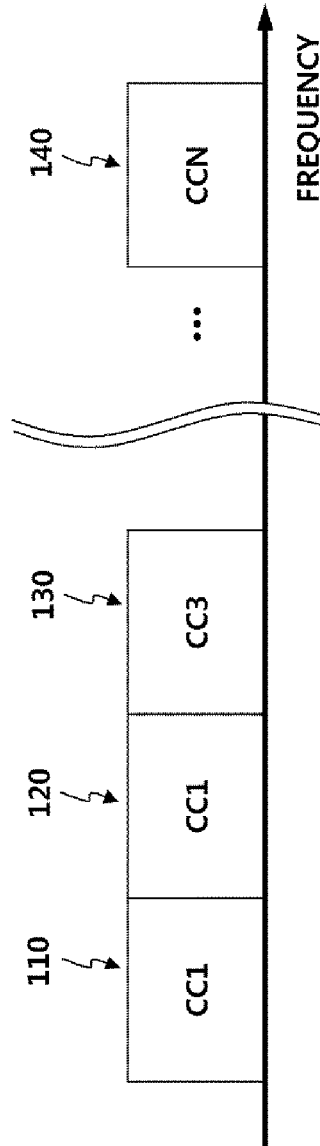
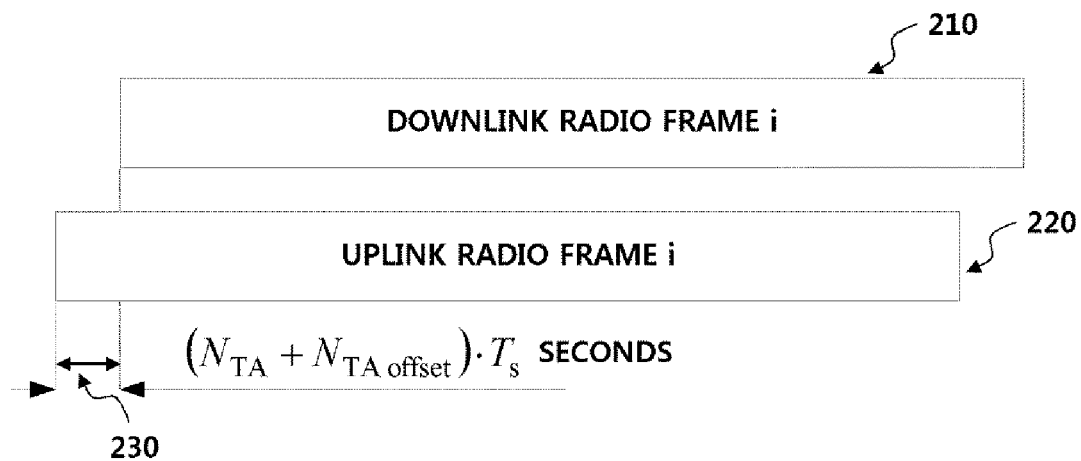


FIG. 2



U.S. Patent

Dec. 26, 2017

Sheet 3 of 11

US 9,854,545 B2

FIG. 3

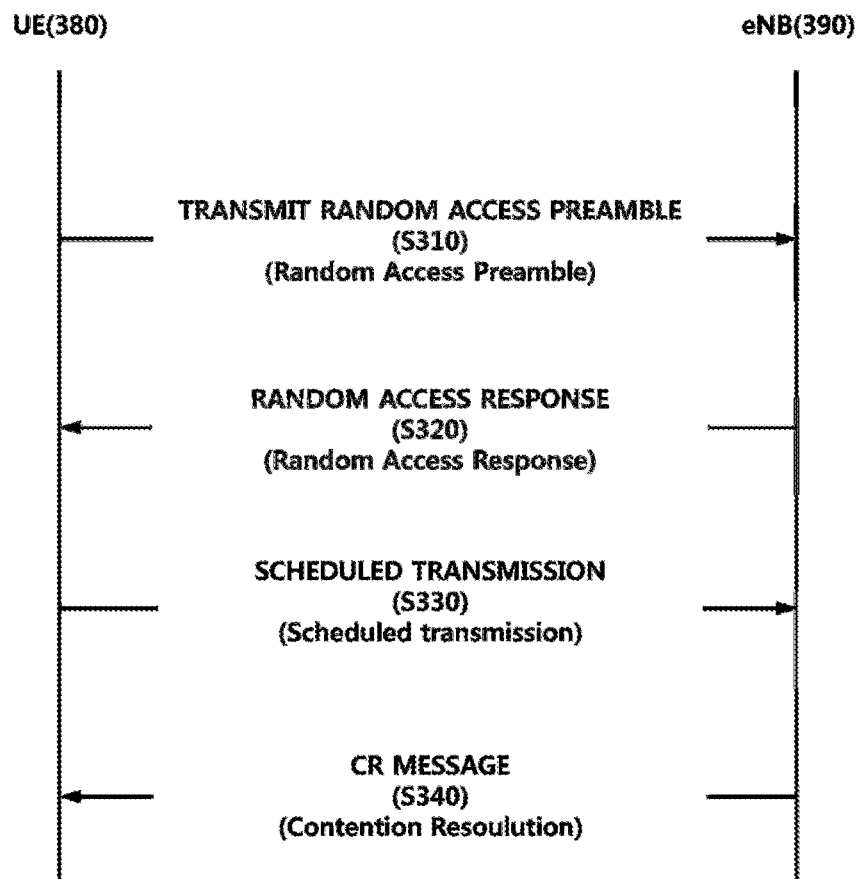


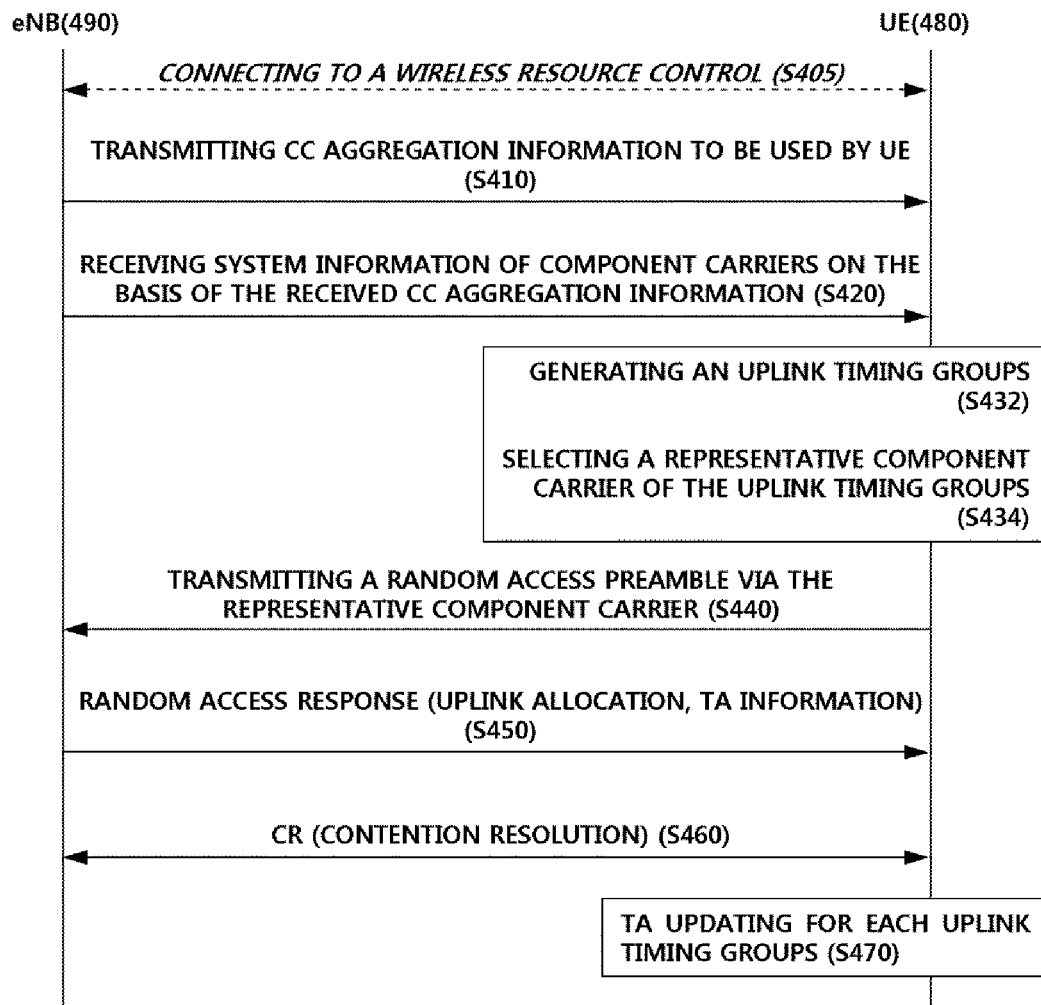
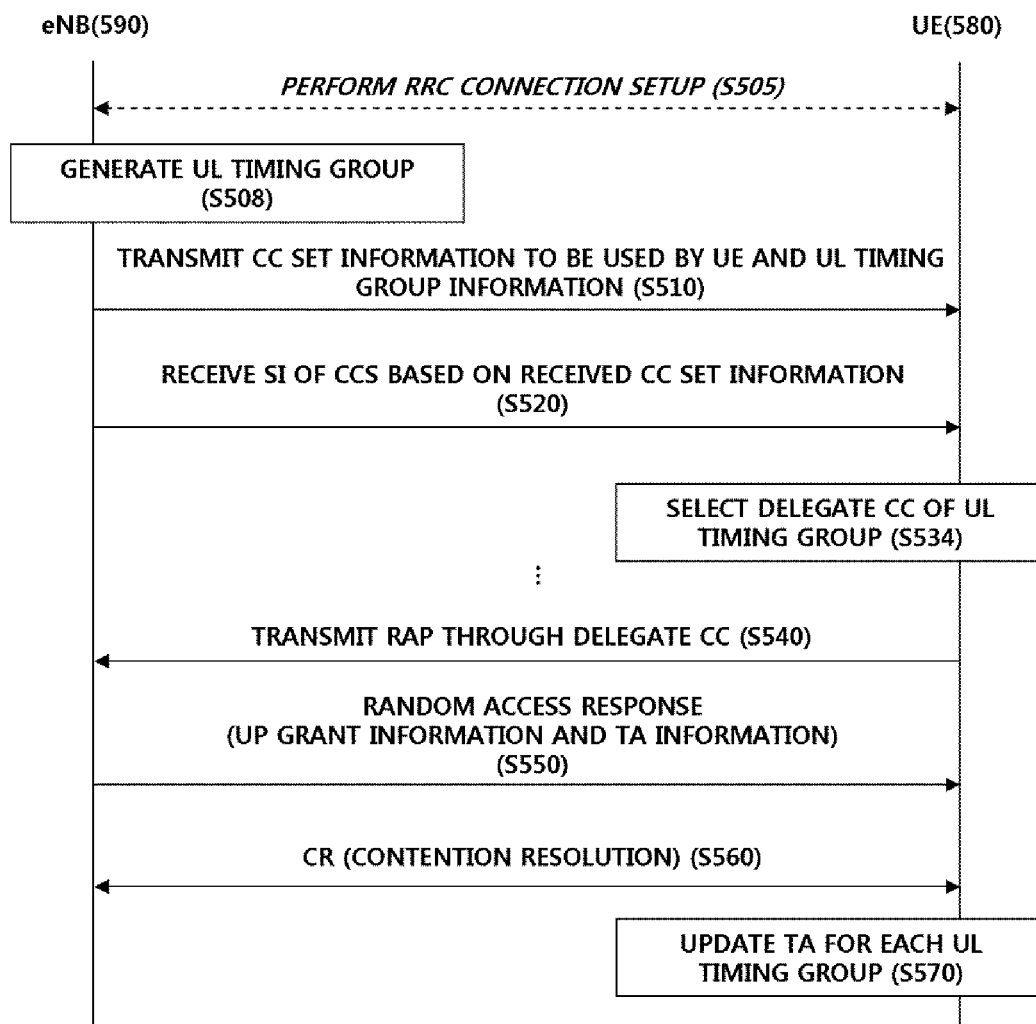
FIG. 4

FIG. 5

U.S. Patent

Dec. 26, 2017

Sheet 6 of 11

US 9,854,545 B2

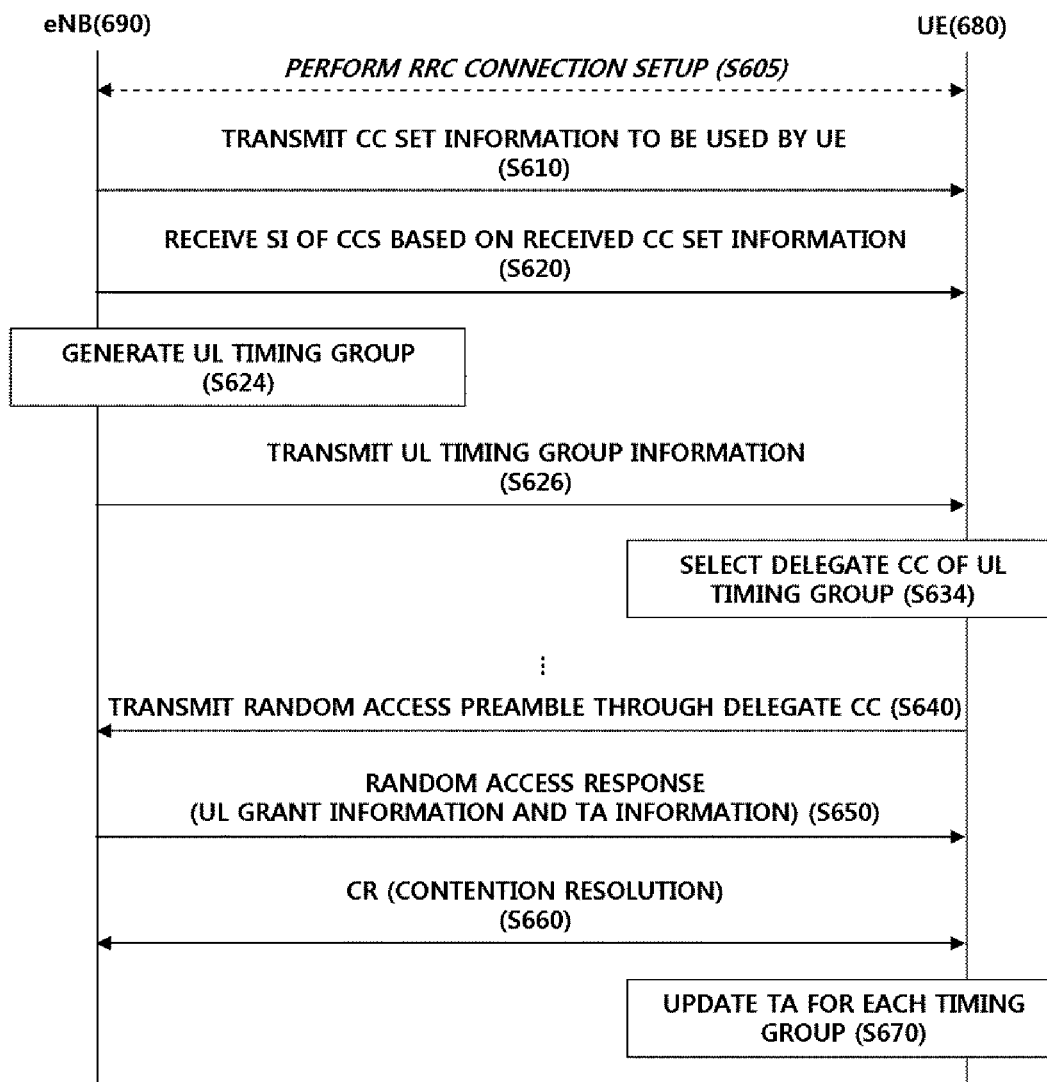
FIG. 6

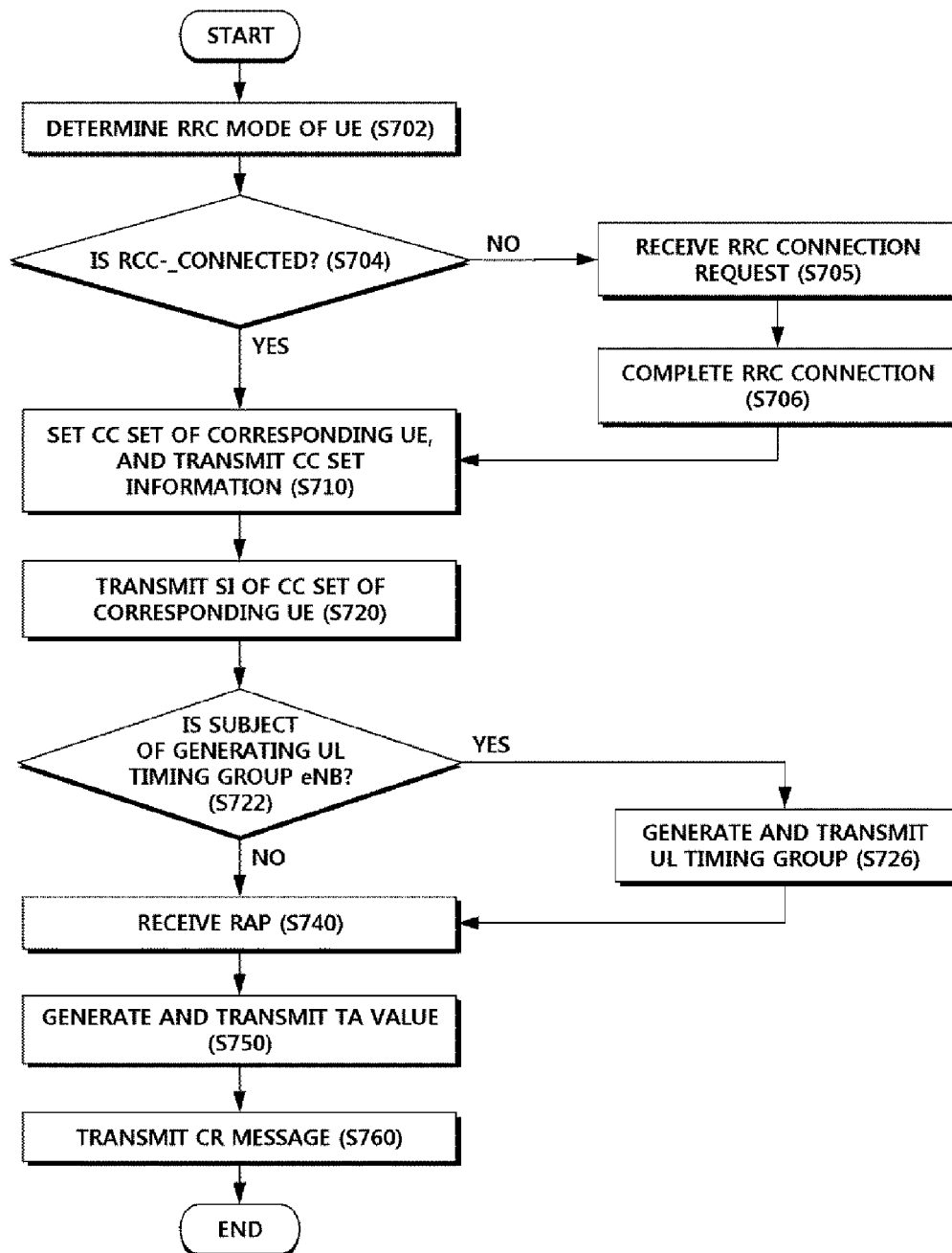
FIG. 7

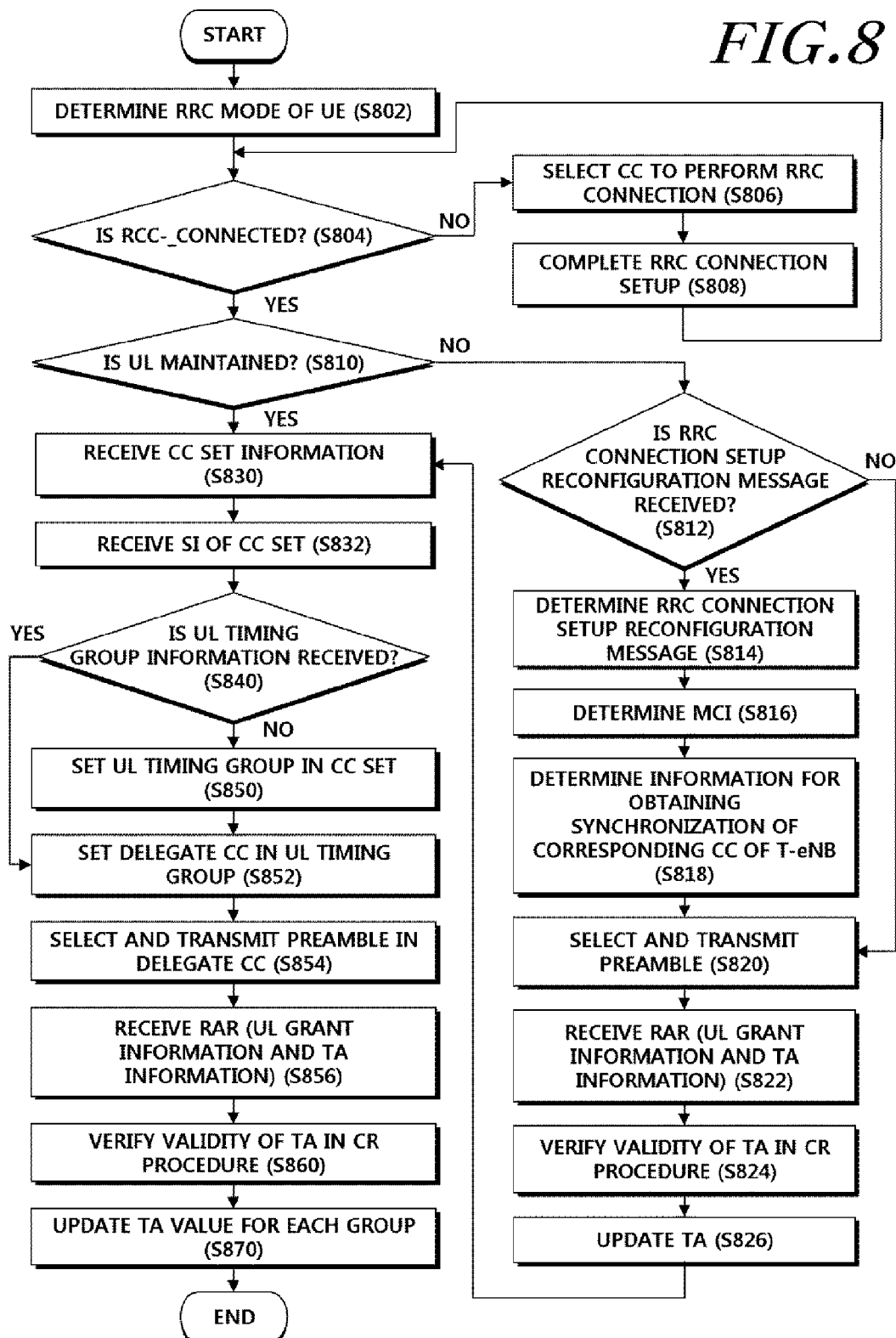
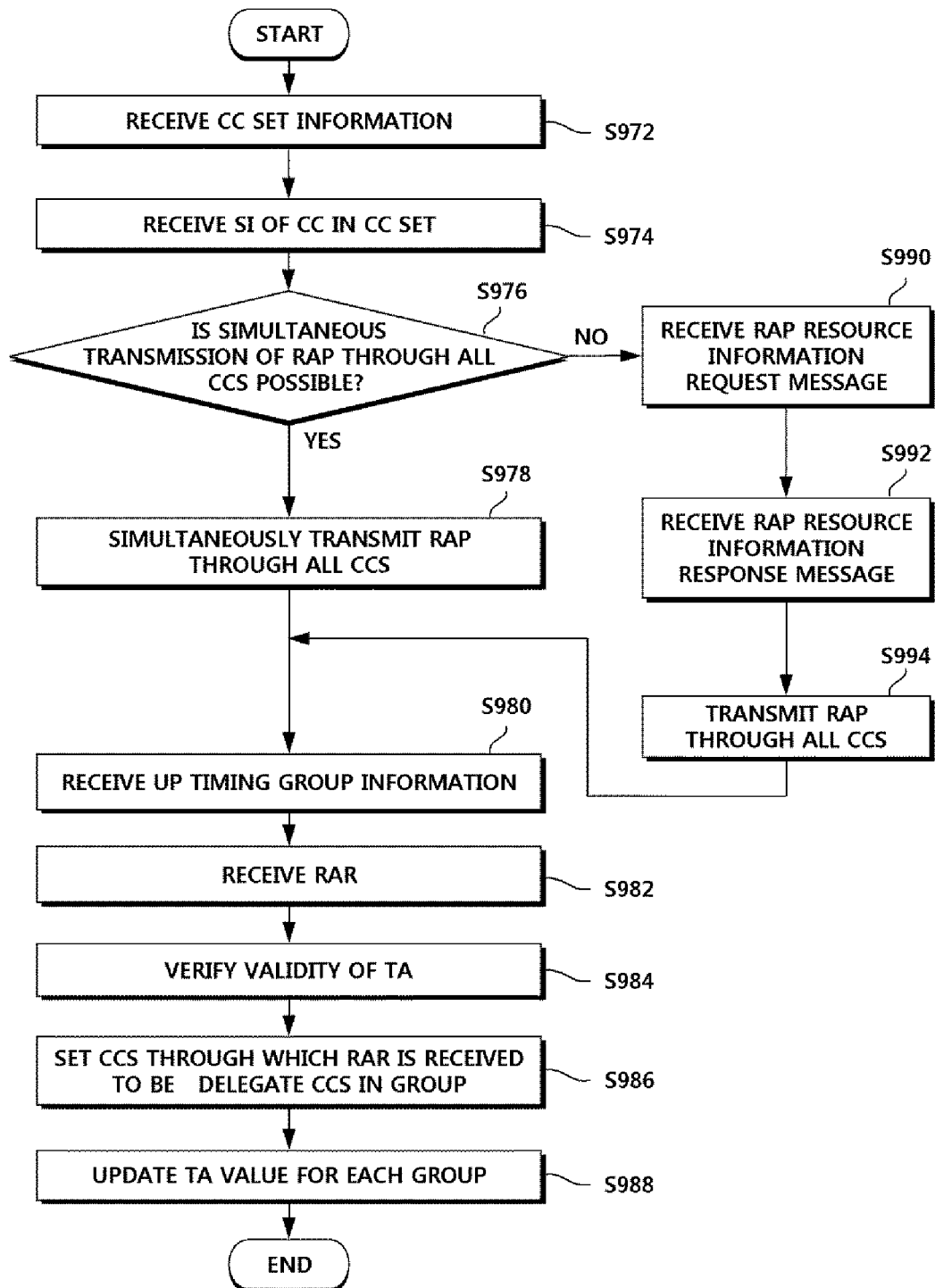
FIG. 8

FIG. 9

U.S. Patent

Dec. 26, 2017

Sheet 10 of 11

US 9,854,545 B2

FIG. 10

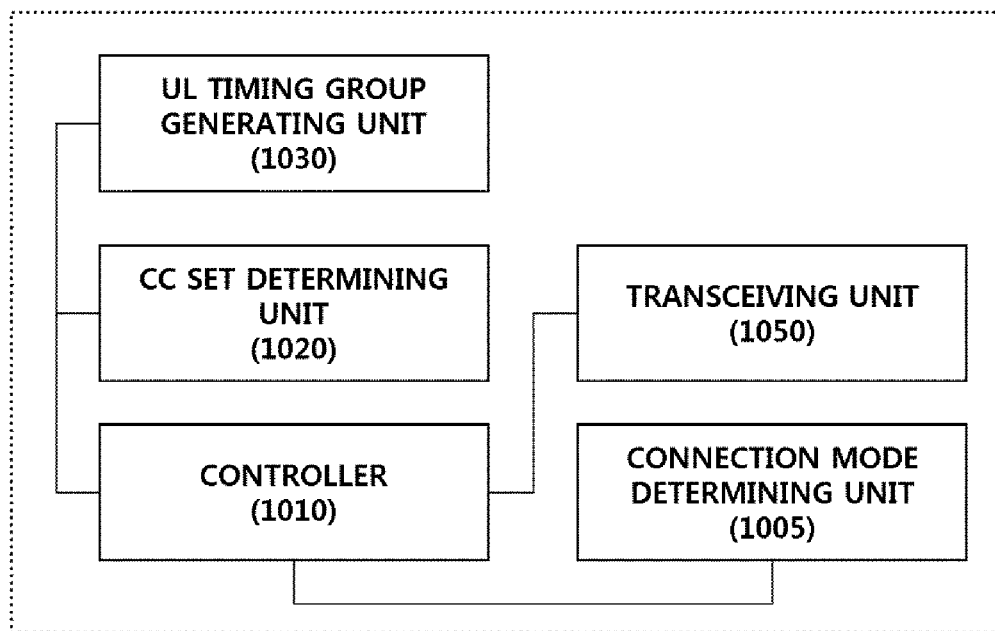
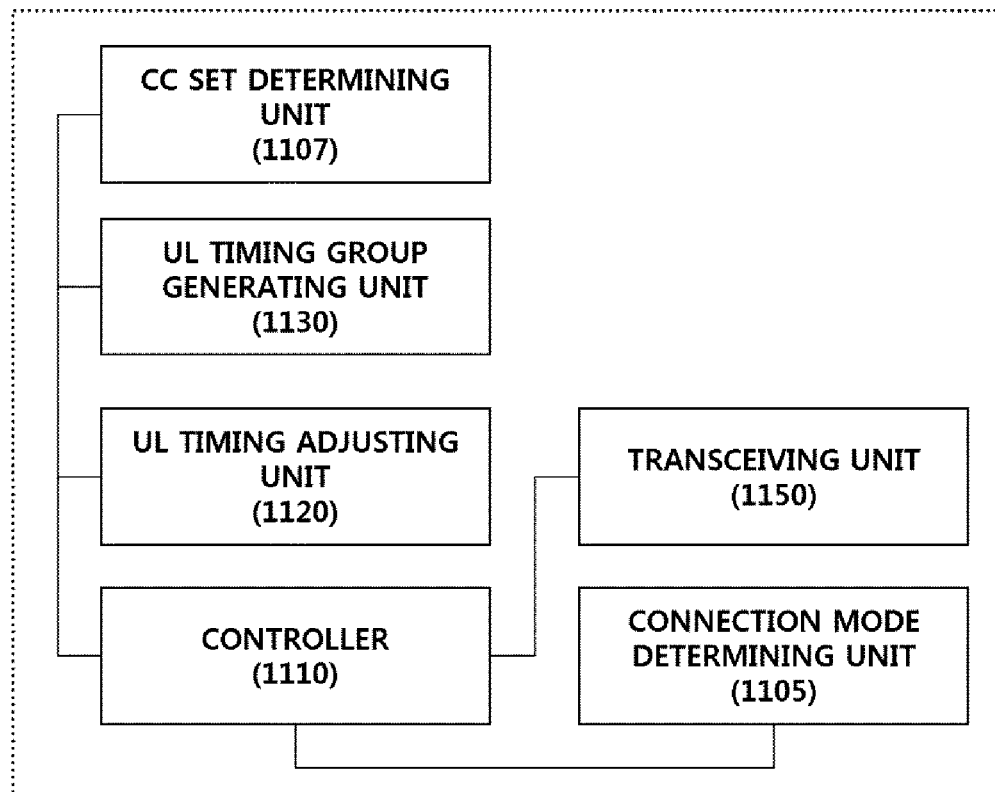


FIG. 11



US 9,854,545 B2

1

APPARATUS AND METHOD FOR ESTABLISHING UPLINK SYNCHRONIZATION IN A WIRELESS COMMUNICATION SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 13/578,531, filed on Aug. 10, 2012, which is the National Stage Entry of International Application No. PCT/KR2011/000909, filed on Feb. 10, 2011, and claims priority from and the benefit of Korean Patent Application No. 10-2010-0012564, filed on Feb. 10, 2010, Korean Patent Application No. 10-2010-0027230, filed on Mar. 26, 2010, and Korean Patent Application No. 10-2011-0008683, filed on Jan. 28, 2011, all of which are hereby incorporated by reference for all purposes as if fully set forth herein.

BACKGROUND

Field

The present invention relates to a method and apparatus for establishing an uplink (UL) synchronization in a wireless communication system, and more particularly, to a method and apparatus for configuring a UL synchronization with respect to at least one Component Carrier (CC).

Discussion of the Background

Synchronization between a user equipment (UE) and an evolved node B (eNB) is an important issue in a wireless communication system since transmission/reception of information between the UE and the eNB may not be performed without synchronization.

Current wireless communication system needs to satisfy a user demand through use of a plurality of CCs, unlike a conventional wireless communication system that supports a single component carrier (CC) or a single service band. However, a detailed scheme for synchronization with respect to the plurality of CCs has not been provided yet.

Accordingly, there is a desire for a scheme for effective synchronization in a wireless communication using a plurality of CCs since synchronization is a factor that has a great effect on an efficiency of a network.

SUMMARY

Therefore, the present invention has been made in view of the above-mentioned problems, and an aspect of the present invention is to provide a method and apparatus for effectively operating a synchronization process by configuring an uplink (UL) synchronization in a wireless communication network supporting a plurality of CCs of Carrier Aggregation system for efficiency of a network, and secures stability of transmission/reception.

Another aspect of the present invention is to provide a method and apparatus for establishing synchronization in a wireless communication system.

Another aspect of the present invention is to provide a method and apparatus for transmitting/receiving synchronization information to be used for establishing synchronization in a wireless communication system.

Another aspect of the present invention is to provide a method and apparatus for configuring a synchronization group with respect to a plurality of CCs in a wireless communication system.

Another aspect of the present invention is to provide a method and apparatus for configuring a synchronization

2

group with respect to a plurality of CCs based on a connection mode of a UE in a wireless communication system.

Another aspect of the present invention is to provide a method and apparatus for configuring a synchronization group based on characteristics of a plurality of CCs available in a wireless communication system.

Another aspect of the present invention is to provide a method and apparatus of a UE that may configure a UL timing synchronization group with respect to a plurality of CCs in a wireless communication system.

Another aspect of the present invention is to provide a method and apparatus of a UE that may obtain synchronization information associated with a plurality of CCs through a random access procedure in a wireless communication system, and may establish and update synchronization with an eNB.

In accordance with an aspect of the present invention, there is provided a method for an eNB to establish an uplink (UL) synchronization in a wireless communication system, the method including: receiving a synchronization request message from a user equipment (UE) through one or more delegate CCs in a UL timing group; and transmitting UL synchronization information corresponding to the UL timing group to the UE through the one or more CCs, so as to establish the UL synchronization, and the one or more delegate CCs are selected by the UE based on a state of the UL timing group and characteristics of a plurality of CCs forming the UL timing group, so as to establish the UL synchronization.

In accordance with another aspect of the present invention, there is provided a method for a UE to establish a UL synchronization in a wireless communication system, the method including: transmitting a synchronization request message to an eNB through one or more delegate CCs in a UL timing group; receiving UL synchronization information corresponding to the UL timing group for establishing the UL synchronization, from the eNB through the one or more delegate CCs; and establishing synchronization by applying, to the UL timing group, the UL synchronization information received through the one or more delegate CCs, and the one or more delegate CCs are selected by the UE based on a state of the UL timing group and characteristics of a plurality of CCs forming the UL timing group, so as to establish the UL synchronization.

In accordance with another aspect of the present invention, there is provided an eNB to establish a UL synchronization in a wireless communication system, the eNB including: a controller to generate UL synchronization information corresponding to a UL timing group, so as to establish the UL synchronization; and a transceiving unit to receive a synchronization request message from a user equipment (UE) through one or more delegate CCs in the UL timing group, and to transmit the UL synchronization information to the UE through the one or more delegate CCs, and the one or more delegate CCs are selected by the UE based on a state of the UL timing group and characteristics of a plurality of CCs forming the UL timing group, so as to establish the UL synchronization.

In accordance with another aspect of the present invention, there is provided a UE to establish a UL synchronization in a wireless communication system, the UE including: a transceiving unit to transmit a synchronization request message to an eNB through one or more delegate CCs in a UL timing group, and to receive UL synchronization information corresponding to the UL timing group through the one or more delegate CCs; a controller to determine the UL synchronization information received by the transceiving

US 9,854,545 B2

3

unit; and a UL timing adjusting unit to establish a UL synchronization of the UL timing group, based on the UL synchronization information determined by the controller, and the one or more delegate CCs are selected by the UE based on a state of the UL timing group and characteristics of a plurality of CCs forming the UL timing group, so as to establish the UL synchronization.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram illustrating an example of configuring a plurality of component carriers (CCs);

FIG. 2 is a diagram illustrating an example associated with a timing advance (TA) of a synchronization process;

FIG. 3 is a diagram illustrating a random access process performed between a user equipment (UE) and an evolved Node-B (eNB);

FIG. 4 is a diagram illustrating a process that obtains an uplink (UL) synchronization according to an embodiment of the present invention;

FIG. 5 is a diagram illustrating a process that obtains a Up Link (UL) synchronization according to another embodiment of the present invention;

FIG. 6 is a diagram illustrating a process that obtains a UL synchronization according to still another embodiment of the present invention;

FIG. 7 is a diagram illustrating a process in which an eNB enables the UE to obtain a UL synchronization in response to a request from the UE according to an embodiment of the present invention;

FIG. 8 is a diagram illustrating a process in which a UE obtains a UL synchronization through use of a UL timing group according to an embodiment of the present invention;

FIG. 9 is a diagram illustrating a process in which a UE obtains a UL synchronization through use of a UL timing group according to an embodiment of the present invention;

FIG. 10 is a block diagram of an eNB according to an embodiment of the present invention; and

FIG. 11 is a block diagram of a UE according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

Hereinafter, exemplary embodiments of the present invention will be described with reference to the accompanying drawings. In the following description, the same elements will be designated by the same reference numerals although they are shown in different drawings. Further, in the following description of the present invention, a detailed description of known functions and configurations incorporated herein will be omitted when it may make the subject matter of the present invention rather unclear.

The specifications will describe a wireless communication system as an example, and operations performed in wireless communication may include all operations performed in a system that manages the wireless communication and a wireless communication device that transmits data. The wireless communication system may provide various communication services such as voice data, packet data, and the like. According to an embodiment, the wireless communication system may include, for example, a user equipment (UE) and an evolved Node-B (eNB).

The UE may be an inclusive concept indicating a user terminal utilized in a wireless communication, including a UE in Wideband Code Division Multiple Access (WCDMA), Long Term Evolution (LTE), High Speed

4

Packet Access (HSPA), and the like, and a mobile station (MS), a user terminal (UT), a subscriber station (SS), a wireless device and the like in Global System for Mobile Communications (GSM).

The eNB or a cell may refer to a fixed station where communication with the UE is performed, and may also be referred to as a Node-B, a base transceiver system (BTS), an access point, and the like.

The eNB or the cell may be construed as an inclusive concept indicating a portion of an area covered by a radio network controller (RNC) in WCDMA, and the like, and the concept may include various cell coverage areas, such as a megacell, macrocell, a microcell, a picocell, a femtocell, and the like.

In the specifications, the UE and the eNB are used as two inclusive transceiving subjects to embody the technology and technical concepts described in the specifications, and may not be limited to a predetermined term or word.

A multiple access scheme applied to the wireless communication system may not be limited. The wireless communication system may utilize varied multiple access schemes, such as Code Division Multiple Access (CDMA), Time Division Multiple Access (TDMA), Frequency Division Multiple Access (FDMA), Orthogonal Frequency Division Multiple Access (OFDMA), Orthogonal Frequency Division Multiple Frequency Division Multiple Access (OFDM-FDMA), Orthogonal Frequency Division Multiple Time Division Multiple Access (OFDM-TDMA), Orthogonal Frequency Division Multiple Code Division Multiple Access (OFDM-CDMA), and the like. Uplink (UL) transmission and downlink (DL) transmission may be performed based on a time division duplex (TDD) scheme that performs transmission based on different times, or based on a frequency division duplex (FDD) scheme that performs transmission based on different frequencies.

An embodiment of the present invention may be applicable to an asynchronous wireless communication scheme that is advanced through GSM, WCDMA, and HSPA, to be LTE and LTE-advanced, and may be applicable to a synchronous wireless communication scheme that is advanced through CDMA and CDMA-2000, to be UMB. Embodiments of the present invention may not be limited to a specific wireless communication scheme, and may be applicable to all technical fields to which a technical idea of the present invention is applicable.

FIG. 1 illustrates an example of a wireless communication system that uses a plurality of CCs according to an embodiment of the present invention.

Referring to FIG. 1, the wireless communication system may be a next generation communication system, including an LTE system and an LTE-A system.

The LTE/LTE-A system may extend a bandwidth to satisfy a high data transmission rate corresponding to a system requirement, and may use a plurality of component carriers (CCs) which are unit carriers. Here, a single CC may have a maximum bandwidth of 20 megahertz (MHz). Resource allocation may be performed within a bandwidth of 20 MHz depending on a service. However, it is merely an example during a process of embodying a system. Depending on a configuration of a system, a single CC may be configured to have a bandwidth smaller than or equal to 20 MHz. Also, a plurality of CCs may be bound and used as a single system band, and may be referred to as a carrier aggregation (CA).

As illustrated in FIG. 1, when five CCs having a maximum bandwidth of 20 MHz are used, a bandwidth may be expanded up to 100 MHz to support a quality of service. In

US 9,854,545 B2

5

this example, an allocable frequency band, which may be determined by each CC, may be contiguous or non-contiguous based on a scheduling of the CA.

Throughout the specifications, a component carrier may be denoted by a CC and may be distinguished by names, for example, CC0, CC1, and the like. However, a number included in a name of each CC may not always match an order of a corresponding CC or a location of a frequency band of the corresponding CC.

Referring to FIG. 1, the CA may be configured to include a first CC (CC1) 110, a second CC (CC2) 120, a third CC (CC3) 130, and an Nth CC (CCN) 140. A UL and a DL allocated to each CC may be different from each other, or may be the same as one another based on a scheduler.

In a wireless communication environment, an electric wave may experience a propagation delay while the electric wave is transferred from a transmitter to a receiver. Accordingly, although both the transmitter and the receiver are accurately aware of a time when the electric wave is transmitted from the transmitter, a time when the electric wave is received by the receiver may be affected by a distance between the transmitter and the receiver, an ambient propagation environment, and the like, and may vary over time when the receiver moves. When the receiver is not accurately aware of a point in time when a signal transmitted from the transmitter is to be received, the receiver may fail to receive the signal, or may receive a signal distorted due to the propagation delay and may fail to perform communication.

Accordingly, in the wireless communication system, synchronization between the eNB and the UE may be established first to receive a signal, irrespective of a UL and a DL. That is, a synchronization process is an essentially important process in a communication system, and maintaining the synchronization process may also significantly affect a stability of the system and a quality of communication.

There may be various types of synchronization, such as a frame synchronization, an information symbol synchronization, a sampling period synchronization, and the like. The sampling period synchronization may need to be obtained basically, so as to distinguish a physical signal.

In DL transmission corresponding to a communication link of transmission in a direction from the eNB to the UE, synchronization may be obtained in the UE based on a signal of the eNB. The eNB may transmit a predetermined signal that is mutually prearranged, so that the UE may readily obtain a DL synchronization, and the UE may need to accurately distinguish a time when the predetermined signal is transmitted from the eNB. In a case of a DL, a single eNB may simultaneously transmit the same synchronization signal to a plurality of UEs and thus, each UE may independently obtain synchronization based on the synchronization signal.

Conversely, in a case of a UL, the eNB may receive signals transmitted from the plurality of UEs and thus, the eNB may have difficulty in obtaining synchronization based on one of the UEs. Accordingly, a synchronization process that is different from the DL may be required.

When distances between the UEs and the eNB are different from each other, the UEs may have different transmission delay times. When each UE transmits UL information based on a corresponding DL synchronization, information transmitted from each UE may be received by the eNB at different times.

Although the uplink information transmitted from each UE is received at different times, the information may be received with a complexity being increased when a trans-

6

mission scheme adopted by the wireless communication system, such as CDMA, is capable of separately receiving the information. However, in a wireless communication system that is based on OFDMA or FDMA, uplink transmission information of all the UEs may be simultaneously received by the eNB and may be demodulated and thus, a reception performance may increase as the uplink transmission information is received at an accurate time, and a reception performance may be rapidly deteriorated as a reception time difference of each UE signal received in the eNB is increased.

Accordingly, in a wireless communication system that utilizes OFDMA or SC-FDMA as a UL transmission scheme, such as LTE, a timing alignment value may be calculated for each UE based on a random access scheme and the like, to obtain a transmission delay time in a DL and a transmission delay time in a UL, and each UE may be informed of the calculated TA value, so that a UL synchronization is obtained.

FIG. 2 illustrates an example associated with a timing advance (TA) in a synchronization process according to an embodiment of the present invention.

In general, a UL radio frame i 220 may need to be transmitted at the same point in time as a point in time when a DL radio frame i 210 is transmitted, so as to perform communication between an eNB and a UE. However, a time difference may exist between the UE and the eNB due to propagation delay and the like.

Accordingly, a TA may be applied to enable the UE to transmit the UL radio frame i 220 a little earlier than the DL frame i 210 by taking the propagation delay into consideration, so that synchronization between the eNB and the UE may be obtained. An equation to calculate the TA may be expressed by Equation 1.

$$TA = (N_{TA} + N_{TA\text{ offset}}) \cdot T_s \text{ seconds} \quad [\text{Equation 1}]$$

Here, N_{TA} denotes a value to be variable based on TA command information transmitted from the eNB, and $N_{TA\text{ offset}}$ denotes a value set based on a frame structure. T_s denotes a sampling period. As shown in FIG. 2, to obtain a UL synchronization, the UE may receive the TA command information provided by the eNB, and may proceed with a TA based on the received TA command information so that UE may obtain synchronization with the eNB for wireless communication.

FIG. 3 illustrates a random access process performed between a UE and an eNB according to an embodiment of the present invention.

To perform transmission and reception of data with an eNB 390, a UE 380 may need to obtain a UL synchronization. To obtain the UL synchronization, the UE 380 may proceed with a process of receiving information required for synchronization, from the eNB 390. FIG. 3 shows a random access procedure for receiving information required for synchronization. The random access procedure may be applicable when a UE is newly coupled to a network through a handover and the like. Also, upon completing the coupling, the UE may proceed with the random access procedure even under a circumstance such as synchronization, a state change, for example, from an RRC_IDLE to an RRC_CONNECTED, and the like.

The UE 380 may randomly select a preamble signature so as to generate a random access preamble (RAP). Subsequently, the UE 380 may transmit the selected preamble to the eNB 390 (step S310). The process of selecting the preamble signature may be contention-based selection or contention-free selection. In this example, the eNB may

US 9,854,545 B2

7

inform the UE of a previously reserved RAP, and the UE may transmit, to the eNB 390, a preamble selected based on received information (step S310). Also, according to the contention-free selection, a procedure associated with a contention resolution (CR) message, which is required in the contention-based selection, may not need to be performed.

Here, the UE 380 may recognize random access-radio network temporary identifier (RA-RNTI) based on a transmission time and a frequency resource temporarily selected for selecting a preamble or for random access channel (RACH) transmission.

The eNB 390 may perform random access response (RAR) with respect to the preamble received from the UE 380. In this example, the eNB 390 may transmit an RAR message through a physical downlink shared channel (PDSCH).

Information transmitted through the RAR message may include, for example, identification information of the UE preamble received by the eNB, an identifier (ID) of the eNB, a temporary cell radio network temporary identifier (C-RNTI), information associated with a time slot where the preamble is received, TA information, and the like. Timing information for a UL synchronization may be received through the RAR message and thus, the UE 380 may perform the UL synchronization with the eNB 390. The UE 380 may perform a scheduled transmission that transmits data at a scheduled time determined based on the TA information received in step S320 (step S330). In this example, the UE 380 may transmit synchronized data through a physical uplink shared channel (PUSCH), and may perform hybrid automatic repeat request (HARD).

Examples of a message transmitted in step S330 may include a radio resource control (RRC) connection request, a tracking area update, a scheduling request, and the like. Also, one of the messages may include a temporary C-RNTI, a C-RNTI (if the UE already has one), UE identification information, and the like.

In steps S310 through S330, collision may occur and thus, when the eNB 390 transmits a CR message (step S340), the UE 380 may i) determine whether a received message corresponds to the UE 380, and may transmit an acknowledgement (ACK) when the received message corresponds to the UE 380 or ii) may not transmit response data when the received message corresponds to another UE. Also, the UE 380 may not transmit the response data when the UE 380 misses DL allocation or fails to decode the message. Also, the CR message may include a C-RNTI, UE identification information, and the like.

Unlike a process of obtaining a TA when a single carrier is utilized, in a wireless system that uses a plurality of CCs, TA values of the CCs may have a high probability of being different from each other when locations of center frequencies of the CCs are significantly distant from each other as shown in FIG. 1, when the CCs are supported by different devices in a network, or the like.

Accordingly, when a synchronization obtaining scheme used for a single carrier is applied as is, the CCs may have difficulty in obtaining the UL synchronization for the CCs. Accordingly, the UE may perform stable UL communication for a few CCs that obtain UL synchronization from among available CCs.

When the UE transmits, based on the same UL synchronization standard, information through CCs of which UL synchronization standards are different from each other, a probability of transmission error may be significantly high, and a time and resources for restoring the error may be

8

wasted. In this example, it is difficult to satisfy a UL quality of service (QoS) for an application program required by a system.

When the wireless communication uses a plurality of CCs, a transmission delay time may be different in a DL based on a supporting scheme in a radio network and a characteristic of each CC with respect to a single UE. Accordingly, when CCs or CCs having the same TA value are configured as a set, a UL synchronization standard may be different for each CC set and thus, UL performance may be deteriorated.

Therefore, embodiments of the present invention for a wireless communication system supporting a plurality of CCs, are provided so that the UE obtains a UL synchronization of a corresponding CC or a group of CCs based on a type of each CC, a location of a center frequency, a network service type, and the like when CCs or groups including at least one CC have different UL synchronization standards.

Hereinafter, a user terminal may be referred to as a UE and a base station may be referred to as an eNB.

FIG. 4 illustrates a process that obtains a UL synchronization according to an embodiment of the present invention.

FIG. 4 shows a process in which a UE configures a group associated with a timing from among a plurality of CCs and performs RAP through a delegate CC when an eNB transmits information associated with the CCs to the UE.

Referring to FIG. 4, when an RRC connection mode is an RRC_CONNECTED mode indicating that a UE 480 and an eNB 490 are connected, step S410 may be performed. When the RRC connection mode is an IDLE mode or requires resetting, step S405 may be performed first, and then step S410 may be performed.

In step S405, RRC connection may be performed. When the RRC connection mode between the eNB 490 and the UE 480 is the IDLE mode or requires resetting, the eNB 490 may have difficulty in defining a CC set of the corresponding UE and transmitting CC set information in the IDLE mode UE. Therefore, the CC set information may be formed by selecting at least one CC to perform RRC connection so that the RRC connection is performed (step S405). At least one CC to perform the RRC connection may be selected based on one of the following methods.

- i) select a CC that is most appropriate for attempting RRC connection based on information measured by the UE 480
- ii) attempt RRC connection based on information fixedly set in a system and stored in an internal memory of the UE 480
- iii) attempt RRC connection based on information transmitted to the UE 480 from the eNB 490 through system information
- iv) attempt RRC connection through CCs corresponding to system information of the available CCs stored in an internal memory of the UE 480

For example, a UE in an IDLE mode may select a single DL CC for the RRC connection based on the conditions, and may receive system information via a broadcasting channel that is transmitted through the selected CC. Based on the received system information, the selected DL CC and a UL CC having a linkage with the DL CC may be configured as a primary serving cell (PCell). The UE may transmit, to an eNB, an RRC connection request message through the PCell. In this example, the UE may transfer the RRC connection request message to the eNB through an RACH procedure.

Here, the DL CC corresponding to the PCell may be referred to as a DL primary CC (DL PCC), and the UL CC corresponding to the PCell may be referred to as a UL

US 9,854,545 B2

9

primary CC (UL PCC). Also, a CC corresponding to a secondary serving cell (SCell) 920 in a DL may be referred to as a DL secondary CC (DL SCC), and a CC corresponding to the SCell in a UL may be referred to as a UL secondary CC (UL SCC).

The PCell and the SCell have characteristics as follows.

First, the PCell may be used for PUCCH transmission.

Second, the PCell is always activated, whereas the SCell 920 is activated or deactivated based on a predetermined condition.

Third, when the radio link failure (RLF) is detected via PCell, RRC reconnection PCell may be triggered. When the RLF is detected via SCell 920, RRC reconnection on SCell may not be triggered.

Fourth, the PCell may be changed by a change of a security key or by a handover procedure accompanying the RACH procedure. In a case of an MSG4 (contention resolution), only a PDCCH that indicates the MSG4 may be transmitted through the PCell, and MSG4 information may be transmitted through the PCell or the SCell.

Fifth, non-access stratum (NAS) information may be received through the PCell.

Sixth, the PCell may be configured as a pair of a DL PCC and a UL PCC.

Seventh, each UE sets a different CC as the PCell.

Eighth, a procedure such as, reconfiguration, adding, and removal of the SCell may be performed by an RRC layer. To add a new SCell, RRC signaling may be used to transmit system information associated with a dedicated SCell.

Technical concept of the PCell and the SCell in embodiments of the present invention may not be limited to the descriptions provided in the foregoing, and may include further examples.

When RRC connection setup is completed through one of the methods, and the RRC connection mode between the eNB 490 and the UE is the RRC_CONNECTED mode, step S410 may be performed.

The eNB 490 may allow the UE 480 to use a plurality of CCs based on a performance of hardware of the UE 480, available frequency resources of the eNB 490, and the like, and may define the plurality of CCs to be a CC set. The eNB 490 may transmit, to the UE 480, CC set information associated with the CC set that is allowed to the UE 480 (step S410).

As described in the foregoing, the UE 480 and the eNB 490 maintain the RRC_CONNECTED mode from step S405 or before. That is, a UL synchronization of a UL CC through which the RRC connection of the UE 480 is set up is maintained. The UE 480 may receive the CC set information determined based on the above condition, from the eNB 490.

According to a scheme of transmitting and receiving the CC set information, the eNB 490 may include the CC set information in an RRC reconfiguration message for transmission to the UE 480, or may use another message for transmission.

Also, the CC set information may be configured by adding/removing each CC. For example, when initial CC set information is transmitted, the CC set information configured of DL CC1, DL CC2, and DL CCN may be configured as an added DL CC list and the list may include CC1, CC2, and CCN. In the same manner, UL CC set information may be configured as an added UL CC list.

As another example, when the CC set information is changed, that is, when the configured DL CC set is changed into CC1, CC3, and CCN, the DL CC set information may

10

be transmitted by configuring CC2 as a removed DL CC list and CC3 as an added DL CC list.

The UE 480 may receive system information (SI) associated with CCs in the CC set, based on the received CC set information (step S420).

When a CC that is incapable of transmitting SI to a corresponding CC exists from among the CCs in the CC set, for example, an extension CC (ECC), or a CC that is incapable of receiving SI transmitted via a broadcasting channel (for example, a DL CC that belongs to an SCell) exists, the SI may be received by a CC that is capable of receiving the SI or may be received by a CC that is capable of receiving SI that is transformed in a form of control information.

The transformed SI may be transmitted to the UE together with the CC set information included in the RRC reconfiguration message transmitted by the eNB, or may be transmitted to the UE through the RRC reconfiguration message after the CC set information is received. Also, the current stage may be performed without receiving the SI associated with the corresponding CC.

The UE 480 may configure a UL timing group including CCs in the CC set as elements of the UL timing group, based on the received SI (step S432). When the UL timing group is configured, considerations may be as follows.

First, whether a plurality of CCs is assigned to different groups may be determined based on the following conditions. That is, a CC that satisfies at least one of the conditions may be configured to be a different group.

a-i) CCs of which a difference in center frequency values is greater than or equal to a threshold, are assigned to different groups. When a difference in the center frequency values is high, delay occurring in a wireless signal propagation process may be changed and thus, a difference in TA values may also increase.

a-ii) CCs to which different beamforming schemes are applied are assigned to different groups. TA values are highly likely to be different from each other when the beamforming schemes are different from each other.

a-iii) CCs that are set to be updated every time a UL synchronization update request exists are assigned to different groups. The setting may be included in SI set by the eNB 490 for transmission, or may be included in other messages for transmission.

a-iv) CCs that do not provide services in a macrocell or CCs that provide services in a space superposed on the macrocell by a femtocell, a picocell, a microcell, a relay, a repeater, and the like may have different characteristics from CCs that provide services by the macrocell and thus, the CCs are configured to be different groups.

a-v) a CC that has a UL synchronization update request from the eNB 490 may be a CC that has a changed synchronization and thus, the CC may be assigned to a different group.

As described in the foregoing, examples of a condition for setting CCs to be a UL timing group may be a-i) through a-v). In addition, CCs are configured to be a single group or to be different groups based on a wireless propagation characteristic, a predetermined measurement value, and the like.

When one of the following conditions are satisfied, CCs may be configured to be a single group.

b-i) CCs of which a difference in center frequency values is within a threshold range may have similar propagation characteristic and thus, the CC may be configured to be a single group.

US 9,854,545 B2

11

b-ii) CCs to which the same beamforming scheme is applied may be configured to be a single group

b-iii) CCs used in devices in the same radio network may be configured to be a single group

b-iv) CCs that do not satisfy conditions a-I through a-v for assigning CCs to different groups may be configured to be a single group

A method for the UE 480 to generate a group may include two schemes, that is, a scheme of generating groups by distinguishing CCs that belong to different groups and a scheme of generating a group by distinguishing CCs to be included in the same group. The two schemes may be used together or one of the two schemes may be used. Conditions to be used in a process of applying each scheme have been described in the foregoing.

When the UL timing group is generated, the UE 480 may select a delegate CC for each group (step S434). In this example, the delegate CC may be selected based on following conditions, from among CCs that are capable of obtaining a TA value to be used for obtaining a UL synchronization.

- c-i) a CC having a lowest center frequency value
 - c-ii) a CC having a center frequency value that is closest to a mean value
 - c-iii) a CC having a highest center frequency value
 - c-iv) a CC having a broadest frequency band
 - c-v) a CC that is set to be used for monitoring DL quality
- A CC satisfying one of the conditions may be selected as a delegate CC.

Here, a CC may be defined to include a DL CC or both the DL CC and a UL CC, and may be defined to be a cell or a serving cell. In other words, the cell may be defined by only DL frequency resources (for example, a CC) through which a wireless signal recognized by a UE reaches a predetermined area, and may be defined to be a pair of the DL frequency resources that is used by the UE to receive a signal from the eNB and UL frequency resources that is used by the UE to transmit a signal to the eNB.

Therefore, with respect to only a UE that is able to form a plurality of CCs, the eNB may be able to form a plurality of serving cells to perform transmission and reception of data with the UE

In this example, a PCell may indicate a single serving cell that provides a security input and NAS mobility information in an RRC establishment state or re-establishment state. Also, based on the capabilities of the UE, at least one cell may be configured to form a serving cell set with the PCell, and the at least one cell may be referred to as an SCell.

Accordingly, a serving cell set configured for a single UE may be configured of a single PCell or of a single PCell and at least one SCell. An adjacent cell in a frequency of the PCell and/or an adjacent cell in a frequency of the SCell may be in the same carrier frequency, and adjacent cells in frequencies of the PCell and the SCell may be in different carrier frequencies.

Here, a CC set for monitoring the DL quality may include an SCell to which a radio link monitoring (RLM) is defined. In particular, the RLM may include a process in which a UE monitors DL quality based on a cell-specific reference (CRS) signal so as to detect DL quality of a serving cell set between the UE and an eNB.

In this example, the UE may predict the DL quality based on predetermined parameters which are defined by a ratio of the measured CRS to energy of control channels.

The RLM may be set based on following conditions. To predict the DL quality through the RLM, a value that expresses a ratio of reception energy of an RE (single

12

sub-carrier in a single OFDM symbol) through which a PDCCH/physical control format indicator channel (PCFICH) is transmitted, to an average RE energy of the CRS based on a dB unit may be used as a criterion.

From among the parameters, a parameter Q_{out} that is a criterion to determine an out-of-sync state may be configured based on a parameter set for transmitting a PDCCH/PCFICH and a value of which a block error rate (BER) of hypothetical PDCCH (based on a DCI format 1A) transmission based on an error of the PCFICH is greater than or equal to 10%. The value may be changed based on a number of antenna ports through which the CRS is transmitted.

For example, when the CRS is transmitted through a single antenna port, a ratio of energy between the PDCCH and the CRS to be determined as Q_{out} may be based on 4 dB, and when the CRS is transmitted through two or more antenna ports, Q_{out} may be based on 1 dB. From among the parameters, a parameter Q_{in} that is a criterion to determine synchronization restoration or in-sync state may be determined based on a value having a sufficiently large reliability when compared to Q_{out} .

That is, a parameter set for transmitting the PDCCH/PCFICH and a value of which a BER of hypothetical PDCCH (based on a DCI format 1C) transmission based on an error of the PCFICH is greater than or equal to 2% may be used. The value may be changed based on a number of antenna ports through which the CRS is transmitted.

For example, when the CRS is transmitted through a single antenna port, a ratio of energy between the PDCCH and the CRS to be determined as Q_{in} may be based on 0 dB, and when the CRS is transmitted through two or more antenna ports, Q_{in} may be based on -3 dB.

A reason that an energy ratio used for determining Q_{in} is lower than Q_{out} is that the energy ratio is based on the parameter set for transmitting the PDCCH/PCFICH and the BER of the hypothetical PDCCH transmission. The parameters set for transmitting the PDCCH/PCFICH may include a DCI format of a PDCCH, a number of OFDM symbols through which control information of a subframe is transmitted, an aggregation level indicating a self-duplication rate of the PDCCH, and the like. The parameters may be affected by a bandwidth of a DL. Q_{out} and Q_{in} may be affected based on whether a UE performs discontinuous reception (DRX) with respect to a corresponding cell.

Therefore, the UE or the eNB may select a delegate CC in each group. In this example, the UE or the eNB may select the delegate CC by selecting an SCell including the delegate CC. In this example, the delegate CC or the SCell may be selected based on the conditions c-i) through c-v), from among CCs that are capable of obtaining a TA value to be used for obtaining a UL synchronization. That is, one of the c-i) through c-v) may be selected as a delegate CC.

In this example, according to a method of selecting a delegate CC for each UL timing group, the same criterion may be used for all groups or a different criterion may be used for each timing group. That is, the delegate CC may be selected based on a network state of each group, characteristics of CCs forming each group, and the like.

After completing steps S432 and S434 for setting a UL timing group and a corresponding delegate CC, to obtain a UL synchronization, the UE 480 may set an RAP through a delegate CC of each group, and may transmit the set preamble by selecting one of the resources defined in SI of each CC (step S440). The preamble may be included in a synchronization request message through which the UE requests synchronization. Transmission of the corresponding preamble may include a case in which the UE 480

US 9,854,545 B2

13

sequentially, simultaneously, or randomly transmits a preamble through a selected CC in time/frequency resources set by the eNB 490.

Cases that require obtaining a UL synchronization may be as follows. Although a condition does not satisfy one of the cases described below, when the UE 480 determines that it is required, the UE 480 may generate an RAP and may transmit the RAP to the eNB 490.

d-i) a case in which the eNB 490 requires re-establishment of the entire DL synchronization

d-ii) a case that initializes and retries all UL data transmission

d-iii) a case in which a time alignment timer of the UE 480 expires

The UE 480 may transmit a preamble to be used for obtaining a UL synchronization with respect to total available CC groups.

Also, the UE 480 may need to obtain a UL synchronization with respect to a few available CC groups. Relevant cases will be described as follows.

e-i) a case in which a CC set is initially set and a TA value does not exist in a corresponding group

e-ii) a case in which a response is not obtained in response to UL transmission data transmitted through CCs in a group of the UE 480

e-iii) a case in which an RRC connection between the eNB 490 and the UE 480 is reconfigured

e-iv) a case in which the UE 480 performs handover of a predetermined CC group to an eNB 490 that is physically different from the UE 480

e-v) a case in which the eNB 490 requests reconfiguration with respect to a predetermined CC group associated with a DL synchronization.

e-vi) a case in which a CC time alignment timer expires (the timer is set for each CC or for each group). When a condition satisfies one of the cases, a process for obtaining a UL synchronization with respect to a CC group including a corresponding CC may be performed.

For example, in steps S432 and S434, CC1, CC2, CC3, CC4, and CC5 exist, and CC1 and CC2 are configured to be group 1, and CC3, CC4, and CC5 are configured to be group 2. A delegate CC of group 1 is CC1, a delegate CC of group 2 is CC3. In this example, when a UL synchronization for the total available CC groups is required, the UE 480 may transmit an RAP through CC1 and CC3. When synchronization needs to be obtained for a few CC groups, that is, when synchronization needs to be obtained for group 2, the UE 480 may transmit an RAP through CC3.

When a UL synchronization needs to be re-established while data is transmitted through a UL, the UE 480 may perform the following operation first, for example, initializing UL data transmission, and then may perform initializing HARQ buffers, releasing a physical uplink control channel (PUCCH)/releasing sounding reference signal (SRS), initializing semi-persistent scheduling allocation/allowance, and the like, as a procedure to obtain a UL synchronization.

The eNB 490 may calculate a TA value for each group with respect to each CC group (each delegate CC) based on the received RAP signal. The eNB 490 may transmit, to the UE 480, UL grant information and a TA value of a UL timing group (a delegate CC) through an RAR message (step S450). The TA value may be an example of UL synchronization information required when the UE adjusts a UL transmission time.

14

Subsequently, when the UE 480 determines that the TA value received in a CR procedure (step S460) is valid, the UE 480 may apply the TA value to another CC in the group for updating (step S470).

As described in the foregoing, when a procedure of obtaining a UL synchronization is performed with respect to all the groups, TA values associated with CC1 and CC3 may be applied to CCs each included in group 1 and group 2. When a TA value of CC3 is received for group 2, the TA value may be applied to CCs included in group 2.

FIG. 5 illustrates a process that obtains a UL synchronization according to another embodiment of the present invention. Here, FIG. 5 shows that an eNB 590 configures a UL timing group.

Referring to FIG. 5, the eNB 590 determines a mode (RRC_CONNECTED/RRC_IDLE) of a UE before transmitting UL timing information. When the eNB 590 is not connected to the UE, the eNB 590 may proceed with RRC connection (step S505), and may use a PCell for RRC connection, which will be performed in the same manner as step S405 of FIG. 4.

A scheme of generating a group in the eNB 590 may be performed based the conditions a-i) through a-v) or b-i) through b-iv) of FIG. 4.

Accordingly, the eNB 590 may transmit CC set information of the UE 580 and UL timing group information of the set UL timing group to the UE 580 (step S510). Here, the UL timing group information may be included in a CC set information message for transmission to the UE 580, or a separate other message may be used for transmission. A case that uses a separate message will be described with reference to FIG. 6. The CC set information message provided for each UE may be an RRC (L3) message, an L1 signaling, or an L2 signaling.

The UE 580 may receive SI of CCs in a set, based on the received CC set information (step S520). In this example, the UE 580 may use the UL timing group generated by the eNB 590 in step S508 as it is, or may slightly change the UL timing group based on a current network state as shown in step S432 of FIG. 4. This may indicate that the UE 580 may change the UL timing group when the UL timing group generated by the eNB 590 is inappropriate for an environment of the UE 580.

That is, after receiving a UL timing group or after changing or newly generating a UL timing group, the UE 580 may select a delegate CC for each UL timing group (step S534). The conditions taken into consideration when a delegate CC is selected for each UL timing group have been described in step S434 of FIG. 4.

After completing selection of a delegate CC for each UL timing group in step S534, when a UL synchronization needs to be obtained, the delegate CC in each group may set an RAP, and may transmit the selected preamble by selecting one of the resources defined in SI of each CC (step S540). The preamble may be included in a synchronization request message through which the UE requests synchronization.

Here, the UE 580 may transmit an RAP transmit message and the like for obtaining the UL timing information. Also, the corresponding preamble may be sequentially, simultaneously, or randomly selected and transmitted by the UE 580 in time/frequency resources set by the eNB 590.

A case that requires the UE 580 to obtain a UL synchronization may be associated with conditions d-i) through d-iii). Also, the UE 580 may transmit a preamble to obtain a UL synchronization with respect to available total CC groups. The UE 580 may need to obtain a UL synchronization with respect to a few available CC groups.

US 9,854,545 B2

15

The eNB 590 may calculate a TA value for each group with respect to each CC group (each delegate CC) based on the received RAP signal, and may include the corresponding TA value together with UL grant information in RAR information for transmission to UE 580 (step S550). The TA value may be an example of UL synchronization information required when the UE adjusts a UL transmission time.

For example, the eNB 590 may calculate a TA value based on the UL timing group set in step S508, and may transmit the calculated TA value. Also, the eNB 590 may transmit the RAR message through a predetermined CC, and may transmit the RAR message through all CCs in the corresponding UL timing group.

When the UE 580 determines that a TA value received in a CR procedure (step S560) is valid, the UE 580 may apply the TA value to remaining CCs in a group so as to update a TA value for each UL timing group (step S570).

FIG. 6 illustrates a process that obtains a UL synchronization according to still another embodiment of the present invention. Here, FIG. 6 shows that an eNB 690 configures a UL timing group and transmits group information through a separate message.

Referring to FIG. 6, the eNB 690 determines a mode (RRC_CONNECTED/RRC_IDLE) of a UE 680. When the eNB 690 is not connected to the UE 680, the eNB 690 may proceed with an RRC connection setup (step S605), and may use a PCell for RRC connection, which will be performed in the same manner as step S405 of FIG. 4 and step S505 of FIG. 5.

The eNB 690 may allow the UE 680 to use a plurality of CCs based on a performance of hardware of the UE 680, available frequency resources of the eNB 690, and the like, and may define the plurality of CCs to be a CC set. The eNB 690 may transmit CC set information of the UE 680 to the UE 680 (step S610). A CC set information message provided for each UE may be a message used for an RRC (L3) message and the like or may be an L1 signaling or an L2 signaling.

As described in the foregoing, the UE 680 and the eNB 690 maintain the RRC_CONNECTED mode from step S605 or before. That is, a UL synchronization of a UL CC through which the RRC connection of the UE 680 is set up is maintained. The UE 680 may receive the CC set information determined based on the above condition, from the eNB 690. As one of the schemes of receiving the CC set information, the eNB 690 may include the CC set information in an RRC reconfiguration message for transmission, and other messages may be used for transmission.

The UE 680 may receive SI of CCs in a set based on the received CC set information (step S620).

The eNB 690 may set a UL timing group with respect to CCs assigned to the UE 580 (step S624). In the process of configuring the UL timing group in the eNB 690, CCs may be configured to be different groups of at least two or to be the same group. The conditions a-i) through a-v) or b-i) through b-iv) may use to set a UL timing group.

A method for the eNB 690 to generate a group may include two schemes, that is, a scheme of generating groups by distinguishing CCs that belong to different groups and a scheme of generating a group by distinguishing CCs to be included in the same group. The two schemes may be used together or one of the two schemes may be used. Conditions to be used in a process of applying each scheme have been described in the foregoing.

The eNB 690 may transmit the UL timing group information to the UE 680 (step S626). The UL timing group information may not be included in the CC set information

16

message and the like for transmission, and The UL timing group information may be transmitted independently with the CC set information through use of a separate message. The UL timing group information may be transmitted through a channel, such as a PDCCH channel, an RRC signaling, and a broadcasting channel, and may be transmitted through an L2 (MAC element control) message.

The UE 680 that receives the CC set information message may use the received UL timing group as it is, or may slightly change the UL timing group based on a current network state. This may include a case in which the UE 680 changes the UL timing group when the UL timing group generated by the eNB 690 is inappropriate for an environment of the UE 680. After receiving the UL timing group or after changing or newly generating the UL timing group, the UE 680 may select a delegate CC for each UL timing group (step S634). The conditions taken into consideration when a delegate CC is selected for each UL timing group have been described in step S434 of FIG. 4, and step S534 of FIG. 5.

After completing selection of a delegate CC for each UL timing group in step S634, when a UL synchronization needs to be obtained, the delegate CC in each group may set an RAP, and may transmit the selected preamble by selecting one of the resources that are allocated for random access and defined in SI of each CC (step S640). The preamble may be sequentially, simultaneously, or randomly selected and transmitted by the UE 680 in time/frequency resources set by the eNB 690. The preamble may be included in a synchronization request message through which the UE requests synchronization.

The eNB 690 may calculate a TA value for each CC group (each delegate CC) based on the received RAP signal, and may include the corresponding TA value together with UL grant information in RAR information for transmission to UE 680 (step S650). For example, the eNB 690 may calculate a TA value based on the UL timing group set in step S624, and may transmit the calculated TA value in advance. Also, the eNB 690 may transmit the RAR message through a predetermined CC, and may transmit the RAR message through all CCs in the corresponding UL timing group. The TA value may be an example of UL synchronization information required when the UE adjusts a UL transmission time.

When the UE 680 determines that a TA value received in a CR procedure (step S660) is valid, the UE 680 may apply the TA value to remaining CCs in a group so as to update a TA value for each UL timing group (step S670).

As described in FIG. 6, the UE 680 may receive a set UL timing group from the eNB 690, and may perform a random access procedure based on a representative value of a corresponding group. Subsequently, the UE 680 may receive a TA value of the timing group based on a preamble associated with the random access procedure, and may adjust a UL timing for obtaining synchronization.

FIG. 7 illustrates a process in which an eNB supports the UE to obtain a UL synchronization in response to a request from the UE according to an embodiment of the present invention.

Referring to FIG. 7, the eNB determines an RRC mode of the UE (step S702). When the RRC mode between the eNB and the UE is an RRC_CONNECTED mode (step S704), the eNB may proceed with step S710.

When the RRC mode is different from the RRC_CONNECTED mode, the eNB may proceed with step S705. The eNB may determine whether an RRC connection request from the UE exists in step S705. The eNB may receive the RRC connection request from the UE (step S705), and may

US 9,854,545 B2

17

complete RRC connection (step S706). In this example, the eNB may receive an RRC connection request message from the UE, may transmit an RRC connection setup message, and may receive an RRC connection setup complete message from the UE so as to complete RRC connection. As described in steps S405, S505, and S605, a PCell may be used for RRC connection.

The eNB may set a CC set including at least one available CC with respect to an RRC_CONNECTED UE, and may transmit CC set information associated with the CC set to the UE (step S710).

The eNB may transmit SI associated with at least one predetermined CC in the CC set, based on the CC set information of the UE (step S720). Here, the CC set information may be transmitted through an RRC message. Also, the SI of the CC set may be transmitted through a broadcasting channel.

The eNB may determine whether a subject of generating a UL timing group is the eNB (step S722). When the UL timing group is generated by the eNB, the eNB may generate a UL timing group based on the CC set information of the UE, and may transmit information associated with the generated UL timing group to the UE (step S726). Here, the UL timing group information may be generated at the same point in time when the CC set information is generated and transmitted in step S710, or may be transmitted together with the CC set information.

The eNB may receive an RAP from the UE (step S740). The preamble may be included in a synchronization request message through which the UE requests synchronization. Step S740 may include a case in which the subject of generating the UL timing group is the UE. That is, the UE may generate a UL timing group based on available CC set information of step S710 and SI of a corresponding CC of step S720, may set a delegate CC for each timing group, and may transmit an RAP through a corresponding delegate CC. Therefore, the eNB may receive the preamble transmitted from the UE. Here, the eNB may receive a synchronization request message, for example, the preamble, simultaneously through a plurality of delegate CCs, or at separated time, that is, sequentially through a delegate CC for each UL timing group.

Subsequently, the eNB may transmit an RAR message with respect to the received preamble. In this example, the eNB may transmit UL grant information for the UE and TA information for each UL timing group along with the RAR message (step S750).

The TA value may be an example of UL synchronization information required when the UE adjusts a UL transmission time. Also, the TA information for each UL timing group may be transmitted through a plurality of delegate CCs, simultaneously or at separated time. Here, the TA information for each UL timing group may be transmitted in a form of a table including a TA value corresponding to a group index. Also, the TA information for each UL timing group may be transmitted in a form including a unit error for each timing group based on a reference TA value. In this example, the error for each group may be expressed by an integer-multiple of a predetermined unit value, or may be specified in detail. The TA information for each UL timing group may be transmitted in a form of an indicator indicating a TA based on a predetermined rule.

The eNB may transmit a CR message to the UE (step S760). This may include an operation that enables the UE to determine the validity of the received TA value and to update a TA value of a corresponding group.

18

FIG. 8 illustrates a process in which a UE obtains a UL synchronization through use of a UL timing group according to an embodiment of the present invention.

Referring to FIG. 8, the UE may determine an RRC mode (step S802). When the RRC mode is different from an RRC_CONNECTED mode, that is, when the RRC mode is an IDLE mode, the UE may perform RRC connection setup.

Accordingly, the UE may select a predetermined CC through which RRC connection is performed (step S806), may transmit an RRC connection request message to the selected predetermined CC, may receive an RRC connection setup message from the eNB through the selected predetermined CC, and may transmit an RRC connection setup complete message to the eNB so as to complete RRC connection setup (step S808).

When the UE corresponds to the RRC_CONNECTED mode (step S804), whether a UL is continuously maintained may be determined (step S810).

When the UL is not maintained, step S812 may be performed. In step S812, the UE may determine whether an RRC connection setup reconfiguration message is received from the eNB (step S812).

Here, when the RRC mode of the UE is the IDLE mode, or when the RRC connection setup reconfiguration is performed, the eNB may have difficulty in defining a CC set and transmitting CC set information. Accordingly, the UE may f-i) select a CC that is most appropriate for attempting RRC connection based on information measured by the UE, or may select at least one CC to perform RRC connection through use of one of f-ii) information fixedly set in a system and stored in an internal memory of the UE, f-iii) information transmitted to the UE from the eNB through SI, or f-iv) SI of available CCs stored in an internal memory of the UE and thus, may form the CC set information. When the mode of the UE is changed to the RRC_CONNECTED mode after completing RRC connection setup, step S830 may be performed.

When the UE performs handover, the UE may determine the received RRC connection setup reconfiguration message (step S814), and determine mobility control information (MCI) (step S816). The UE may determine information to be used for obtaining synchronization of a corresponding CC from a target eNB (T-eNB), based on the MCI information. That is, the UE may obtain a UL synchronization from the T-eNB. When the UE does not perform handover, the UE may merely determine the received RRC connection setup reconfiguration message (step S814), and may not proceed with steps S816 and S818.

In other words, when the UE does not perform handover in the process of obtaining a UL synchronization, the UE may proceed with a procedure for obtaining a UL synchronization between a source eNB (S-eNB) and a corresponding CC so as to obtain the UL synchronization. As another example, when the UE performs handover, the UE may proceed with a procedure for obtaining a UL synchronization of a corresponding CC based on SI of a CC of a T-eNB received from an S-eNB, so as to obtain the UL synchronization. Desirably, a random access procedure may be used, and other procedures may also be applicable.

Subsequently, to obtain synchronization with the S-eNB or the T-eNB, the UE may select a preamble and may transmit the preamble to the S-eNB or the T-eNB (step S820). The preamble may be included in a synchronization request message through which the UE requests synchronization. The UE may receive an RAR message from the S-eNB or the T-eNB in response to transmission of the preamble. In the RAR message, UL grant information for the

US 9,854,545 B2

19

UE and TA information for each group including at least one CC to be used for obtaining a UL synchronization may be included (step S822).

The UE may verify whether the TA received through a CR procedure in step S822 is valid (step S824), and the UE may update a UL timing group including at least one CC based on the received TA value (step S826) when the UE determines that the TA is valid.

When the RRC connection setup reconfiguration message is not received, step S820 may be performed.

When a UL is maintained or when the UE obtains a UL synchronization, the UE may receive CC set information from the eNB (step S830). Also, the UE may receive SI of the received CC set (step S832).

Subsequently, the UE may determine whether UL timing group information is received (step S840). In this example, when the UL timing group information is generated by the eNB, the UE may receive the UL timing group through the CC set information receiving process or through a separate message. The UL timing group information may include delegate CC information for each group. When the delegate CC information for each group is included in the UL timing group, step S852 may not be performed. When the delegate CC information for each group is not included in the UL timing group, the UE may determine the received UL timing group, and may set a delegate CC for the corresponding UL timing group (step S852). The delegate CC may be set based on the conditions c-i) through c-v) of FIG. 4. Also, the delegate CC used for adjusting a TA value of each UL timing group may be set by applying the same criterion to all groups, or by applying a different criterion based on a characteristic of each UL timing group.

When the UL timing group information is not received or when the received timing group is inappropriate for a radio network state where the UE is located or inappropriate for the UE, the UE may set UL timing group information based on the received CC set information (step S850). Also, the UE may set a predetermined CC in the set UL timing group, as a delegate CC for the timing group (step S852).

The UE may select a preamble and may transmit the preamble through the delegate CC (step S854). This may also be applicable when a TA needs to be updated after the delegate CC is set.

The UE may receive an RAR message from the eNB. In this example, the UE may receive UL grant information for the UE and the TA information for each UL group (step S856). Here, the UE may determine a TA value in a form of a table corresponding to a group index of each UL timing group. Also, the UE may determine a TA difference value in a form including a unit error for each timing group based on a predetermined reference TA value. Also, the UE may determine an error for each UL timing group that has a size of an integer-multiple of a predetermined unit value, and may also determine an error for each UL timing group that is specified in detail. Also, the UE may determine a TA indicator determined to be an indicator based on a predetermined rule.

Subsequently, the UE may verify the validity of a TA through a CR procedure (step S860).

When the UE determines that the TA is valid, the UE may update a TA value for each UL timing group (step S870).

Here, the UE may transmit the updated TA value for each UL timing group to the eNB through a delegate CC. That is, a procedure of determining the TA value may be additionally performed to obtain accurate synchronization with the eNB.

FIG. 9 illustrates operations of a UE according to an embodiment of the present invention. Here, FIG. 9 shows

20

the operations of the UE when setting of an initial UL timing group is performed in an eNB.

Referring to FIG. 9, the UE may receive CC set information from the eNB (step S972). The CC set information may be received via a PCC or a Pcell. The PCC may correspond to the PCell as described in the foregoing. A UE in an IDLE mode may select a single DL CC based on the condition described in the foregoing, for RRC connection, and may receive SI through a broadcasting channel transmitted through the selected CC. The CC set information may be transmitted through an RRC message.

The UE may receive SI associated with CCs in the CC set, based on the received CC set information (step S974). The SI may be transmitted to a plurality of UEs in common through a broadcasting channel or may be transmitted through an RRC message in a form of a dedicated channel. The SI may be transmitted through the PCC. Accordingly, the UE may configure UL CCs in the CC set based on the SI.

In step S974, the UE may receive an RAP of each CC or information associated with time/frequency resources to be used by the UE, from the eNB. The UE may configure an initial UL timing group based on the received RAP of each CC or the information associated with the time/frequency resources. The RAP or the information associated with the time/frequency resources may be included in the SI for transmission through the PCC, or may be transmitted in a form of an RRC message.

The UE may determine whether simultaneous transmission of the RAP through all UL CCs configured for obtaining a UL synchronization is possible, based on CC parameters and RACH information included in the received SI (step S976).

Here, the UE may determine a UE-specific RACH parameter from among RACH parameters of the UL CCs configured by the eNB.

In this example, when RAP information is set in the UE-specific RACH parameter, the UE may determine the RAP information of the UE and may set an RAP to be transmitted through each of the configured UL CCs. Here, the RAP information may be preamble information set to be different for each UE for distinguishing the UEs.

When time/frequency resource information is set in the UE-specific RACH parameter, the UE may determine the time/frequency resource information of the UE, and may set an RAP to be transmitted to the configured UL CCs. Here, the time/frequency resource information may be set by the eNB to be different for each UE.

When simultaneous transmission of the RAP through all the configured UL CCs is possible in step S976, the UE may simultaneously transmit the RAP (step S978).

Conversely, when it is determined that the UE is incapable of simultaneously transmitting the RAP through all the UL CCs in step S976, the UE may proceed with step S990.

With respect to the simultaneous transmission of the RAP, the UE may determine RACH parameters included in SI of each of a plurality of UL CCs, and determine a plurality of time/frequency resources defined in the RACH parameters, and may select a RAP transmission time (rach_t) for transmitting the RACH at the same time. The RAP transmission time (rach_t) may correspond to a time when the RAPs are simultaneously transmitted by the UE through all the UL CCs.

When the UE is incapable of setting the RAP transmission time (rach_t), that is, when the UE is incapable of transmitting the RAP through all the configured UL CC at the same

US 9,854,545 B2

21

time, the UE may transmit an RAP resource information request message to the eNB (step S990).

For example, it is assumed that a time for determining the RACH parameters of all the UL CCs and transmitting RAP is limited to t0 and t1. When the UE determines that transmitting RAP through CC1, CC3, and CCN is allowed at t0, and is not allowed at t1, and the UE determines that transmitting RAP through CC2 is allowed at t1, and is not allowed at t0, the UE may transmit an RAP resource information request message to the eNB.

Subsequently, in response to the RAP resource information request, the UE may receive an RAP resource information response message from the eNB (step S992). Here, the eNB that receives the RAP resource information request message may determine that the UE is incapable of simultaneously transmitting the RAP through all the CCs. Therefore, the eNB may include transmission time/frequency resource to be used for RAP transmission of the UE and a type of a preamble in the RAP resource information response message for transmission to the UE.

Accordingly, the UE may transmit the RAP through all UL CCs configured based on information included in the RAP resource information response message (step S994). When the RAP resource information does not exist in the RAP resource information response message received from the eNB, a time that is closest to the time when the RAP needs to be transmitted may be selected so that the RAP may be simultaneously transmitted through all the UL CCs. In this example, the same RAP may be selected from all the CCs and may be simultaneously transmitted.

Subsequently, the UL timing group information may be received from the eNB through a PCC. That is, the eNB may determine RAPs transmitted from the UE, may determine that the UE requests configuration of a UL timing group, may calculate a TA value based on the preambles received through the RAPs, and may generate the UL timing group of the UE based on the calculated TA. The UL timing group information of the generated UL timing group may be transmitted to the UE.

The UL timing group information may be received through the PCC (PCell) in a form of a PDCCH or control information of a MAC message, or may be received through an RRC message.

The UE may simultaneously receive RAR from the eNB through a few or all of DL CCs having linkages with all the configured UL CCs (step S982). The linkage may be set fixedly in a wireless communication system, or may be set for each eNB based on SI, or may be set for each UE or for each UE group based on an RRC message.

The RAR message may include, for example, identification information of the UE preamble received by the eNB, an identifier (ID) of the eNB, a temporary C-RNTI, information associated with a time slot where the UE preamble is received, UL grant information, TA information for obtaining a UL synchronization, and the like.

Accordingly, the UE may transmit data through a PUSCH through use of time/frequency resource information included in the UL grant information at a scheduled time determined based on the received TA information, and may perform HARQ.

The UE may simultaneously verify the validity of the TA with respect to CCs through which the RAR is received (step S984). In this example, when RAP information is set in the UE-specific RACH parameter, the UE may omit verifying the validity of the TA.

As described in the foregoing, the UE may determine whether C-RNTI, T_C-RNTI, or UE identity included in an

22

ACK message received from the eNB is identical to C-RNTI, T_C-RNTI, or UE identity assigned to the UE, so as to simultaneously verify the validity of the TA. Here, the UE may transmit an L2/L3 message including the C-RNTI, the T_C-RNTI, or the UE identity to the eNB, and may receive an L1/L2 message from the eNB since the ACK message is based on the HARQ operation.

The UE may recognize that the eNB sets UL CCs having linkages with the received DL CC through which the RAR is received as delegate CCs in a group, and may set the UL CCs as the delegate CCs in the group (step S986).

The UE may apply a TA value of the delegate CC received in step S972 to remaining CCs in each group for updating (step S988).

FIG. 10 illustrates a configuration of a transmitting apparatus according to an embodiment of the present invention.

Referring to FIG. 10, a transmitting apparatus 1000 may include a connection mode determining unit 1005 to determine an RRC mode of a UE, a CC set determining unit 1020 to determine a CC set including at least one CC available to the UE, a UL timing group generating unit 1030 to generate a UL timing group, a transceiving unit 1050, and a controller 1010 to control the above component elements.

The controller 1010 may generate UL synchronization information corresponding to the UL timing group, so as to establish a UL synchronization. The transceiving unit 1050 may receive a synchronization request message from the UE through at least one delegate CC in the UL timing group, and may transmit the UL synchronization information to the UE through the at least one delegate CC. The at least one delegate CC may be selected by the UE based on a state of the UL timing group and characteristics of a plurality of CCs forming the UL timing group, so as to obtain the UL synchronization. In particular, the at least one delegate CC may correspond to at least one of c-i) through c-v). The CC may be included in the serving cell as described in the foregoing.

In particular, the RRC mode determining unit 1005 may determine a connection mode between the UE and the eNB, and when the UE and the eNB are not connected, that is, when the connection mode is an RRC_IDLE mode or UL synchronization is not established, the RRC mode determining unit 1005 may change the connection mode of the UE to an RRC_CONNECTED mode or may enable the UL synchronization to be established. In this example, RRC connection setup may be performed through use of the UE and a PCC as described in the foregoing.

For example, the RRC mode determining unit 1005 may operate the transceiving unit 1050 to receive an RRC connection request transmitted from the UE, and to transmit an RRC connection setup message to the UE. Also, the RRC mode determining unit 1005 may receive an RRC connection setup complete message from the UE, may complete the RRC connection setup, and may determine an UE RRC_CONNECTED mode.

The CC set determining unit 1020 may determine at least one CC available to the UE, and may set a CC set of the UE. In this example, the CC set for the UE may be set based on a difference in UL synchronization times of the available (configurable) CCs, type information of each CC, a center frequency location of each CC, a service type of each CC, a network service for each CC, and the like.

The controller 1010 may set the CC set determined by the CC set determining unit 1020 as a CC set to be used by the UE, and the transceiving unit 1050 may transmit informa-

US 9,854,545 B2

23

tion associated with the set CC set to the UE through a PCell or a primary CC, before receiving the synchronization request message.

The UL timing group generating unit **1030** may generate the UL timing group of the UE based on the CC set determined by the CC set determining unit **1020**. Here, the UL timing group may be generated to satisfy at least one of the conditions a-i) through a-v) or b-i) through b-iv), and may be determined by comparing a difference in center frequency values of CCs with a threshold, determining whether the CCs have the same beamforming scheme or different beamforming schemes, determining whether the CCs are updated in response to a UL synchronization update request, or determining whether the CCs correspond to CCs that are incapable of providing services in a macrocell but are capable of providing services in a space superposed by a cell smaller than the macrocell, such as a femtocell, a picocell, a microcell, a relay, a repeater, and the like.

The transceiving unit **1050** may transmit the CC set information and UL timing group information to the UE. In this example, the transceiving unit **1050** may transmit the UL timing group information together with the CC set information as shown in FIG. 5, or may transmit the UL timing group information and the CC set information separately as shown in FIG. 6. Also, the transceiving unit **1050** may additionally transmit SI after transmitting the CC set information. Therefore, the UE may be able to configure the UL timing group based on the CC set information and the SI.

The transceiving unit **1050** may receive, from the UE, the synchronization request message requesting synchronization, for example, a message including an RAP. That is, the RAP transmitted through the delegate CC determined by the UE for the UL timing group may be determined, and a TA value for each UL timing group may be transmitted. The synchronization request message may be received through at least one delegate CC, simultaneously or sequentially at separated time.

The transceiving unit **1050** may change a portion or all of the UL timing group determined by the UL timing group generating unit **1030**, based on the RAP message transmitted from the UE.

The controller **1010** may control the transceiving unit **1050** to generate information associated with synchronization based on the received RAP, for example, a message including UL grant information, TA information associated with the synchronization, and the like, and to transmit the generated information to the UE. In this example, the message including the TA information may include an RAR message. The information associated with the synchronization may include TA information required to move up a UL transmission time. Therefore, the controller **1010** may control the transceiving unit **1050** to generate and transmit synchronization information with respect to the UL timing group.

Here, the controller **1010** may generate TA information for each UL timing group in a form of a table including a TA value corresponding to a group index, in a form of a TA value including a unit error for each timing group. The error for each timing group may have a size of an integer-multiple of a predetermined unit value, or may be specified in detail. Also, the controller **1010** may control the transceiving unit **1050** to transmit the TA information for each UL timing group as an indicator indicating a TA based on a predetermined rule. The TA value may be an example of the UL synchronization information required when the UE adjusts a UL transmission time, and the synchronization information

24

for the UL timing group may be transmitted through one or more delegate CCs, simultaneously or at separated time.

The UL synchronization information, as described in the foregoing, may be calculated by comparing, with a predetermined threshold, a difference in center frequency values of a plurality of CCs in the CC set configured for the UE, or may be calculated to enable the CCs to have different transmission times by determining whether the CCs correspond to CCs having the same beamforming scheme, correspond to CCs updated in response to a synchronization update request, or correspond to CCs that do not provide services in a macrocell but provide services in a space superposed by a coverage cell smaller than the macrocell.

Also, the controller **1010** may control all component elements, and a few component elements may independently operate. The component elements of FIG. 10 may be configured as a single module or two or more modules, or may be configured to perform a single function in two or more modules.

FIG. 11 illustrates a configuration of a receiving apparatus according to an embodiment of the present invention.

Referring to FIG. 11, a receiving apparatus **1110** may include a connection mode determining unit **1105**, a CC set determining unit **1107**, a controller **1110**, a UL timing adjusting unit **1120**, a UL timing group generating unit **1130**, and a transceiving unit **1150**.

The transceiving unit **1150** may transmit a synchronization request message to an eNB through one or more CCs in a UL timing group, and may receive UL synchronization information through the one or more CCs. The controller **1110** may control the transceiving unit. The controller **1110** may determine the UL synchronization information received through the transceiving unit. The UL timing adjusting unit **1120** may establish a UL synchronization of the UL timing group based on the UL synchronization information determined by the controller. That is, the UL timing adjusting unit **1120** may establish the UL synchronization of the UL timing group based on the UL synchronization information received through the transceiving unit. Here, the controller **1110** may determine UL grant information and a TA value calculated to adjust a UL transmission time for each group corresponding to the UL timing group, through an RAR message received in response to the synchronization request message transmitted through the transceiving unit. The UL timing adjusting unit **1120** may establish a UL synchronization based on the UL synchronization information determined by the controller. In this example, the UL timing adjusting unit **1120** may establish the UL synchronization based on a TA value distinguished based on the UL timing group, based on a unit error distinguished based on the UL timing group, or based on an error distinguished based on the UL timing group and having a size of an integer-multiple of a determined unit value, or using an indicator associated with a rule determined based on the UL timing group. The UL synchronization information may be distinguished based on a group index of the UL timing group.

Here, the one or more delegate CCs may be selected by the UE based on a state of the UL timing group and characteristics of a plurality of CCs forming the UL timing group, so as to obtain the UL synchronization. In particular, the one or more delegate CCs may correspond to at least one of c-i) through c-v). The CCs may be included in a serving cell as described in the foregoing.

In particular, the connection mode determining unit **1105** may determine a connection mode with the eNB. That is, when the connection mode is an UE RRC_IDLE mode or UL synchronization with the eNB is not established, the

US 9,854,545 B2

25

connection mode determining unit **1105** may enable the UE to change the connection mode to an RRC_CONNECTED mode or enable the UL synchronization to be established. In this example, RRC connection setup may be performed through use of the UE and a PCC as described in the foregoing.

For example, the connection mode determining unit **1005** may transmit an RRC connection request message to the eNB through use of the transceiving unit **1050**, may receive an RRC connection setup message from the eNB, and may complete RRC connection setup through use of an RRC connection setup complete message.

The transceiving unit **1150** may perform transmission and reception of information with the eNB. For example, the transceiving unit **1150** may receive CC set information and information associated with synchronization from the eNB. In particular, the transceiving unit **1150** may receive the CC set information from the eNB through a PCell or a primary CC, before transmitting the synchronization request message. After receiving the CC set information, the transceiving unit **1150** may receive SI associated with the CCs in the CC set, from the eNB. The SI may include frequency band information of a CC, information associated with an available frequency magnitude, and the like.

The CC set determining unit **1107** may determine at least one CC available to the UE, from the CC set information. The CC set may be determined based on a difference in UL synchronization times of the CCs available to the UE, type information of each CC, a center frequency location of each CC, a service type of each CC, a network service for each CC, and the like.

The UL timing group generating unit **1130** may generate a UL timing group of the UE based on the CC set determined by the CC set determining unit **920**. Here, the UL timing group may be configured by the UE based on the conditions described in FIG. **10** (at least one of conditions a-i) through a-v) or b-I through b-iv)). Also, the UL timing group generating unit **1130** may select a delegate CC of the UL timing group.

For example, when the UL timing group generating unit **1130** receives, from the eNB, UL timing group information of CCs together with the CC set information, the UL timing group generating unit **1130** may select a delegate CC from the received UL timing group. Also, the UL timing group generating unit **1130** may receive, through the transceiving unit **1150**, the UL timing group information separately from the CC set information, through a separate signaling.

Therefore, when the transceiving unit **1150** does not receive the UL timing group information of CCs or the UL timing group information generated by the eNB is inappropriate for a network state of the UE, the UL timing group generating unit **1130** may configure a new UL timing group.

Also, the controller **1110** may control the transceiving unit **1150** to transmit a synchronization request message requesting synchronization to the eNB through the delegate CC, and to receive information associated with synchronization from the eNB through the delegate CC.

For example, the controller **1110** may control the transceiving unit **1150** to transmit a message including a RAP selected by the UE, and to receive an RAR message transmitted from the eNB. Also, the controller **1110** may control the transceiving unit **1150** to perform, with the eNB, transmission and reception of a message for RRC reconfiguration and synchronization. The synchronization request message may be transmitted through one or more delegate CCs simultaneously or at separated time.

26

Also, the controller **1110** may control the UL timing group generating unit **930** to change a portion or all of the determined UL timing group, based on the RAR message.

In particular, the controller **1110** may perform controlling so as to determine a TA value associated with each UL timing group based on the set UL timing group included in the RAR message. Also, the controller **1110** may perform controlling so as to determine frequency resource information assigned for UL transmission of the UE.

The UL timing adjusting unit **1120** may determine the TA value determined by the controller **1110**, and may apply the TA value to all CCs of the corresponding UL timing group where the delegate CC is included. That is, the TA value may be applied to the corresponding UL timing group for synchronization with the eNB. Here, TA information for each UL timing group may be in a form of a table including a TA value corresponding to a group index, in a form of a TA value including a unit error for each timing group, in a form of an error having a size of an integer-multiple of a predetermined unit value, for each timing group, in a form of an error specified in detail for each timing group, or in a form of an indicator indicating a TA based on a predetermined rule. Therefore, the UL timing adjusting unit **1120** may obtain synchronization by applying a determined TA to each UL timing group. The TA value may be an example of UL synchronization information required when the UE adjusts a UL transmission time, and the synchronization information for the UL timing group may be received through one or more delegate CCs simultaneously or at separated time.

For example, when the TA information is included in the synchronization information, the TA information may be set equally to all CCs in the UL timing group.

As described in the foregoing, the controller **1110** may control all component elements, and a few component elements may independently operate. The component elements of FIG. **11** may be configured as a single module or two or more modules, and may be configured to perform a single function in two or more modules.

Based on the descriptions of FIG. **9**, the transceiving unit **1150** may receive SI of CCs in the CC set based on the CC set information, and the controller **1110** may control the transceiving unit **1105** to simultaneously transmit the synchronization request message to the eNB through all UL CCs in the CC set, based on the received SI.

Subsequently, the transceiving unit **1105** may receive UL timing group information from the eNB, and simultaneously receive UL synchronization information through a few or all of DL CCs associated with the received UL timing group, and the controller **1110** may set a UL CC associated with a CC through which the UL synchronization information is received as a delegate CC of the received UL timing group.

Therefore, according to an embodiment of the present invention, when a plurality of CCs is used, a different UL synchronization may be obtained for each CC or for each CC group and thus, when the UE transmits information in a UL through a plurality of CCs, data transmission error due to an error in obtaining synchronization and delay in receiving information in the eNB may be effectively reduced.

Also, when a UL synchronization standard is different for each of the plurality of CCs, the UE may obtain a UL synchronization based on a type of each CC, a center frequency location, and a service type.

What is claimed is:

1. A method for establishing an uplink (UL) synchronization in a wireless communication system by an evolved NodeB (eNB), the method comprising:

US 9,854,545 B2

27

transmitting, to a User Equipment (UE), Radio Resource Control (RRC) signaling including a UL timing group information set through a primary Component Carrier (CC), the UL timing group information set comprising one or more UL timing groups, the one or more UL timing groups each comprising one or more UL CCs; 5
receiving a Random Access Preamble (RAP) through one or more UL CCs, each of the one or more UL CCs transmitting an RAP being set as a delegate CC in the respective UL timing group; and
transmitting a Random Access Response (RAR) including a Timing Advance (TA) value for UL CCs in the respective UL timing group,
wherein each TA value is calculated by the eNB for the respective UL timing group based on the received RAP 15
transmitting an RAP being set as a delegate CC of the respective UL timing group, and
wherein each TA value is configured to be applied to CCs in the respective UL timing group.

2. A method for establishing an uplink (UL) synchroni- 20
zation by a User Equipment (UE), the method comprising:
receiving a Radio Resource Control (RRC) signaling including a UL timing group information set, which has been set by an evolved NodeB (eNB);
configuring one or more UL timing groups based on the 25
UL timing group information set, the one or more UL timing groups each comprising one or more UL CCs;
transmitting a Random Access Preamble (RAP) through one or more UL CCs, each of the one or more UL CCs transmitting an RAP being set as a delegate CC in the 30
respective UL timing group;
receiving a Random Access Response (RAR) including a Timing Advanced (TA) value for UL CCs in the respec-

28

tive UL timing group, wherein each TA value is transmitted from the eNB for the respective UL timing group based on the transmitted RAP associated with a delegate CC of the respective UL timing group; and
applying each TA value to CCs in the respective UL timing group.

3. A User Equipment (UE) to establish an uplink (UL) synchronization in a wireless communication system, the UE comprising:

a transceiver configured to receive a Radio Resource Control (RRC) signaling including a UL timing group information set, which has been set by an evolved NodeB (eNB);

a controller configured to configure one or more UL timing groups based on the UL timing group information set, the one or more UL timing groups each comprising one or more UL CCs,

wherein the transceiver transmits a Random Access Preamble (RAP) through one or more UL CCs, each of the one or more UL CCs transmitting an RAP being set as a delegate CC in the respective UL timing group, and receives a Random Access Response (RAR) including a Timing Advanced (TA) value for UL CCs in the respective UL timing group,

wherein each TA value is transmitted from the eNB for the respective UL timing group based on the transmitted RAP associated with a delegate CC of the respective UL timing group, and

wherein the controller applies each TA value to CCs in the respective UL timing group.

* * * * *

EXHIBIT 3



US010869247B1

(12) **United States Patent**
Zhang et al.

(10) **Patent No.:** **US 10,869,247 B1**

(45) **Date of Patent:** **Dec. 15, 2020**

(54) **SUPPORTING UPLINK TRANSMISSIONS**

(56) **References Cited**

(71) Applicant: **Signal Trust for Wireless Innovation,**
Wilmington, DE (US)

U.S. PATENT DOCUMENTS

5,628,631 A 5/1997 Aneha
5,794,149 A 8/1998 Hoo

(Continued)

(72) Inventors: **Guodong Zhang**, Syosset, NY (US);
Sung-Hyuk Shin, Northvale, NJ (US);
Stephen E. Terry, Northport, NY (US);
James M. Miller, Verona, NJ (US);
Stephen G. Dick, Nesconset, NY (US)

FOREIGN PATENT DOCUMENTS

DE 10225428 12/2003
EP 0 977 393 2/2000

(Continued)

(73) Assignee: **Signal Trust for Wireless Innovation,**
Wilmington, DE (US)

OTHER PUBLICATIONS

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

“Hybrid ARQ text proposal for Section 7 of TR25.896” TSG-RAN WG1 #31, R1-030208, Tokyo, Japan, Feb. 18-21, 2002, 4 pages.

(Continued)

(21) Appl. No.: **17/008,439**

Primary Examiner — Brian S Roberts

(22) Filed: **Aug. 31, 2020**

(74) *Attorney, Agent, or Firm* — Volpe Koenig

(57) **ABSTRACT**

A method and a wireless transmit/receive unit (WTRU) supporting uplink transmissions. The method being used in a WTRU and comprising transmitting a data block to a base station using a hybrid automatic repeat request (H-ARQ) process, receiving uplink scheduling information from the base station, wherein the uplink scheduling information includes a H-ARQ process identification for the H-ARQ process, and determining whether to retransmit the data block based on the received uplink scheduling information and not based on whether the WTRU has received a negative acknowledgement (NACK) from the base station. The uplink scheduling information includes physical channel resources. The uplink scheduling information is received from a primary cell and the WTRU transmits to the primary cell and at least one secondary cell. The scheduling information indicates a modulation and coding scheme.

Related U.S. Application Data

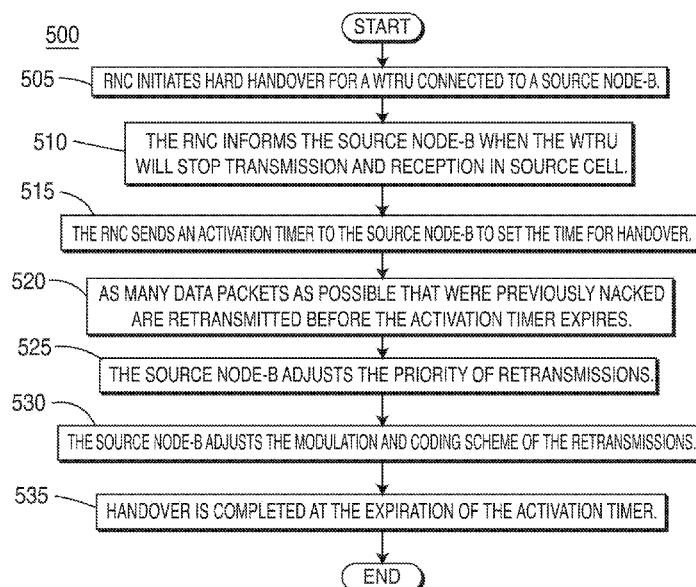
(63) Continuation of application No. 16/545,398, filed on Aug. 20, 2019, now Pat. No. 10,791,491, which is a (Continued)

(51) **Int. Cl.**
H04W 36/18 (2009.01)
H04L 1/18 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H04W 36/18** (2013.01); **H04L 1/1812** (2013.01); **H04L 1/1887** (2013.01);
(Continued)

(58) **Field of Classification Search**
None
See application file for complete search history.

20 Claims, 4 Drawing Sheets



US 10,869,247 B1

Page 2

Related U.S. Application Data

continuation of application No. 16/283,407, filed on Feb. 22, 2019, now Pat. No. 10,791,490, which is a continuation of application No. 15/699,418, filed on Sep. 8, 2017, now Pat. No. 10,219,196, which is a continuation of application No. 14/869,313, filed on Sep. 29, 2015, now Pat. No. 9,763,156, which is a continuation of application No. 13/908,242, filed on Jun. 3, 2013, now Pat. No. 9,215,636, which is a continuation of application No. 13/308,950, filed on Dec. 1, 2011, now Pat. No. 8,457,072, which is a continuation of application No. 11/434,330, filed on May 15, 2006, now Pat. No. 8,130,720, which is a continuation of application No. 10/962,720, filed on Oct. 12, 2004, now Pat. No. 7,046,648.

(60) Provisional application No. 60/578,674, filed on Jun. 10, 2004, provisional application No. 60/520,692, filed on Nov. 17, 2003, provisional application No. 60/519,990, filed on Nov. 14, 2003, provisional application No. 60/517,656, filed on Nov. 5, 2003.

(51) Int. Cl.

H04W 74/04 (2009.01)
H04W 74/00 (2009.01)
H04W 88/08 (2009.01)
H04B 7/022 (2017.01)
H04W 36/30 (2009.01)

(52) U.S. Cl.

CPC **H04L 1/1893** (2013.01); **H04W 74/004** (2013.01); **H04W 74/04** (2013.01); **H04B 7/022** (2013.01); **H04W 36/30** (2013.01); **H04W 88/08** (2013.01)

(56) References Cited

U.S. PATENT DOCUMENTS

5,933,787 A 8/1999 Gilhousen et al.
5,946,320 A 8/1999 Decker et al.
6,434,396 B1 8/2002 Rune
6,507,567 B1 1/2003 Willars
6,628,631 B1 9/2003 Mazawa et al.
6,643,813 B1 11/2003 Johansson et al.
6,650,905 B1 11/2003 Toskala et al.
6,678,249 B2 1/2004 Toskala et al.
6,678,523 B1 1/2004 Ghosh et al.
6,690,939 B1 2/2004 Jonsson et al.
6,754,496 B2 6/2004 Mohebbi et al.
6,778,830 B1 8/2004 Oizumi et al.
6,829,482 B2 12/2004 Rune et al.
6,850,771 B2 2/2005 Malladi et al.
6,892,071 B2 5/2005 Park et al.
6,907,245 B2 6/2005 Ohlsson et al.
6,915,465 B2 7/2005 Fujiwara et al.
6,977,888 B1 12/2005 Frenger et al.
7,013,143 B2 3/2006 Love et al.
7,026,911 B2 4/2006 Aono et al.
7,046,648 B2 5/2006 Zhang et al.
7,054,633 B2 5/2006 Seo et al.
7,065,359 B2 6/2006 Chuah et al.
7,103,729 B2 9/2006 Altahan et al.
7,124,350 B2 10/2006 Chao et al.
7,158,504 B2 1/2007 Kadaba et al.
7,185,256 B2 2/2007 Miki et al.
7,206,598 B2 4/2007 Attar et al.
7,266,384 B2 9/2007 Kim et al.
7,269,420 B2 9/2007 Heo et al.
7,277,407 B2 10/2007 Kim et al.
7,283,508 B2 10/2007 Choi et al.
7,283,509 B2 10/2007 Moon et al.
7,283,782 B2 10/2007 Sinnarajah et al.

7,315,741 B2 1/2008 Chun
7,317,700 B2 1/2008 Hwang
7,346,035 B2 3/2008 Lee et al.
7,366,538 B2 4/2008 Seki et al.
7,372,898 B2 5/2008 Shin et al.
7,403,513 B2 7/2008 Lee et al.
7,414,989 B2 8/2008 Kuchibhotla et al.
7,428,424 B2 9/2008 Hwang et al.
7,433,337 B2 10/2008 Chao et al.
7,519,016 B2 4/2009 Lee et al.
7,558,230 B2 7/2009 Lee et al.
7,606,205 B2 10/2009 Ranta-Aho et al.
7,848,290 B2 12/2010 Cheng et al.
7,903,610 B2 3/2011 Cheng et al.
7,974,630 B1 7/2011 Haumont et al.
8,023,463 B2 9/2011 Dick et al.
8,682,325 B1 3/2014 Cooper
9,438,381 B2 9/2016 Dick et al.
10,390,279 B2 8/2019 Dick et al.
2001/0020285 A1 9/2001 Fujiwara et al.
2002/0080719 A1* 6/2002 Parkvall H04L 1/1825
370/235
2002/0093937 A1 7/2002 Kim et al.
2002/0095635 A1 7/2002 Wager et al.
2002/0115460 A1 8/2002 Rune et al.
2002/0115467 A1 8/2002 Hamabe
2002/0172208 A1 11/2002 Malkamaki
2002/0191544 A1 12/2002 Cheng et al.
2002/0198025 A1 12/2002 Brownlee et al.
2003/0002470 A1 1/2003 Park et al.
2003/0007480 A1 1/2003 Kim et al.
2003/0031119 A1 2/2003 Kim et al.
2003/0043786 A1 3/2003 Kali et al.
2003/0054824 A1 3/2003 Choi et al.
2003/0081692 A1 5/2003 Kwan et al.
2003/0123403 A1 7/2003 Jiang
2003/0123470 A1 7/2003 Kim et al.
2003/0131124 A1 7/2003 Yi et al.
2003/0147370 A1 8/2003 Wu
2003/0161284 A1 8/2003 Chen
2003/0171118 A1 9/2003 Miya
2003/0176195 A1 9/2003 Dick et al.
2003/0202500 A1 10/2003 Ha et al.
2003/0210668 A1 11/2003 Malladi et al.
2004/0004954 A1 1/2004 Terry et al.
2004/0072567 A1 4/2004 Cao et al.
2004/0085934 A1 5/2004 Balachandran et al.
2004/0109433 A1* 6/2004 Khan H04L 1/1671
370/345
2004/0120306 A1 6/2004 Wigard et al.
2004/0160925 A1 8/2004 Heo et al.
2004/0202129 A1 10/2004 Kolding et al.
2004/0203991 A1 10/2004 Chen et al.
2004/0219917 A1 11/2004 Love et al.
2004/0219919 A1 11/2004 Whinnett et al.
2004/0219920 A1 11/2004 Love et al.
2004/0228313 A1 11/2004 Cheng et al.
2005/0041694 A1 2/2005 Liu
2005/0047354 A1 3/2005 Zeira et al.
2005/0048920 A1 3/2005 Liu
2005/0083888 A1 4/2005 Smee et al.
2005/0207374 A1 9/2005 Petrovic et al.
2006/0045010 A1 3/2006 Baker et al.
2006/0105796 A1 5/2006 Malladi et al.
2006/0274712 A1 12/2006 Malladi et al.
2007/0047501 A1 3/2007 Usuda et al.
2007/0079207 A1 4/2007 Seidel et al.

FOREIGN PATENT DOCUMENTS

EP 1 217 777 6/2002
GB 2 353 439 2/2001
JP 04-157821 5/1992
JP 2000-217139 8/2000
JP 2001-8251 1/2001
JP 2001-128209 5/2001
JP 2002-009741 1/2002
JP 2003-134180 5/2003
JP 2003-163960 6/2003

US 10,869,247 B1

Page 3

(56) References Cited

FOREIGN PATENT DOCUMENTS

JP	2007-511135	4/2007
KR	20020095231	12/2002
KR	20030003943	1/2003
KR	20030040972	5/2003
RU	2003112283	12/2005
RU	2005110767	10/2006
TW	536896	6/2003
TW	200303689	9/2003
WO	99/027740	6/1999
WO	00/35226	6/2000
WO	00/074263	12/2000
WO	02/01893	1/2002
WO	02/37572	5/2002
WO	02/037872	5/2002
WO	02/047317	6/2002
WO	02/082108	10/2002
WO	02/101966	12/2002
WO	02/102109	12/2002
WO	03/003643	1/2003
WO	03/026231	3/2003
WO	03/037027	5/2003
WO	03/047155	6/2003
WO	03/053087	6/2003
WO	03/067953	8/2003
WO	03/088545	10/2003
WO	2005/048503	5/2005

OTHER PUBLICATIONS

3GPP TSG RAN WG1 #31, Tdoc R1-03-0273, Qualcomm, "Channel Structure for Consideration in Enhanced Uplink", Tokyo, Japan, Feb. 18-21, 2003.

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Feasibility Study for Enhanced Uplink for UTRA FDD; (Release 6)," 3GPP TR 25.896 V1.0.2 (Oct. 2003).

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Feasibility Study for Enhanced Uplink for UTRA FDD (Release 6)," 3GPP TR 25.896 V6.0.0 (Mar. 2004).

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Multiplexing and channel coding (FDD) (Release 1999)," 3GPP TS 25.212 V3.11.0 (Sep. 2002).

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Medium Access Control (MAC) protocol specification (Release 1999)," 3GPP TS 25.321 V3.16.0 (Sep. 2003).

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Multiplexing and channel coding (FDD) (Release 4)," 3GPP TS 25.212 V4.6.0 (Sep. 2002).

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Multiplexing and channel coding (FDD) (Release 5)," 3GPP TS 25.212 V5.6.0 (Sep. 2003).

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Multiplexing and channel coding (FDD) (Release 5)," 3GPP TS 25.212 V5.9.0 (Jun. 2004).

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Multiplexing and channel coding (FDD) (Release 6)," 3GPP TS 25.212 V6.2.0 (Jun. 2004).

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Medium Access Control (MAC) protocol specification (Release 1999)," 3GPP TS 25.321 V3.17.0 (Jun. 2004).

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Medium Access Control (MAC) protocol specification (Release 6)," 3GPP TS 25.321 V6.2.0 (Jun. 2004).

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Medium Access Control (MAC) protocol specification (Release 4)," 3GPP TS 25.321 V4.9.0 (Sep. 2003).

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Medium Access Control (MAC) protocol specification (Release 5)," 3GPP TS 25.321 V5.9.0 (Jun. 2004).

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Medium Access Control (MAC) protocol specification (Release 4)," 3GPP TS 25.321 V4.10.0 (Jun. 2004).

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Medium Access Control (MAC) protocol specification (Release 5)," 3GPP TS 25.321 V5.6.0 (Sep. 2003).

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Feasibility Study for Enhanced Uplink for UTRA FDD; (Release 6)," 3GPP TR 25.896 V1.0.1 (Oct. 2003).

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Radio Resource Control (RRC) protocol specification (Release 1999)," 3GPP TS 25.331 V3.16.0 (Sep. 2003).

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Radio Resource Control (RRC) protocol specification (Release 1999)," 3GPP TS 25.331 V3.20.0 (Sep. 2004).

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Radio Resource Control (RRC) protocol specification (Release 4)," 3GPP TS 25.331 V4.11.0 (Sep. 2003).

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Radio Resource Control (RRC) protocol specification (Release 4)," 3GPP TS 25.331 V4.15.0 (Jun. 2004).

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Radio Resource Control (RRC); Protocol Specification (Release 5)," 3GPP TS 25.331 V5.6.0 (Sep. 2003).

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Radio Resource Control (RRC); Protocol Specification (Release 5)," 3GPP TS 25.331 V5.10.0 (Sep. 2004).

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Radio Resource Control (RRC); Protocol Specification (Release 6)," 3GPP TS 25.331 V6.3.0 (Sep. 2004).

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; UTRAN Iub interface NBAP signaling (Release 1999)," 3GPP TS 25.433 V3.14.2 (Sep. 2004).

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; UTRAN Iub interface NBAP signaling (Release 1999)," 3GPP TS 25.433 V3.14.0 (Sep. 2003).

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; UTRAN Iub interface NBAP signaling (Release 4)," 3GPP TS 25.433 V4.10.0 (Sep. 2003).

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; UTRAN Iub interface NBAP signaling (Release 4)," 3GPP TS 25.433 V4.13.0 (Sep. 2004).

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; UTRAN Iub interface NBAP signaling (Release 5)," 3GPP TS 25.433 V5.6.0 (Sep. 2003).

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; UTRAN Iub interface NBAP signaling (Release 5)," 3GPP TS 25.433 V5.10.0 (Sep. 2004).

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; UTRAN Iub interface NBAP signaling (Release 6)," 3GPP TS 25.433 V6.3.0 (Sep. 2004).

3GPP, "Third Generation Partnership Project; Technical Specification Group Radio Access Network; FDD Enhanced Uplink; Overall Description; Stage 2 (Release 6)," 3GPP TS 25.309 V6.0.0 (Sep. 2004).

3GPP2 C.20003-C, "Medium Access Control (MAC) Standard for cdma2000 Spread Spectrum Systems", 3rd Generation Partnership Project 2 "3GPP2", Version 2.0, Release C, Aug. 2004.

US 10,869,247 B1

Page 4

(56) **References Cited**

OTHER PUBLICATIONS

3GPP2 C.S0004-C, "Signaling Link Access Control (LAC) Standard for cdma2000 Spread Spectrum Systems", 3rd Generation Partnership Project 2 "3GPP2", Version 2.0, Release C, Jul. 23, 2004.

3GPP2 C.S0005-C, "Upper Layer (Layer 3) Signaling Standard for cdma2000 Spread Spectrum Systems", 3rd Generation Partnership Project 2 "3GPP2", Version 2.0, Release c, Jul. 23, 2004.

ETSI, UMTS XX. 15 V0.3.0 Jan. 1999, UTRA Handover, 21pp. GPP2 C.S0002-C, "Physical Layer Standard for cdma2000 Spread Spectrum Systems", 3rd Generation Partnership Project 2 "3GPP2", Version 2.0, Release C, Jul. 23, 2004.

Heck et al., "Diversity Effects on the Soft Handover Gain in UMTS Networks," Proceedings of the IEEE Vehicular Technology Conference, vol. 2, pp. 1269-1273 (Sep. 2002).

Interdigital, "Performance Analysis of HARQ in Soft Handover," 3GPP TSG-RAN WG1 #34 meeting, R1-030979 (Oct. 6-10, 2003).

Nokia, "HARQ overhead issues", TSG-RAN1 #33, R1-030733 (Aug. 25-29, 2003).

Panasonic, "HARQ operation during Soft Handover," 3GPP TSG-RAN WG1 Meeting #33, R1-030802, New York, USA (Aug. 25-29, 2003).

Panasonic, HARQ Operation During Soft Handover, 3GPP TSG-RAN WG1 Meeting #33 R1-030802, Aug. 25-29, 2003.

Qualcomm, "Impact of Downlink Support Channels," 3GPP TSG-RAN WG1 #32, Tdoc R1-03-0433, Paris, France (May 19-23, 2003).

R1-030803, "HARQ operation during Soft Handover", Panasonic, TSG RAN1 #33.

Samsung, "HARQ performance in soft handover", TSG RAN1 #33, R1-030765 (Aug. 25-29, 2003).

Samsung, "HARQ Structure", 3GPP TSG-RAN WG1 #31, R1-030247, Tokyo, Japan, 3 pages (Feb. 18-21, 2003).

Samsung, "Transport channel multiplexing options considering SHO", 3GPP TSG RAN WG1 #33, R1-030767, New York, USA, 5 pages (Aug. 25-29, 2003).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Feasibility Study for Enhanced Uplink for UTRA FDD; (Release 6, " 3GPP TR 25.896 V0.4.2 (R1-030952) (Sep. 2003).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Requirements for support of radio resource management (FDD) (Release 1999)," 3GPP TS 25.133 V3.19.0 (Sep. 2004).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Requirements for support of radio resource management (FDD) (Release 4)," 3GPP TS 25.133 V4.10.0 (Sep. 2003).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Requirements for support of radio resource management (FDD) (Release 4)," 3GPP TS 25.133 V4.13.0 (Sep. 2004).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Requirements for support of radio resource management (FDD) (Release 5)," 3GPP TS 25.133 V5.12.0 (Sep. 2004).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Requirements for support of radio resource management (FDD) (Release 6)," 3GPP TS 25.133 V6.7.0 (Sep. 2004).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Requirements for support of radio resource management (FDD) (Release 1999)," 3GPP TS 25.133 V3.15.0 (Sep. 2003).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Requirements for support of radio resource management (FDD) (Release 5)," 3GPP TS 25.133 V5.8.0 (Sep. 2003).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Requirements for support of radio resource management (FDD) (Release 6)," 3GPP TS 25.133 V6.3.0 (Sep. 2003).

Third Generation Partnership Project, Technical Specification Group Radio Access Network; Feasibility Study for Enhanced Uplink for UTRA FDD (Release 6), 3GPP TR 25.896 V0.2.1 (R1-030372) pp. 14-17 (Feb. 2003).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Physical layer procedures (FDD) (Release 1999)," 3GPP TS 25.214 V3.12.0 (Mar. 2003).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Physical layer procedures (FDD) (Release 4)," 3GPP TS 25.214 V4.6.0 (Mar. 2003).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Physical layer procedures (FDD) (Release 5)," 3GPP TS 25.214 V5.6.0 (Sep. 2003).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Physical layer procedures (FDD) (Release 5)," 3GPP TS 25.214 V5.9.0 (Jun. 2004).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Physical channels and mapping of transport channels onto physical channels (FDD) (Release 1999)," 3GPP TS 25.211 V3.12.0 (Sep. 2002).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Physical channels and mapping of transport channels onto physical channels (FDD) (Release 4)," 3GPP TS 25.211 V4.6.0 (Sep. 2002).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Physical channels and mapping of transport channels onto physical channels (FDD) (Release 5)," 3GPP TS 25.211 V5.5.0 (Sep. 2003).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Physical channels and mapping of transport channels onto physical channels (FDD) (Release 5)," 3GPP TS 25.211 V5.6.0 (Sep. 2004).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Physical channels and mapping of transport channels onto physical channels (FDD) (Release 6)," 3GPP TS 25.211 V6.2.0 (Sep. 2004).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Physical layer procedures (FDD) (Release 6)," 3GPP TS 25.214 V6.3.0 (Sep. 2004).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; High Speed Downlink Packet Access (HSDPA); Overall description; Stage 2 (Release 6)," 3GPP TS 25.308 V6.2.0 (Sep. 2004).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; High Speed Downlink Packet Access (HSDPA); Overall description; Stage 2 (Release 5)," 3GPP TS 25.308 V5.6.0 (Sep. 2004).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; High Speed Downlink Packet Access (HSDPA); Overall description; Stage 2 (Release 5)," 3GPP TS 25.308 V5.4.0 (Mar. 2003).

TSGR1#3(99)187, "Improvements to Site Selection Delivery Transmission (SSDT)", TSG-RAN Working Group 1 meeting #3, Source: Motorola, Stockholm, Sweden, 5 pages (Mar. 22-26, 1999). http://www.3gpp.org/tsg_ran/WG1_RL1/TSGR1_03/Docs/pdfs/R1-99187.PDF.

Ericsson, "E-DCH multiplexing and transport channel structure," TSG-RAN Working Group 2 meeting #42, Tdoc R2-040917, Montreal, Canada, (May 2004).

Holma et al., "WCDMA for UMTS—Radio Access for Third Generation Mobile Communications," First Edition, (2000).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network, FDD Enhanced Uplink, Overall description, Stage 2 (Release 6)," 3GPP TS 25.309 V0.2.0 (Jun. 2004).

3GPP, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; UTRAN Iub Interface User Plane Protocols for Common Transport Channel data streams (Release 5)," 3GPP TS 25.435 V5.5.0 (Jun. 2003).

US 10,869,247 B1

Page 5

(56)

References Cited

OTHER PUBLICATIONS

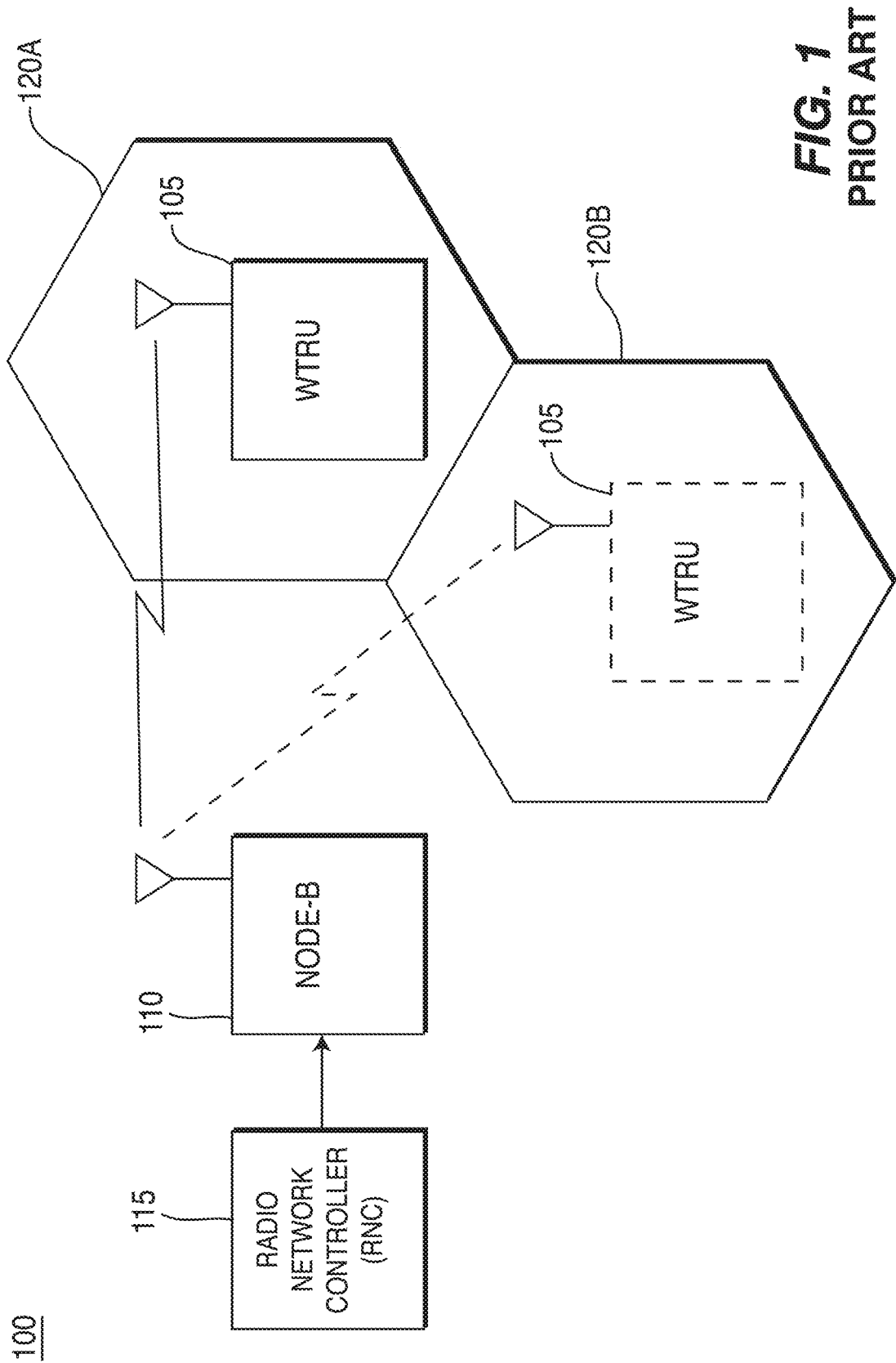
3GPP, “3rd Generation Partnership Project; Technical Specification Group Radio Access Network; UTRAN Iub Interface User Plane Protocols for Common Transport Channel data streams (Release 6),” 3GPP TS 25.435 V6.1.0 (Mar. 2004).

3GPP, “3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Radio resource management strategies (Release 5),” 3GPP TR 25.922 V5.0.0 (Mar. 2002).

Universal Mobile Telecommunications System (UMTS); “Radio resource management strategies (3GPP Tr 25.922 version 5.1.0 Release 5),” ETSI TR 125 922 V5.1.0 (Sep. 2003).

Universal Mobile Telecommunications System (UMTS); “Radio resource management strategies (3GPP TR 25.922 version 6.0.1 Release 6),” ETSI TR 125 922 V6.0.1 (Apr. 2004).

* cited by examiner

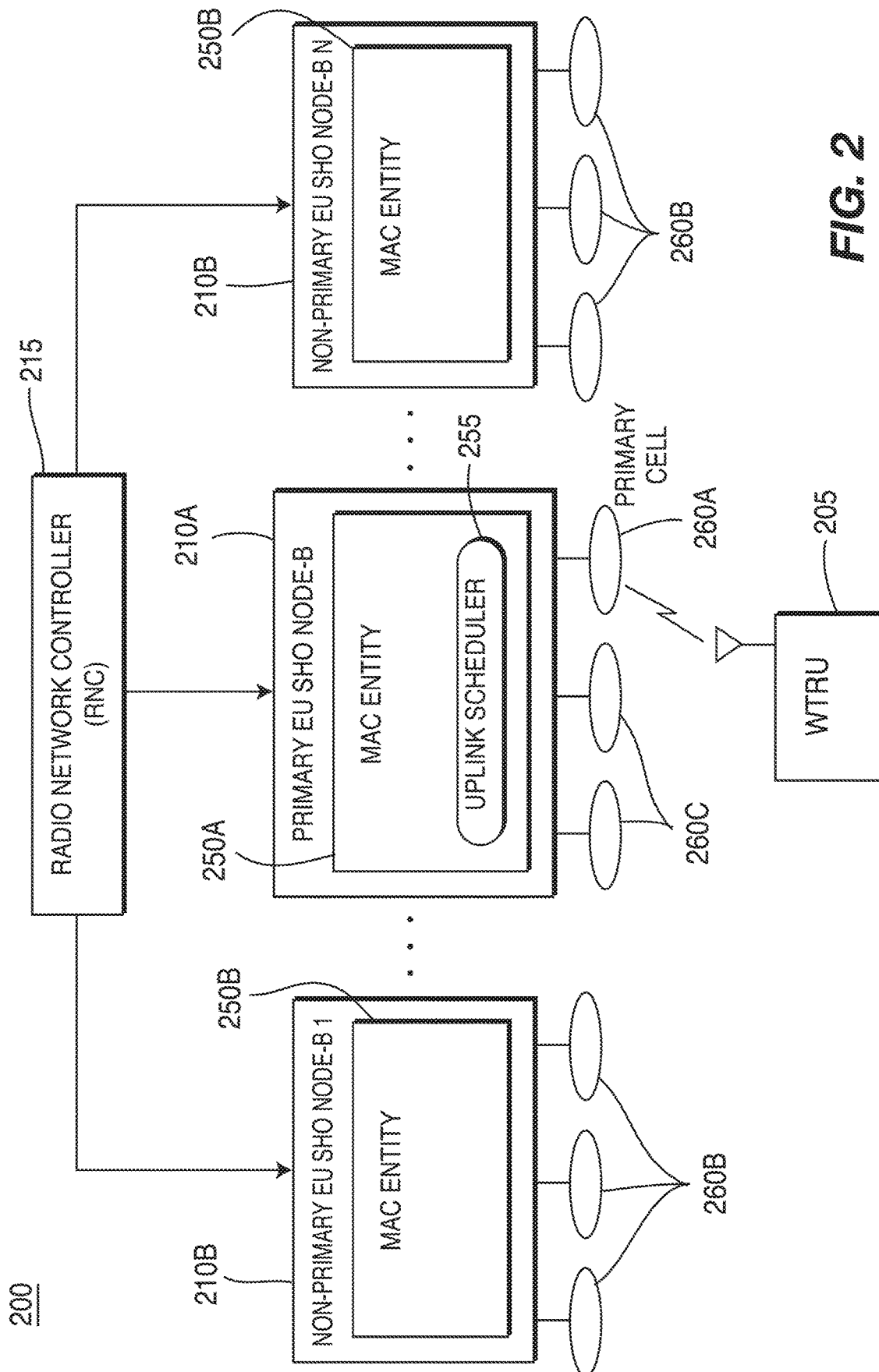


U.S. Patent

Dec. 15, 2020

Sheet 2 of 4

US 10,869,247 B1



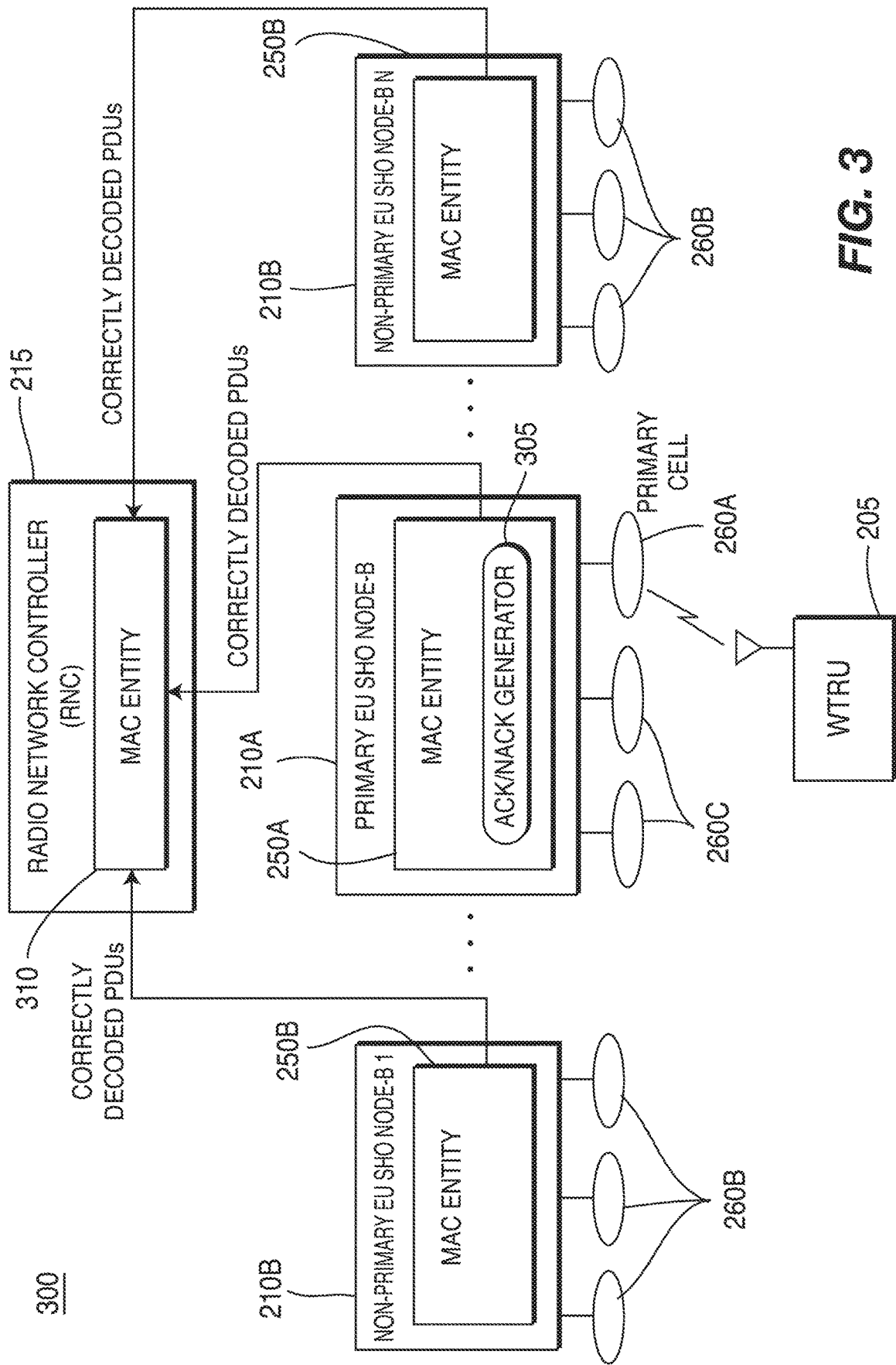
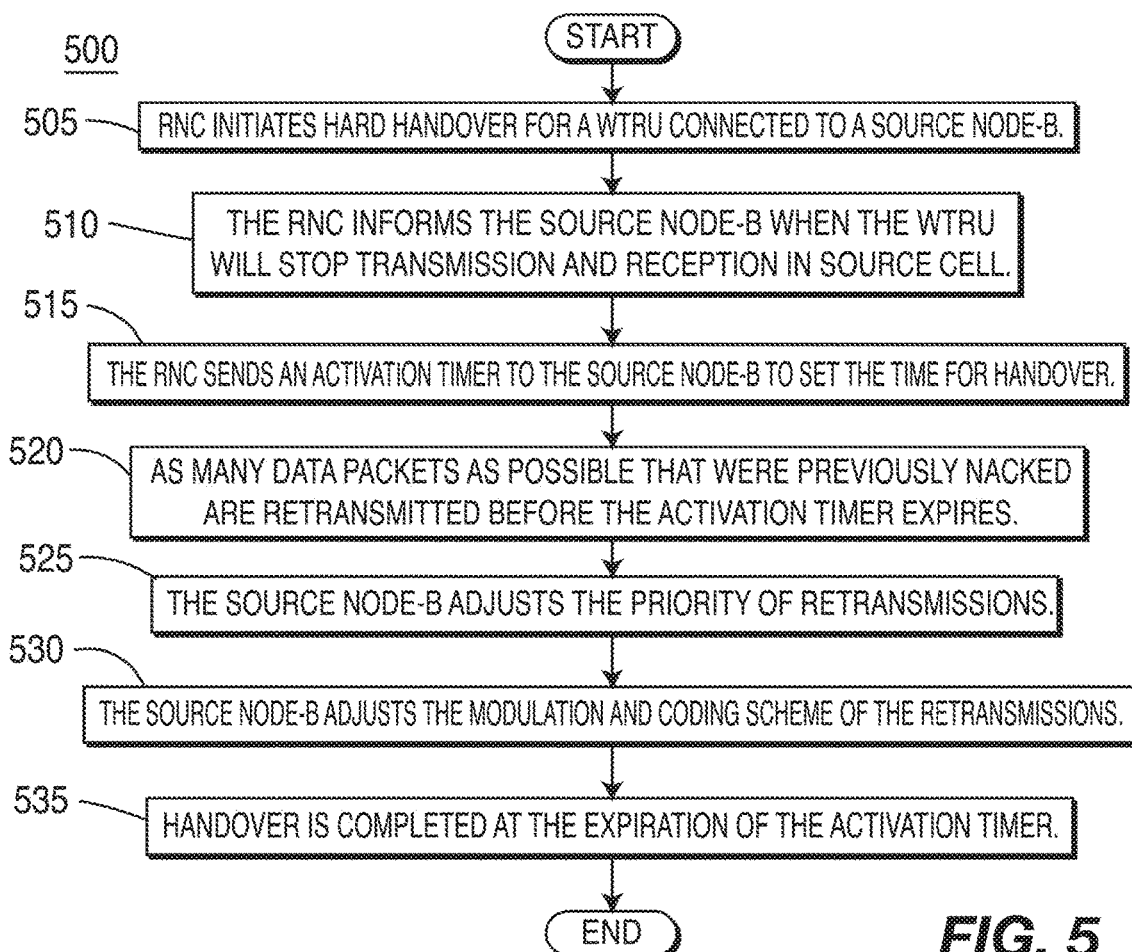
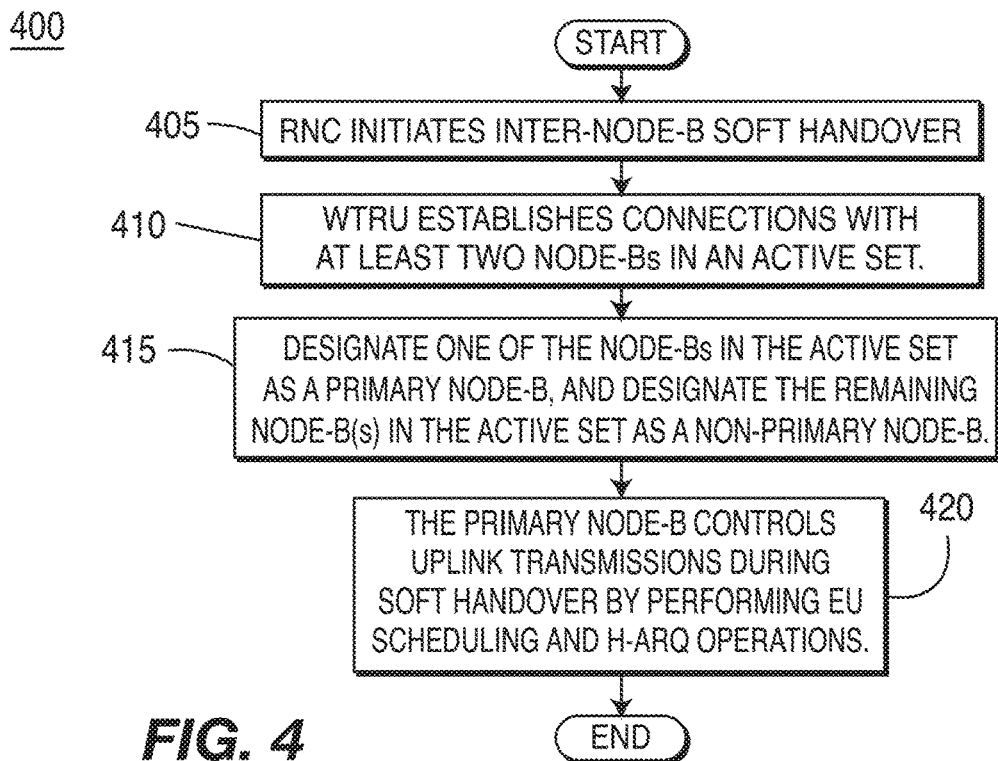


FIG. 3



US 10,869,247 B1

1

SUPPORTING UPLINK TRANSMISSIONS**CROSS REFERENCE TO RELATED APPLICATIONS**

This application is a continuation of U.S. patent application Ser. No. 16/545,398, filed Aug. 20, 2019, which is a continuation of U.S. patent application Ser. No. 16/283,407, filed Feb. 22, 2019, which is a continuation of U.S. patent application Ser. No. 15/699,418 filed on Sep. 8, 2017, now U.S. Pat. No. 10,219,196 issued on Feb. 26, 2019, which is a continuation of U.S. patent application Ser. No. 14/869,313, filed on Sep. 29, 2015, now U.S. Pat. No. 9,763,156 issued on Sep. 12, 2017, which is a continuation of U.S. patent application Ser. No. 13/908,242 filed on Jun. 3, 2013, now U.S. Pat. No. 9,215,636 issued on Dec. 15, 2015, which is a continuation of U.S. patent application Ser. No. 13/308,950 filed on Dec. 1, 2011, now U.S. Pat. No. 8,457,072 issued on Jun. 4, 2013, which is a continuation of U.S. patent application Ser. No. 11/434,330 filed on May 15, 2006, now U.S. Pat. No. 8,130,720 issued on Mar. 6, 2012, which is a continuation of U.S. patent application Ser. No. 10/962,720 filed Oct. 12, 2004, now U.S. Pat. No. 7,046,648 issued on May 16, 2006, which claims the benefit of U.S. Provisional Application Ser. No. 60/578,674 filed Jun. 10, 2004; 60/520,692 filed Nov. 17, 2003; 60/519,990 filed Nov. 14, 2003; and 60/517,656 filed Nov. 5, 2003, all of which are incorporated by reference as if fully set forth. This application is also related to a co-pending patent application, entitled “Supporting Uplink Transmissions”, Ser. No. 17/008,468, filed on Aug. 31, 2020.

FIELD OF INVENTION

The present invention is related to a wireless communication system. More particularly, the present invention is related to a method and apparatus for coordinating Node-Bs and supporting enhanced uplink (EU) transmissions during handover.

BACKGROUND

Many schemes have been proposed to improve coverage, throughput, and transmission latency for EU transmissions in third generation partnership project (3GPP). One of the developments is to move the functions for scheduling and assigning uplink (UL) physical channel resources from a radio network controller (RNC) to a Node-B. A Node-B can make more efficient decisions and manage UL radio resources on a short-term basis better than the RNC, even if the RNC retains overall control over Node-Bs. A similar approach has already been adopted in downlink for high speed data packet access (HSDPA) in both universal mobile telecommunication system (UMTS) frequency division duplex (FDD) and time division duplex (TDD) modes.

It has also been recognized that performance is greatly enhanced with the use of medium access control (MAC) level automatic repeat request (ARQ) and hybrid ARQ (H-ARQ). Application of these techniques during soft handover provides additional significant benefits.

FIG. 1 shows a conventional wireless multi-cell communication system **100** including a wireless transmit/receive unit (WTRU) **105**, a Node-B **110**, an RNC **115**, and at least two cells **120A**, **120B**. Each of the cells **120A**, **120B**, is served by the Node-B **110**. Node-B **110** is controlled by the

2

RNC **115**. When a change in the cell offering the best radio conditions is determined between cells **120A** and **120B**, a handover process is initiated.

An “intra-Node-B handover” occurs when a WTRU changes from one cell to another cell controlled by the same Node-B, as shown in FIG. 1. An “inter-Node-B handover” occurs when a WTRU changes from one cell to another cell controlled by a different Node-B. In the latter case, the Node-B that controls the cell before the handover is called a source Node-B, and the Node-B that controls the cell after the handover is called a target Node-B.

During soft handover, a WTRU establishes a plurality of connections with a plurality of Node-Bs in an active set. In this situation, a problem may arise for scheduling and H-ARQ operation. A WTRU may receive conflicting EU transmission scheduling from more than one Node-B. It is also difficult for the WTRU to receive, decode and process H-ARQ positive and negative acknowledgements (ACKs/NACKs) generated by a plurality of Node-Bs. The soft buffer of an H-ARQ process in Node-Bs may be corrupted during soft handover.

One method to support H-ARQ across multiple Node-Bs, when the WTRU is in soft handover, is to place the ACK/NACK generation function in the RNC, which derives a single ACK/NACK based on the results from the multiple Node-Bs. However, this approach presents a significant delay to the ACK/NACK process, which is highly undesirable for performance reasons.

When a WTRU undergoes an inter-Node-B hard handover, there is a possibility that a source Node-B, which is a Node-B before hard handover is completed, may not successfully receive EU transmissions for data packets that have been NACKed prior to hard handover activation time. Other WTRUs competing for UL resources may not be provided with enough physical resources in the source cell. If data blocks that have been NACKed prior to the handover are retransmitted to the source Node-B before the handover activation timer expires, those data blocks can be combined with the previous data blocks for H-ARQ decoding. In this way, the decoding takes the advantage of previous, although failed, transmissions of those data blocks in the source cell. If data blocks that have been NACKed prior to the handover are not retransmitted to the source Node-B before the handover activation timer is expired, they have to be transmitted again in the target cell as new data blocks. In this case, the previous transmissions of those data blocks in the source cell are not utilized.

SUMMARY

An enhanced uplink user equipment is in soft handover. A radio network controller selects a primary Node-B out of a plurality of Node-Bs supporting the soft handover. The radio network controller receiving successfully received enhanced uplink data packets from the plurality of Node-Bs. The radio network controller reordered the successfully received enhanced uplink data packets for in-sequence deliver. The primary Node-B sends specified scheduling information to the user equipment that the other Node-Bs does not transmit. At least the primary Node-B transmits acknowledgements and negative acknowledgements to the user equipment.

BRIEF DESCRIPTION OF THE DRAWINGS

A more detailed understanding of the invention may be had from the following description, given by way of

US 10,869,247 B1

3

example and to be understood in conjunction with the accompanying drawings wherein:

FIG. 1 shows a conventional wireless communication system;

FIG. 2 shows a system which uses a UL scheduler located in a primary Node-B during soft handover for EU in accordance with the present invention;

FIG. 3 shows a system which uses an ACK/NACK generation function located in a primary Node-B during soft handover for EU in accordance with the present invention;

FIG. 4 is a flowchart of a process including method steps for coordinating Node-Bs during soft handover in accordance with one embodiment of the present invention; and

FIG. 5 is a flowchart of a process including method steps for prioritizing the transmission of NACKed data in a source Node-B before hard handover is completed in accordance with a separate embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will be described with reference to the drawing figures wherein like numerals represent like elements throughout.

Hereafter, the terminology "WTRU" includes but is not limited to a user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a pager, or any other type of device capable of operating in a wireless environment.

When referred to hereafter, the terminology "Node-B" includes but is not limited to a base station, a site controller, an access point or any other type of interfacing device in a wireless environment.

The present invention may be implemented in any type of wireless communication systems, such as UMTS-FDD, TDD, time division synchronous code division multiple access (TDSCDMA), code division multiple access 2000 (CDMA2000) (EV-DO and EV-DV) or any other type of wireless communication system.

The features of the present invention may be incorporated into an IC or be configured in a circuit comprising a multitude of interconnecting components.

FIG. 2 shows a wireless multi-cell communication system 200 which uses a UL scheduler located in a primary Node-B in accordance with the present invention. The wireless multi-cell communication system 200 includes a WTRU 205, a plurality of Node-Bs 210 (i.e., 210A, 210B), an RNC 215 and a plurality of cells 260 (i.e., 260A, 260B, 260C). Cells 260A and 260C are served by the Node-B 210A. Cells 260B are served by the Node-Bs 210B. All of the Node-Bs 210 are controlled by the RNC 215.

During soft handover, the WTRU 205 establishes multiple connections with the Node-Bs 210 included in an active set. Each transmission from the WTRU 205 is processed independently at each of the Node-Bs 210. One of the Node-Bs 210 in the active set is designated as a primary Node-B 210A, and the other Node-Bs are designated as non-primary Node-Bs 210B.

As shown in FIG. 2, the primary Node-B 210A includes a MAC entity 250A including a UL scheduler 255. Each of the non-primary Node-Bs 210B also includes a MAC entity 250B. Each of the MAC entities 250A, 250B, handles EU transmissions. The UL scheduler 255 in the MAC entity 250A is responsible for scheduling the EU transmissions.

In accordance with one embodiment of the present invention, the UL scheduler 255 is implemented only at the primary Node-B 210A during soft handover. The WTRU 205 receives a UL transmission schedule only from the

4

primary Node-B 210A in a primary cell 260A. However, the primary Node-B 210A cannot send the scheduling information to the non-primary Node-Bs 210B in every transmission time interval (TTI). In order to allow the primary Node-B 210A to allocate resources for the WTRU 205 to transmit in cells controlled by the non-primary Node-Bs 210B, those resources scheduled by the primary Node-B 250A in a plurality of cells 260B controlled by the non-primary Node-Bs 210B cannot be assigned by the non-primary Node-Bs 210B. Therefore, some physical resources common to all of the cells in the active EU subset should be assigned and reserved by a particular Node-B for the WTRU 205 during the soft handover, so that those resources can be used only by the primary Node-B 210A.

The UL scheduler 255 located in the primary Node-B 210A considers the interference level caused by the EU transmission at any cell 260A, 260B, 260C, in the EU active subset to be below a predetermined maximum allowed interference level. Thus, the primary Node-B 250A limits the transmit power level of the WTRU 205 such that the interference levels are also within the maximum allowed interference levels at other cells 260B, 260C. To achieve this, the RNC 215 needs to relay necessary information, such as transmission power level and interference level, of the cells 260B controlled by the non-primary Node-Bs 210B to the primary Node-B 210A, which then uses the information to schedule the UL transmissions.

The EU scheduling information is transmitted to the WTRU 205 only by the primary Node-B 210A through the primary cell 260A. During soft handover, the WTRU 205 receives EU scheduling information only in the primary cell 260A, although the EU scheduling information is valid in all other cells 260B, 260C.

In one embodiment, the primary Node-B 250A is selected by either the RNC 215 or the WTRU 205. The RNC 215 may choose a Node-B that has the highest percentage of correctly received data blocks during a predefined time window as a primary Node-B.

In another embodiment, the RNC 215 generates statistics for each Node-B, such as a bit error rate (BER) or a frame error rate (FER), or the like, over a predetermined time period. Then, the RNC 215 may select a Node-B having the best performance to be the primary Node-B 210A. The RNC 215 then notifies the WTRU 205 and all other Node-Bs about the primary Node-B 210A via radio resource control (RRC) and Iub signaling, respectively.

In another embodiment, the WTRU 102 may choose a Node-B 210 that has the best downlink pilot power, (i.e., best downlink path loss or highest code power), as a primary Node-B 210A. The WTRU 205 measures the power of pilot signals received from all Node-Bs 210 and selects the Node-B 210 having the highest pilot power to be the primary Node-B 210A. The WTRU 205 then notifies all other Node-Bs about the primary Node-B 210A via fast physical layer signaling.

The WTRU 205 may report the downlink pilot power of all cells 260 to the RNC 215. The RNC 215 then chooses one Node-B 210 to be the primary Node-B 210A based on the combined uplink and downlink quality. The uplink quality of a cell 260 based on the percentage of correctly received data blocks, (or BER, FER, or the like), during a predefined time window, and the downlink quality of a cell 260 is based on the WTRU received downlink pilot power. Then, the RNC 215 notifies the WTRU 205 and all of the Node-Bs 210 about the primary Node-B 210A via RRC and Iub signaling, respectively.

US 10,869,247 B1

5

The present invention is advantageous over prior art systems. Using the present invention, a WTRU does not receive conflicting scheduling of EU transmissions from Node-Bs during soft handover. In addition, EU transmission is scheduled in consideration of an interference level and radio resources in cells controlled by non-primary Node-Bs. Signaling delay from the primary Node-B 210A to the WTRU 205 is much lower as compared to signaling delay from the RNC 215 to the WTRU 205.

In a separate embodiment, FIG. 3 shows a wireless multi-cell communication system 300, similar to the system 200 shown in FIG. 2. As shown in FIG. 3, the primary Node-B 210A includes a MAC entity 250A including an ACK/NACK generator 305. Only the primary Node-B 210A has the ACK/NACK generator 305. The primary Node-B 210A may perform H-ARQ with incremental redundancy, or only ARQ without implementing incremental redundancy.

Still referring to FIG. 3, the primary Node-B 210A receives at least one data packet from the WTRU 205 through the primary cell 260A and performs an error check on the data packet. Any error checking method, such as a cyclic redundancy check (CRC), may be utilized. If the primary Node-B 210A correctly decodes the data packet, such as passing the CRC, the primary Node-B 210A transmits an ACK to the WTRU 205 and also transmits the correctly decoded data packet to the RNC 215. If the primary Node-B 210A fails to correctly decode the data packet, the primary Node-B 210A transmits a NACK to the WTRU 205.

The non-primary Node-Bs 210B also perform an error check on the data packet. However, the non-primary Node-Bs 210B do not send ACKs or NACKs to the WTRU 205. Instead, the non-primary Node-Bs send successfully decoded data packets to the RNC 215. During soft handover, only the primary Node-B 210A generates H-ARQ (or ARQ), ACKs and NACKs, and controls retransmissions.

The MAC layer WTRU identities received by the non-primary Node-Bs 210B may be used for routing of successfully received transmissions in a universal terrestrial radio access network (UTRAN). Since the non-primary Node-Bs 210B are not aware of which WTRUs have been scheduled for EU transmission by the primary Node-B 210A, the non-primary Node-Bs 210B may rely on in-band MAC layer signaling of the WTRU ID to route correctly received transmissions to the correct RNC radio link. Even though the primary Node-B 210A may be aware of which WTRU is scheduled, the same method may be implemented by the primary Node-B 210A.

Preferably, the primary Node-B 210A may use soft combining to process transmissions, while the non-primary Node-Bs 210B may process each transmission without soft combining. If the primary Node-B sends a NACK to the WTRU 205, the NACKed data packet is stored in a buffer of the primary Node-B 210A, and the NACKed data packet is combined with a retransmitted data packet. In contrast, the non-primary Node-Bs 210B do not store the NACKed data packets. This eliminates the problem of soft buffer corruption between the Node-Bs 210, and the complexities of multiple independent ACKs and/or NACKs.

When an incremental combining process is implemented, measures should be taken to avoid soft buffer corruption. Sequence information or a new data indicator is required to enable a Node-B 210 to detect that the WTRU 205 is no longer repeating data for a particular WTRU H-ARQ process, but instead is sending new data. This is specifically required because the Node-B 210 has no other way to learn that a new transmission has started. Alternatively, the non-

6

primary Node-Bs 210B may simply perform an ARQ, without using an incremental combining process. This eliminates the soft buffer corruption problem.

In the case where non-primary Node-Bs 210B perform simple ARQ without incremental combining, the WTRU 205 must transmit self-decodable data packets to ensure that all of the Node-Bs 210 may decode transmissions, regardless of the result of earlier transmissions. Preferably, the H-ARQ functionality is terminated at the Node-Bs 210. Each of the Node-Bs 210 sends to the RNC 215 successfully decoded data packets with explicit identification of transmission, such as a transmission sequence number (TSN). The RNC 215 may optionally use data packets delivered from the non-primary Node-Bs 210B. A MAC entity 310, located in the RNC 215, is used to implement an in-sequence delivery process for delivering data to higher layers over all of the packets received from the Node-Bs 210. After the RNC MAC entity 310 has completed its re-ordering process, it sends the data to a radio link control (RLC) (not shown). Missed packets are identified at the RNC 215 and the WTRU 205 is informed through RLC messaging.

Alternatively, EU transmissions may identify WTRU ID, H-ARQ process, transmission sequence and/or new data indication (NDI) to allow for soft combining in the non-primary Node-B's 210B. If this method is used to allow soft combining in the non-primary Node-Bs 210B, the primary Node-B 210A may not have to rely on scheduling and H-ARQ ACK/NACK decisions to determine when combining should be performed.

There are two options for the transmission of ACK/NACK messages. The first option is a synchronous transmission. The ACK/NACK messages are transmitted after a unique time delay with respect to the corresponding uplink transmission or the EU channel allocation message. The second option is an asynchronous transmission. There is no unique delay between the transmission of ACK/NACK messages and the corresponding uplink transmission or the EU channel allocation message. Explicit information in the ACK/NACK message identifies the corresponding uplink transmission to enable the WTRU 205 to make the correct association between the ACK/NACK message and the transmission. This association is made by either identifying the H-ARQ process number and/or a unique sequence number, such as a TSN with each ACK/NACK feedback message to the WTRU 205.

In a separate embodiment, preferably implemented for the asynchronous ACK/NACK feedback case, the non-primary Node-Bs 210B may provide H-ARQ ACK/NACK results to the primary Node-B 210A in order to avoid unnecessary retransmissions for transmissions that are not correctly received by the primary Node-B 210A, but are correctly received by the non-primary Node-Bs 210B. A non-primary Node-B 210B does not directly send an ACK or NACK message to the WTRU 205. The non-primary Node-Bs 210B sends ACK/NACK or CRC results to the RNC 215. Then, the RNC 215 sends ACK or CRC results to the primary Node-B 210A.

In order to speed up H-ARQ processing, the first ACK message from any non-primary Node-B 210B received by the RNC is preferably immediately forwarded to the primary Node-B 210A. The primary Node-B 210A also immediately generates an ACK message if the transmission is received correctly in the primary Node-B 210A without waiting for feedback from the non-primary Node-Bs 210B. The primary Node-B 210A also generates an ACK message immediately upon reception of a forwarded ACK message from the RNC, even if other ACK messages may be forwarded. Since an

US 10,869,247 B1

7

ACK is generated if any of the paths are successful, an ACK can be generated as soon as the first successful transmission is found.

Alternatively, in order to simplify the design of the ACK/NACK generator 205, only a subset of the generating nodes may be used. For example, ACKs may be generated only at the RNC, or at the RNC and the primary Node-B 210A.

When the WTRU 205 sends an uplink transmission, for each H-ARQ process the WTRU 205 waits at least the time required for the primary Node-B 210A to send ACK/NACK feedback. For each H-ARQ process, if an ACK is received by the WTRU 205, the WTRU 205 may send new data in the next available or assigned opportunity.

A NACK message can only originate in the RNC 215 since it is the only node that has all of the information necessary in the soft handover to determine that there have been no successful receptions at any Node-B 210. The RNC 215 generates a NACK command if the RNC 215 receives no ACK from the Node-Bs 210 within a predetermined time interval. The RNC 215 forwards the NACK message to the WTRU 205 via the primary Node-B 210A.

It is also possible that this procedure can be implemented without an explicit NACK command. In this case, the lack of ACK reception within a particular period of time is considered the same as an explicit NACK command at either the primary Node-B 210A and/or the WTRU 205.

FIG. 4 is a flowchart of a process 400 including method steps for coordinating Node-Bs during soft handover in accordance with one embodiment of the present invention. In step 405, the RNC 215 makes a decision to initiate an inter-Node-B soft handover. In step 410, the WTRU 205 establishes connections with at least two Node-Bs 210 in an active set. In step 415, one of the Node-Bs 210 in the active set is designated as a primary Node-B 210A and the one or more Node-B(s) 210 remaining in the active set are designated as a non-primary Node-Bs 210B. In step 420, the primary Node-B 210A controls UL transmissions during soft handover by performing EU scheduling and H-ARQ operations.

FIG. 5 is a flowchart of a process 500 including method steps for prioritizing the transmission of NACKed data in a source Node-B before hard handover is completed in accordance with a separate embodiment of the present invention. In step 505, the RNC 215 makes a decision to initiate a hard handover for a WTRU 205 connected to a source Node-B 210. In step 510, the RNC 215 informs the source Node-B 210 when the WTRU 205 will stop transmission and reception in the source cell 260. In step 515, the RNC 215 sends an activation timer to the source Node-B 210 to set the time for handover.

Still referring to FIG. 5, if the source Node-B 210 determines that there are data packets that were previously NACKed, as many previously NACKed data packets as possible should be retransmitted before the handover activation timer expires. Otherwise, the system may lose the benefit of incrementally combining the previous transmission with the retransmission. Therefore, the source Node-B scheduler 255 takes the handover activation time into account when it schedules the data packets that have been NACKed. If there is not enough radio resource for the source Node-B 210 to schedule transmission of all the NACKed data packets in time, the source Node-B 210 should manage to schedule transmission of as many NACKed data packets as possible.

Still referring to FIG. 5, in order to transmit as many NACKed data packets as possible before the activation timer

8

expires, the source Node-B 210 adjusts the priority of transmissions (step 525) and, in step 530, the source node-B 210 adjusts the MCS of the transmissions (step 530). Higher priority of scheduling is given to the data packets that have been NACKed. If the radio resources are sufficient, a more robust MCS may be used to increase the probability of successful transmissions from the WTRU 205 to the source Node-B 210. In step 535, the handover is completed at the expiration of the activation timer.

In order for the WTRU 205 to understand that the scheduled uplink transmission is intended for data blocks with previous transmission failures, the source Node-B 210 uplink scheduler 255 may specify that the scheduled UL transmission is intended for the data blocks that were previously NACKed. This may be implemented by including H-ARQ process identification in the UL scheduling information that is sent from the source Node-B 210 to the WTRU 205. By receiving the scheduling information from the source Node-B 210, the WTRU 205 knows that the scheduled transmission is for specific data associated with HARQ process identification sent together with the scheduling information.

While this invention has been particularly shown and described with reference to preferred embodiments, it will be understood by those skilled in the art that various changes in forms and details may be made therein without departing from the scope of the invention as described above.

What is claimed is:

1. A wireless transmit/receive unit (WTRU) comprising: at least one transceiver; and a processor; wherein the at least one transceiver and the processor are configured to cause the WTRU to: transmit, using a hybrid automatic repeat request (H-ARQ) process, a data block to a base station; receive uplink scheduling information from the base station, wherein the uplink scheduling information includes a H-ARQ process identification for the H-ARQ process; and determine whether to retransmit the data block based on the received uplink scheduling information and not based on whether the WTRU has received a negative acknowledgement (NACK) from the base station.
2. The WTRU of claim 1, wherein the at least one transceiver and the processor are further configured to cause the WTRU to, in response to a determination to retransmit the data block, retransmit the data block.
3. The WTRU of claim 2, wherein the data block is retransmitted using physical channel resources included in the uplink scheduling information.
4. The WTRU of claim 1, wherein the reception of the uplink scheduling information initiates retransmission of a negatively acknowledged (NACK'ed) data block.
5. The WTRU of claim 1, wherein the uplink scheduling information includes physical channel resources.
6. The WTRU of claim 1, wherein the uplink scheduling information is received from a primary cell and the WTRU transmits to the primary cell and at least one secondary cell.
7. The WTRU of claim 1, wherein the at least one transceiver and the processor are further configured to cause the WTRU to receive an ACK/NACK signal from the base station.
8. The WTRU of claim 1, wherein the scheduling information indicates a modulation and coding scheme.
9. The WTRU of claim 1, wherein the transmitted data block has a first modulation and coding scheme (MCS) and

US 10,869,247 B1

9

the scheduling information indicates a second MCS, wherein the first MCS and the second MCS are different.

10. The WTRU of claim 9, wherein the at least one transceiver and the processor are further configured to cause the WTRU to, in response to a determination to retransmit the data block, retransmit the data block using the second MCS.

11. A method comprising:

transmitting, by a wireless transmit/receive unit (WTRU), a data block to a base station using a hybrid automatic repeat request (H-ARQ) process;

receiving, by the WTRU, uplink scheduling information from the base station, wherein the uplink scheduling information includes a H-ARQ process identification for the H-ARQ process; and

determining, by the WTRU, whether to retransmit the data block based on the received uplink scheduling information and not based on whether the WTRU has received a negative acknowledgement (NACK) from the base station.

12. The method of claim 11 further comprising, in response to a determination to retransmit the data block, retransmitting, by the WTRU, the data block.

10

13. The method of claim 12, wherein the data block is retransmitted using physical channel resources included in the uplink scheduling information.

14. The method of claim 11, wherein the reception of the uplink scheduling information initiates retransmission of a negatively acknowledged (NACK'ed) data block.

15. The method of claim 11, wherein the uplink scheduling information includes physical channel resources.

16. The method of claim 11, wherein the uplink scheduling information is received from a primary cell and the WTRU transmits to the primary cell and at least one secondary cell.

17. The method of claim 11 further comprising receiving, by the WTRU, an ACK/NACK signal from the base station.

18. The method of claim 11, wherein the scheduling information indicates a modulation and coding scheme.

19. The method of claim 11, wherein the transmitted data block has a first modulation and coding scheme (MCS) and the scheduling information indicates a second MCS, wherein the first MCS and the second MCS are different.

20. The method of claim 19 further comprising, in response to a determination to retransmit the data block, retransmitting the data block using the second MCS.

* * * * *

EXHIBIT 4



US009313809B2

(12) **United States Patent**
Pelletier et al.

(10) **Patent No.:** **US 9,313,809 B2**
(45) **Date of Patent:** ***Apr. 12, 2016**

(54) **METHOD AND APPARATUS FOR
TERMINATING TRANSMISSION OF A
MESSAGE IN AN ENHANCED RANDOM
ACCESS CHANNEL**

(52) **U.S. Cl.**
CPC **H04W 74/0833** (2013.01); **H04L 5/0053**
(2013.01); **H04W 28/04** (2013.01);
(Continued)

(71) Applicant: **Signal Trust for Wireless Innovation,**
Wilmington, DE (US)

(58) **Field of Classification Search**
CPC H04W 76/046; H04W 76/062; H04W
76/068
USPC 370/328, 329, 338, 341, 348; 455/450,
455/464; 709/226, 229
See application file for complete search history.

(72) Inventors: **Benoit Pelletier**, Roxboro (CA); **Diana
Pani**, Montreal (CA); **Rocco
DiGirolamo**, Laval (CA); **Christopher
R. Cave**, Dollard-des-Ormeaux (CA);
Vincent Roy, Longueuil (CA); **Paul
Marinier**, Brossard (CA); **Eldad M.
Zeira**, Huntington, NY (US)

(56) **References Cited**

U.S. PATENT DOCUMENTS

(73) Assignee: **Signal Trust for Wireless Innovation,**
Wilmington, DE (US)

6,167,248 A 12/2000 Hamalainen et al.
6,246,692 B1 6/2001 Dai et al.
(Continued)

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

This patent is subject to a terminal dis-
claimer.

FOREIGN PATENT DOCUMENTS

CA 2 615 915 3/2004
GB 2 371 179 7/2002

(Continued)

OTHER PUBLICATIONS

(21) Appl. No.: **14/319,608**

(22) Filed: **Jun. 30, 2014**

(65) **Prior Publication Data**

US 2014/0307683 A1 Oct. 16, 2014

Related U.S. Application Data

(63) Continuation of application No. 12/238,910, filed on
Sep. 26, 2008, now Pat. No. 8,774,104.

(60) Provisional application No. 60/975,985, filed on Sep.
28, 2007, provisional application No. 60/982,528,

(Continued)

(51) **Int. Cl.**
H04W 4/00 (2009.01)
H04W 74/08 (2009.01)

(Continued)

Ericsson, "Contention resolution for enhanced uplink in CELL_
FACH," 3GPP TSG RAN WG2 #60bis, R2-080043, Sevilla, Spain
(Jan. 14-18, 2008).

(Continued)

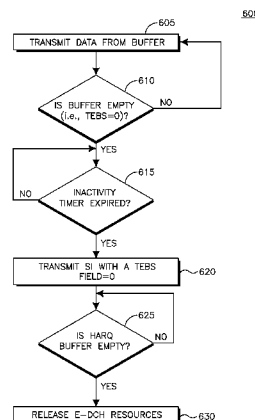
Primary Examiner — Kan Yuen

(74) *Attorney, Agent, or Firm* — Volpe and Koenig, P.C.

(57) **ABSTRACT**

A method and an apparatus is provided for terminating an
enhanced random access channel (E-RACH) message in an
E-RACH transmission. Triggers for terminating the E-RACH
message are provided. The actions upon termination of the
E-RACH messages are provided to release enhanced dedi-
cated channel (E-DCH) resources while in cell forward
access channel (CELL_FACH) state or transition to cell dedi-
cated channel (CELL_DCH) state.

73 Claims, 9 Drawing Sheets



US 9,313,809 B2

Page 2

Related U.S. Application Data

filed on Oct. 25, 2007, provisional application No. 61/018,999, filed on Jan. 4, 2008, provisional application No. 61/025,441, filed on Feb. 1, 2008, provisional application No. 61/038,576, filed on Mar. 21, 2008, provisional application No. 61/074,288, filed on Jun. 20, 2008, provisional application No. 61/083,409, filed on Jul. 24, 2008.

(51) Int. Cl.

H04W 76/04 (2009.01)
H04W 76/06 (2009.01)
H04W 28/04 (2009.01)
H04L 5/00 (2006.01)
H04W 72/04 (2009.01)
H04W 72/12 (2009.01)

(52) U.S. Cl.

CPC *H04W 72/04* (2013.01); *H04W 72/0406* (2013.01); *H04W 76/046* (2013.01); *H04W 76/068* (2013.01); *H04W 72/12* (2013.01)

(56)

References Cited

U.S. PATENT DOCUMENTS

6,721,566	B2	4/2004	Longoni et al.
6,845,238	B1	1/2005	Muller
7,079,489	B2	7/2006	Massie et al.
7,406,314	B2	7/2008	Sharma
7,477,609	B2	1/2009	Agin
7,480,269	B2	1/2009	Heo et al.
7,508,792	B2	3/2009	Petrovic et al.
7,643,515	B2	1/2010	Willenegger
7,890,094	B2	2/2011	Iwamura
7,894,390	B2	2/2011	Nakamata et al.
2004/0052229	A1	3/2004	Terry et al.
2004/0068505	A1	4/2004	Lee et al.
2004/0117860	A1	6/2004	Yi et al.
2005/0026623	A1	2/2005	Fisher
2005/0053035	A1	3/2005	Kwak et al.
2005/0054298	A1	3/2005	Chen
2005/0101299	A1	5/2005	Farnsworth
2005/0180371	A1	8/2005	Malkamaki et al.
2005/0249163	A1 *	11/2005	Kim et al. 370/335
2005/0250504	A1	11/2005	Mikola
2006/0023629	A1	2/2006	Kim et al.
2006/0039326	A1	2/2006	Jeong et al.
2006/0140154	A1	6/2006	Kwak et al.
2006/0251027	A1	11/2006	Chun et al.
2007/0047445	A1 *	3/2007	Usuda et al. 370/236
2007/0115871	A1	5/2007	Zhang et al.
2007/0135113	A1	6/2007	Moinet et al.
2007/0213059	A1	9/2007	Shaheen
2007/0223609	A1	9/2007	Obuchi et al.
2008/0008152	A1	1/2008	Lohr et al.
2008/0049669	A1	2/2008	Lundby et al.
2008/0125043	A1	5/2008	Karmanenko et al.
2008/0192766	A1	8/2008	Ranta-Aho et al.
2008/0268852	A1	10/2008	Petrovic et al.
2009/0061881	A1	3/2009	Gonsa et al.
2009/0086671	A1	4/2009	Pelletier et al.
2009/0135769	A1	5/2009	Sambhwani et al.
2009/0143074	A1	6/2009	Pelletier et al.
2009/0168704	A1	7/2009	Lee et al.
2009/0168724	A1	7/2009	Umesh et al.
2009/0219868	A1	9/2009	Lee et al.
2009/0225709	A1	9/2009	Wager et al.
2009/0225739	A1	9/2009	Yeo et al.
2010/0091652	A1	4/2010	Lin
2010/0215005	A1	8/2010	Pradas et al.
2010/0216471	A1	8/2010	Meyer et al.
2010/0278143	A1	11/2010	Chun et al.
2011/0164540	A1	7/2011	Lee et al.
2012/0327833	A1	12/2012	Kim et al.

FOREIGN PATENT DOCUMENTS

WO	2004/100598	11/2004
WO	2005/006829	1/2005
WO	2005/020474	3/2005
WO	2005/089050	9/2005
WO	2005/101886	10/2005
WO	2006/043782	4/2006
WO	2007/048470	5/2007
WO	2007/077250	7/2007
WO	2007/078155	7/2007
WO	2008/097489	8/2008
WO	2008/137421	11/2008

OTHER PUBLICATIONS

Ericsson, "Enhanced Uplink for CELL_FACH," 3GPP TSG RAN WG1 #50-bis, R1-073954, Shanghai, China (Oct. 8-12, 2007).

Ericsson, "Implicit release for enhanced uplink in CELL_FACH," 3GPP TSG RAN WG2 #61bis, R2-081501 (Mar. 31-Apr. 8, 2008).

Ericsson, "Resource release of common E-DCH in CELL_FACH," 3GPP TSG RAN WG2 #60bis, R2-080044 (Jan. 14-18, 2008).

Huawei, "Release procedure of E-RACH," 3GPP TSG RAN2 #60bis, R2-080262 (Jan. 14-18, 2008).

Infineon Technologies, "Multiplexing option selection in case of E_DCH_TRANSMISSION equal FALSE," 3GPP TSG-RAN WG2 Meeting #58, R2-072054, Kobe, Japan, (May 7-11, 2007).

Infineon, "CELL_FACH E-DCH scheduling simplifications," 3GPP TSG-RAN WG2 Meeting #61, R2-080894, Sorrento, Italy, (Feb. 11-15, 2008).

Infineon, "Resource release mechanisms for CELL_FACH E-DCH," 3GPP TSG-RAN WG2 Meeting #60bis, R2-080148 (Jan. 14-18, 2008).

Nokia Corporation et al., "Introduction of Enhanced Uplink in CELL_FACH in 25.319," 3GPP TSG RAN WG2 meeting #62, R2-082368, Kansas City, USA (May 5-9, 2008). (See pp. 5-7 and 30-35).

Nokia Corporation, et al., "Introduction of Uplink Enhanced CELL_FACH in 25.321 (Draft CR)", Change Request, 25-23, CR CRNum, Current Version: 8.1.0, 3GPP TSG-RAN WG2 Meeting #62, R2-082371, (Kansas City, USA, May 5-9, 2008).

Nokia et al., "CELL_FACH state E-DCH—coverage comparison," 3GPP TSG-RAN WG1 Meeting #50bis, R1-074302 (Oct. 8-12, 2007).

Nokia et al., "Enhanced CELL_FACH State with E-DCH," 3GPP TSG-RAN WG2 Meeting #59bis, R1-074300 (Oct. 8-12, 2007).

Nokia et al., "Resource assignment for E-DCH access in CELL_FACH state," 3GPP TSG-RAN WG1 Meeting #50-BIS, R1-074303 (Oct. 8-12, 2007).

Nokia Siemens Networks, "Draft CR on TS25.435 for Enhanced Uplink in CELL_FACH", Change Request, 25.435, CR, Current Version: 7.8.0, 3GPP TSG-RAN WG3 Meeting #60, R3-081276, (Kansas City, USA, May 5-9, 2008).

Nokia Siemens Networks, "Introduction of Enhanced CELL_FACH state," 3GPP TSG-2 Meeting #57, R2-071556, St. Julian's, Malta (Mar. 26-30, 2007).

NSN et al., "Further Discussion on Enhanced CELL_FACH in REL8," 3GPP TSG-RAN WG-2 Meeting #59, R2-073254, (Athens, Greece, Aug. 20-24, 2007).

NTT Docomo, Inc., "Issues regarding persistent scheduling," 3GPP TSG RAN WG2 #59, R2-073567, Athens, Greece (Aug. 20-24, 2007).

Qualcomm Europe, "LI/2 aspects for enhanced UL for CELL_FACH," 3GPP TSG-RAN WG1 #50-bis, R1-074126 (Oct. 8-12, 2007).

Qualcomm Europe, "E-DCH Resource Release in CELL_FACH," 3GPP TSG-RAN WG3 #60, R3-081091, Kansas City, Missouri, US (May 5-9, 2008).

Qualcomm Europe, "Empty Buffer Status reporting and Implicit release for CCH messages using enhanced uplink in CELL_FACH," 3GPP TSG-RAN WG2 #61-bis, R2-081581, Shenzhen, China (Mar. 31-Apr. 4, 2008).

US 9,313,809 B2

Page 3

(56)

References Cited

OTHER PUBLICATIONS

Qualcomm Europe, "E-RNTI handling in Active Set Update procedure," 3GPP TSG-RAN WG 2 Meeting #51, R2-060682 (Feb. 13-17, 2006).

Qualcomm Europe, "Layer 1/2 aspects for enhanced UL for CELL_FACH," 3GPP TSG-RAN WG2 #59bis, R2-074390 (Oct. 8-12, 2007).

Third Generation Partnership Project Support Team, "Minutes of the 59bis TSG-WG2 Meeting (Shanghai, China, Oct. 8-12, 2007)," TSG-RAN WG2 meeting #60, R2-075189, (Korea Nov. 5-9, 2007).

Third Generation Partnership Project Work Area, "Enhanced Uplink for CELL_FACH State in FDD", TSG-RAN #37 Meeting, RP-070677, (Riga, Latvia, Sep. 11-14, 2007).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Enhanced Uplink; Overall Description; Stage 2 (Release 7)," 3GPP TS 25.319, V7.2.0, (Mar. 2007).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Enhanced Uplink; Overall Description; Stage 2 (Release 7)," 3GPP TS 25.319, V7.6.0, (May 2007).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Enhanced Uplink; Overall Description; Stage 2 (Release 7)," 3GPP TS 25.319, V8.3.0, (Sep. 2008).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Physical Channels and Mapping of Transport Channels Onto Physical Channels (FDD) (Release 7)," TS 25.211, V7.3.0, (Sep. 2007).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Physical Channels and Mapping of Transport Channels Onto Physical Channels (FDD) (Release 8)," TS 25.211, V8.2.0, (Sep. 2008).

Third Generation Partnership Project, Technical Specification Group Radio Access Network; Medium Access Control (MAC) Protocol Specification (Release 7), 3GPP TS 25.321, V7.5.0, (Jun. 2007).

Third Generation Partnership Project, Technical Specification Group Radio Access Network; Medium Access Control (MAC) Protocol Specification (Release 7), 3GPP TS 25.321, V7.10.0, (Jun. 2008).

Third Generation Partnership Project, Technical Specification Group Radio Access Network; Medium Access Control (MAC) Protocol Specification (Release 7), 3GPP TS 25.321, V8.3.0, (Sep. 2008).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; UTRAN Iur Interface User Plane Protocols for Common Transport Channel Data Streams (Release 6)," 3GPP TS 25.425 V6.4.0 (Dec. 2006).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; UTRAN Iur Interface User Plane Protocols for Common Transport Channel Data Streams (Release 6)," 3GPP TS 25.425 V6.5.0 (Sep. 2008).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; UTRAN Iur Interface User Plane Protocols for Common Transport Channel Data Streams (Release 7)," 3GPP TS 25.425 V7.8.0 (Sep. 2008).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; UTRAN Iur Interface User Plane Protocols for Common Transport Channel Data Streams (Release 8)," 3GPP TS 25.425 V8.0.0 (Sep. 2008).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Medium Access Control (MAC) protocol specification (Release 1999)," 3GPP TS 25.321 V3.17.0 (Jun. 2004).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Medium Access Control (MAC) protocol specification (Release 4)," 3GPP TS 25.321 V4.10.0 (Jun. 2004).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Medium Access Control (MAC) protocol specification (Release 5)," 3GPP TS 25.321 V5.13.0 (Mar. 2007).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Medium Access Control (MAC) protocol specification (Release 5)," 3GPP TS 25.321 V5.14.0 (Sep. 2008).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Medium Access Control (MAC) protocol specification (Release 6)," 3GPP TS 25.321 V6.13.0 (Jun. 2007).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Medium Access Control (MAC) protocol specification (Release 6)," 3GPP TS 25.321 V6.16.0 (Sep. 2008).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Physical channels and mapping of transport channels onto physical channels (FDD) (Release 1999)," 3GPP TS 25.211 V3.12.0 (Sep. 2002).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Physical channels and mapping of transport channels onto physical channels (FDD) (Release 4)," 3GPP TS 25.211 V4.6.0 (Sep. 2002).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Physical channels and mapping of transport channels onto physical channels (FDD) (Release 5)," 3GPP TS 25.211 V5.8.0 (Dec. 2005).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Physical channels and mapping of transport channels onto physical channels (FDD) (Release 6)," 3GPP TS 25.211 V6.8.0 (Sep. 2007).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Physical channels and mapping of transport channels onto physical channels (FDD) (Release 6)," 3GPP TS 25.211 V6.9.0 (Nov. 2007).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Physical channels and mapping of transport channels onto physical channels (FDD) (Release 7)," 3GPP TS 25.211 V7.6.0 (May 2008).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; UTRAN Iur Interface User Plane Protocols for Common Transport Channel Data Streams (Release 7)," 3GPP TS 25.425 V7.4.0 (Jun. 2007).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; UTRAN Iub/Iur interface user plane protocol for DCH data streams (Release 7)," 3GPP TS 25.427 V7.4.0 (Mar. 2007).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; UTRAN Iub/Iur interface user plane protocol for DCH data streams (Release 8)," 3GPP TS 25.427 V8.0.0 (Mar. 2008).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; UTRAN Iub/Iur interface user plane protocol for DCH data streams (Release 7)," 3GPP TS 25.427 V7.5.0 (Sep. 2007).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; UTRAN Iub/Iur interface user plane protocol for DCH data streams (Release 5)," 3GPP TS 25.427 V5.5.0 (Jun. 2005).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; UTRAN Iub/Iur interface user plane protocol for DCH data streams (Release 6)," 3GPP TS 25.427 V6.8.0 (Dec. 2006).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; UTRAN Iub/Iur interface user plane protocol for DCH data streams (Release 4)," 3GPP TS 25.427 V4.5.0 (Dec. 2003).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; UTRAN Iub/Iur interface user plane protocol for DCH data streams (Release 1999)," 3GPP TS 25.427 V3.11.0 (Dec. 2003).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; UTRAN Iur interface user plane protocols for Common Transport Channel data streams (Release 1999)," 3GPP TS 25.425 V3.8.0 (Dec. 2003).

US 9,313,809 B2

Page 4

(56)

References Cited

OTHER PUBLICATIONS

Third Generation Partnership Project; “Technical Specification Group Radio Access Network; UTRAN Iur interface user plane protocol for Common Transport Channel data streams (Release 4),” 3GPP TS 25.425 V4.4.0 (Dec. 2003).
Third Generation Partnership Project; “Technical Specification Group Radio Access Network; UTRAN Iur interface user plane pro-

ocol for Common Transport Channel data streams (Release 5),” 3GPP TS 25.425 V5.8.0 (Jun. 2005).
Third Generation Partnership Prorgam Support Team, “Current Minutes of the 59bis TSG-RAN WG2 Meeting (Shanghai, China, Oct. 8-12, 2007),” TSG-RAN WG2 Meeting #60, R2-7xxxx, (Korea, Nov. 5-9, 2007).
TSG-RAN-WG2, “Reply LS on Enhanced Uplink for CELL_FACH state in FDD,” 3GPP TSG-RAN-WG2 Meeting #60, R2-075472 (Nov. 5-9, 2007).
* cited by examiner

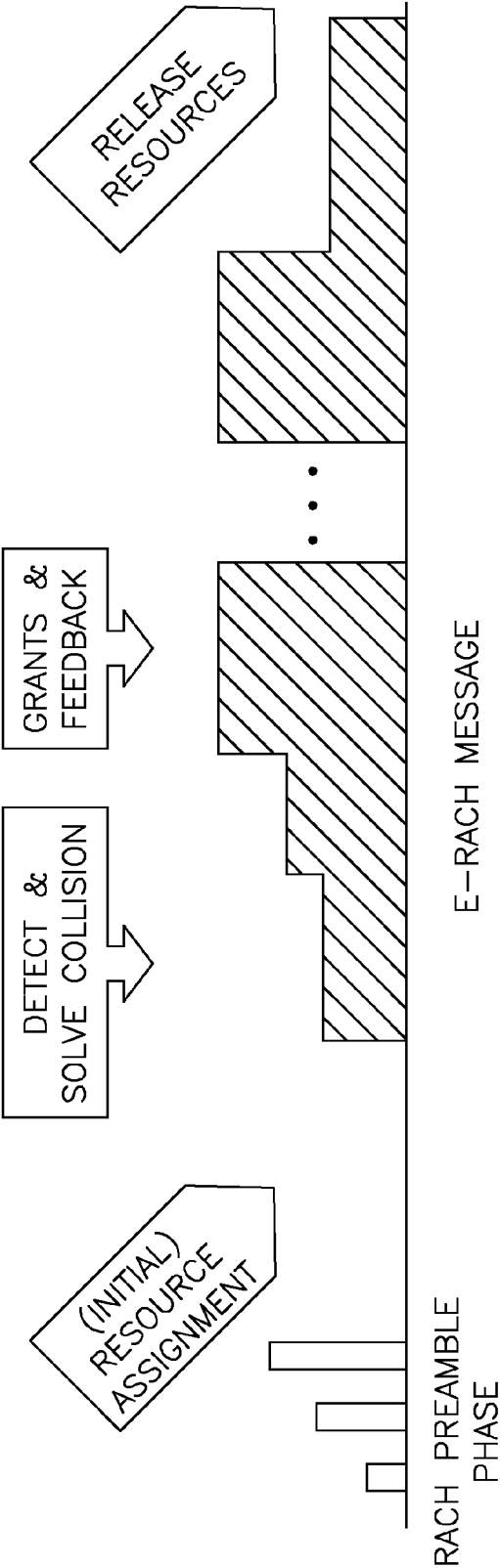


FIG. 1 (PRIOR ART)

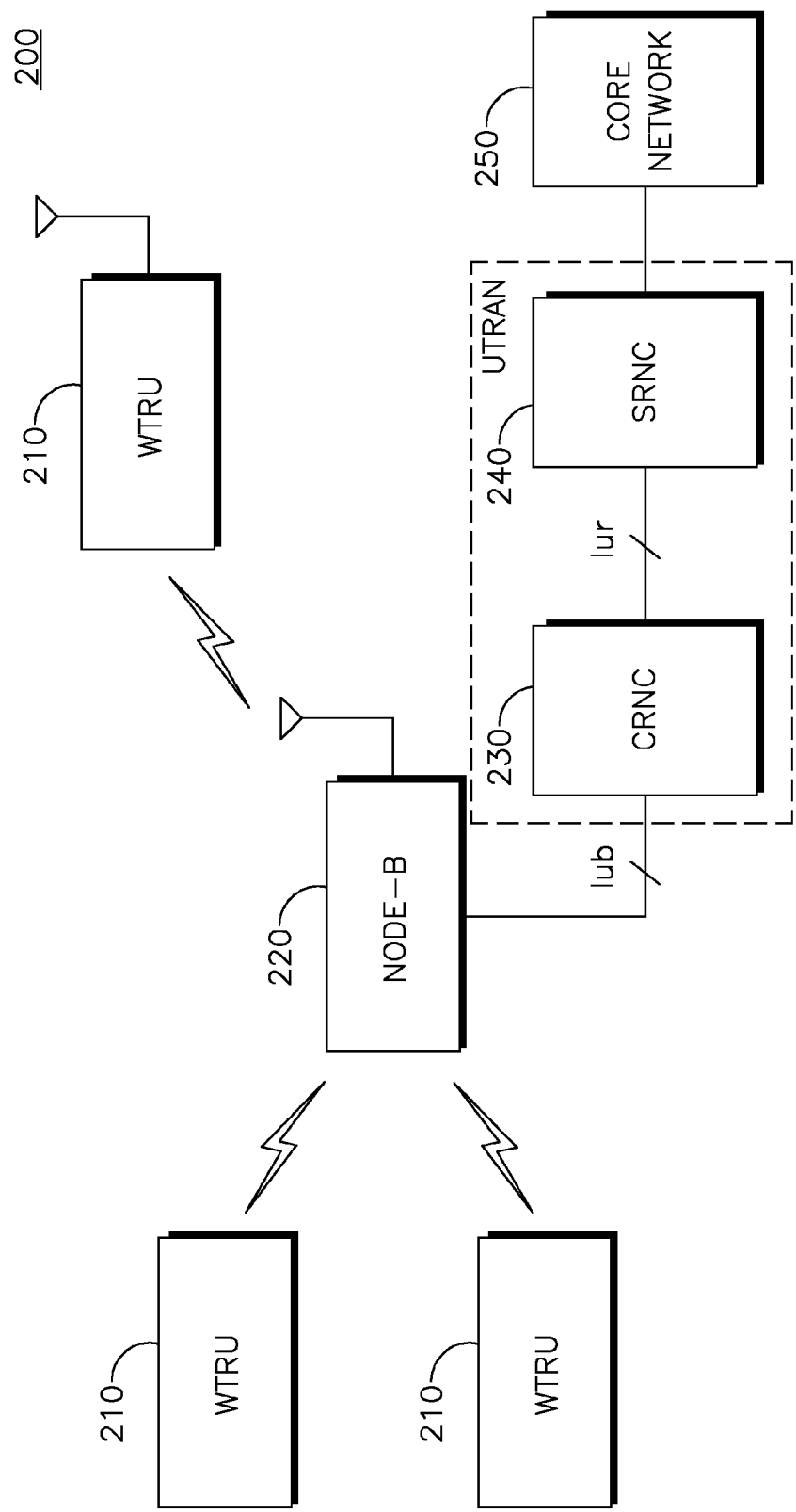


FIG. 2

300

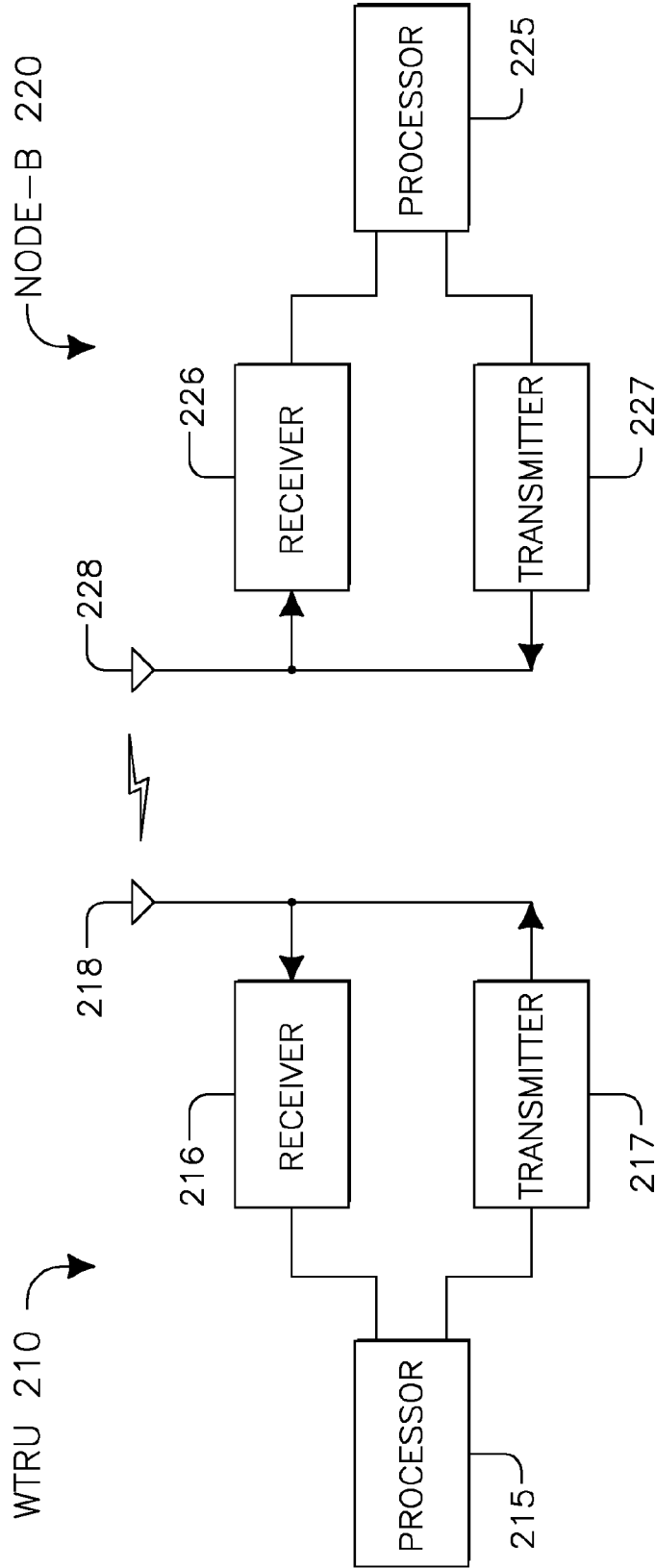


FIG. 3

400

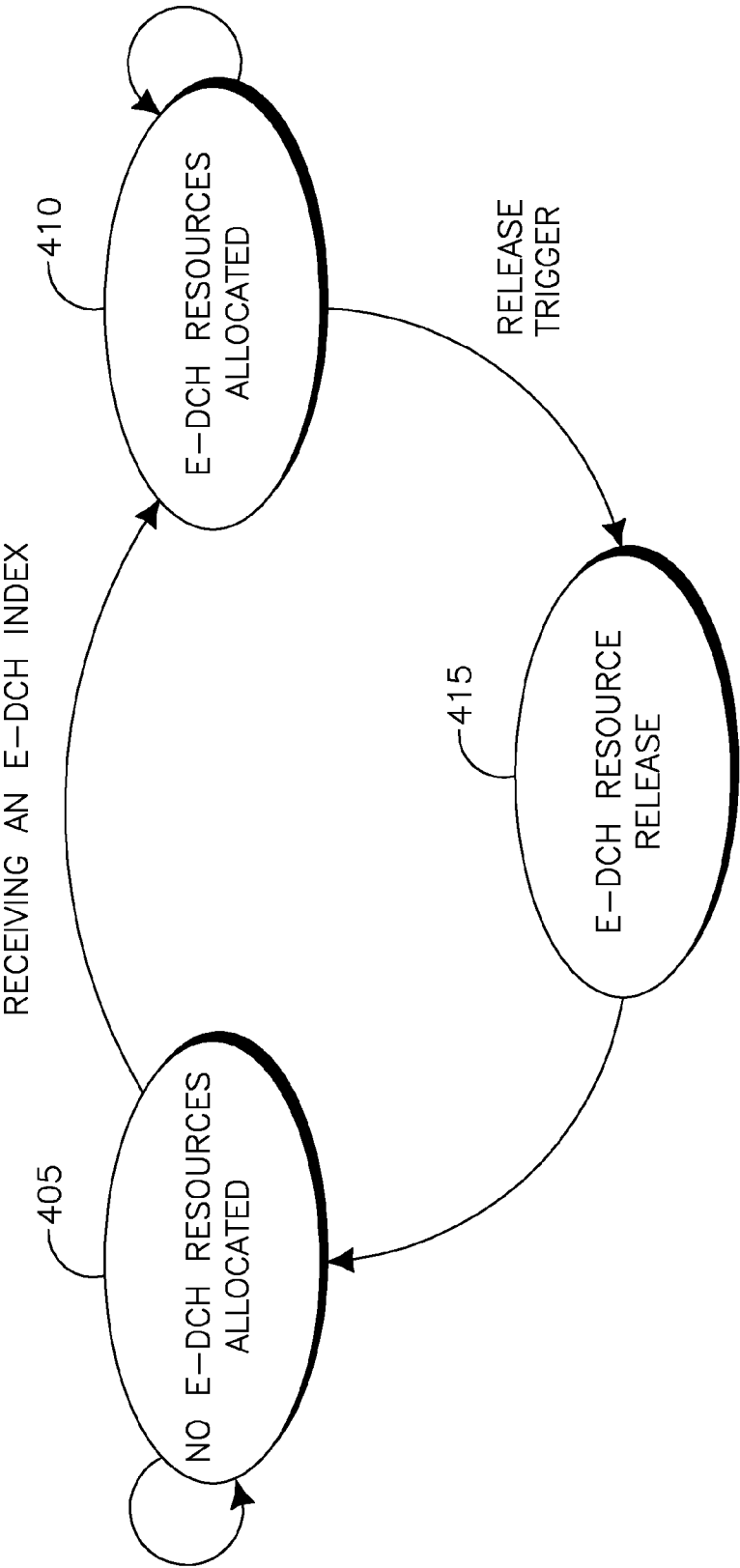
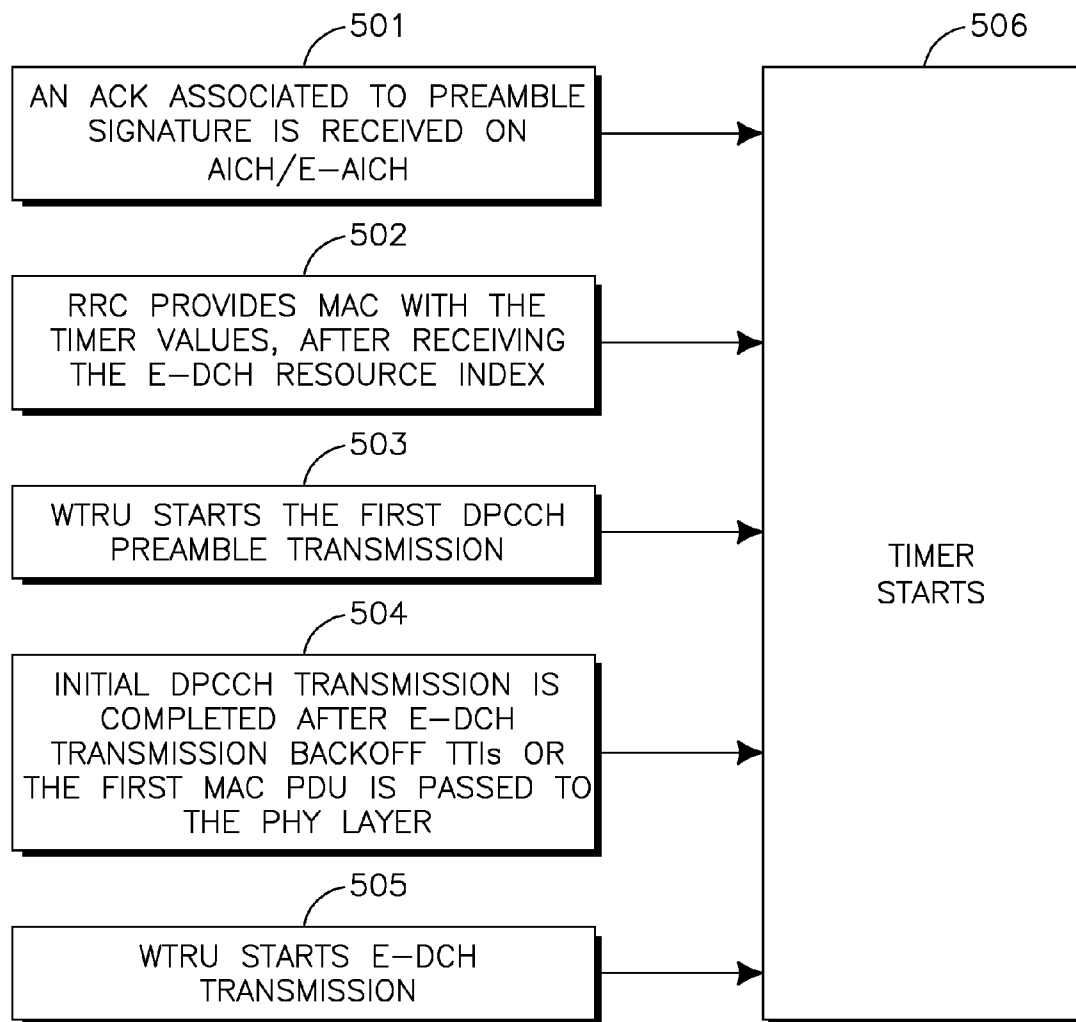
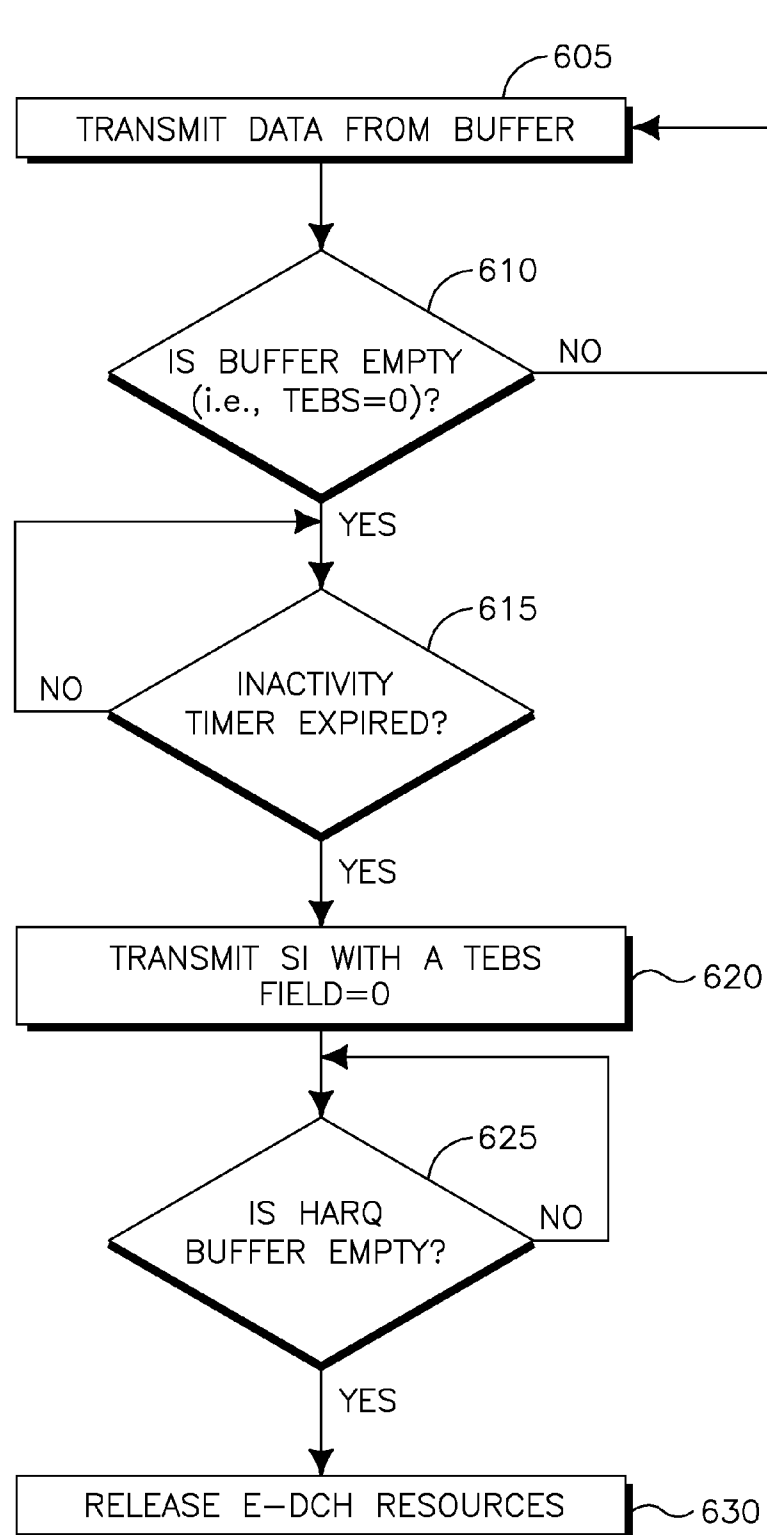
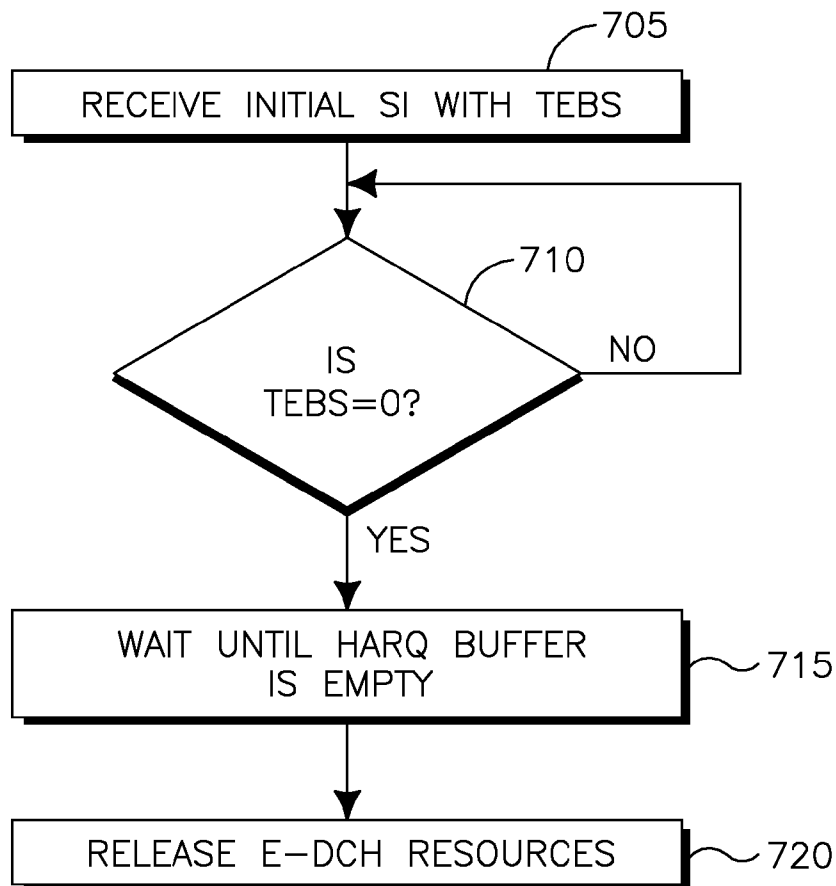


FIG. 4

500**FIG. 5**

**FIG. 6**

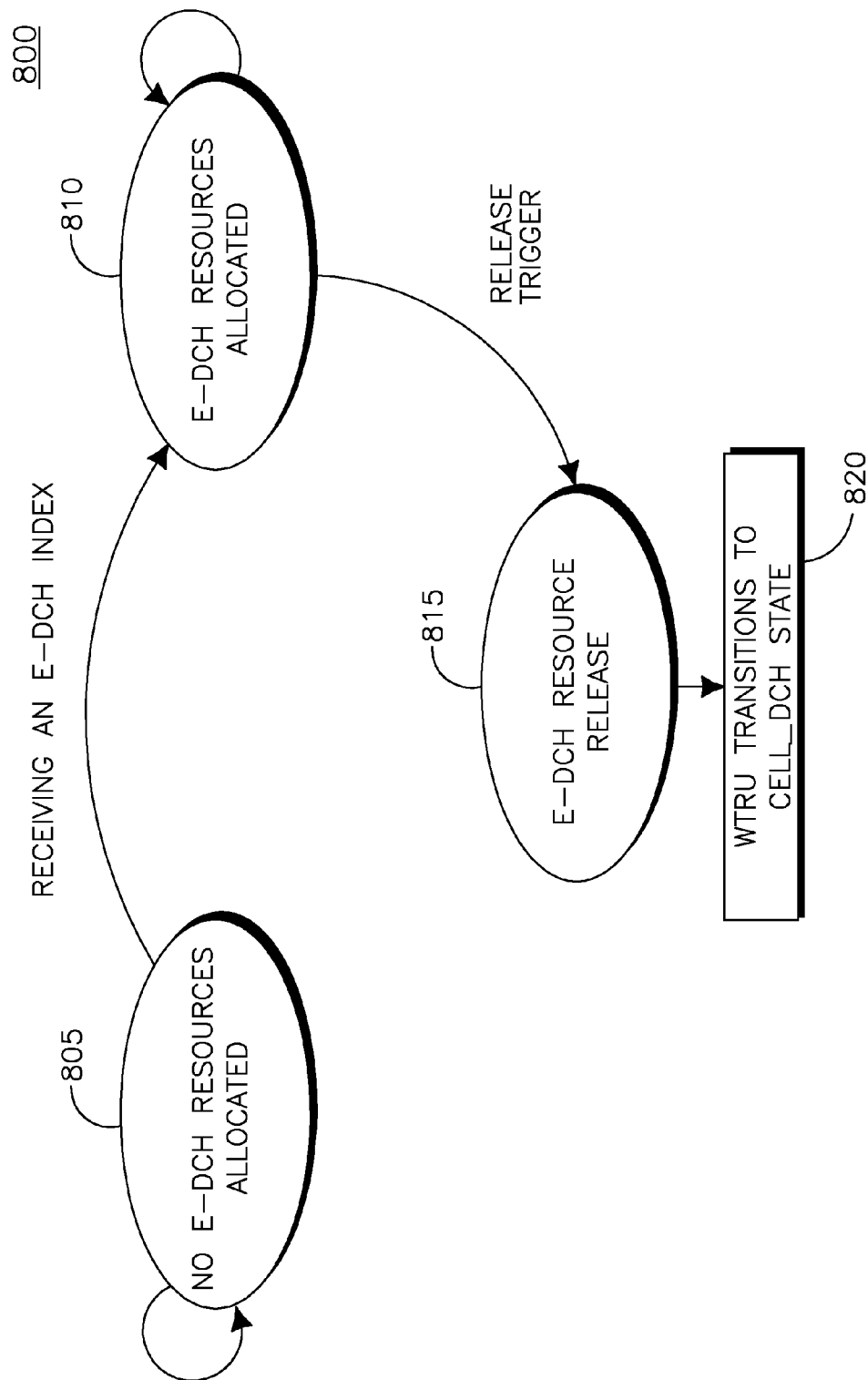
700**FIG. 7**

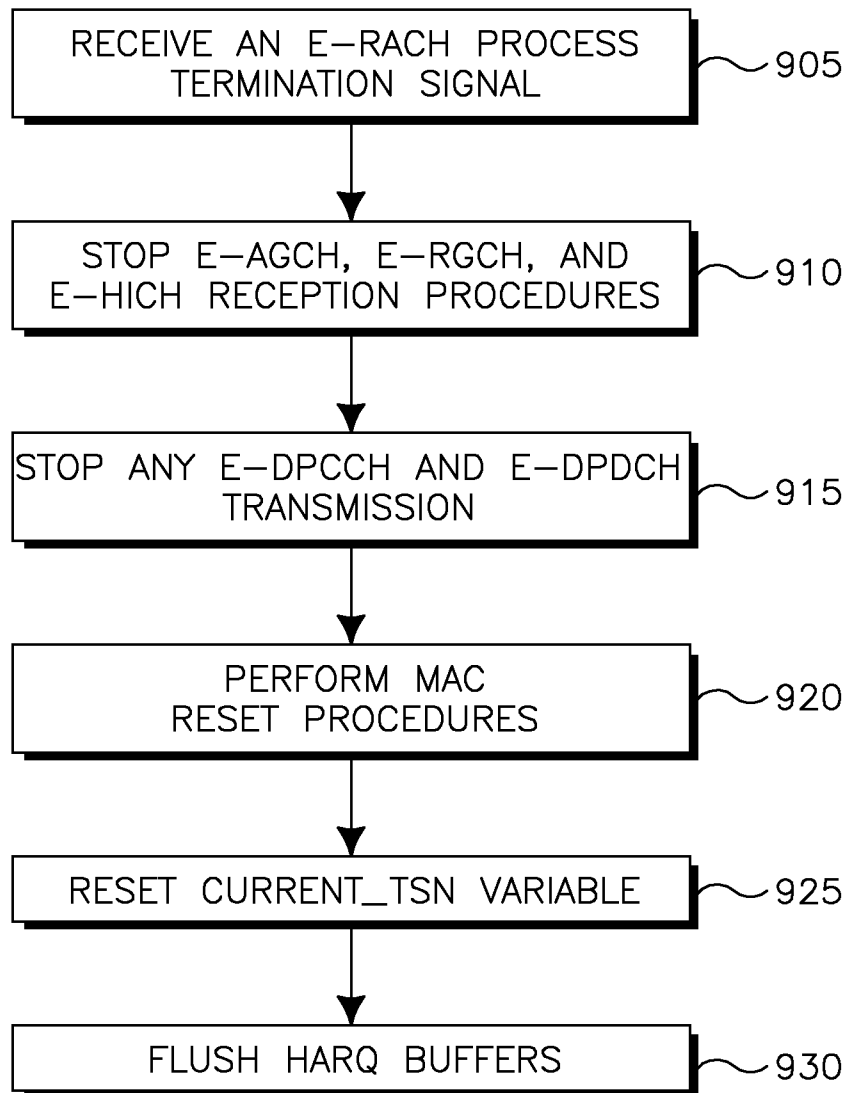
U.S. Patent

Apr. 12, 2016

Sheet 8 of 9

US 9,313,809 B2

**FIG. 8**

900**FIG. 9**

US 9,313,809 B2

1

METHOD AND APPARATUS FOR TERMINATING TRANSMISSION OF A MESSAGE IN AN ENHANCED RANDOM ACCESS CHANNEL

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 12/238,910 filed Sep. 26, 2008, which claims the benefit of U.S. Provisional Application No. 60/975,985 filed on Sep. 28, 2007; U.S. Provisional Application No. 60/982,528 filed on Oct. 25, 2007; U.S. Provisional Application No. 61/018,999, filed on Jan. 4, 2008; U.S. Provisional Application No. 61/025,441 filed on Feb. 1, 2008; U.S. Provisional Application No. 61/038,576 filed on Mar. 21, 2008; U.S. Provisional Application No. 61/074,288 filed on Jun. 20, 2008; and U.S. Provisional Application No. 61/083,409 filed on Jul. 24, 2008, which are incorporated by reference as if fully set forth. This application is also related to the application referred to as Ser. No. 14/319,975 filed on the same date herewith and is incorporated by reference as if fully set forth.

FIELD OF INVENTION

The present application is related to wireless communication.

BACKGROUND

In wireless communications systems, access to radio resources is controlled by a radio network. When a wireless transmit receive unit (WTRU) has data to transmit to the network, the WTRU requires access to the radio resources before transmitting its data payload. In a Third Generation Partnership Project (3GPP) network, the WTRU may transmit on the uplink using a contentious channel known as a random access channel (RACH). Because access to the RACH is contentious, a collision might occur when multiple WTRUs are accessing the resources simultaneously.

The current RACH access procedure in the 3GPP comprises a preamble phase with power ramp-up, followed by channel acquisition information and message transmission for random access. Because the RACH is a shared channel, in order to avoid WTRUs holding the shared radio resource for a long time, only relatively short message payloads are transmitted on the RACH; this leads to a relatively small data rate. The RACH is thus used for the transmission of short control messages. Typically, the WTRUs demanding larger data rates may be configured by the network to use dedicated resources.

The data rate provided by the RACH is sufficient for the transmission of short control messages supporting mostly speech communications, however it may be inefficient for transmission of data messages associated to the new non real-time data services such as internet browsing, e-mail, etc. For such data services, the traffic is ruptured by nature and long periods of inactivity may exist between successive transmissions. For example, applications requiring frequent transmission of keep-alive messages, may result in an inefficient utilization of dedicated resources. In such cases, it may be advantageous for the network to use shared resources for data transmission instead. The difficulty however, resides in the low data rate offered by the RACH.

To overcome these difficulties, it was proposed to use the enhanced dedicated channel (E-DCH) in the CELL_FACH state to increase the data rate of the shared channel.

2

FIG. 1 is a diagram of an enhanced RACH (E-RACH) access. The E-RACH procedure may include, a RACH preamble phase and an E-RACH message phase. During the initial RACH preamble phase, a WTRU transmits a RACH preamble, it continues transmitting the preamble while ramping up the power of the transmission until it receives an initial resource assignment. The WTRU may also perform collision detection and resolution, if other WTRUs are attempting to access the RACH during this time. Once the WTRU has received permission to access the RACH, the WTRU may transmit data until the resources are released or the WTRU transitions to another state.

As mentioned above, it was proposed to use the E-DCH in a CELL_FACH state to increase the data rate of the shared channel. However, in the current standard, there are no methods to terminate the E-RACH message phase. Accordingly, it would be beneficial to provide a method and apparatus to terminate an E-RACH message phase in an E-RACH.

SUMMARY

A method and an apparatus is provided for terminating an E-RACH message in an E-RACH transmission. Triggers for terminating the E-RACH message are also provided. The actions upon termination of the E-RACH messages or transition to CELL_DCH state are provided in order to release the shared E-DCH resources while in the CELL_FACH state.

A method for terminating an enhanced random access channel (E-RACH) message in an E-RACH transmission determining that a buffer is empty; triggering a transmission of a scheduling information (SI) with the value of total enhanced dedicated channel (E-DCH) buffer status (TEBS) equal to zero; determining last hybrid automatic repeat request (HARQ) data transmission; and releasing the E-DCH resources allocation is provided.

A method for terminating an enhanced random access channel (E-RACH) message in an E-RACH transmission where the network waits until a HARQ buffer is empty and when the SI with a value of zero is received, the resources are released.

BRIEF DESCRIPTION OF THE DRAWINGS

A more detailed understanding may be had from the following description, given by way of example and to be understood in conjunction with the accompanying drawings wherein:

FIG. 1 is a diagram of an E-RACH access with an E-DCH; FIG. 2 shows a wireless communication system;

FIG. 3 is a functional block diagram of a WTRU and the base station of the wireless communication system shown in FIG. 2;

FIG. 4 is a flow diagram of a E-DCH resource allocation and de-allocation;

FIG. 5 is a diagram of triggers for starting the timer that the WTRU may initiate for the timers;

FIG. 6 is a flow diagram of a method to release E-DCH resources based on the status of a WTRU's queue or buffer;

FIG. 7 is a flow diagram of a network configured to determine termination of an E-RACH message transmission;

FIG. 8 is a flow diagram of E-DCH resources release when the WTRU transitions from the CELL_FACH state to the CELL_DCH state; and

FIG. 9 is a flow diagram for releasing the E-DCH resources while in the CELL_FACH state.

DETAILED DESCRIPTION

When referred to hereafter, the terminology "wireless transmit/receive unit (WTRU)" includes but is not limited to

US 9,313,809 B2

3

a user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital assistant (PDA), a computer, or any other type of user device capable of operating in a wireless environment. When referred to hereafter, the terminology “base station” includes

but is not limited to a Node-B, a site controller, an access point (AP), or any other type of interfacing device capable of operating in a wireless environment.

When referred to herein, the term RACH and E-RACH may be used to describe a resource that is selected by a WTRU for uplink contention based access. The term E-RACH resource may also indicate any combination of a scrambling code, a channelization code, a timeslot, an access opportunity, or a signature sequence that are associated to an E-RACH channel in a future system architecture. The term E-RACH may also indicate the use of the E-DCH in CELL_FACH, CELL_PCH, URA_PCH states or Idle mode.

When referred to hereafter, the term enhanced medium access control (MAC)-e/es entities may refer to the MAC entities used to perform E-DCH transmission in the CELL_FACH state, which in release 8 is referred to as MAC-i/is. MAC-e/es and MAC-i/is are the MAC entities that handle the transport channel such as the enhanced dedicated transport channel (E-DCH).

FIG. 2 shows a wireless communication system 200 including a plurality of WTRUs 210, a base station 220, a CRNC 230, an SRNC 240, and a core network 250. As shown in FIG. 2, the WTRUs 210 are in communication with the base station 220, which is in communication with the CRNC 230 and the SRNC 240. Although three WTRUs 210, one base station 220, one CRNC 230, and one SRNC 240 are shown in FIG. 3, it should be noted that any combination of wireless and wired devices may be included in the wireless communication system 200.

FIG. 3 is a functional block diagram 300 of a WTRU 210 and the base station 220 of the wireless communication system 200 of FIG. 2. As shown in FIG. 3, the WTRU 210 is in communication with the base station 220 and both are configured to perform a method to terminate transmission of a message in an E-RACH.

In addition to the components that may be found in a typical WTRU, the WTRU 210 includes a processor 215, a receiver 216, a transmitter 217, and an antenna 218. The processor 215 is configured to perform a method to terminate transmission of a message in an E-RACH. The receiver 216 and the transmitter 217 are in communication with the processor 215. The antenna 218 is in communication with both the receiver 216 and the transmitter 217 to facilitate the transmission and reception of wireless data.

In addition to the components that may be found in a typical base station, the base station 220 includes a processor 225, a receiver 226, a transmitter 227, and an antenna 228. The processor 225 is configured to perform a method to terminate transmission of a message in an E-RACH. The receiver 226 and the transmitter 227 are in communication with the processor 225. The antenna 228 is in communication with both the receiver 226 and the transmitter 227 to facilitate the transmission and reception of wireless data.

FIG. 4 is a flow diagram of E-DCH resource allocation and de-allocation 400 using triggering for a WTRU. The first state corresponds to a WTRU 210 that operates with no E-DCH resources allocated to it 405. Once uplink (UL) data has to be transmitted, the WTRU 210 requests E-DCH resources from the network, by transmitting a preamble and waiting for the response on the acquisition indication channel (AICH). In other words, the WTRU 210 may remain in this state until it receives a positive acknowledgement (ACK) on the AICH, or

4

a negative acknowledgement (NACK) on the AICH followed by a resource assignment index over the E-AICH, which may also be referred to as the WTRU 210 receiving an E-DCH index. After receiving the E-DCH resource assignment, the WTRU may transition to the next state wherein E-DCH resources are allocated for enhanced uplink transmissions 410. The WTRU 210 may use these E-DCH resources for UL transmission until it receives a trigger, at which point the WTRU 210 will release the resources 415. After the WTRU 210 releases the resources, it returns to the initial state. As will be described in further detail hereafter, the trigger may be timer based, it may be based on the WTRU buffer status, or may be based on signaling from the RNC or the Node-B 220.

In one embodiment, the WTRU 210 may be configured to include a timer module. The timer module may include multiple timers, wherein a timer may be associated to each logical channel or each MAC-d flow. The timer module may be configured to indicate the maximum allowable transmission time for a logical channel (i.e., dedicated control channel (DCCH), dedicated traffic channel (DTCH), common control channel (CCCH), etc.). The values for the timer module may be preconfigured or signaled to the WTRU 210. The timers may be activated upon the WTRU's 210 first transmission, once an E-DCH resource index is received. The WTRU may be configured to release an E-DCH resource upon expiry of its associated timer. For example, the WTRU 210 may be configured to release a common E-DCH resource when the maximum common E-DCH resource allocation time for the CCCH has been reached. This embodiment would allow the flexibility to configure a smaller transmission time duration for a logical channel such as the CCCH.

The timer module may also be configured based on logical channel identity and the absence of an E-DCH radio network temporary identifier (E-RNTI). More specifically, a maximum E-DCH allocation time may be allocated to the CCCH transmission when an E-RNTI is not present. If the timer expires, and the WTRU 210 that is performing a CCCH transmission does not have the E-RNTI present, the E-RACH access is terminated and the resources are released. If a CCCH transmission is occurring and an E-RNTI is present, (which may occur during period cell update procedure) then the WTRU 210 is not configured to have a maximum E-DCH allocation time and the timer will not affect the WTRU 210.

Alternatively, the network may configure the transmission duration timer based on the presence or absence of an E-RNTI. The WTRU 210 may be configured to have a maximum E-DCH allocation time if it has data (user plane or control plane) to transmit and no E-RNTI is present. Otherwise if an E-RNTI is present the WTRU 210 is not configured with a maximum E-DCH allocation time.

FIG. 5 shows a diagram of triggers for starting the timer that the WTRU 210 may initiate for the timers T_1 and T_2 500. The timers such as collision resolution T_1 and CCCH timer T_2 are started according to one of the triggers 501 to 505. This embodiment may include any combination of at least one of the shown trigger 501-505 for starting the timer 506. The timer may start if an ACK associated to the preamble signature transmitted is received on the AICH or E-AICH 501. The timer may start as soon as the radio resource control (RRC) provides the MAC with the timer values, and after receiving the E-DCH resource index 502. The timer may start if the WTRU 210 starts the first dedicated physical control channel (DPCCH) preamble transmission 503. The timer may start when the initial DPCCH transmission is completed after E-DCH transmission backoff transmission time intervals (TTIs) or the first MAC protocol data unit (PDU) is passed to the physical layer 504. Or, the timer may start when the

US 9,313,809 B2

5

WTRU 210 starts the E-DCH transmission 505. In addition, the WTRU 210 may initiate the timer when the collision resolution E-DCH absolute grant channel (E-AGCH) carrying the WTRU 210 E-RNTI is received. Other triggers may also be used as designed.

Alternatively, the WTRU 210 timer module may be configured such that the length of time available to the WTRU 210 is based on the number of data bits that need to be transmitted. The length of the time variable to the WTRU 210 may also be based on the number of radio link controller (RLC) or MAC PDUs. Additionally, it may also be based on the number of RLC service data units (SDUs).

Alternatively, the E-RACH message duration may be fixed at either 10 msec or 20 msec (as is specified in the current 3GPP standards). As a result, the E-RACH message phase may be active for a maximum number of frames or subframes. An E-RACH message duration information element (IE) may be broadcast as part of the system information broadcast (SIB), or may be included as part of L1 signaling. For example, the E-RACH message duration IE may be transmitted with the initial resource assignment or during the collision resolution phase. In addition, the E-RACH message duration may be linked to an access service class.

Alternatively, the WTRU 210 may count the number of transmissions and retransmissions and use the count as a trigger to stop the transmission of the E-RACH message phase. For example, if the WTRU 210 is configured for repeat automatic repeat request (ARQ) type of operation and transmission on consecutive TTIs, then the WTRU may be configured to terminate the transmission of the E-RACH message phase after K retransmissions. It is noted that the value of K may be preconfigured in the WTRU, broadcasted as part of the SIB, or signaled during the E-RACH allocation phase.

FIG. 6 is a flow diagram of a method to release E-DCH resources based on the status of a WTRU's 210 queue or buffer. When the WTRU 210 has data in the transmit buffer, the WTRU 210 may transmit the data 605. After a transmission, the WTRUs 210 may check if the transmit buffer is empty 610. If the transmit buffer is not empty, then the WTRU 210 will transmit the data that is in the buffer 605. If the transmit buffer is empty 610 (i.e., the Total E-DCH Buffer Status (TEBS) is equal to zero), optionally it is checked if an inactivity timer has expired 615. If the inactivity timer has expired, then the WTRU 210 may be configured to transmit a special or reserved value of the SI where TEBS is set to zero 620. The WTRU 210 may be configured to release E-DCH resource 630 after the inactivity timer has expired 615, wherein the inactivity timer is started once the TEBS is equal to zero. The WTRU 210 is considered to be inactive, if no UL or downlink (DL) traffic has been received. Alternatively, the implicit release timers (i.e., the inactivity timer) may be restarted based on a trigger mechanism when the WTRU 210 decodes its H-RNTI on the high speed shared control channel (HS-SCCH). Once the inactivity timer has expired, the WTRU 210 may be configured to transmit a special or reserved value of the SI 620. For example, the special or reserved value of the SI may comprise a TEBS with a value set to zero 620. The SI with the TEBS set to zero may be used to signal to the network for releasing the resources. After successfully transmitting the SI and emptying the HARQ buffers 625, the WTRU 210 releases the E-DCH resources 630.

Alternatively, the WTRU 210 may transmit a signal to the network indicating to release the resources. The signal may comprise a special combination of the SI and a Happy Bit, a new MAC signaling, where a special combination of MAC header fields may be re-interpreted. Alternatively, a field may be added in the enhanced MAC-e header or MAC-e trailer

6

denoting a request to terminate transmission of the E-RACH message phase. For example, the WTRU 210 may transmit this signal to the network via a reserved data description indicator (DDI) combination. In another alternative, the signal may be a new RRC message; special value of the enhanced transport format combination index (E-TFCI) field in the E-DPCCH or a special combination of the E-DPCCH fields; or, a new L1 message. The final decision to release the resources may be determined by the network; which may indicate the release of resources back to the WTRU 210. Alternatively, the WTRU 210 may simply stop transmission of the E-DCH as a means to indicate the termination of the E-RACH message phase, at which point the network may release the radio resources.

Alternatively, the timer module may be configured to start when the WTRU 210 has transmitted all PDUs which were present when the E-RACH was initiated, or the buffer has passed a predetermined threshold level. The threshold level may be an absolute value or based on a relative measure using the initial queue size.

Releasing the resources upon the transmission of all PDUs in the buffer that pass a predetermined threshold level, may free up the E-RACH resources for other WTRUs 210. For example, the threshold levels may be set to allow the network to tradeoff fairness between WTRUs 210 and transmission delay. These levels may be configured through system information or they may be preconfigured in the WTRU 210.

In addition, there may be procedures for physical layer that may trigger a termination of the E-RACH message transmission. This includes cell reselection and measurements controlled by the FACH measurement occasions or detection of radio link (RL) failure.

Alternatively, the WTRU 210 may suspend all transmission during the measurement occasion. Also, the scheduler at the Node-B 220 may be aware of the measurement occasion and may also suspend any grant, ACK, or NACK downlink transmission. Upon resuming normal operation, the network may optionally transmit an initial grant so that the power control loop may be re-established. Or, the network may wait for an indication from the WTRU 210 using a preamble power ramp or similar procedure. Optionally, the WTRU 210 may indicate the reason for termination in the termination signal or the termination message. Reasons for E-RACH termination may include a RL failure and E-RACH transmission complete.

FIG. 7 shows a flow diagram of a network configured to determine termination of an E-RACH message transmission 700. The termination of the E-RACH message phase may be established by the network based on the reception of the amount of data indicated in an initial SI 705 by the Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access Network (UTRAN). Alternatively, it may be established based on the UTRAN receiving the amount of data indicated in subsequent SIs or indicated using a different mechanism. The UTRAN may use the values of SI to determine when to terminate the message transmission. More specifically, an SI with TEBS set to zero 710 signals to the network that the WTRU 210 is releasing the resources once the transmission of data in the HARQ buffers is completed. The UTRAN releases E-DCH resources 720 after SI with TEBS set to zero is received and there is no more HARQ transmission 715.

Alternatively, the UTRAN may simply turn off transmission of the associated F-DPCH and explicit additional signaling is not used. This approach may be used in the case where both the WTRU 210 and the network are aware that the transmission is to be terminated.

US 9,313,809 B2

7

Alternatively, SI may be transmitted every time the buffer occupancy changes. Alternatively, an SI may be transmitted every time the buffer occupancy changes by a pre-defined or signaled amount (i.e., additional data is received in the buffer), even if the new data is not from higher priority logical channels. If the TEBS is equal to zero then the SI triggering mechanism may be modified to allow the SI to be transmitted. The SI with TEBS set to zero signals to the network that the WTRU is releasing the resources once the transmission of data in the HARQ buffers is completed and the UTRAN also releases the E-DCH resources. Alternatively, an SI may be transmitted in every HARQ transmission when the WTRU 210 is in CELL_FACH state or occupying E-RACH resources.

In another termination option, the UTRAN may explicitly signal the end of the E-RACH transmission. Once the UTRAN determines the end of the E-RACH message transmission, it signals to the WTRU 210 by transmitting a special value over the E-AGCH (e.g., a 0 grant). Or, the UTRAN signals to the WTRU 210 by transmitting an RRC message over the FACH or over the High Speed Downlink Shared channel (HS-DSCH) if the WTRU 210 is configured for HS-DSCH in CELL_FACH state. Alternatively, the network signals to the WTRU 210 by using L1 signaling. This may include stopping the fractional dedicated physical channel (F-DPCH) or transmitting a flag or combination of pre-determined fields on the HS-SCCH if the WTRU 210 is configured for HS-DSCH in CELL_FACH state, for example, using an HS-SCCH order.

Alternatively, the termination of the E-RACH message may be established based on a lack of activity on the enhanced dedicated physical data channel (E-DPDCH) or enhanced DPCH (E-DPCCH) transmission.

The termination of the E-RACH part may also be established based on the status of the WTRU 210 scheduling requests. As an example, the UTRAN may monitor the received SI or Happy Bit status. If this information indicates low usage, the network may decide to terminate the current transmission of the E-RACH message so that the other WTRUs 210 may have an opportunity to access the resources. Alternatively, if this information indicates high usage and continued need with the Happy Bit set to unhappy, then the UTRAN may decide to transition the WTRU 210 to CELL_DCH state. As another alternative, the UTRAN may use the traffic volume measurement report (such as uplink RRC measurement report) to determine that the WTRU 210 does not have any further data or a small amount of data to transmit.

Alternatively, the UTRAN may implicitly signal the WTRU 210 to release the E-RACH resource by not transmitting predefined physical channels or signals for a predetermined amount of time. In other words, the WTRU 210 releases the E-RACH resources if it does not receive any transmission from the UTRAN on either channel E-AGCH destined to the WTRU 210, E-RGCH associated with E-RACH resource that is used by the WTRU 210, F-DPCH associated with the E-RACH resource that is used by the WTRU 210, and/or, HS-SCCH or high speed physical downlink shared channel (HS-PDSCH) that is destined to the WTRU 210.

Optionally, the UTRAN may indicate the reason for termination in the termination signal or termination message. Reasons for E-RACH termination may include, but are not limited to an RL failure, completion of the E-RACH transmission, and network congestion.

FIG. 8 is a flow diagram of the E-DCH resources released when the WTRU 210 transitions from the CELL_FACH state to the CELL_DCH state. The WTRU 210 operates without

8

any E-DCH resources allocated 805. Upon receiving an E-DCH resource assignment on the AICH or E-AICH or a NACK on the AICH followed by a resource assignment index over the E-AICH, which may also be referred to as the WTRU 210 receiving an E-DCH index, the WTRU 210 may access the E-DCH resources allocated to it in the CELL_FACH state 810. The WTRU 210 retains control of the E-DCH resources until it receives a reconfiguration message, (e.g., via the FACH or the HS-DSCH), indicating that a switch to the CELL_DCH state may be performed. The E-DCH resources are then released 815. And, the WTRU 210 may transition to the CELL_DCH state 820. If the UTRAN reconfigures the WTRU 210 to the CELL_DCH state with dedicated E-DCH resources while the WTRU 210 is transmitting over the E-RACH, then the WTRU 210 may release the E-RACH resources at the activation time that is specified in the reconfiguration message in the case of synchronous reconfiguration. Alternatively, the WTRU 210 may release the E-RACH resources at a fixed delay prior to or after the activation time. Alternatively, the WTRU 210 may release the E-RACH resources immediately upon reception of the RRC reconfiguration message.

Additionally, the WTRU 210 may be configured to release the E-RACH resources at the same time as it configures itself for a transmission over the dedicated E-DCH resources. Alternatively, the WTRU 210 may release the E-RACH resources at a fixed delay prior to or after configuring itself for transmission using the dedicated E-DCH resources; or, release the E-RACH resources once the WTRU 210 is fully synchronized with the UTRAN with the dedicated E-DCH resources.

FIG. 9 is a flow chart of a procedure for releasing the E-DCH resources while in the CELL_FACH state or idle mode, when the E-RACH termination triggers occur. The WTRU 210 begins the E-RACH termination process 905. The WTRU 210 may be configured to stop any E-AGCH, E-RGCH, and E-HICH reception procedures that are occurring 910. The WTRU 210 may be further configured to stop any E-DPCCH and E-DPDCH transmission procedures that are occurring 915. The WTRU 210 may then perform a MAC reset procedure 920 and release HARQ buffers 930. The enhanced MAC-e/es reset procedure may include flushing the HARQ processes, discarding any remaining segments in the segmentation entity of the enhanced MAC-e/es and resetting the CURRENT_transmission sequence number (TSN) value to zero. Alternatively, if the remaining segment is from a DTCH or a DCCH logical channel the WTRU 210 may resume transmission of the segment at a remaining process. An indication may be transmitted to the SRNC 240 via Iub signaling to discard any stored segment and reset the TSN reordering numbers.

If the E-DCH has terminated and the DTCH or the DCCH transmission is active, the WTRU 210 may flush the HARQ processes 930 and discard any remaining segments in the segmentation entity of the MAC-i/is.

The other logical channels or queues of the MAC-i/is entity that do not correspond to the CCCH are not reset. The Node-B 220 may be configured to perform a reset of the MAC-i entity of the CCCH. In other words, any segment may be discarded and the expected TSN is set to its initial value. If the MAC-is entity is in the CRNC 230, Node-B 220 uses Iub signaling indicating to the MAC-is entity to perform a reset. In addition, the MAC-i entity associated to the E-DCH resource is reset (i.e., HARQ soft buffers are flushed).

When the WTRU 210 performs a full MAC-i/is reset, the MAC-is entity in the SRNC 240 may be notified via a new Iub/Iur signaling that E-RACH access has been terminated;

US 9,313,809 B2

9

thus MAC-e entity in the SRNC 240 may also perform a reset. More specifically, when the Node-B 220 terminates the E-DCH connection with the WTRU 210, it releases the E-DCH resources, flushes the HARQ buffers, and notifies the SRNC 240 or CRNC 230 that the connection has been terminated and thus the CRNC 230 or SRNC 240 also perform a reset of the MAC. The CRNC 230 or SRNC 240 is notified via Iub or Iur signaling. A new control bit may be introduced in the Iub or Iur frame format or a new frame format may be defined to signal to the SRNC 240 or CRNC 230 the release of the resources.

Also, optionally, the reset of the MAC-i/is or only discarding of the segments may be performed after a time interval (Tr) because the termination of the E-RACH resource. The timer is also initiated in the network side. Tr may be a system configured timer signaled to the WTRU 210 via RRC message, via system information block (SIB), or preconfigured in the WTRU 210. The timer is initiated as soon as the E-DCH resources are terminated in the WTRU 210.

The WTRU 210 may be configured to stop the timer if it is running and if the WTRU 210 attempts to perform E-RACH access. Also, the WTRU 210 may also stop the timer, if the WTRU 210 attempts the E-RACH access and obtains the E-DCH resources assigned, or the WTRU 210 obtains the E-DCH resources assigned and resolves the contention resolution phase.

Alternatively, the WTRU 210, the Node-B 220 and/or the RNCs may be configured with a TSN_RESET_TIMER, wherein the WTRU 210 is configured to perform a TSN reset when the timer expires. Optionally, the WTRU 210 may perform a full enhanced MAC-e/es reset procedure when the timer expires.

The E-DCH resources are released when a transition from CELL_FACH to CELL_DCH occurs.

The WTRU 210 and the RNC may reset the value of the last used TSN number (i.e., CURRENT_TSN) to the initial value upon the release of the E-DCH resource set being used by the WTRU 210. The WTRU 210 and the RNC may each include synchronized timers, wherein the expiry of the timer signals the release of the E-DCH resources. After the timer expires and the resources are released, the WTRU 210 may reset the TSN and optionally perform a full enhanced MAC-e/es reset procedure.

Alternatively, the UTRAN may order the release of the resources. The UTRAN may signal the WTRU indicating that the resources must be released. In this case, upon reception of the message, the WTRU 210 and UTRAN reset the TSN to an initial value.

Alternatively, the TSN number may be reset upon the expiration of an inactivity timer. In this case, an inactivity timer may be started in both the WTRU 210 and the network after the last MAC-e PDU is transmitted and received, respectively. If the timer expires, the WTRU 210 and the RNC resets the TSN to its initial value. Optionally, a full enhanced MAC-e/es reset procedure may be performed.

In another alternative, the TSN number may not reset. The last TSN values used are stored in memory and continuously incremented for each new transmission, regardless of the E-DCH resource set being used or the time in which the transmission is taking place.

Alternatively, the TSN number may be set to its initial value and optionally a full enhanced MAC-e/es reset may take place when a cell reselection occurs. Resetting the TSN or the MAC-e/es may always occur after the WTRU 210 performs cell reselection. Alternatively, it may only occur when a serving radio network subsystem (SRNS) relocation occurs. The RNC may signal the TSN reset via an explicit enhanced

10

MAC-e/es reset indicator or the WTRU 210 may implicitly detect that SRNS relocation has occurred due to the presence or the change of a new UTRAN RNTI (U-RNTI).

Although features and elements are described above in particular combinations, each feature or element may be used alone without the other features and elements or in various combinations with or without other features and elements. The methods or flow charts provided herein may be implemented in a computer program, software, or firmware tangibly embodied in a computer-readable storage medium for execution by a general purpose computer or a processor. Examples of computer-readable storage mediums include a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, and optical media such as CD-ROM disks, and digital versatile disks (DVDs).

Suitable processors include, by way of example, a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Arrays (FPGAs) circuits, any other type of integrated circuit (IC), and/or a state machine.

A processor in association with software may be used to implement a radio frequency transceiver for use in a wireless transmit receive unit (WTRU), user equipment (UE), terminal, base station, radio network controller (RNC), or any host computer. The WTRU may be used in conjunction with modules, implemented in hardware and/or software, such as a camera, a video camera module, a videophone, a speakerphone, a vibration device, a speaker, a microphone, a television transceiver, a hands free headset, a keyboard, a Bluetooth® module, a frequency modulated (FM) radio unit, a liquid crystal display (LCD) display unit, an organic light-emitting diode (OLED) display unit, a digital music player, a media player, a video game player module, an Internet browser, and/or any wireless local area network (WLAN) or Ultra Wide Band (UWB) module.

What is claimed is:

1. A method performed by a wireless transmit/receive unit (WTRU) to communicate with a base station using an enhanced dedicated channel (E-DCH) resource while in a cell forward access channel (CELL_FACH) state, the method comprising:

determining if a E-DCH buffer is empty;
transmitting to the base station scheduling information (SI), wherein the SI includes a total E-DCH buffer status (TEBS) equal to zero when the E-DCH buffer is determined to be empty;
determining if a hybrid automatic repeat request (HARQ) buffer is empty;
and
releasing the E-DCH resource when the transmission of the SI with the TEBS equal to zero has been made and the HARQ buffer is empty.

2. The method as in claim 1, further comprising starting an inactivity timer when the E-DCH buffer is empty.

3. The method as in claim 2, further comprising triggering the transmission of the SI when the inactivity timer expires.

4. The method as in claim 1, further comprising transmitting using the E-DCH resource when a response is received on an E-DCH acquisition indication channel (E-AICH) to a preamble transmitted by the WTRU.

US 9,313,809 B2

11

5. The method as in claim 1, further comprising completing an E-DCH transmission when a cell reselection or a radio link failure occurs.

6. A wireless transmit/receive unit (WTRU) capable of communicating with a base station using an enhanced dedicated channel (E-DCH) resource while in a cell forward access channel (CELL_FACH) state, the WTRU comprising:

a E-DCH buffer;
a transmitter;
a hybrid automatic repeat request (HARQ) buffer; and
a processor;

wherein the processor:

determines if the E-DCH buffer is empty;
causes the transmitter to transmit to the base station scheduling information (SI), wherein the SI includes a total E-DCH buffer status (TEBS) equal to zero for the E-DCH buffer when the processor has determined that the E-DCH buffer is empty;

determines if the HARQ buffer is empty; and
releases the E-DCH resource when the transmission of the SI with the TEBS equal to zero has been made and the HARQ buffer is empty.

7. The WTRU as in claim 6, wherein the processor completes an E-DCH transmission when a cell reselection or a radio link failure occurs.

8. The WTRU as in claim 6, wherein the processor starts an inactivity timer when the E-DCH buffer is empty.

9. The WTRU as in claim 8, wherein the transmitter transmits the SI when the inactivity timer expires.

10. The WTRU as in claim 6, wherein the transmitter transmits using the E-DCH resource when a response is received on an E-DCH acquisition indication channel (E-AICH) to a preamble transmitted by the WTRU.

11. A wireless transmit/receive unit (WTRU) capable of communicating with a base station using an enhanced dedicated channel (E-DCH) resource, the WTRU comprising:

a transmitter; and
a processor;

wherein the processor:

determines if an E-DCH buffer is empty;
transmits to the base station scheduling information (SI), wherein the SI includes a total E-DCH buffer status (TEBS) equal to zero for the E-DCH buffer when the processor has determined that the E-DCH buffer is empty;

determines if a last hybrid automatic repeat request (HARQ) data transmission has been made; and
releases the E-DCH resource when the transmission of the SI with the TEBS equal to zero has been made and the last HARQ data transmission has been made.

12. The WTRU as in claim 11, wherein the processor completes an E-DCH transmission when a cell reselection or a radio link failure occurs.

13. The WTRU as in claim 11, wherein the processor starts an inactivity timer when the E-DCH buffer is empty.

14. The WTRU as in claim 13, wherein the transmitter transmits the SI when the inactivity timer expires.

15. The WTRU as in claim 11, wherein the transmitter transmits using the E-DCH resource when a response is received on an E-DCH acquisition indication channel (E-AICH) to a preamble transmitted by the WTRU.

16. A method performed by a wireless transmit/receive unit (WTRU) to communicate with a base station using an enhanced dedicated channel (E-DCH) resource while in a cell forward access channel (CELL_FACH) state, the method comprising:

determining that a E-DCH buffer is empty;

12

transmitting to the base station scheduling information (SI), wherein the SI includes a total E-DCH buffer status (TEBS) equal to zero for the empty E-DCH buffer; determining if a last hybrid automatic repeat request (HARQ) buffer is empty; and

releasing the E-DCH resource when the transmission of the SI with the TEBS equal to zero has been made and the last HARQ buffer is empty.

17. The method as in claim 16, further comprising starting an inactivity timer when the E-DCH buffer is empty.

18. The method as in claim 17, further comprising triggering the transmission of the SI when the inactivity timer expires.

19. The method as in claim 16, further comprising transmitting using the E-DCH resource when a response is received on an E-DCH acquisition indication channel (E-AICH) to a preamble transmitted by the WTRU.

20. The method as in claim 16, further comprising completing an E-DCH transmission when a cell reselection or a radio link failure occurs.

21. A method performed by a wireless transmit/receive unit (WTRU) to communicate with a base station using an enhanced dedicated channel (E-DCH) resource while in a cell forward access channel (CELL_FACH) state, the method comprising:

determining that a E-DCH buffer is empty;
transmitting to the base station scheduling information (SI), wherein the SI includes a total E-DCH buffer status (TEBS) equal to zero for the empty E-DCH buffer; and
releasing the E-DCH resource when the transmission of the SI with the TEBS equal to zero has been made and a hybrid automatic repeat request (HARQ) buffer is empty.

22. The method as in claim 21, further comprising starting an inactivity timer when the E-DCH buffer is empty.

23. The method as in claim 22, further comprising triggering the transmission of the SI when the inactivity timer expires.

24. The method as in claim 21, further comprising transmitting using the E-DCH resource when a response is received on an E-DCH acquisition indication channel (E-AICH) to a preamble transmitted by the WTRU.

25. The method as in claim 21, wherein an E-DCH transmission is completed when a cell reselection or a radio link failure occurs.

26. A wireless transmit/receive unit (WTRU) capable of communicating with a base station using an enhanced dedicated channel (E-DCH) resource while in a cell forward access channel (CELL_FACH) state, the WTRU comprising:

a E-DCH buffer;
a transmitter;
a hybrid automatic repeat request (HARQ) buffer; and
a processor;

wherein the processor:

determines if the E-DCH buffer is empty;
causes the transmitter to transmit to the base station scheduling information (SI), wherein the SI includes a total E-DCH buffer status (TEBS) equal to zero for the E-DCH buffer when the processor has determined that the E-DCH buffer is empty; and
releases the E-DCH resource when the transmission of the SI with the TEBS equal to zero has been made and the HARQ buffer is empty.

27. The WTRU as in claim 26, wherein the processor completes an E-DCH transmission when a cell reselection or a radio link failure occurs.

US 9,313,809 B2

13

28. The WTRU as in claim 26, wherein the processor starts an inactivity timer when the E-DCH buffer is empty.

29. The WTRU as in claim 28, wherein the processor causes the transmitter to transmit the SI when the inactivity timer expires.

30. The WTRU as in claim 26, wherein the transmitter transmits using the E-DCH resource when a response is received on an E-DCH acquisition indication channel (E-AICH) to a preamble transmitted by the WTRU.

31. A wireless transmit/receive unit (WTRU) capable of communicating with a base station using an enhanced dedicated channel (E-DCH) resource, the WTRU comprising:

a transmitter; and

a processor;

wherein the processor:

determines if an E-DCH buffer is empty;

causes the transmitter to transmit to the base station scheduling information (SI), wherein the SI includes a total E-DCH buffer status (TEBS) equal to zero for the E-DCH buffer when the processor has determined that the E-DCH buffer is empty; and

releases the E-DCH resource when the transmission of the SI with the TEBS equal to zero has been made and a last hybrid automatic repeat request (HARQ) data transmission has been made.

32. The WTRU as in claim 31, the processor completes an E-DCH transmission when a cell reselection or a radio link failure occurs.

33. The WTRU as in claim 31, wherein the processor starts an inactivity timer when the E-DCH buffer is empty.

34. The WTRU as in claim 33, wherein the processor causes the transmitter to transmit the SI when the inactivity timer expires.

35. The WTRU as in claim 31, wherein the transmitter transmits using the E-DCH resource when a response is received on an E-DCH acquisition indication channel (E-AICH) to a preamble transmitted by the WTRU.

36. A method performed by a wireless transmit/receive unit (WTRU) to communicate with a base station using an enhanced dedicated channel (E-DCH) resource while in a cell forward access channel (CELL_FACH) state, the method comprising:

determining that a E-DCH buffer is empty;

transmitting to the base station scheduling information (SI), wherein the SI includes a total E-DCH buffer status (TEBS) equal to zero for the empty E-DCH buffer; and releasing the E-DCH resource when the transmission of the SI with the TEBS equal to zero has been made and a last hybrid automatic repeat request (HARQ) buffer is empty.

37. The method as in claim 36, further comprising starting an inactivity timer when the E-DCH buffer is empty.

38. The method as in claim 37, further comprising triggering the transmission of the SI when the inactivity timer expires.

39. The method as in claim 36, further comprising transmitting using the E-DCH resource when a response is received on an E-DCH acquisition indication channel (E-AICH) to a preamble transmitted by the WTRU.

40. The method as in claim 36, further comprising completing an E-DCH transmission when a cell reselection or a radio link failure occurs.

41. A method performed by a wireless transmit/receive unit (WTRU) to communicate with a base station using an enhanced dedicated channel (E-DCH) resource while in a cell forward access channel (CELL_FACH) state, the method comprising:

14

transmitting to the base station scheduling information (SI) including a total E-DCH buffer status (TEBS) equal to zero; and

releasing the E-DCH resource when the transmission of the SI with the TEBS equal to zero has been made and a hybrid automatic repeat request (HARQ) buffer is empty.

42. The method as in claim 41, further comprising starting an inactivity timer when the E-DCH buffer is empty.

43. The method as in claim 42, further comprising triggering the transmission of the SI when the inactivity timer expires.

44. The method as in claim 41, further comprising transmitting using the E-DCH resource when a response is received on an E-DCH acquisition indication channel (E-AICH) to a preamble transmitted by the WTRU.

45. The method as in claim 41, further comprising completing an E-DCH transmission when a cell reselection or a radio link failure occurs.

46. An apparatus capable of communicating with a base station using an enhanced dedicated channel (E-DCH) resource while in a cell forward access channel (CELL_FACH) state, the apparatus comprising:

an E-DCH buffer;

a transmitter;

a hybrid automatic repeat request (HARQ) buffer; and

a processor,

wherein the processor:

causes the transmitter to transmit to the base station scheduling information (SI) including a total E-DCH buffer status (TEBS) equal to zero; and

releases the E-DCH resource when the transmission of the SI with the TEBS equal to zero has been made and the HARQ buffer is empty.

47. The apparatus as in claim 46, wherein the processor completes an E-DCH transmission when a cell reselection or a radio link failure occurs.

48. The apparatus as in claim 46, wherein the processor starts an inactivity timer when the E-DCH buffer is empty.

49. The apparatus as in claim 48, wherein the processor causes the transmitter to transmit the SI when the inactivity timer expires.

50. The apparatus as in claim 46, wherein the processor causes the transmitter to transmit an E-DCH transmission to the base station when a response is received on an E-DCH acquisition indication channel (E-AICH) to a preamble transmitted by the WTRU.

51. A wireless transmit/receive unit (WTRU) capable of communicating with a base station using an enhanced dedicated channel (E-DCH) resource, the WTRU comprising:

a transmitter; and

a processor,

wherein the processor:

causes the transmitter to transmit to the base station scheduling information (SI) including a total E-DCH buffer status (TEBS) equal to zero; and

releases the E-DCH resource when the transmission of the SI with the TEBS equal to zero has been made and a last hybrid automatic repeat request (HARQ) data transmission has been made.

52. The WTRU as in claim 51, wherein the processor completes an E-DCH transmission when a cell reselection or a radio link failure occurs.

53. The WTRU as in claim 51, wherein the processor starts an inactivity timer when the E-DCH buffer is empty.

US 9,313,809 B2

15

54. The WTRU as in claim 53, wherein the processor causes the transmitter to transmit the SI when the inactivity timer expires.

55. The WTRU as in claim 51, wherein the transmitter transmits using the E-DCH resource to the base station when a response is received on an E-DCH acquisition indication channel (E-AICH) to a preamble transmitted by the WTRU.

56. A method performed by a wireless transmit/receiver unit (WTRU) to communicate with a base station using an enhanced dedicated channel (E-DCH) resource while in a cell forward access channel (CELL_FACH) state, the method comprising:

transmitting to the base station scheduling information (SI) including a total E-DCH buffer status (TEBS) equal to zero; and

releasing the E-DCH resource when the transmission of the SI with the TEBS equal to zero has been made and a last hybrid automatic repeat request (HARQ) buffer is empty.

57. The method as in claim 56, further comprising starting an inactivity timer when the E-DCH buffer is empty.

58. The method as in claim 57, further comprising triggering the transmission of the SI when the inactivity timer expires.

59. The method as in claim 56, further comprising transmitting using the E-DCH resource to the base station when a response is received on an E-DCH acquisition indication channel (E-AICH) to a preamble transmitted by the WTRU.

60. The method as in claim 56, further comprising completing an E-DCH transmission when a cell reselection or a radio link failure occurs.

61. An apparatus comprising:

a receiver;
a transmitter; and
a processor,

wherein the processor:

allocates an enhanced uplink (EU) resource and an associated hybrid automatic repeat request (HARQ) process for a wireless transmit receive unit (WTRU) based on a request received from the WTRU by the receiver;

causes the transmitter to transmit to the WTRU information regarding the allocated EU resource, and

releases the allocated EU resource when a scheduling information (SI) is received from the WTRU by the receiver with an E-DCH buffer status (TEBS) equal to zero and a HARQ transmission associated with the HARQ process is completed.

62. The apparatus of claim 61, wherein the processor causes the transmitter to transmit the allocated EU resources information to the WTRU via an enhanced acquisition indication channel.

63. The apparatus of claim 61, wherein the receiver receives a random access channel preamble from the WTRU

16

and the transmitter transmits a response to the random access channel preamble prior to the transmission of the allocated EU resources information.

64. The apparatus of claim 63, wherein the receiver receives EU data from the WTRU after the transmission of the allocated EU resources information.

65. The apparatus of claim 64, wherein the HARQ process generates acknowledgments (ACKs) and negative acknowledgements (NACKs) in response to the received EU data, and the transmitter transmits the HARQ ACKs and NACKs to the WTRU.

66. The apparatus of claim 61, wherein the HARQ process is completed when a HARQ buffer controlled by the HARQ process is empty.

67. The apparatus of claim 61, wherein the apparatus is a base station.

68. A method performed by a base station to communicate with a wireless transmit/receive unit (WTRU), the method comprising:

receiving a request from the WTRU;

allocating an enhanced uplink (EU) resource and an associated hybrid automatic repeat request (HARQ) process for the WTRU based on the received request;

transmitting information regarding the allocated EU resources to the WTRU;

and

releasing the allocated EU resource when a scheduling information (SI) is received from the WTRU with an E-DCH buffer status (TEBS) equal to zero and a HARQ transmission associated with the HARQ process is completed.

69. The method of claim 68, further comprising transmitting the allocated EU resources information to the WTRU via an enhanced acquisition indication channel.

70. The method of claim 68, further comprising:

receiving a random access channel preamble from the WTRU; and

transmitting a response to the random access channel preamble prior to the transmission of the allocated EU resources information.

71. The method of claim 70, further comprising:

receiving EU data from the WTRU after the transmission of the allocated EU resources information.

72. The method of claim 71, further comprising:

generating, by the HARQ process, acknowledgments (ACKs) and negative acknowledgements (NACKs) in response to the received EU data; and

transmitting the HARQ ACKs and NACKs to the WTRU.

73. The method of claim 68, wherein the HARQ process is completed when a HARQ buffer controlled by the HARQ process is empty.

* * * * *

EXHIBIT 5

(10) **Patent No.:** US 9,065,486 B2
(45) **Date of Patent:** *Jun. 23, 2015

(54) **DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES**

USPC 714/755, 786, 490, 752, 701, 800
See application file for complete search history.

(71) Applicant: **InterDigital Technology Corporation,**
Wilmington, DE (US)

(72) Inventors: **Philip J. Pietraski**, Jericho, NY (US);
Gregory S. Sternberg, Mt. Laurel, NJ
(US)

(73) Assignee: **InterDigital Technology Corporation,**
Wilmington, DE (US)

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

This patent is subject to a terminal disclaimer.

(21) Appl. No.: 14/300,734

(22) Filed: **Jun. 10, 2014**

(65) **Prior Publication Data**

US 2014/0289592 A1 Sep. 25, 2014

Related U.S. Application Data

(63) Continuation of application No. 13/744,984, filed on Jan. 18, 2013, now Pat. No. 8,788,920, which is a continuation of application No. 13/309,962, filed on Dec. 2, 2011, now Pat. No. 8,359,520, which is a

(Continued)

(51) **Int. Cl.**
H03M 13/00 (2006.01)
H03M 13/27 (2006.01)
H03M 13/29 (2006.01)

(52) **U.S. CI.**
CPC *H03M 13/2771* (2013.01); *H03M 13/2957*
(2013.01); *H03M 13/6362* (2013.01); *H03M*
13/6381 (2013.01); *H03M 13/005* (2013.01);
H03M 13/2792 (2013.01)

(58) **Field of Classification Search**

CPC H03M 13/091

References Cited

U.S. PATENT DOCUMENTS

6,266,795	B1	7/2001	Wei
6,370,669	B1	4/2002	Eroz et al.

(Continued)

FOREIGN PATENT DOCUMENTS

KR	2002-0004478	1/2002
WO	00/11791	3/2000

(Continued)

OTHER PUBLICATIONS

“Universal Mobile Telecommunications System (UMTS); Multiplexing and channel coding (FDD); (3GPP TS 25.212 version 5.1.0 Release 5),” ETSI TS 125 212 V5.1.0 (Jun. 2002).

(Continued)

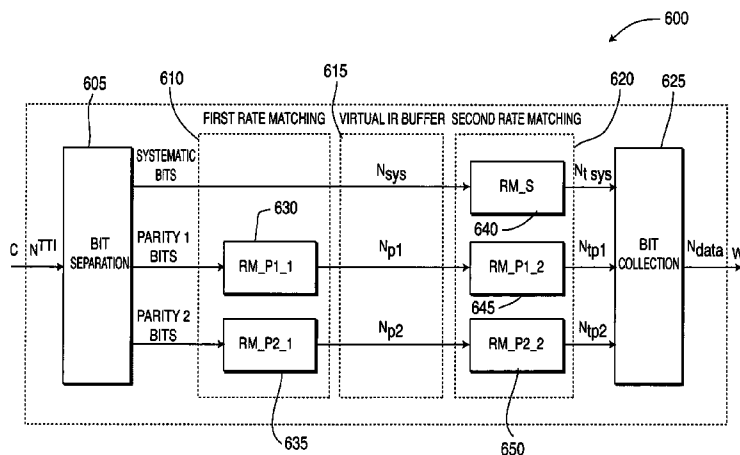
Primary Examiner — Fritz Alphonse

(74) *Attorney, Agent, or Firm* — Volpe and Koenig, P.C.

(57) **ABSTRACT**

Detecting, avoiding and/or correcting problematic puncturing patterns in parity bit streams used when implementing punctured Turbo codes is achieved without having to avoid desirable code rates. This enables identification/avoidance of regions of relatively poor Turbo code performance. Forward error correction comprising Turbo coding and puncturing achieves a smooth functional relationship between any measure of performance and the effective coding rate resulting from combining the lower rate code generated by the Turbo encoder with puncturing of the parity bits. In one embodiment, methods to correct/avoid degradations due to Turbo coding are implemented by puncturing interactions when two or more stages of rate matching are employed.

6 Claims, 12 Drawing Sheets



US 9,065,486 B2

Page 2

Related U.S. Application Data

continuation of application No. 11/974,381, filed on Oct. 12, 2007, now Pat. No. 8,074,143, which is a continuation of application No. 10/725,779, filed on Dec. 2, 2003, now Pat. No. 7,293,217.

- (60) Provisional application No. 60/470,921, filed on May 15, 2003, provisional application No. 60/444,068, filed on Jan. 30, 2003, provisional application No. 60/434,232, filed on Dec. 16, 2002.

(56) References Cited**U.S. PATENT DOCUMENTS**

6,397,367	B1	5/2002	Park et al.	
6,476,734	B2	11/2002	Jeong et al.	
6,601,214	B1	7/2003	Hammons, Jr.	
6,622,281	B1	9/2003	Yun et al.	
6,631,491	B1	10/2003	Shibutani et al.	
6,665,813	B1	12/2003	Forsman et al.	
6,665,833	B1	12/2003	Tong et al.	
6,744,744	B1	6/2004	Tong et al.	
6,845,482	B2	1/2005	Yao et al.	
7,028,230	B2	4/2006	Manninen et al.	
7,076,726	B1	7/2006	Yun et al.	
7,089,450	B2	8/2006	Anderson et al.	
7,295,625	B2	11/2007	Doetsch et al.	
8,726,121	B2 *	5/2014	Malladi et al.	714/755
2002/0027956	A1	3/2002	Lee et al.	
2002/0141433	A1	10/2002	Kwon et al.	
2003/0007476	A1	1/2003	Kim et al.	
2009/0041110	A1 *	2/2009	Malladi	375/240

FOREIGN PATENT DOCUMENTS

WO	00/65446	6/2000
WO	00/41343	7/2000
WO	00/48353	8/2000
WO	02/33910	4/2002
WO	03/069784	8/2003

OTHER PUBLICATIONS

Interdigital, "Turbo-Coding and Puncturing Interactions On HS-DSCH in R5 HSDPA", TSG-RAN Working Group 1 Meeting #32, R1-030444, (Paris, France May 19-23, 2003).

Mo et al., "Analysis of Puncturing Pattern for High Rate Turbo Codes," IEEE International, 0-7803-5538-5/99, 1999, pp. 547-550.

Nortel Networks, "Proposal for Rate Matching for Turbo Codes," pp. 1-5 (May 12, 1999).

Siemens et al., "HSDPA for the 1.28 Mcps TDD Option—A-VRC Test Methodology and Simulation Assumptions", TSG-RAN Working Group 4 (Radio) Meeting #26, R4-030223, (Madrid, Spain Feb. 17-21, 2003).

Siemens, "Turbo Coder Irregularities in HSDPA", 3GPP TSG-RAN Working Group 1 #32, Toc R1-030421, (Paris, France May 19-23, 2003).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Multiplexing and Channel Coding (FDD) (Release 6)", 3GPP TS 25.212 V6.1.0 (Mar. 2004).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Multiplexing and Channel Coding (TDD) (Release 6)", 3GPP TS 25.222 V6.0.0 (Dec. 2003).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Channel Coding and Multiplexing Examples (Release 4)", 3GPP TS 25.944 V4.1.0 (Jun. 2001).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Medium Access Control (MAC) Protocol Specification (Release 5)", 3GPP TS 25.321 V5.6.0 (Sep. 2003).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; MAC Protocol Specification (Release 5)", 3GPP TS 25.321 V5.2.0 (Sep. 2002).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Medium Access Control (MAC) Protocol Specification (Release 4)", 3GPP TS 25.321 V4.9.0 (Sep. 2003).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; MAC Protocol Specification (Release 4)", 3GPP TS 25.321 V4.6.0 (Sep. 2002).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Medium Access Control (MAC) Protocol Specification (Release 1999)", 3GPP TS 25.321 V3.16.0 (Sep. 2003).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; MAC Protocol Specification (Release 1999)", 3GPP TS 25.321 V3.13.0 (Sep. 2002).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Channel Coding and Multiplexing Samples (Release 1999)", 3GPP TR 25.944 V3.5.0 (Jun. 2001).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Multiplexing and Channel Coding (FDD) (Release 5)", 3GPP TS 25.212 V5.2.0 (Sep. 2002).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Multiplexing and Channel Coding (FDD) (Release 5)", 3GPP TS 25.212 V5.4.0 (Mar. 2003).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Multiplexing and Channel Coding (FDD) (Release 5)", 3GPP TS 25.212 V5.6.0 (Sep. 2003).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Multiplexing and Channel Coding (TDD) (Release 5)", 3GPP TS 25.222 V5.7.0 (Sep. 2004).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Multiplexing and Channel Coding (TDD) (Release 1999)", 3GPP TS 25.222 V3.8.0 (Mar. 2002).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Multiplexing and Channel Coding (TDD) (Release 1999)", 3GPP TS 25.222 V3.10.0 (Sep. 2002).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Multiplexing and Channel Coding (TDD) (Release 4)", 3GPP TS 25.222 V4.5.0 (Sep. 2002).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Multiplexing and Channel Coding (TDD) (Release 4)", 3GPP TS 25.222 V4.6.0 (Dec. 2002).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Multiplexing and Channel Coding (TDD) (Release 5)", 3GPP TS 25.222 V5.2.1 (Oct. 2002).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Multiplexing and Channel Coding (TDD) (Release 5)", 3GPP TS 25.222 V5.4.0 (Mar. 2003).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; Multiplexing and Channel Coding (TDD) (Release 5)", 3GPP TS 25.222 V5.5.0 (Jun. 2003).

Third Generation Partnership Project, "Technical Specification Group Radio Access Network; High Speed Downlink Packet Access: Physical Layer Aspects (Release 5)", 3GPP TR 25.858 V5.0.0 (Mar. 2002).

* cited by examiner

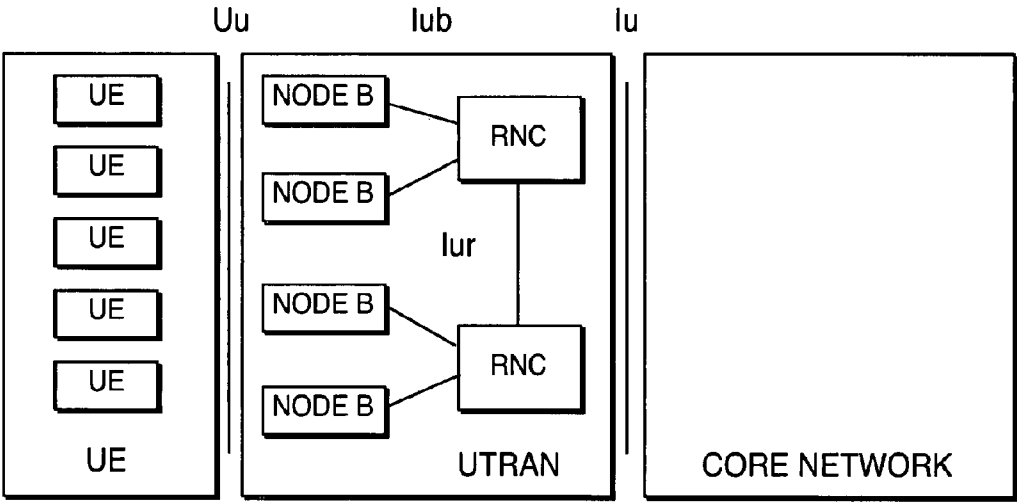
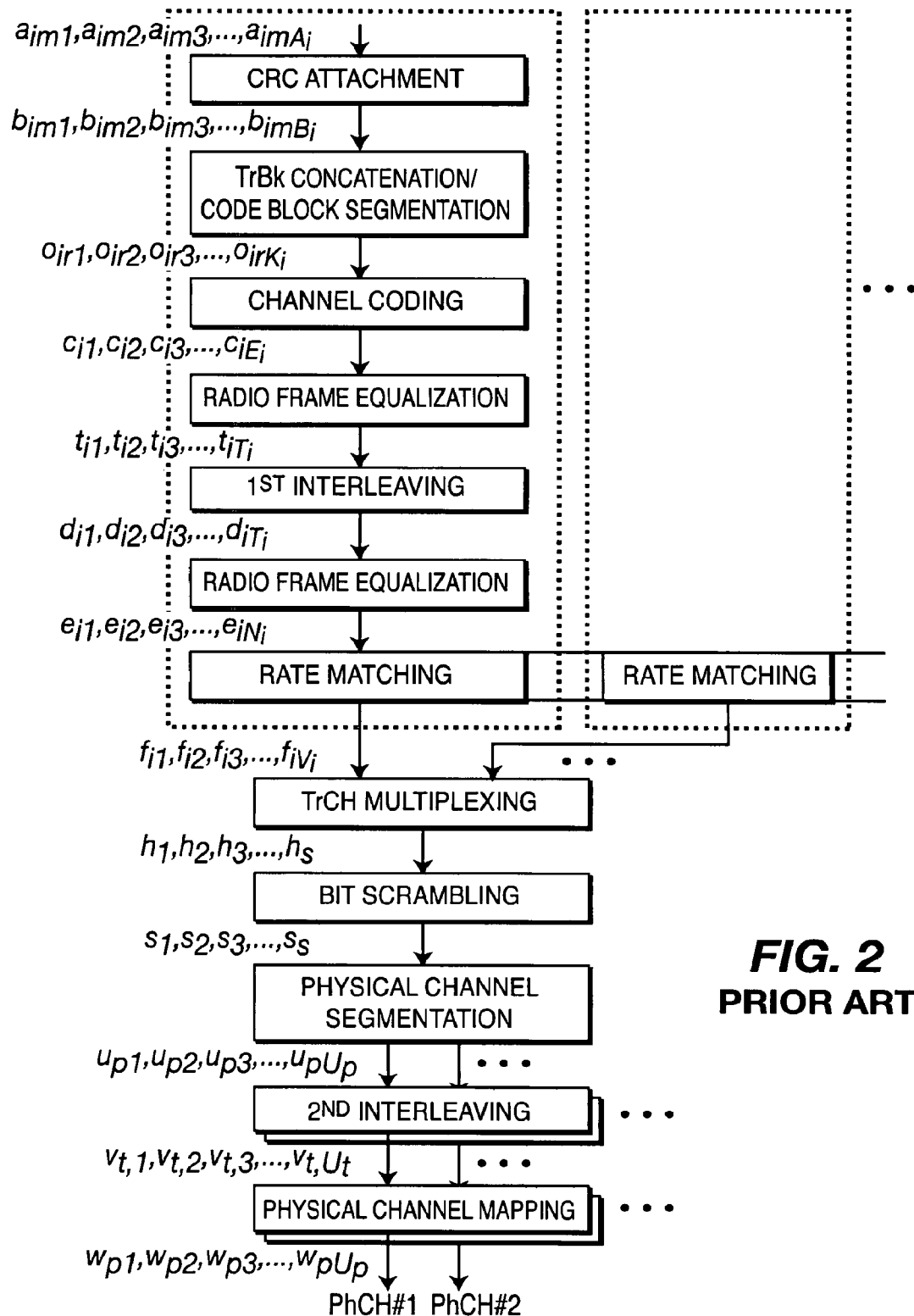


FIG. 1
PRIOR ART



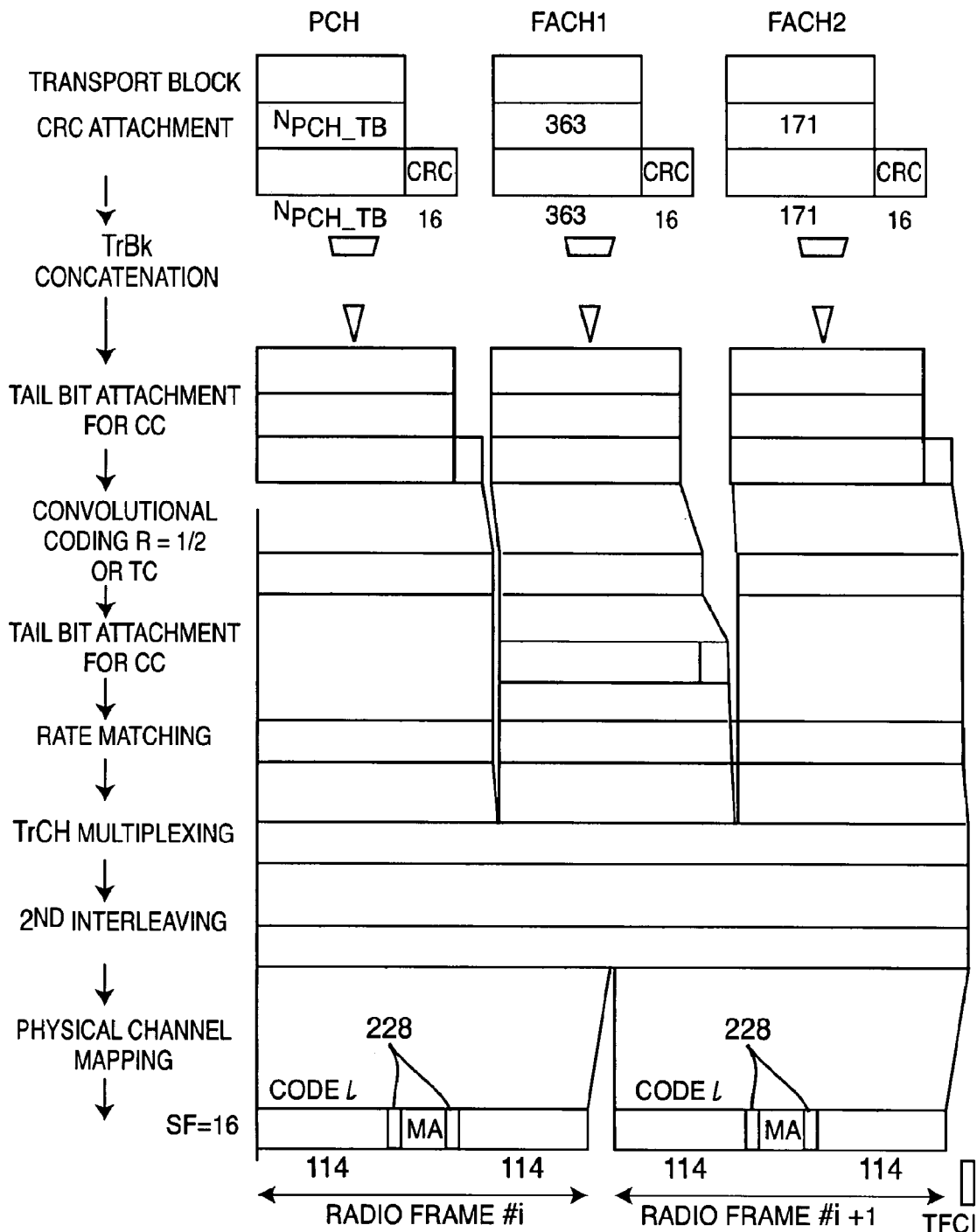
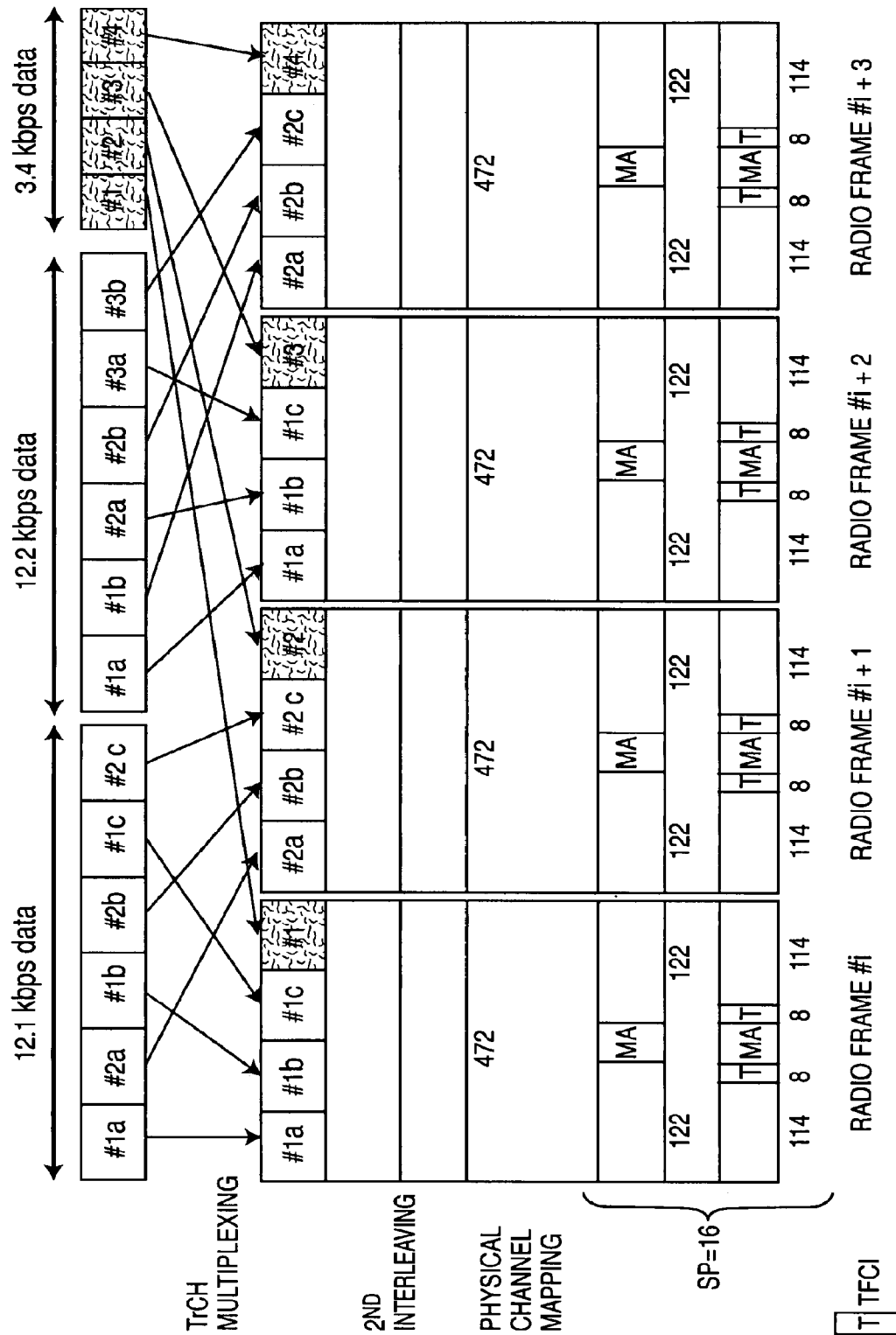
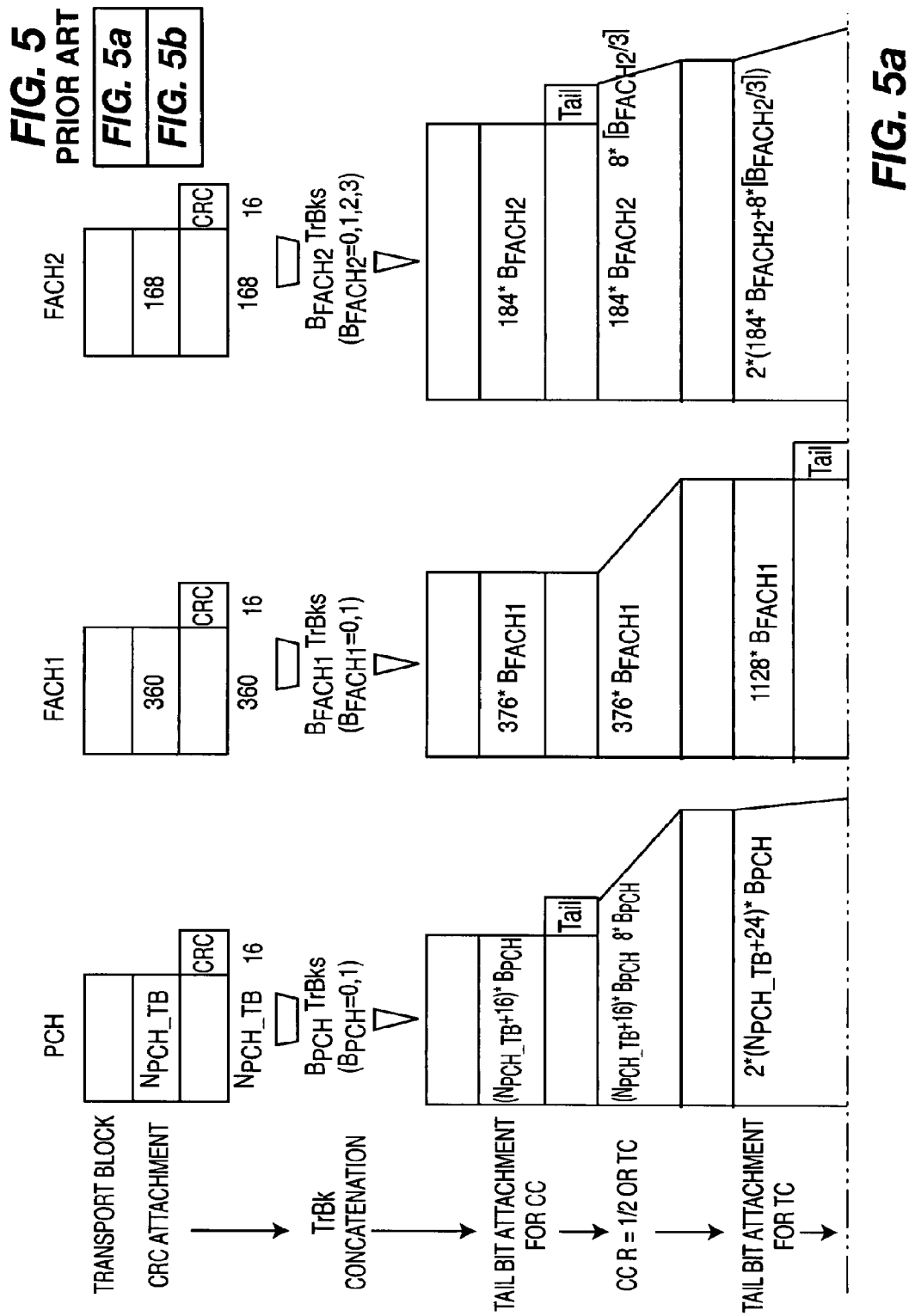
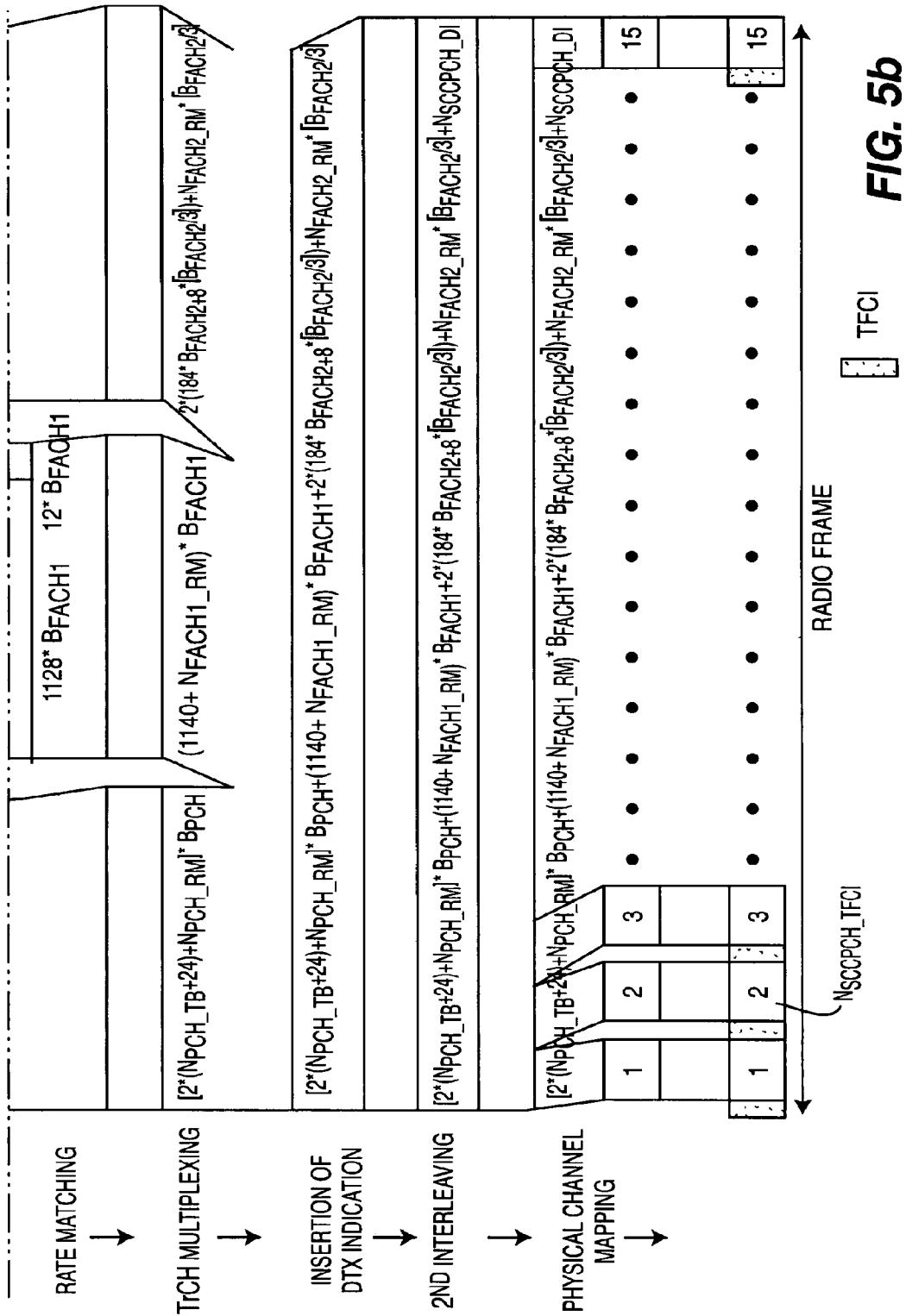


FIG. 3
PRIOR ART

**FIG. 4 PRIOR ART**





U.S. Patent

Jun. 23, 2015

Sheet 7 of 12

US 9,065,486 B2

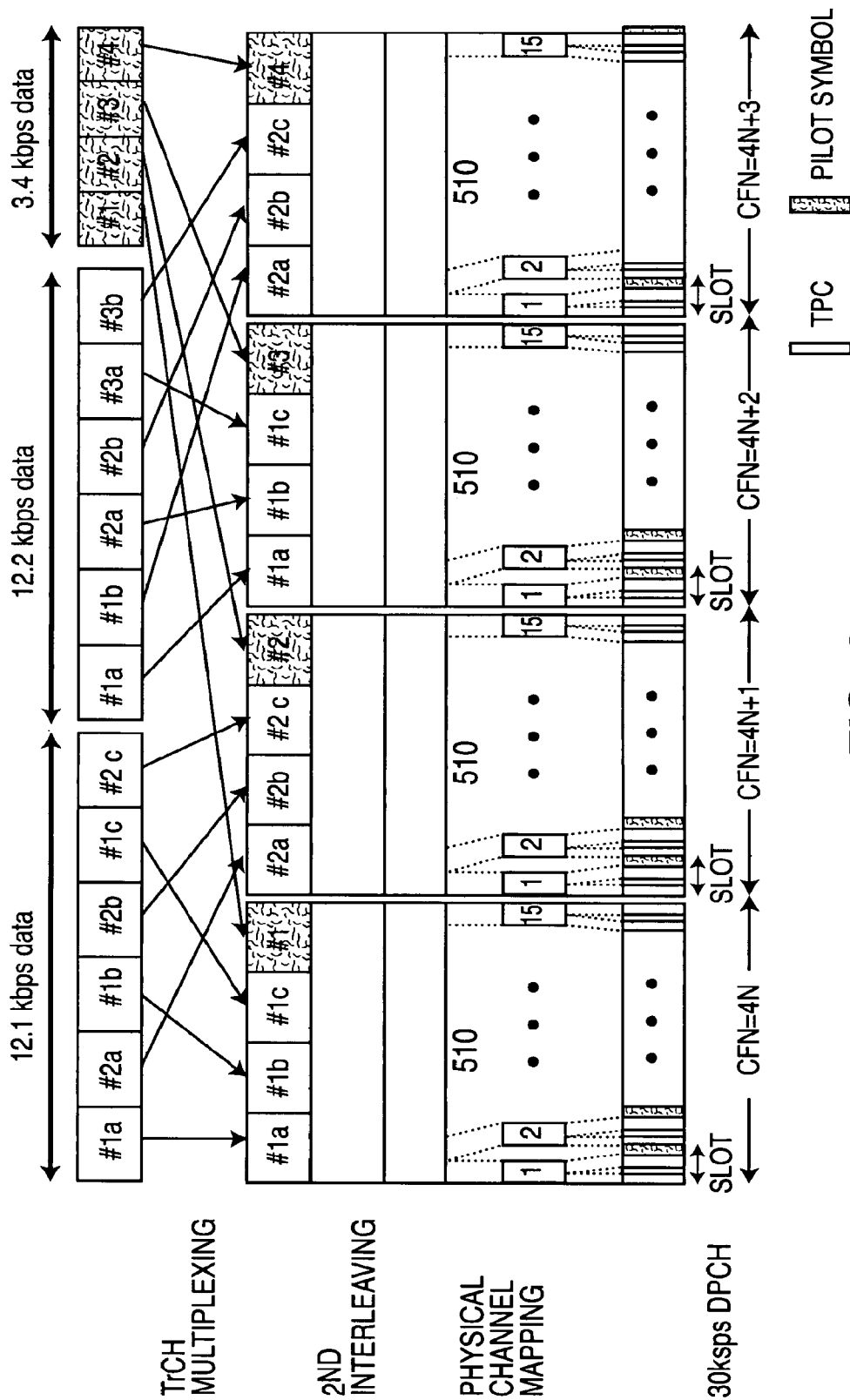


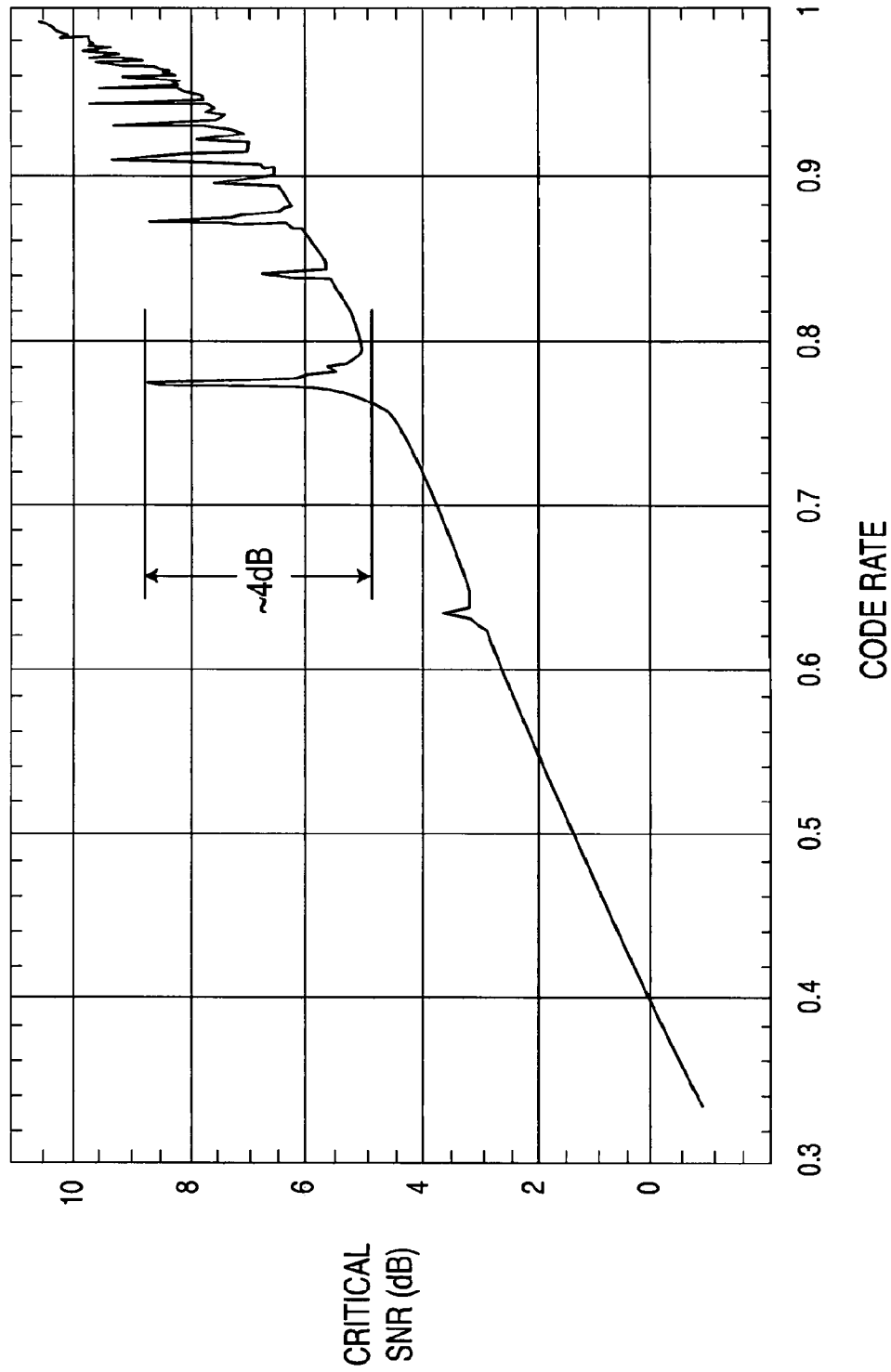
FIG. 6
PRIOR ART

U.S. Patent

Jun. 23, 2015

Sheet 8 of 12

US 9,065,486 B2



U.S. Patent

Jun. 23, 2015

Sheet 9 of 12

US 9,065,486 B2

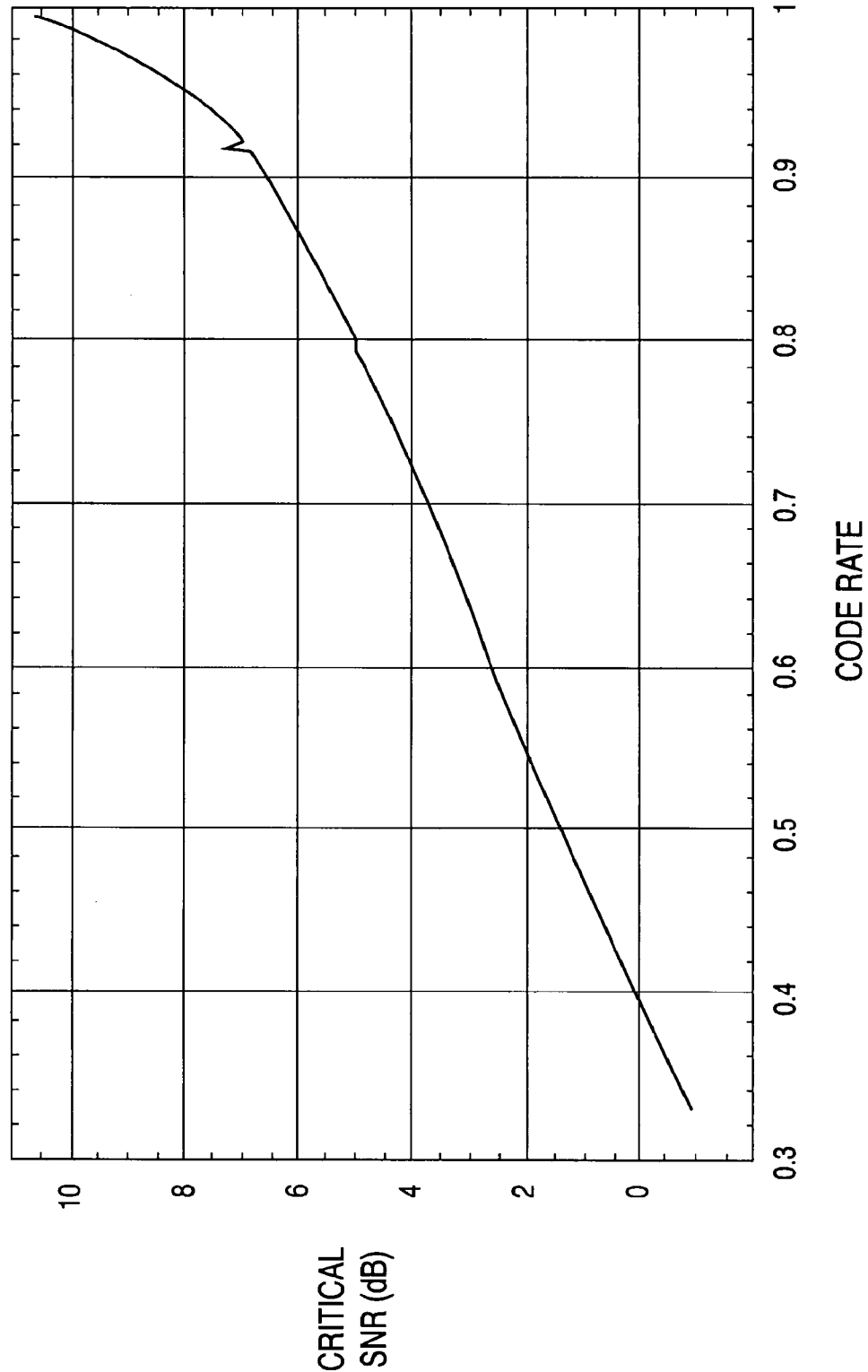


FIG. 8

U.S. Patent

Jun. 23, 2015

Sheet 10 of 12

US 9,065,486 B2

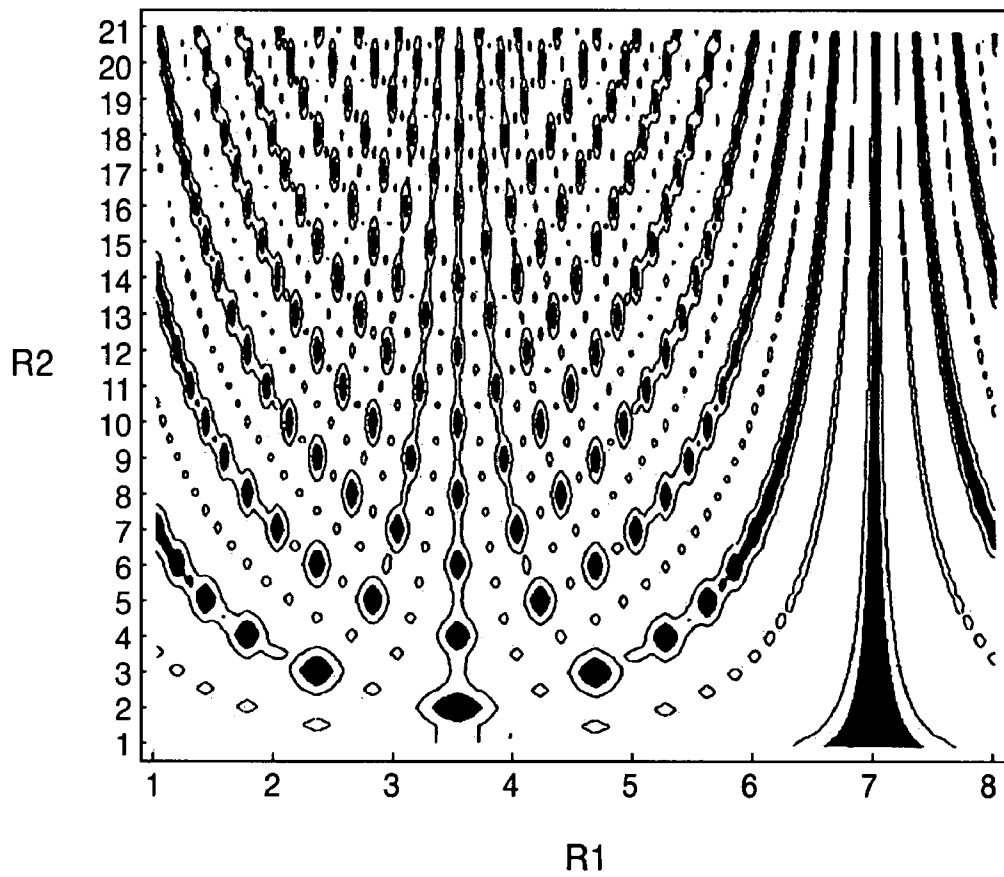
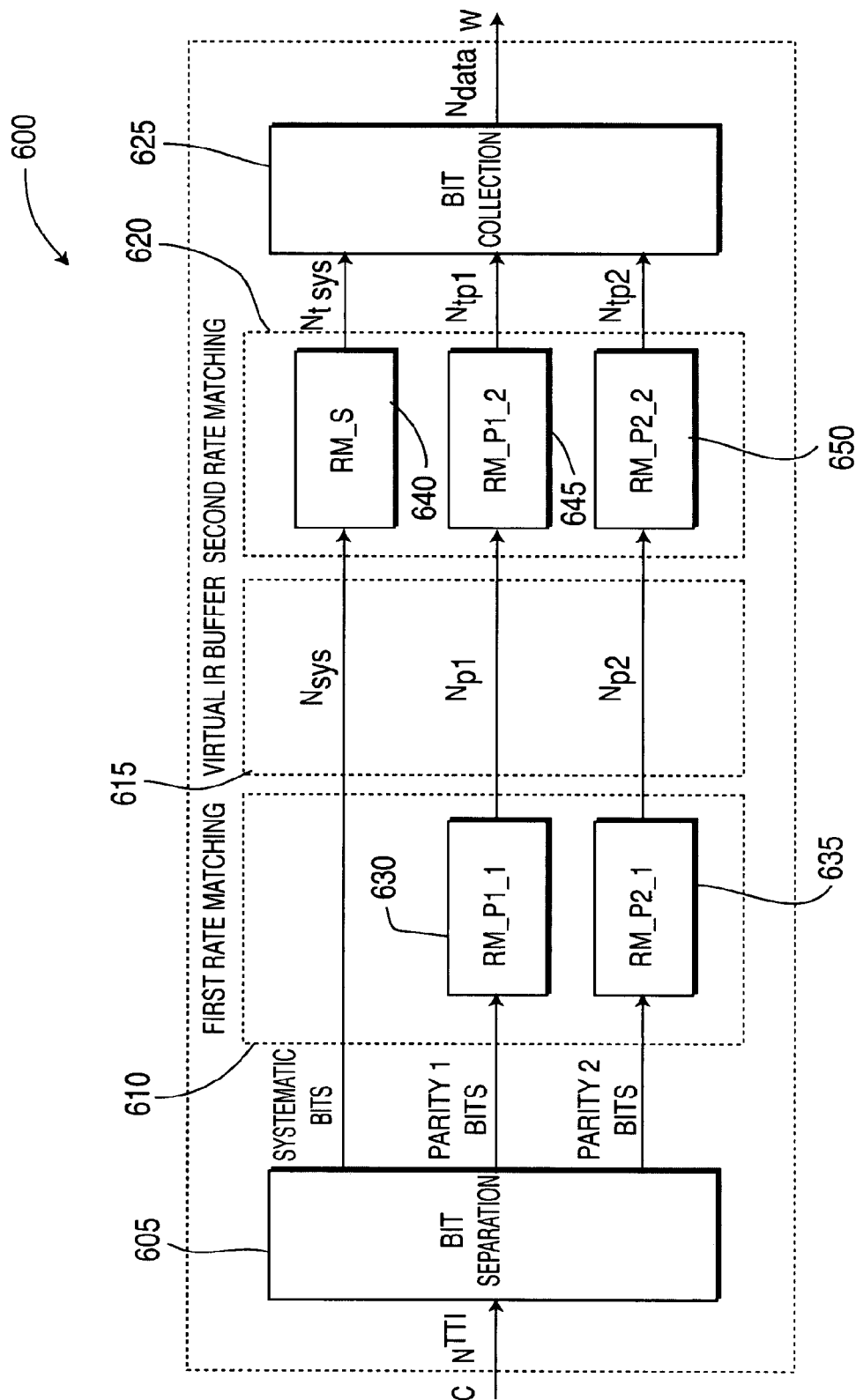


FIG. 9

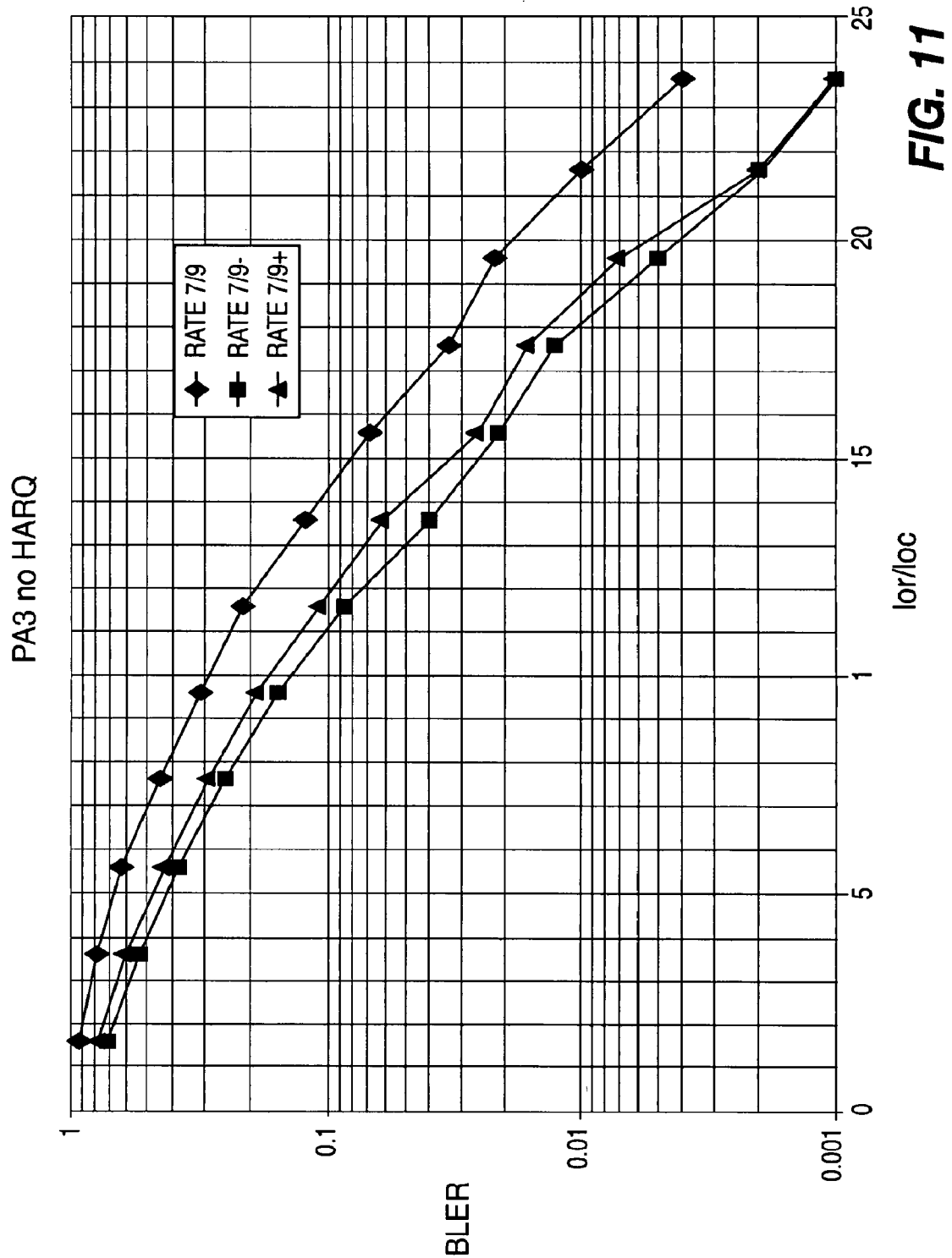
**FIG. 10**

U.S. Patent

Jun. 23, 2015

Sheet 12 of 12

US 9,065,486 B2



US 9,065,486 B2

1

**DETECTION, AVOIDANCE AND/OR
CORRECTION OF PROBLEMATIC
PUNCTURING PATTERNS IN PARITY BIT
STREAMS USED WHEN IMPLEMENTING
TURBO CODES**

CROSS REFERENCE TO RELATED
APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 13/744,984, filed on Jan. 18, 2013, which is a continuation of U.S. patent application Ser. No. 13/309,962, filed on Dec. 2, 2011, which issued as U.S. Pat. No. 8,359,520 on Jan. 22, 2013; which is a continuation of U.S. patent application Ser. No. 11/974,381 filed on Oct. 12, 2007, which issued as U.S. Pat. No. 8,074,143 on Dec. 6, 2011; which is a continuation of U.S. patent application Ser. No. 10/725,779, filed on Dec. 2, 2003, which issued as U.S. Pat. No. 7,293,217 on Nov. 6, 2007, which claims the benefit of U.S. Provisional Patent Application Ser. No. 60/434,232, filed on Dec. 16, 2002, Ser. No. 60/444,068, filed on Jan. 30, 2003, Ser. No. 60/470,921, filed on May 15, 2003, and Ser. No. 60/494,404 filed on Aug. 11, 2003, which are incorporated by reference herein as if fully set forth herein.

FIELD OF THE INVENTION

This invention generally relates to the use of Turbo codes in general, and, more particularly to a method for detecting and correcting performance degradation in punctured Turbo codes using a Turbo encoder.

BACKGROUND

Wireless communication systems are well known in the art. Generally, such systems comprise communication stations that transmit and receive wireless communication signals between each other. Typically, base stations are provided which are capable of conducting wireless concurrent communications with a plurality of subscriber stations. In Code Division Multiple Access (CDMA) systems specified by the Third Generation Partnership Project (3GPP), base stations are called Node Bs, subscriber stations are called User Equipments (UE) and the wireless interface between the Node Bs and UEs is known as the Uu interface. FIG. 1 illustrates a typical 3GPP CDMA system.

The Uu radio interface of a 3GPP communications system uses Transport Channels (TrCH) for transfer of user data and signaling between UEs and Node Bs. In 3GPP Time Division Duplex (TDD) communications, TrCH data is conveyed by one or more physical channels defined by mutually exclusive physical resources. TrCH data is transferred in sequential groups of Transport Blocks (TB) defined as Transport Block Sets (TBS). Each TBS is transmitted in a given Transmission Time Interval (TTI) which may span a plurality of consecutive system time frames. A typical system time frame is 10 milliseconds and TTIs are currently specified as spanning 1, 2, 4 or 8 of such time frames.

FIG. 2 illustrates the processing of TrCHs in TTD mode into a Coded Composite TrCH (CCTrCH) and then into one or more physical channel data streams in accordance with 3GPP TS 25.222 v3.8.0. Starting with the TB of data, Cyclic Redundancy Check (CRC) bits are attached and TB concatenation and code block segmentation is performed. Convolution coding or turbo coding is then performed, but in some instances no coding is specified. The steps after coding, include radio frame equalization, a first interleaving, radio

2

frame segmentation and rate matching. The radio frame segmentation divides the data over the number of frames in the specified TTI. The rate matching function operates by means of bit repetition or puncturing and defines the number of bits for each processed TrCH which are thereafter multiplexed to form a CCTrCH data stream.

The processing of the CCTrCH data stream includes bit scrambling, physical channel segmentation, a second interleaving and mapping onto one or more physical channels. The number of physical channels corresponds to the physical channel segmentation. For uplink transmissions, UE to Node B, the maximum number of physical channels for transmission of a CCTrCH is currently specified as two. For downlink transmissions, Node B to UEs, the maximum number of physical channels for transmission of a CCTrCH is currently specified as sixteen. Each physical channel data stream is then spread with a channelization code and modulated for over air transmission on an assigned frequency.

In the reception/decoding of the TrCH data, the processing is essentially reversed by the receiving station. Accordingly, UE and Node B physical reception of TrCHs require knowledge of TrCH processing parameters to reconstruct the TBS data. For each TrCH, a Transport Format Set (TFS) is specified containing a predetermined number of Transport Formats (TF). Each TF specifies a variety of dynamic parameters, including TB and TBS sizes, and a variety of semi static parameters, including TTI, coding type, coding rate, rate matching parameter and CRC length. The predefined collection of TFSs for the TrCHs of a CCTrCH for a particular frame is denoted as a Transport Format Combination (TFC).

Receiving station processing is facilitated by the transmission of a Transport Format Combination Indicator (TFCI) for a CCTrCH. 3GPP optionally provides for "blind transport format detection" by the receiving station, in which case the receiving station considers the potential valid TFCIs. Where there is only one valid TFCI, that TFCI is used in either case.

In 3GPP, time slot transmissions are made in predefined bursts where the transmitted physical channel data is divided into a beginning time slot portion and an ending time slot portion. A selected midamble is included between the two physical channel data portions. The TFCI is currently specified as transmitted in two parts on either side of the midamble and also between the two physical channel data portions. Two examples from 3GPP TR 25.944 V3.5.0 are illustrated in FIGS. 3 and 4 respectively where the block labeled MA represents the midamble and the block labeled T represents the parts of the TFCI. In FIG. 4, the CCTrCH is mapped to two physical channels, but only one physical channel includes the TFCI.

FIGS. 5A, 5B and 6 are diagrams of channel coding and multiplexing examples in accordance with 3GPP Frequency Division Duplex (FDD) specifications.

The various encoding steps implemented in communication systems play a key role in both performance and capacity of a wireless telecommunications systems. In particular, the turbo coding of the data being processed for wireless transmission plays a significant role for both TDD and FDD communications in a 3GPP system.

Turbo coding principles have found widespread applications in information theory and, in part, have entered into mainstream telecommunication theory and practice. These principles are used in error control, detection, interference suppression, equalization, and other communications-related areas. Turbo codes are a form of parallel, recursive systematic convolution codes, which can be used for channel coding and decoding in order to detect and correct errors that may occur in the transmission of digital data through different channels.

US 9,065,486 B2

3

Turbo codes are particularly useful for data transfers in which, under certain conditions, the data transfer rate can approach the theoretical limits of Shannon's Law. These favorable conditions generally include large block size transfers, which are particularly useful in mobile communications.

FIG. 7 shows how particular codes created by puncturing exhibit poorer than expected performance. As much as a 4 dB loss can be measured in the critical Signal-to-Noise Ratio (SNR) value.

Typically, high-rate Turbo codes are created by puncturing (i.e., eliminating) parity bits of a lower-rate code until the desired code rate is attained. Particular codes created by puncturing exhibit poorer than expected performance due to certain punctured bit patterns. Because the recursive encoding blocks in a Turbo encoder have an infinite impulse response, information about each systematic bit is distributed across many of the parity bits.

In any error control coding scheme that employs puncturing, the location of the punctured bits will have an impact on performance. This is because puncturing strings of successive bits can be viewed as burst errors by the decoder. All error control mechanisms can only correct burst errors that are less than some threshold. Therefore, it is important when designing the puncturing scheme that the burst error correcting abilities of the code be considered. In the absence of specific knowledge of the error control coding scheme, a good rule is to minimize the maximum string of punctured bits. For high coding rates this corresponds to distributing the non-punctured bits uniformly across the transmitted block. Puncturing schemes that uniformly distribute the non-punctured bits can deleteriously interact with certain error control codes, causing a degradation of decoder performance.

Because the recursive encoding blocks in the Turbo encoder have infinite impulse response, information about each systematic bit is distributed across many of the parity bits. The impact of certain periodic non-puncture patterns in the parity bits can be qualitatively illustrated by considering how much information remains in the surviving parity bits.

Regions where performance of the punctured Turbo code is degraded can be determined by measuring how close the puncturing pattern is to being periodic with period related to the period of the semi-periodic impulse response of the recursive encoding blocks of the Turbo encoder.

For a 3GPP Turbo encoder, the constituent recursive encoders have an impulse response that is periodic with a period of 7 symbols for positive time (semi-periodic). This can readily be seen by interpretation of the encoder as an M-sequence generator, i.e., if the shift register starts in the zero state and a one is applied only at $t=0$, then the encoder is exactly a Linear Feedback Shift Register (LFSR) with an associated 3rd order primitive polynomial and initial state $\{1\ 0\ 0\}$, thus a period $2^3-1=7$ M-sequence is generated for positive time.

The encoder is a Linear Time Invariant (LTI) system on a binary field. Therefore, the output of the encoder is a sum of shifted versions of the impulse response of the encoder, each shifted impulse response corresponding to the locations of the 1's in the TB. If we consider an input that is all 0's for $t>T$, then the output of the constituent recursive encoding block will also be semi-periodic for $t>T$.

Certain non-puncturing periods may result in a loss of distributed information about a small group of bits across the set of parity bits. For example, let the TB consist of 7 bits followed by many zeros. Now consider the problem of trying to determine the seven bits by observation of the output of one encoder after heavy puncturing. Each observation is made at the output is a sum of a subset of the 7 bits, the subset being

4

determined by the non-puncture period and the impulse response of the recursive encoding block. For most non-puncture patterns (those that have a period relatively prime with the period of the semi-periodic impulse response), sums over 7 different subsets can eventually be observed. Therefore, a system of 7 equations with 7 unknowns can be formed. Assuming they are linearly independent, the values of the 7 bits may be determined. However, consider the case where the non-puncture period is simple (one surviving parity bit per period) and the same as the period of the recursive encoding block, 7. Then every observation for $t>6$ is the sum of the same subset of the 7 bits and so no new information is obtained, i.e., a rank-1 system of equations is formed and a unique solution does not exist. This is due to the periodic nature of the signal. When the non-puncture period is relatively prime with the period of the recursive encoding block, a series of observations of the parity bits will eventually form a rank-7 system of equations. For our 7-bit group, this is sufficient to uniquely determine the bits, i.e., information sufficient to determine the bits are distributed across the surviving parity bits. When the periods are not relatively prime, the rank of the system becomes L/K where L is the period of the recursive encoding block and K is the Greatest Common Divisor (GCD) of L and N where N is the period of the non-puncture pattern.

In the above illustration, a long sequence of zeros after the small group of bits was supposed for clarity sake. However, allowing additional groups of bits to follow the first group does not add to the distributed information about earlier groups. This can be seen from the causality of the system.

It is also possible that some distributed information is lost even for non-simple periods, e.g., consider the case where the non-puncture pattern alternates between a simple period of three and four. This results in a period 7 non-puncture pattern but with two surviving parity bits per period. The same argument above leads to a rank-2 system of seven equations which is still insufficient to uniquely determine the group of bits, but does reduce the dimension of the space they may span. Clearly, some information about the small group of bits is lost for some non-punctured patterns.

In order to obtain adequate performance, it is necessary to detect, avoid and/or correct the problematic puncturing patterns in the parity bit streams without having to avoid code rates. Typically, problematic interactions occur between the Turbo coder output and puncturing in the rate matching stages.

It would be desirable to have a method for creating high-rate Turbo codes that avoids problematic interactions by modifying the puncturing patterns.

SUMMARY OF THE INVENTION

According to the present invention, degradations in quality of punctured error correction coded transmissions are identified and the code transmissions are modified accordingly. A puncturing pattern which approximates a particular code rate is identified, and a value for anticipated degradation is adjusted in accordance with a matching of the puncturing pattern and the particular code rate.

For both FDD and TDD, two stages of rate matching and two puncturing operations are included, and this is done because of a certain technique called, incremental redundancy, which allows for a wireless transmit/receive unit (WTRU) to receive and soft combine multiple transmissions of the same TB from the base station. If the transmission fails the first time, the signal is retransmitted with more data in an attempt to obtain a successful communication the second

US 9,065,486 B2

5

time. In order to do that, two different stages of puncturing are used because the WTRU has certain capabilities, certain buffer sizes that it can support, and in order to be able to fit the retransmissions that are combined into the buffer, there are two stages of puncturing. The first stage of rate matching punctures enough bits such that the surviving bits fit into a buffer, and the second stage of puncturing (or repetition) is to achieve the desired overall code rate. When the two stages of rate matching are combined, a plot of problematic regions of coding rate is a multidimensional plot. Thus, there are two rates now involved, which are a rate in a first stage of puncturing and a rate in a second stage of puncturing.

According to a first embodiment of the present invention, P1/P2 puncturing biasing for a single stage of rate matching is implemented using the punctured error correction coded transmissions.

According to a second embodiment, two or more stages may be employed at each stage of rate matching for detecting and correcting performance in punctured Turbo codes on a High Speed Downlink Shared Channel (HS-DSCH) in R5 High Speed Downlink Packet Access (HSDPA).

BRIEF DESCRIPTION OF THE DRAWINGS

A more detailed understanding of the invention may be had from the following description of a preferred embodiment, to be understood in conjunction with the accompanying drawing wherein:

FIG. 1 is a schematic diagram of a typical CDMA system in accordance with current 3GPP specifications;

FIG. 2 is a processing diagram of TrCH data for a CCTrCH in accordance with 3GPP TDD specifications;

FIGS. 3 and 4 are diagrams of channel coding and multiplexing examples in accordance with 3GPP TDD specifications;

FIGS. 5A, 5B and 6 are diagrams of channel coding and multiplexing examples in accordance with 3GPP FDD specifications;

FIG. 7 shows typical results of particular codes being created by puncturing, where as much as 4 dB loss can be measured in critical SNR value;

FIG. 8 graphically depicts the SNR required to successfully decode a data block (critical SNR) with high probability vs. Code Rate when P1/P2 biasing is applied;

FIG. 9 is a plot of the problematic regions with respect to an ordered pair (r1,r2) which are the rates of puncturing the parity streams in the first and second stages of rate matching, respectively;

FIG. 10 is a schematic block diagram showing a circuit for 3GPP rate matching for HSDPA, using a Turbo coded HS-DSCH; and

FIG. 11 graphically depicts initial Block Error Rate (BLER) for HS-DSCH transport blocks with certain effective coding rates.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

In accordance with the present invention, several methods and embodiments are disclosed for detecting, avoiding and/or correcting the problematic puncturing patterns in the parity bit streams without having to avoid code rates.

The present invention is potentially applicable to layers 1 and 2 in a FDD, CDMA 2000 and TDD Universal Mobile Telecommunications System (UMTS) modes of transmission as well as other modes of transmission. Additionally, methods

6

are described hereinafter for modifying the puncturing patterns such that performance of degraded Turbo code is restored.

In accordance with the present invention, the methods disclosed herein may be implemented in a wireless transmit/receive unit (WTRU) and/or a base station. Hereinafter, a WTRU includes but is not limited to a UE, mobile station, fixed or mobile subscriber unit, pager, or any other type of device capable of operating in a wireless environment. When referred to hereafter, a base station includes but is not limited to a base station, Node-B, site controller, access point or other interfacing device in a wireless environment.

FIG. 8 graphically depicts the SNR required to successfully decode a data block (critical SNR) with high probability versus Code Rate when biasing of parity bits P1/P2 is applied. As shown in FIG. 7, it has been found that particular codes created by puncturing the rate 1/3 3GPP Turbo code exhibit poorer than expected performance, as can be seen from the peaks in the figure.

FIG. 9 is a plot of the problematic regions with respect to an ordered pair (r1,r2) which are the rates of puncturing the parity streams in the first and second stages of rate matching, respectively. As can be seen, there are particular regions where the rates of puncturing of the parity streams are such that some combinations of rates are particularly problematic.

In one embodiment, puncture biasing for parity bits P1 and P2 is implemented for one stage rate matching. FIG. 10 is a schematic block diagram showing circuitry 600 for 3GPP rate matching for HSDPA, using a Turbo coded HS-DSCH. The circuitry 600 implements a 3GPP rate-matching scheme for HSDPA. The circuitry 600 includes a bit separation circuit 605, a first rate matching stage 610, a virtual incremental redundancy (IR) buffer 615, a second rate matching stage 620 and a bit collection circuit 625. The first rate matching stage 610 includes a Parity 1 (P1) bit rate matching circuit 630 and Parity 2 (P2) bit rate matching circuit 635. The second rate matching stage 620 includes a systematic bit rate matching circuit 640, a Parity 1 (P1) bit rate matching circuit 645 for the second rate matching and a Parity 2 (P2) bit rate matching circuit 650 for the second rate matching. In operation, the systematic bits, Parity 1 (P1) and Parity 2 (P2) bits are processed through the first rate matching stage 610, virtual IR buffer 615, second rate matching stage 620 and bit collection circuit 625. Note that the Parity 1 (P1) and Parity 2 (P2) bits are treated separately. The systematic bits, Parity 1 (P1) and Parity 2 (P2) bits are combined at the bit collection circuit 625 to provide a single data output N_{data} . Also note that if the number of coded bits is less than or equal to the size of the virtual IR buffer 615, the first rate matching stage 610 is transparent. The transparent first stage case and Rel-4 rate matching are considered.

In its actual implementation, it is anticipated that the different circuit functions will be executed by a common circuit or circuits, such as microprocessor circuitry, and in accordance with program instructions. The specific circuit functions used to implement the invention would therefore be a matter of choice of those configuring the circuitry within the rate matching circuitry 600.

The rate matching algorithm performs puncturing if the overall code rate is greater than 1/3 and repetition if the code rate is less than 1/3. Currently code rates greater than 1/3 are accomplished by applying the same puncturing rate to both P1 and P2 bits (to within one bit) but with different puncturing pattern phases. In order to avoid non-puncturing periodicities that have been shown to degrade the Turbo code performance, the puncturing rates for P1 and P2 be independently biased. For example, if the number of P1 bits is decreased by A and

US 9,065,486 B2

7

the number of P2 bits is increased by Δ , the overall code rate is unchanged but the problematic non-puncturing periods can be avoided. Given this approach to avoiding the problematic code rates, an analytical expression for the requisite bias, has been derived.

A simple and efficient method of modifying the puncture patterns is biasing the number of punctured bits in P1 and P2 by adding additional puncturing to one and removing it from the other. The amount of the bias should be no more than is needed to avoid certain periodicities. In biasing the puncturing rates of P1 and P2 bits, two constraints must be met.

When non-puncturing patterns with period $7\hat{N}/2$ ($\hat{N}=1, 2, 3 \dots$) are used, degradation in performance results. These non-puncturing patterns will be employed whenever the average non-puncturing period of P1 or P2 bits is within ± 1 or $\pm 1/2$ of $7\hat{N}/2$ for even and odd $\hat{N}$ respectively.

The average non-puncturing rate of the P1 and P2 rate matching blocks is $I/(P/2)$ where I is the number of bits at the input to each branch of rate matching and P is the total number of parity bits (P1 and P2) at the output of rate matching. Therefore, the desired code rate will lead to a problematic puncturing pattern if,

$$\left| \frac{I}{(P/2)} - \frac{7\hat{N}}{2} \right| < 1 - \frac{\hat{N}}{2} + \left\lfloor \frac{\hat{N}}{2} \right\rfloor, \quad \text{Equation 1}$$

for $\hat{N} > 0$ where,

$$\hat{N} = \left\lfloor \frac{4I}{7P} + \frac{1}{2} \right\rfloor. \quad \text{Equation 2}$$

In biasing the puncturing rates of the parity bit streams 1 and 2, P1 and P2, two constraints must be met.

First, the number of surviving bits in parity bit stream 1 must be increased sufficiently by an amount Δ to avoid the problematic puncturing patterns. Second, the number of surviving bits in parity bit stream 2 must be decreased by an equal amount Δ that is also sufficient to avoid problematic puncturing patterns.

These two constraints can be combined in to the following expression for Δ , where:

$$\Delta = \left\lceil \max \left\{ \left\lfloor \frac{I}{\frac{7\hat{N}-1}{2}} - \frac{P}{2}, \frac{P}{2} - \left\lfloor \frac{I}{\frac{7\hat{N}+1}{2}} \right\rfloor \right\} \right\rceil \quad \text{Equation 3}$$

Alternatively, non-punctured bits may be increased in P2 and decreased in P1. The procedure to determine and apply the necessary P1/P2 bias is as follows:

Step 1) Compute $\hat{N}$ using Equation 2.

Step 2) Determine if the desired code rate results in a problematic puncturing pattern using Equation 1. If it does, continue to Step 3, otherwise set

$$\Delta = 0 \quad \left(\text{if } \left| \frac{I}{(P/2)} - \frac{7\hat{N}}{2} \right| \geq 1 - \frac{\hat{N}}{2} + \left\lfloor \frac{\hat{N}}{2} \right\rfloor \right).$$

Step 3) Compute the bias Δ using Equation 3.

Step 4) Compute rate matching parameters by modifying Table in TS25.212/222.

8

In order to avoid puncturing patterns that degrade Turbo code performance, the amount of puncturing applied to parity bit streams 1 and 2 respectively could be slightly different, while keeping the overall number of punctured bits constant.

If the number of punctured bits in parity bit stream 1 is decreased by Δ and accordingly, the number punctured bits in parity bit stream 2 bits is increased by Δ , the overall code rate is unchanged, but the problematic puncturing patterns can be avoided. Note that bit collection and bit de-collection stages need to be adjusted correspondingly for this case. Since individual regions of degraded performance tend to be small, it may be advantageous to simply avoid the use of code rates with degraded performance. Since code rates with degraded performance can now be identified using the above equation, it is a simple matter to avoid them.

For Hybrid Automatic Repeat reQuest (HARQ) as deployed in 3GPP, it may be necessary to employ two stages of rate matching. This occurs whenever incremental redundancy (IR) is employed and the number of bits input to the rate-matching algorithm is larger than the virtual IR buffer. Note that when Chase combining HARQ is used, there is no need for a special IR buffer; a received bit buffer would be sufficient. (If constellation rearrangement were not used, a buffer of received symbols would be sufficient.) If it is determined that IR provides only a small improvement over Chase combining, then removal of IR from the standards may be advisable.

In order to obtain higher data rates, the 3GPP has introduced the HSDPA option wherein link adaptation is performed. One component of the link adaptation is Adaptive Modulation and Coding (AMC). With AMC, a channel quality estimate is used to select the modulation type and code rate that attains the largest throughput. When the channel quality is high, QAM modulation and a high code rate are selected. High code rates are obtained by puncturing a rate 1/3 Turbo code. During the design of the channel quality indication (CQI) table, it was observed that certain Transport Block Set Sizes (TBSS) exhibited poorer than expected performance. The CQI table is used to map a channel quality estimate into a recommended modulation and TBSS. This problem of poorer than expected performance is currently addressed by simply "hand tweaking" the CQI table to avoid the TBSSs that cause problems. In AMC, this leads to less than optimal throughput since optimal code rates will inevitably be avoided.

Support for link adaptation by means of AMC is an integral feature of R5 HSDPA. With AMC, modulation type and code rate on HS-DSCH can be varied according to channel conditions. Variable coding rates on HS-DSCH are achieved by means of rate matching (repetition or puncturing) output of the R99 Turbo-coder in a pre-determined manner, i.e. as a function of TBSS and available number of Physical Channel bits. Both R99/R4 and R5 use the same code rate 1/3 Turbo-coder. While the principle of rate-matching is the same for both R4 and R5, the likely and more frequent use of higher effective code rates ($>1/2$), the use of multiple stages of rate matching, and the standard allowing for the possibility of Incremental Redundancy (IR) differentiate R99/R4 and R5.

HSDPA performance requirements in WG4 have indicated unusually high and rather unpredictable SNR performance degradations for Turbo-coded and punctured transport blocks on HS-DSCH up to several dB for a range of effective coding rates above 1/2.

The Turbo-coding performance on HS-DSCH is heavily impacted by unfavorable puncturing patterns of the parity bit streams output by the baseline rate 1/3 Turbo-coder. Although the original WG4 simulation results were provided in a TDD-

US 9,065,486 B2

9

context, exactly the same degradations also occur in FDD, the reason being that Turbo-coding and rate-matching (TS25.212 and TS25.222) on HS-DSCH transport blocks (where the problematic interactions originate) are done exactly the same way for both modes.

The poorer than expected performance at some data rates is also a problem with a fixed modulation and coding scheme. If a user is assigned a code rate that exhibits the problem, the poor performance of the code will be compensated for by power control thus reducing cell capacity.

In another embodiment, adjustments to the parity stream puncturing allows the Medium Access Control-High Speed (MAC-hs) to simply select any desired transport block size as an outcome of the scheduler decision. It would be required to slightly change the generation of the puncturing patterns in the rate-matching stages in TS25.212/222. For example, one implementing modification to the current FDD standard as set for in TS 25.212 is appended hereto along with a brief discussion of why the modification is desirable.

For both the case of 1st rate-matching stage being transparent and the case of both 1st and 2nd rate-matching stage being employed, a number of acceptable solutions exist to avoid the problematic interactions by means of adjustments to the parity bit puncturing.

One of these solutions, e.g. a simple biasing method, is outlined below in the interest of providing a conceptual example for the case of the Pt rate-matching stage being transparent.

Currently, coding rates > 1/3 are accomplished by applying the same amount of puncturing to both parity bit streams 1 and 2 at the output W of the Turbo-coder (FIG. 10), although the puncturing pattern "phases" can be adjusted.

When a particular code rate is desired and it is determined that its use will result in degraded performance, a slightly lower code rate may be selected to avoid the degradation. Good choice for the substituted code rate would be the largest allowable code rate less than the desired code rate that has been determined to have an acceptable degradation.

If it is desirable for a system to be allowed to make unrestricted use of available code rates, then performance may be restored by modification of the puncture pattern. The key to restoring performance to the punctured Turbo code is to avoid the case where the surviving parity bits are overly redundant with respect to the systematic bits, i.e., modify the puncturing pattern to improve performance. One way to accomplish this is to sample the parity bits such that all the points corresponding to one complete period of the semi-periodic impulse response are sampled with as few samples as possible while maintaining the same code rate and not overly distorting the uniformity of the puncturing over the data block or creating overly large imbalances in the number of surviving parity bits in P1 and P2.

It should also be noted that this method of mitigation could also be applied to systems with more than 2 parity streams. For example, the 3GPP Turbo code (CDMA 2000) includes four parity streams. If a problematic puncturing pattern occurs it can be alleviated by adjusting the puncturing rates of each of the individual parity streams while maintaining a constant overall effective coding rate.

In the case of single stage of rate matching, as used in R99/R4 and in many R5 configurations, the problematic interactions between the Turbo-coded output and the punctured transmitted sequence occurs in regions where the puncturing patterns are nearly periodic with surviving bit period equal to a multiple of 7, and when an average 1 out of every 3.5 parity bits survive.

10

These degradations correspond to rank-1 and rank-2 scenario respectively. This case corresponds to the rank-1 scenario. Rank-2 scenarios have less impact on the SNR degradation than rank-1 scenarios. Since higher rank scenarios (>2) do not significantly contribute to performance degradation, ranks other than rank-1 and rank-2 scenarios are not considered here.

The code rates at the center of these regions are determined by:

$$CR = \frac{1}{1 + \frac{2}{3.5N}} = \frac{3.5N}{3.5N + 2} \quad N = 1, 2, \dots \quad \text{Equation 4}$$

The critical code rate, CR, corresponds to a rank-1 scenario when N is even and rank-2 when N is odd. For rank-1, we have critical code rates CR=7/9, 7/8, 21/23, ... and for rank-2, we have CR=7/11, 21/25, ...

The ratio of the number of systematic bits and the number of parity bits in either parity bit stream 1 or 2 can be considered as "parity puncturing rate". When surviving bit patterns with parity puncturing rate close or equal to 7N/2 (N=1, 2, 3, ...) are used, degradation in performance results. Some amount of Turbo-coding and puncturing interaction will also occur whenever the average periodicity of surviving bits of the parity bit streams 1 or 2 is within ± 1 or $\pm 1/2$ of 7N/2 for even and odd N respectively.

When two (or more) stages of rate matching are employed, problematic puncturing patterns can be generated by any stage, or by the interaction between the stages of rate matching.

A closed form expression(s) has been developed for the Release 5 3GPP Turbo coder/Rate Matching that predicts the performance degradation. The expression takes as input either the triplet {Bits Before 1st stage of rate Matching, Max Bits after 1st Rate Matching, Bits after 2nd Rate matching} or the pair {Rate of 1st stage Rate Matching with respect to parity bits, Rate of 2nd stage Rate Matching with respect to parity bits}. The output, as depicted in Equation 5 below, is a rational number that may be compared to a threshold to accept/reject the configuration as providing/not providing acceptable performance. The parameters r1 and r2 represent the rates associated with the 1st and 2nd stages of rate matching with respect to the parity bit streams. Although complicated, the Equation 5 is a piecewise linear and continuous function in r1, r2 and is therefore trivial to evaluate.

$$\lambda(r1, r2) = \quad \text{Equation 5}$$

$$\sum_{n=1}^{L-1} \alpha_n \left[\left(1 - \left\lceil \frac{1}{L} \lfloor r1 \lfloor nr2 \rfloor \rfloor - \left\lceil \frac{1}{L} \lfloor r1 \lfloor nr2 \rfloor \rfloor \right\rceil \right) (nr2 - \lfloor r2 \rfloor) \right. \\ \left. (r1 \lfloor nr2 \rfloor - \lfloor r1 \lfloor nr2 \rfloor \rfloor) + \right. \\ \left. \left(1 - \left\lceil \frac{1}{L} \lfloor r1 \lfloor nr2 \rfloor \rfloor - \left\lceil \frac{1}{L} \lfloor r1 \lfloor nr2 \rfloor \rfloor \right\rceil \right) \right. \\ \left. (nr2 - \lfloor nr2 \rfloor) (-r1 \lfloor nr2 \rfloor - \lfloor r1 \lfloor nr2 \rfloor \rfloor + 1) + \right. \\ \left. \left(1 - \left\lceil \frac{1}{L} \lfloor r1 \lfloor nr2 \rfloor \rfloor - \left\lceil \frac{1}{L} \lfloor r1 \lfloor nr2 \rfloor \rfloor \right\rceil \right) \right. \\ \left. (-nr2 + \lfloor nr2 \rfloor + 1) (r1 \lfloor nr2 \rfloor - \lfloor r1 \lfloor nr2 \rfloor \rfloor) + \right. \\ \left. \left(1 - \left\lceil \frac{1}{L} \lfloor r1 \lfloor nr2 \rfloor \rfloor - \left\lceil \frac{1}{L} \lfloor r1 \lfloor nr2 \rfloor \rfloor \right\rceil \right) \right. \\ \left. (-nr2 + \lfloor nr2 \rfloor + 1) (-r1 \lfloor nr2 \rfloor + \lfloor r1 \lfloor nr2 \rfloor \rfloor + 1) \right] \\$$

US 9,065,486 B2

11

A threshold comparison could then be based on this equation to test whether or not the Code Rate pair will perform adequately. Equivalently, the triple: {Data Block Size, Size After 1st Stage Rate-Matching, Size After 2nd Stage Rate-Matching} can be used since this triple maps directly into the Code Rate pair.

The effect of the periodicity of the puncturing pattern can also be mitigated by interleaving the parity bits before rate-matching occurs. In this way, after de-interleaving, periodic sampling of the parity bits is avoided even when periodic sampling is done in rate-matching.

The functionality of the channel interleaver can be incorporated into the rate-matching block interleaver. This can be accomplished by adding additional constraints to the rate-matching block interleaver (those defined by the channel interleaver) when the interleaver is designed. This however will require an additional interleaver for the systematic bits.

Note that the rearrangement of the non-punctured bits only needs to occur on a range equal to the period of the semi-periodic impulse response of the recursive encoding blocks of the Turbo encoder. Therefore, small time-varying interleavers can be added to the parity bit streams to prevent problematic puncturing patterns. This has the advantage of requiring less memory and helps to minimize the distortion of the uniformity of the puncturing.

Certain parameters may be made to vary as a function of time (or bit index) to generate puncturing patterns that will mitigate performance degradations. One such example for 3GPP includes modification of the rate-matching parameters X_p , e_{ini} , e_{minus} and e_{plus} parameters throughout the execution of the rate-matching. In this way, the parameters affecting the puncturing pattern may change at one or more locations within the block of bits being punctured. By allowing the parameters to change, the instantaneous code rates may be different from the desired overall code rate (thereby avoiding the puncturing interaction) while still maintaining the same overall code rate. For example: 1) e_{plus} and e_{minus} may change frequently throughout the puncturing algorithm thus breaking up any possible long runs of deleterious puncturing. 2) Parameters may be changed so that the code rate is changed so that it is higher in some portions of the code block and lower in others.

The above methods are examples of modifications to the puncturing pattern used to generate specific code rates. All such methods may be considered special cases and specific implementations of the more general concept of a permutation of the puncturing pattern. Any method of changing the puncturing pattern, i.e., generating some permutation of the original puncturing pattern, has the potential of changing the overall performance of a code.

One can achieve the desired overall code rate while avoiding problematic puncturing patterns by adjusting the amount of puncturing performed in each stage. This method, when placed in the context of the 3GPP HSDPA Turbo Code/Rate Matching algorithm leads to artificially reducing the size of the virtual Incremental Redundancy (IR) buffer. In general the approach implies a modification to the individual puncturing rates of each of the stages such that a desirable overall puncturing pattern results.

Stage Rate Biasing is easily accomplished by changing the operating point (the r_1 , r_2 pair) to some point on a curve of constant code rate (i.e., where the product $r_1 r_2$ is unchanged) where performance degradation is tolerable.

The combination of adjusting the stage puncturing rates as well as the relative rates of puncturing in the two parity streams can also mitigate the problematic interaction between the puncturing pattern and the Turbo Code performance.

12

This can be envisioned as splitting the operating point into two points. One of the points corresponds to the rates of 1st and 2nd stage rate matching for the first parity bit stream and the second point for the second parity bit stream. The two points should be selected so that the overall code rate is unchanged, both points lie in regions of acceptable performance, and the total number of surviving bits after the first stage of rate matching does not exceed imposed limits such as an IR buffer.

The present invention provides several simple and efficient techniques of detecting, avoiding and/or correcting problematic puncturing patterns in the parity bit streams without having to avoid desired code rates. According to the present invention, degradations in punctured error correction coded transmissions are reduced by identifying a puncturing pattern which approximates a particular code rate, and adjusting a value for anticipated degradation in accordance with the matching of the puncturing pattern and the particular code rate.

When creating high rate codes via puncturing, it is generally desirable to distribute, as uniformly as possible, the bits that are punctured. Using this guideline, it is inevitable that certain code rates will require the resulting non-punctured bit pattern to be less effective. One such example occurs when the non-punctured bit pattern is periodic, with a period equal to the period of the semi-periodic impulse response of the recursive encoding blocks of the Turbo encoder. An algorithm may be used to identify all puncturing patterns with degraded performance.

In a particular embodiment of the invention, the capacity of a WTRU is determined, including buffer sizes that are supported by the WTRU. The puncturing is used to reduce the number of bits to fit into the buffer, and the overall code rate is adjusted so as to provide sufficient error correction capability. This provides a first rate in a first stage of puncturing and a second rate in a second stage of puncturing.

According to the present invention, detecting, avoiding and/or correcting problematic puncture patterns in parity bit streams and punctured Turbo codes is achieved without having to avoid desirable code rates. This is applicable without limitation, to FDD, TDD and other modes of transmission, and enables identification/avoidance of regions of relatively poor Turbo code performance, which might result from the prior art bit-puncturing scheme. The invention provides for forward error correction comprising Turbo coding and puncturing that achieve a smooth functional relationship between any measure of performance and the effective coding rate resulting from combining the lower rate code generated by the Turbo encoder with puncturing of the parity bits. Examples of measures of performance would be BLER, bit error rate (BER), required signal-to-interference ratio (SIR), or required SNR.

The patterns of the puncturing are created by creating an encoded transmission at a particular data rate and excluding some of the encoded bits. At the receiver end, zeros or other "filler" bits are put in place of the punctured bits, and the decoding operation is based on the received signal with the missing bits. According to the present invention, the puncturing pattern is modified in order to eliminate degradation which would occur under particular puncturing patterns. In particular, if the puncturing pattern is regular or has a periodic nature, it is more likely to result in signal degradation. By eliminating the degradation, it is possible to achieve the desired code rate.

The present invention is particularly useful for 3GPP-coding, and can be used for low chip rate TDD, high chip rate TDD and FDD.

US 9,065,486 B2

13

One such example of a periodicity occurs when the non-punctured bit pattern is periodic with period equal to the period of the semi-periodic impulse response of the recursive encoding blocks of the Turbo encoder. An algorithm is provided to identify all puncturing patterns with degraded performance. Additionally, modification of the puncturing patterns is performed such that performance of the Turbo code is restored.

Modifications to puncturing are used to restore Turbo performance. If it is desirable for a system to be allowed to make unrestricted use of available code rates, then performance may be restored by modification of the puncture pattern. Therefore if it is deemed desirable for a system to be allowed to make unrestricted use of available code rates, then performance may be restored by modification of the puncture pattern.

Adaptive coding means that on the fly, information is obtained from the WTRU that indicates the channel quality. Based on that, the transmitter adjusts its code rate amongst other parameters. In instances of poor reception, a substantial amount of redundancy is added, which results in a very low code rate, but which allows transfer of data through with the required block error probability.

The channel quality estimation procedure does not inherently take into account the possibility that problematic puncturing may have been used, nor should it. The channel quality is typically based on signal power and noise power, but it does not take into account the fact that the encoder may have been punctured in a problematic way, therefore AMC will not serve to avoid problematic code rates. With good channel quality, very little coding is needed and it is possible to use a higher order modulation. If the channel quality is poor, the code rate is reduced. Therefore, a reduced data rate is used to provide the desired error performance. The channel quality indicator is used to monitor the channel quality and in turn provides input to the data rate controller.

Capacity is measured by determining a combined data rate to all users supported. If one or more users in a cell are tuned to a problematic code rate, then those users are presumed to require more power and thereby reduce capacity. In many cases the problematic coding rates are known or can be determined via this invention and therefore it is possible to avoid these rates.

The present invention provides an ability to identify problem rates in advance through some analytical means, and responding to this information by avoiding these rates either dynamically or statically. This can be achieved by detecting problematic patterns or by using a formula or table of rates to avoid. If a transmission calls for one of the problem rates, the actual transmission is provided at a rate which is slightly different. The result is, the problem rate is avoided.

These are representative examples of modifications to the puncturing pattern used to generate specific code rates, as applicable to layer 1 and layer 2 in the TDD and FDD mode of transmission in accordance with the present invention. Variations to the examples described are conceivable. All such variations may be considered special cases and specific implementations of the more general concept of a permutation of the puncturing pattern. Any method of changing the puncturing pattern, i.e., generating some permutation of the original puncturing pattern, has the potential of changing the overall performance of a code, and it is the intent to include permutations and methods of generating such permutations of the puncturing pattern envisaged in the present invention. All modifications and improvements to the basic concept of the invention as set forth hereinabove are envisaged to be within the ambit of the present invention.

14

FIG. 11 shows the BLER performance of 3 different HS-DSCH transport blocks of increasing size 4554, 4705 and 4858 bits respectively. All of them are rate 1/3 Turbo-coded, and then punctured down to 6072 bits mapped to the High Speed Physical Downlink Shared Channels (HS-PDSCH). This results in an effective coding rate of 0.75 (labeled 7/9-), 0.77 (labeled 7/9) and 0.80 (labeled 7/9+) for the 3 increasing transport blocks sizes.

When increasing the effective coding rate (or equivalently increasing the puncturing rate) of a Turbo-coded transport block on HS-DSCH, one should expect that BLER performance degrades in a proportioned manner, i.e. gets increasingly worse for increasingly higher effective coding rates. This unfortunately does not always happen, and it can be seen in this example that the rate 0.77 (7/9) coded transport block needs some 3 dB more SNR than a rate 0.80 coded transport block to achieve the same BLER of approximately 10%.

The reason for the observed degradations is that the periodicity (period=7) in the output of the two Turbo-coder parity bit streams, as given by the impulse responses of the constituent recursive convolutional encoders, deleteriously interacts with the periodicity of the puncturing patterns applied by the second and/or the first rate matching stages in many cases. This effect is increasingly more frequent for increasingly higher puncturing rates.

In the analyses that follow, a single R99 rate-matching block is assumed. However, the concepts apply more generally to R4 and R5 with and without incremental redundancy. The main conclusion for both cases is that the critical puncturing rates leading to SNR degradation are predictable in principle, but would require a rather complex set of parameters to be taken into account.

The setting of critical puncturing rates is avoided in the MAC-hs in the Node B, which has the particular advantage that it would not require a change in current standards and could leave details open to vendor-specific implementation. While this approach is preferable, the look-up tables used are complex and restrictions on possible MAC-hs scheduler decisions are imposed.

Alternatively, slight modifications are made to the puncturing patterns as generated by the current rate-matching stages for HS-DSCH in TS25.212/222. These modifications constitute only a small change in the way the rate matching parameters are generated in TS25.212/222, e.g., parameters for HARQ second rate matching, and more importantly do not require any additional signaling.

Due to the apparent simplicity of the second option (slight modification of the generation of the puncturing pattern on Turbo-coded parity bit streams) and its transparency for the MAC-hs scheduler (simply selects whatever transport block size is desired as outcome of the scheduler decision), a corresponding change is made in TS25.212/222 to remedy this problem.

The constituent recursive convolutional encoders in the Turbo-coder as by TS25.212/222 have infinite impulse responses that are periodic with period 7 for positive time. The impact of certain patterns of surviving (i.e. non-punctured) bits in the parity bit stream can be qualitatively illustrated by considering how much information remains in these surviving parity bits.

The Turbo-coder produces 3 bit streams, systematic bits corresponding to the input sequence, parity bit stream 1 (output of 1st constituent encoder) and parity bit stream 2 (output of 2nd constituent encoder).

Note that the constituent recursive convolutional encoder is an LTI system on GF₂. Therefore, the output of the encoder is a sum of shifted versions of the impulse response of the

US 9,065,486 B2

15

encoder. Each shifted version of the impulse response corresponds to the locations of the 1's in the TB.

Certain puncturing patterns may result in a loss of distributed information about a small group of bits across the set of bits in one of the parity bit streams. For example, let the TB consist of 7 bits followed by many zeros. Now consider the problem of trying to determine the seven bits by observation of the output of one encoder after heavy puncturing. Each observation made at the output is a sum of a subset of the 7 bits. The subset for each particular observation is determined by the surviving bit period and the impulse response of the recursive encoding block.

For most puncture patterns, sums over 7 different subsets of the 7 bits can eventually be observed. Therefore, a system of 7 equations with 7 unknowns can be formed. Assuming that they are linearly independent, the values of the 7 bits may be determined.

However, when the periodicity of surviving bits is simple (one surviving parity bit per period) and the same as the period of the recursive encoding block, 7, then, due to the periodicity of the signal, every observation for $t > 6$ is the sum of the same subset of the 7 bits and so no new information is obtained by subsequent observations. Thus, a rank-1 system of equations is formed and a unique solution does not exist.

When the periodicity of surviving bits is not a multiple of 7, making observations of the parity bits will eventually form a rank-7 system of equations after several observations. For our 7-bit group, this is sufficient to uniquely determine the bits, i.e. information sufficient to determine the bits is distributed across the surviving parity bits.

It is also possible that some distributed information is lost even for non-simple periods, e.g., consider the case where the non-puncture pattern alternates between a simple period of three and four (two surviving parity bits per period with period=7).

This results in a period 7 non-puncture pattern but with two surviving parity bits per period. The same argument above leads to a rank-2 system of seven equations. This is still insufficient to uniquely determine the group of bits, but does reduce the dimension of the space they may span. Clearly, some information about the TB may also be lost for non-simple surviving bit patterns.

At least two alternative approaches exist to avoid the problematic interactions between Turbo-coder output and puncturing in the rate-matching stages.

The avoidance of problematic puncturing patterns is an approach that requires the MAC-hs to avoid using puncturing patterns that lead to SNR degradation and does not use certain combinations for mapping incoming transport blocks sizes to HS-PDSCHs.

Avoidance would either require building lookup tables that identify the problematical configurations or evaluating the predicted degradation expression described previously in the MAC-hs scheduler.

An advantage of the look-up table approach is that no change in current standards would be required and that any particular implementation could be left vendor-specific.

A disadvantage of the avoidance approach is that it is complicated by the fact that there are several dimensions to the problem that will all play a role in determining if a particular configuration will give rise to degradation. Parameters the MAC-hs scheduler would need to take into account in addition include:

- (1) transport block set size of HS-DSCH transmission;
- (2) number of soft information bits to be stored at the WTRU for HARQ; and

16

(3) number of physical channel bits allocated for the HS-PDSCHs.

For FDD, these parameters are implied by the combination indicator for number of channelization codes and modulation format i ($1 < i < 29$), and the transport block size k_i , ($0 < k_i < 62$) in TS25.321.

Described below is one embodiment of the present invention that includes a combination of previously described techniques.

The hybrid ARQ functionality matches the number of bits at the output of the channel coder to the total number of bits of the HS-PDSCH set to which the HS-DSCH is mapped. The hybrid ARQ functionality is controlled by the redundancy version (RV) parameters. The exact set of bits at the output of the hybrid ARQ functionality depends on the number of input bits, the number of output bits, and the RV parameters.

The hybrid ARQ functionality consists of two rate-matching stages and a virtual buffer.

The first rate matching stage matches the number of input bits to the virtual IR buffer, information about which is provided by higher layers. Note that, if the number of input bits does not exceed the virtual IR buffering capability, the first rate-matching stage is transparent.

The second rate matching stage matches the number of bits after first rate matching stage to the number of physical channel bits available in the HS-PDSCH set in the TTI.

Definitions of notations used:

N^{TTI} : Number of bits in a transmission time interval before rate matching.

ΔN_i : An intermediate calculation variable.

$\Delta N_{i,j}^{TTI}$: If positive-number of bits to be repeated in each transmission time interval on TrCH i with transport format l .

If negative-number of bits to be punctured in each transmission time interval on TrCH i with transport format l .

ΔN_{PARITY} : Number of bits to adjust the length of parity streams by, in HARQ 1st stage rate-matching.

N_{data} : Total number of bits that are available for the HS-DSCH in a TTI.

e_{ini} : Initial value of variable e in the rate matching pattern determination algorithm.

e_{plus} : Increment of variable e in the rate matching pattern determination algorithm.

e_{minus} : Decrement of variable e in the rate matching pattern determination algorithm.

b : Indicates systematic and parity bits

$b=1$: Systematic bit, x_k .

$b=2$: 1st parity bit (from the upper Turbo constituent encoder), Z_k .

$b=3$: 2nd parity bit (from the lower Turbo constituent encoder), Z'_k .

The HARQ bit separation function shall be performed in the same way as bit separation for turbo encoded TrCHs.

HARQ first stage rate matching for the HS-DSCH transport channel shall be performed using the method described below with the following specific parameters.

The maximum number of soft bits available in the virtual IR buffer is N_{IR} which is signaled from higher layers for each HARQ process. The number of coded bits in a TTI before rate matching is N^{TTI} this is deduced from information signaled from higher layers and parameters signaled on the High Speed Synchronization Control Channel (HS-SCCH) for each TTI. Note that HARQ processing and physical layer storage occurs independently for each HARQ process currently active.

If N_{IR} is greater than or equal to N^{TTI} (i.e. all coded bits of the corresponding TTI can be stored) the first rate matching

US 9,065,486 B2

17

stage shall be transparent. This can, for example, be achieved by setting $e_{minus}=0$. Note that no repetition is performed.

If N_{IR} is smaller than N^{TTI} the parity bit streams are punctured by setting the rate matching parameter $\Delta N_{iI}^{TTI}=N_{IR}-N^{TTI}$ where the subscripts i and I refer to transport channel and transport format in the referenced sub-clause. Note the negative value is expected when the rate matching implements puncturing. Bits selected for puncturing which appear as δ shall be discarded and not counted in the totals for the streams through the virtual IR buffer.

If first stage puncturing is to be performed, the procedure below shall be applied. Index b is used to indicate systematic (b=1), 1st parity (b=2), and 2nd parity bit (b=3). The parameter ΔN_{PARITY} is the change in length to the parity streams to circumvent problematic puncturing rates.

The first stage rate matching delta is calculated as follows:

```

if puncturing is to be performed
   $X_i = \lfloor N^{TTI} / 3 \rfloor$ ;  $PR = \frac{\lfloor -\Delta N_{iI}^{TTI} / 2 \rfloor}{X_i}$ ;
   $\Delta N_{PARITY} = 0$ ;  $\delta_{PR} = 49$ ;  $\alpha = 1$ 
  while ( $\alpha \leq 4$ )
     $round = \left\lfloor \frac{7 \cdot \alpha \cdot PR + \frac{1}{2}}{7 \cdot \alpha} \right\rfloor$ 
     $\lambda = PR - round$ 
    if ( $|\lambda| > \frac{1}{\delta_{PR}}$ ) or ( $PR > \frac{48}{49}$ ) or ( $PR < -\frac{1}{49}$ ) then
       $\alpha = \alpha + 1$ 
       $\delta_{PR} = 98$ 
    else if ( $\lambda > 0$ ) then
       $\Delta N_{PARITY} = \left\lfloor \lfloor -\Delta N_{iI}^{TTI} / 2 \rfloor - X_i \cdot \left( round - \frac{1}{\delta_{PR}} \right) \right\rfloor$ 
       $\alpha = 5$ 
    else
       $\Delta N_{PARITY} = \left\lfloor \lfloor -\Delta N_{iI}^{TTI} / 2 \rfloor - X_i \cdot \left( round + \frac{1}{\delta_{PR}} \right) \right\rfloor$ 
       $\alpha = 5$ 
    end if
  end while
   $\Delta N_i = \begin{cases} \lfloor -\Delta N_{iI}^{TTI} / 2 \rfloor - \Delta N_{PARITY}, & b = 2 \\ \lfloor -\Delta N_{iI}^{TTI} / 2 \rfloor + \Delta N_{PARITY}, & b = 3 \end{cases}$ 
  a = 2 when b = 2
  a = 1 when b = 3

```

If ΔN_i is calculated as 0 for b=2 or b=3, then the following procedure and the rate matching algorithm shall not be performed for the corresponding parity bit stream.

For each radio frame, the rate-matching pattern shall be calculated, where:

X_i is as above,

$$e_{ini} = X_i$$

$$e_{plus} = a \times X_i$$

$$e_{minus} = a \times |\Delta N_i|$$

HARQ second stage rate matching for the HS-DSCH transport channel shall be done using one of two possible methods.

If second stage puncturing is to be performed, and the Composite Puncturing Rate of one of the parity streams, calculated using the formula below falls in any of the intervals [91/128, 92/128], [217/256, 222/256], [231/256, 232/256], [237/256, 238/256] or [487/512, 488/512], then puncturing of that parity stream shall be performed. Note, puncturing may be carried out on one, both, or neither of the two parity streams, but never on the systematic parity stream.

18

Composite Puncturing Ratio,

$$CPR = \begin{cases} \frac{\lfloor N^{TTI} / 3 \rfloor - N_{i,p1}}{\lfloor N^{TTI} / 3 \rfloor}, & b = 2 \\ \frac{\lfloor N^{TTI} / 3 \rfloor - N_{i,p2}}{\lfloor N^{TTI} / 3 \rfloor}, & b = 3 \end{cases}$$

Otherwise, second stage rate matching for the HS-DSCH transport channel shall be done with the following specific parameters. Bits selected for puncturing which appear as δ shall be discarded and are not counted in the streams towards the bit collection.

The parameters of the second rate matching stage depend on the value of the RV parameters s and r. The parameter s can take the value 0 or 1 to distinguish between transmissions that prioritize systematic bits (s=1) and non systematic bits (s=0). The parameter r (range 0 to $r_{max}-1$) changes the initial error variable e_{ini} in the case of puncturing. In case of repetition both parameters r and s change the initial error variable e_{ini} . The parameters X_i , e_{plus} and e_{minus} are calculated as per table 1 below.

Denote the number of bits before second rate matching as N_{sys} for the systematic bits, N_{p1} for the parity 1 bits, and N_{p2} for the parity 2 bits, respectively. Denote the number of physical channels used for the HS-DSCH by P. N_{data} is the number of bits available to the HS-DSCH in one TTI and defined as $N_{data} = P \times 3 \times N_{data1}$. The rate matching parameters are determined as follows.

For $N_{data} \leq N_{sys} + N_{p1} + N_{p2}$, puncturing is performed in the second rate matching stage. The number of transmitted systematic bits in a transmission is $N_{t,sys} = \min\{N_{sys}, N_{data}\}$ for a transmission that prioritizes systematic bits and $N_{t,sys} = \max\{N_{data} - (N_{p1} + N_{p2}), 0\}$ for a transmission that prioritizes non systematic bits.

For $N_{data} > N_{sys} + N_{p1} + N_{p2}$ repetition is performed in the second rate matching stage. A similar repetition rate in all bit streams is achieved by setting the number of transmitted systematic bits to

$$N_{t,sys} = \left\lfloor N_{sys} \cdot \frac{N_{data}}{N_{sys} + 2N_{p1}} \right\rfloor.$$

The number of parity bits in a transmission is:

$$N_{i,p1} = \max\left\{\left\lfloor \frac{N_{data} - N_{t,sys}}{2} \right\rfloor - \Delta N_{PARITY}, 0\right\}$$

and

$$N_{i,p2} = N_{data} - (N_{t,sys} + N_{i,p1})$$

for the parity 1 and parity 2 bits, respectively.

TABLE 1

Parameters for HARQ second rate matching			
	X_i	e_{plus}	e_{minus}
Systematic RM S	N_{sys}	N_{sys}	$ N_{sys} - N_{t,sys} $
Parity 1 RM P1_2	N_{p1}	$2 \cdot N_{p1}$	$2 \cdot N_{p1} - N_{t,p1} $
Parity 2 RM P2_2	N_{p2}	N_{p2}	$ N_{p2} - N_{t,p2} $

US 9,065,486 B2

19

Table 1 above summarizes the resulting parameter choice for the second rate matching stage. The rate matching parameter e_{int} is calculated for each bit stream according to the RV parameters r and s using $e_{int}(r) = \{(X_i - \lfloor r \cdot e_{plus} / r_{max} \rfloor - 1) \bmod e_{plus}\} + 1$ in the case of puncturing, i.e., $N_{data} \leq N_{sys} + N_{p1} + N_{p2}$, and $e_{int}(r) = \{(X_i - \lfloor (s+2) \cdot r \cdot e_{plus} / (2 \cdot r_{max}) \rfloor - 1) \bmod e_{plus}\} + 1$ for repetition, i.e., $N_{data} > N_{sys} + N_{p1} + N_{p2}$. Where $r \in \{0, 1, \dots, r_{max} - 1\}$ and r_{max} is the total number of redundancy versions allowed by varying r . Note that r_{max} varies depending on the modulation mode, i.e. for 16QAM $r_{max} = 2$ and for QPSK $r_{max} = 4$.

Note: For the modulo operation the following clarification is used: the value of $(x \bmod y)$ is strictly in the range of 0 to $y-1$ (i.e. $-1 \bmod 10 = 9$).

HARQ second stage rate matching for the HS-DSCH transport channel shall be done with the method described below, which separates each stream into segments with specific parameters calculated below. Bits selected for puncturing which appear as δ shall be discarded and are not counted in the streams towards the bit collection.

The parity stream will be segmented into 3 segments, the first segment will be made up of the first X_{seg1} bits of the parity stream, the second segment will be made up of the next X_{seg2} bits, and the last segment will be made up of the remaining X_{seg3} bits.

The first segment is denoted by $x_{i,1}, x_{i,2}, \dots, x_{i,X_{seg1}}$

The second segment by $x_{i,X_{seg1}+1}, x_{i,X_{seg1}+2}, \dots, x_{i,X_{seg2}}$

And the final segment by $x_{i,X_{seg1}+X_{seg2}+1},$

$x_{i,X_{seg1}+X_{seg2}+2}, \dots, x_{i,X_i}$
Where $X_{seg1} = 42 \cdot \lfloor X_i / 98 \rfloor$, $X_{seg2} = 56 \cdot \lfloor X_i / 98 \rfloor$, $X_{seg3} = X_i \bmod 98$

Note: If X_i is less than 98 only the third segment exists, and if X_i is a multiple of 98 then the third segment will be empty. For the case where a particular segment is empty, then of course no puncturing is performed on that non-existent segment.

Additional parameters for HARQ Second Rate Matching Stage for problematic puncturing rates

Parameters P , N_{data} , N_{sys} , N_{p1} , N_{p2} , $N_{p,t1}$, and $N_{p,t2}$ are calculated, additional parameters are defined below.

Denote the number of parity 1 bits before second rate matching after segmentation as $N_{p1,seg1}$, $N_{p1,seg2}$, $N_{p1,seg3}$ for the parity 1 bits in the 1st, 2nd and 3rd segment respectively. Denote the number of parity 2 bits before second rate matching after segmentation as $N_{p2,seg1}$, $N_{p2,seg2}$, $N_{p2,seg3}$ for the parity 2 bits in the 1st, 2nd and 3rd segment respectively. The rate matching parameters are determined as follows.

For $N_{data} \leq N_{sys} + N_{p1} + N_{p2}$, puncturing is performed in the second rate matching stage.

The number of parity bits after segmentation is

$$N_{pb,seg1} = 42 \cdot \lfloor N_{pb} / 98 \rfloor$$

$$N_{pb,seg2} = 56 \cdot \lfloor N_{pb} / 98 \rfloor$$

$$N_{pb,seg3} = N_{pb} \bmod 98$$

The number of parity bits in each segment for parity 1 bits ($b=2$), and parity 2 bits ($b=3$) is:

$$N_{i,pb,seg1} = \left\lfloor \frac{49 \cdot N_{i,pb} \cdot \lfloor N_{pb} / 98 \rfloor}{N_{pb}} + \frac{1}{2} \right\rfloor;$$

$$N_{i,pb,seg2} = \left\lfloor \frac{49 \cdot N_{i,pb} \cdot \lfloor N_{pb} / 98 \rfloor}{N_{pb}} + \frac{1}{2} \right\rfloor;$$

$$N_{i,pb,seg3} = N_{i,pb} - (N_{i,pb,seg1} + N_{i,pb,seg2})$$

The parameters X_i , e_{plus} and e_{minus} are calculated as per table 2 below.

20

TABLE 2

Parameters for dithered HARQ second rate matching				
Stream	Segment	X_i	e_{plus}	e_{minus}
Systematic		N_{sys}	N_{sys}	$ N_{sys} - N_{t,sys} $
RM S				
Parity 1	1st	$N_{p1,seg1}$	$2 \cdot N_{p1,seg1}$	$2 \cdot N_{p1,seg1} - N_{t,p1,seg1} $
RM	2nd	$N_{p1,seg2}$	$2 \cdot N_{p1,seg2}$	$2 \cdot N_{p1,seg2} - N_{t,p1,seg2} $
P1_2	3rd	$N_{p1,seg3}$	$2 \cdot N_{p1,seg3}$	$2 \cdot N_{p1,seg3} - N_{t,p1,seg3} $
Parity 2	1st	$N_{p2,seg1}$	$N_{p2,seg1}$	$ N_{p2,seg1} - N_{t,p2,seg1} $
RM	2nd	$N_{p2,seg2}$	$N_{p2,seg2}$	$ N_{p2,seg2} - N_{t,p2,seg2} $
P2_2	3rd	$N_{p2,seg3}$	$N_{p2,seg3}$	$ N_{p2,seg3} - N_{t,p2,seg3} $

The rate matching parameter e_{int} is calculated for each segment of bit stream according to the RV parameters r and s using $e_{int}(r) = \{(X_i - \lfloor r \cdot e_{plus} / r_{max} \rfloor - 1) \bmod e_{plus}\} + 1$ in the case of puncturing. Where $r \in \{0, 1, \dots, r_{max} - 1\}$ and r_{max} is the total number of redundancy versions allowed by varying r . Note that r_{max} varies depending on the modulation mode, i.e. for 16QAM $r_{max} = 2$ and for QPSK $r_{max} = 4$.

Note: For the modulo operation the following clarification is used: the value of $(x \bmod y)$ is strictly in the range of 0 to $y-1$ (i.e. $-1 \bmod 10 = 9$). The rate matching algorithm is called for each segment of the parity stream in turn.

For both parity streams, after the rate matching algorithm has been called for each of the three segments, the three punctured segments should be concatenated together in their original order.

The re-concatenated bit stream is denoted by: $x_{o,seg1,1},$

$x_{o,seg1,2}, \dots, x_{o,seg1,N_{t,p1,seg1}}, x_{o,seg2,1}, x_{o,seg2,2}, \dots, x_{o,seg2,N_{t,p2,seg2}},$

$x_{o,seg3,1}, x_{o,seg3,2}, \dots, x_{o,seg3,N_{t,p1,seg3}}$
The HARQ bit collection is achieved using a rectangular interleaver of size $N_{row} \times N_{col}$. The number of rows and columns are determined from:

$N_{row} = 4$ for 16QAM and $N_{row} = 2$ for QPSK

$$N_{col} = N_{data} / N_{row}$$

where N_{data} is used.

Data is written into the interleaver column by column, and read out of the interleaver column by column starting from the first column.

$N_{t,sys}$ is the number of transmitted systematic bits. Intermediate values N_r and N_c are calculated using:

$$N_r = \left\lfloor \frac{N_{t,sys}}{N_{col}} \right\rfloor$$

and

$$N_c = N_{t,sys} - N_r \cdot N_{col}.$$

If $N_c = 0$ and $N_r > 0$, the systematic bits are written into rows $1 \dots N_r$.

Otherwise systematic bits are written into rows $1 \dots N_r + 1$ in the first N_c columns and, if $N_c > 0$, also into rows $1 \dots N_r$ in the remaining $N_{col} - N_c$ columns.

The remaining space is filled with parity bits. The parity bits are written column wise into the remaining rows of the respective columns. Parity 1 and 2 bits are written in alternating order, starting with a parity 2 bit in the first available column with the lowest index number. If the two parity streams are of unequal length, Parity 1 and 2 bits shall be written alternately, again starting with a parity 2 bit, until the end of the shorter parity stream, then the remaining parity bits from the longer stream shall be written.

In the case of 16QAM for each column the bits are read out of the interleaver in the order row 1, row 2, row 3, row 4. In the

US 9,065,486 B2

21

case of QPSK for each column the bits are read out of the interleaver in the order row1, row2.

When the analysis of the rate matching issue was restricted to the situation in which the first stage HS-DSCH rate matching is transparent it was shown that the performance degradation arises from an interaction between the periodicity of the rate matching pattern and the inherent periodicity of the turbo encoder. In particular, it was shown that at the problematic code rates, the positions (in the unpunctured bit stream) of survivor (i.e. non punctured) bits lie in the same position or positions within a modulo 7 period for long segments of the unpunctured stream. It has been demonstrated that performance degradations arise via exactly the same mechanism when the first stage is not transparent.

In the following description, a "puncturing pattern" is defined to be the pattern of positions of bits that are punctured from an original stream. "Puncturing Rate" is defined to be the reciprocal of the number of bits between punctured bit positions (inclusive of the punctured positions) in the original bit stream.

In the case of two-stage rate matching, puncturing that leads to degradation may occur in two ways:

- 1) A pattern arising from bits punctured in the first stage only
- 2) A pattern arising from bits punctured after the second stage; this pattern is dependent upon both the first and second rate matching stages.

In order to avoid either of these puncturing mechanisms that cause a performance degradation, the following methodology has been adopted:

In the first stage, test whether the puncturing will cause a problematic puncturing pattern. This is achieved by evaluating an "implicit duration" function, which predicts the length of periodicity in the puncturing pattern. The first stage rate matching is only adjusted if the calculated implicit duration indicates a necessity. In this case, the amount of bits punctured in the first parity stream is increased slightly, whilst in the second stream the number is correspondingly decreased slightly. This has the effect of shifting the puncturing rates in both streams to break up modulo 7 periodicity, whilst keeping the total amount of punctured bits the same. The adjustment in the puncturing rate in each of the streams is kept sufficiently small to leave the coding performance in each stream unaffected.

In the second stage, a composite puncturing rate for each stream, taking into account adjustments to the puncturing rate carried out at the first stage is calculated. The composite puncturing rate in each stream is compared with a look up table, which predicts rates at which modulo-7 periodic patterns, and hence coding degradations will arise. If the composite rate of a stream falls within a range of problematic rates, a "dithering" algorithm is applied.

Differing puncturing rates are applied in the two parity streams if the puncturing pattern in the first stage will lead to a performance degradation, or is likely to contribute to an unwanted pattern after second stage rate matching. In this case, the number of bits punctured in the first parity stream is reduced by an amount ΔN_{PARITY} , whilst the number of bits punctured in the second stream is increased by the same amount. The decision as to whether such a change should take place is based upon a calculated parameter, which estimates the inverse of the length of runs of survivor bits which hold the same modulo 7 position in the unpunctured stream. This length becomes greater than 49 bits (i.e. 7 modulo 7 periods), then the adjustment to the lengths of the streams is applied.

The dithered puncturing algorithm may be applied to either or both of the two parity streams in the second stage. When

22

processing a parity stream, the algorithm employs two puncturing rates, one higher than the original, and one lower, it then switches between these two puncturing rates whilst applying puncturing to the parity bit stream. The total number of bits punctured is kept the same as it would have been with the original algorithm. Generically it is possible to have one or many switching points between the two puncturing rates within a parity stream. The number of points is not critical to the performance, since the fraction of the bit stream punctured at each rate is independent of the number of switching points.

The number of switching points is set to one (or two), meaning that the punctured stream consists of two (or three) segments in which the first segment uses a lower puncturing rate than the original, the second uses a higher puncturing rate. If the two segments do not account for the whole of the parity stream, a third segment is allowed at the end that is punctured at the original rate. The third segment is kept short, and allows for puncturing exactly the correct amount of bits to maintain the overall puncturing rate. By breaking the parity stream into a low number of segments in this way, the original rate matching algorithm can easily be used with some minor parameter changes.

The difference between the higher puncturing rate in the first segment and the original rate, and also between the lower puncturing rate in the second segment and the original has been set to 1/49. This selection allows for problematic rates to be avoided in all cases whilst not representing a significant change in coding rate.

In the majority of cases, the modified rate matching algorithm operates in exactly the same manner as previously defined. In the minority of cases in which either the first or second stage rate matching would lead to a performance degradation, unequal length streams and/or dithering are applied. Both of these modifications do not change the body of the rate matching procedure in any way, but rather the rate matching parameters that are applied. Furthermore, in an implementation, the modifications can be achieved with a modification to the Rate Matching DSP software without affecting any other part of the system.

The foregoing is a description of a preferred embodiment and alternative solutions to providing detecting, avoiding/correcting problematic Turbo code puncturing patterns. While this invention has been particularly shown and described with reference to preferred embodiments, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the scope of the invention as described hereinabove.

What is claimed is:

1. An apparatus for use in wireless communications comprising:

- a first interleaver configured to interleave systematic bits;
- a second interleaver configured to interleave a first parity bit stream;
- a third interleaver configured to interleave a second parity bit stream;
- a buffer configured to buffer the interleaved systematic bits, the interleaved first parity bit stream and the interleaved second parity bit stream; and
- a rate matching unit configured to select bits for transmission based on a plurality of redundancy versions; wherein at least one redundancy version of the set selects systematic bits over first and second parity bits and at least one redundancy version of the set selects first and second parity bits over systematic bits.

US 9,065,486 B2

23

2. The apparatus of claim 1 wherein selecting of bits by the rate matching unit in response to a selected redundancy version changes in response to a location of the bits in the buffer.
3. A method for use in an apparatus of a wireless communications comprising:
- interleaving, by the apparatus, systematic bits;
 - interleaving, by the apparatus, a first parity bit stream;
 - interleaving, by the apparatus, a second parity bit stream;
 - buffering, by the apparatus, the interleaved systematic bits, the interleaved first parity bit stream and the interleaved second parity bit stream; and
 - selecting, by the apparatus, bits for transmission based on a plurality of redundancy versions; wherein at least one redundancy version of the set selects systematic bits over first and second parity bits and at least one redundancy version of the set selects first and second parity bits over systematic bits.
4. The method of claim 3 wherein the selecting of bits for transmission in response to a selected redundancy version changes in response to a location of the bits in the buffer.

24

5. A wireless transmit/receive unit comprising:
- circuitry configured to interleave systematic bits;
 - circuitry is further configured to interleave a first parity bit stream;
 - circuitry is further configured to interleave a second parity bit stream;
 - circuitry is further configured to buffer the interleaved systematic bits, the interleaved first parity bit stream and the interleaved second parity bit stream; and
 - circuitry is further configured to select bits for transmission based on a plurality of redundancy versions; wherein at least one redundancy version of the set selects systematic bits over first and second parity bits and at least one redundancy version of the set selects first and second parity bits over systematic bits.
6. The wireless transmit/receive unit of claim 5 wherein selecting of bits based on a selected redundancy version changes in response to a location of the bits in the buffer.

* * * * *

EXHIBIT 6



US007283839B2

(12) **United States Patent**
You et al.

(10) **Patent No.:** **US 7,283,839 B2**
(45) **Date of Patent:** **Oct. 16, 2007**

(54) **WIRELESS COMMUNICATING TERMINAL
FOR PROVIDING INTEGRATED
MESSAGING SERVICE AND METHOD
THEREOF**

(75) Inventors: **Jin-Woo You**, Seoul (KR); **SangWoo Suk**, Seoul (KR)

(73) Assignee: **Curitel Communications, Inc.** (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 226 days.

(21) Appl. No.: **11/106,160**

(22) Filed: **Apr. 13, 2005**

(65) **Prior Publication Data**

US 2005/0245281 A1 Nov. 3, 2005

(30) **Foreign Application Priority Data**

Apr. 14, 2004 (KR) 10-2004-0025882
Oct. 18, 2004 (KR) 10-2004-0083073

(51) **Int. Cl.**
H04M 1/00 (2006.01)

(52) **U.S. Cl.** **455/550.1**; 455/466; 455/418;
709/213; 709/201

(58) **Field of Classification Search** 455/550.1,
455/466, 418; 709/213, 201
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,556,217 B1 * 4/2003 Makipaa et al. 345/667
6,952,712 B2 * 10/2005 Yoshimura et al. 709/201
7,136,917 B2 * 11/2006 Kawai et al. 709/223

2001/0028605 A1 * 10/2001 Higuchi et al. 368/37
2002/0015112 A1 * 2/2002 Nagakubo et al. 348/734
2003/0005125 A1 * 1/2003 Berthaud et al. 709/226
2003/0095518 A1 * 5/2003 Suwa 370/336
2004/0015547 A1 1/2004 Griffin et al.
2004/0165721 A1 * 8/2004 Sano et al. 380/28
2004/0253965 A1 * 12/2004 Sato et al. 455/456.3
2005/0164721 A1 * 7/2005 Yeh et al. 455/466

FOREIGN PATENT DOCUMENTS

EP 1 109 415 A2 6/2001
EP 1 349 407 A2 1/2003

* cited by examiner

Primary Examiner—Dan Le

(74) *Attorney, Agent, or Firm*—Blakely Sokoloff Taylor & Zafman

(57) **ABSTRACT**

Provided is a wireless communication terminal having a function of providing an integrated messaging service. The wireless communication terminal includes: a wireless transceiver for transceiving a message to/from an outside device through a wireless network; a storage for storing an integrated messaging service program and messages; a keypad for receiving a message content and a menu selecting signal in the IUI; a displayer for displaying the message content and description data in the IUI; and a controller for providing the IUI to the keypad and the displayer, determining a message kind of the message to be transmitted, generating an outgoing message including identification data, transmitting the outgoing message, displaying the message content and the description data in the IUI, determining a message kind of a received message, dividing the received message into a message content and description data, and displaying the message content and the description data in the IUI.

5 Claims, 6 Drawing Sheets

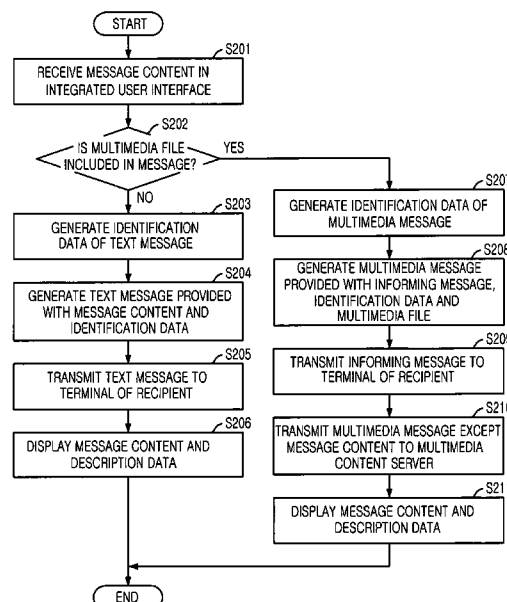


FIG. 1

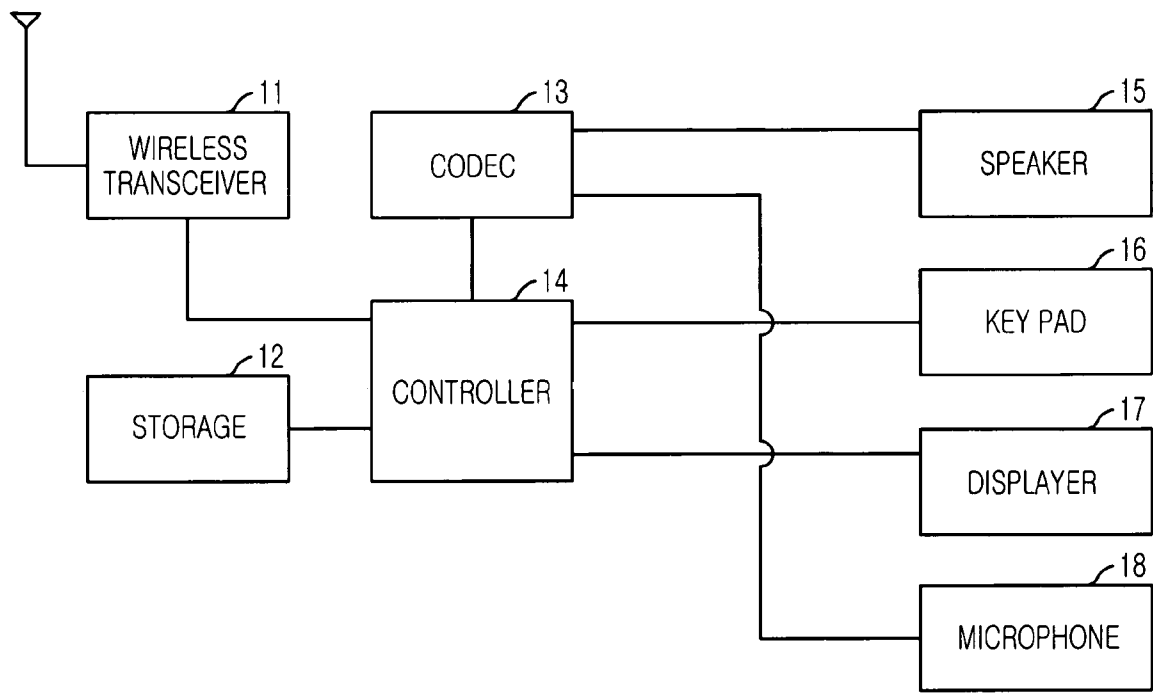


FIG. 2

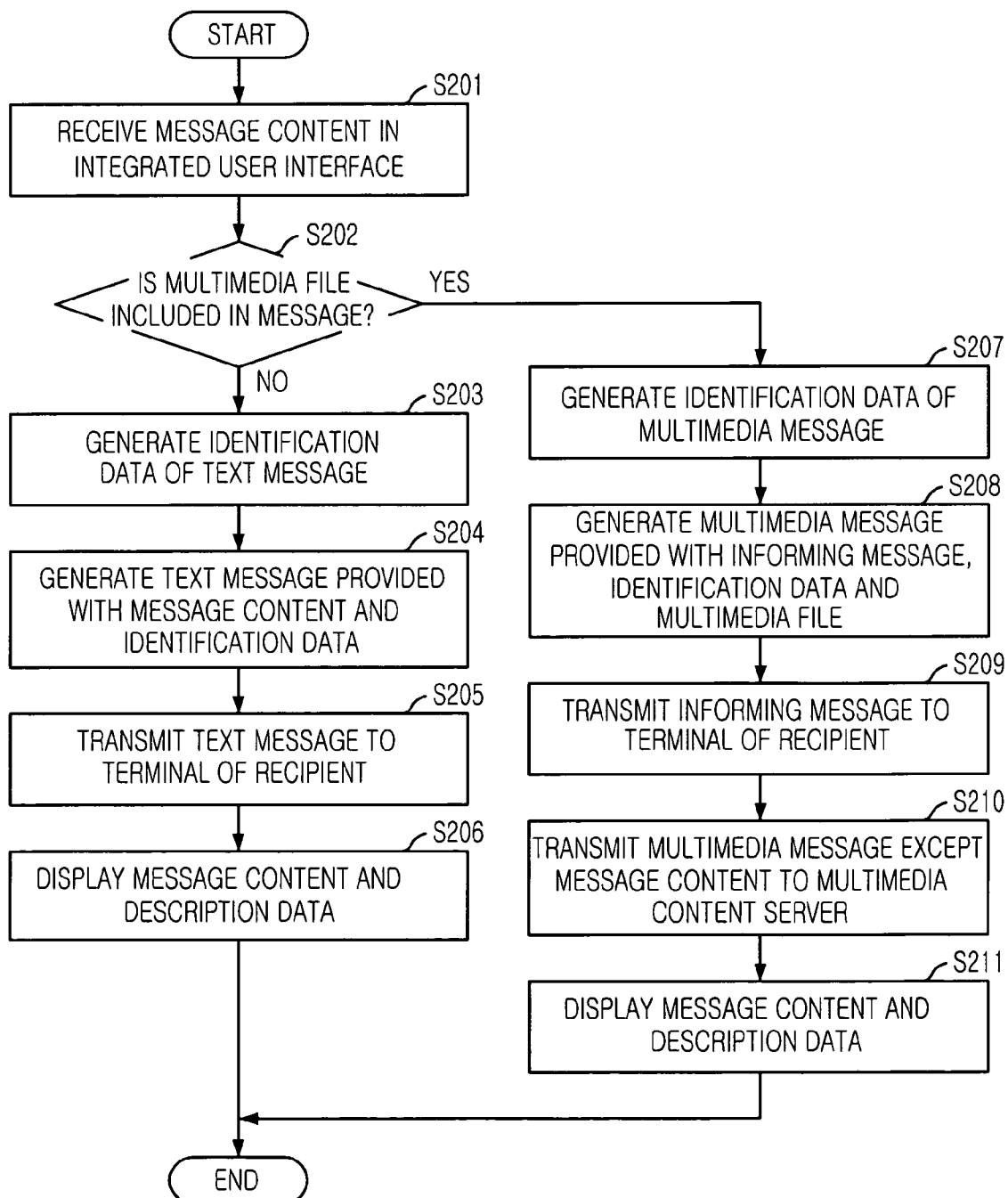


FIG. 3

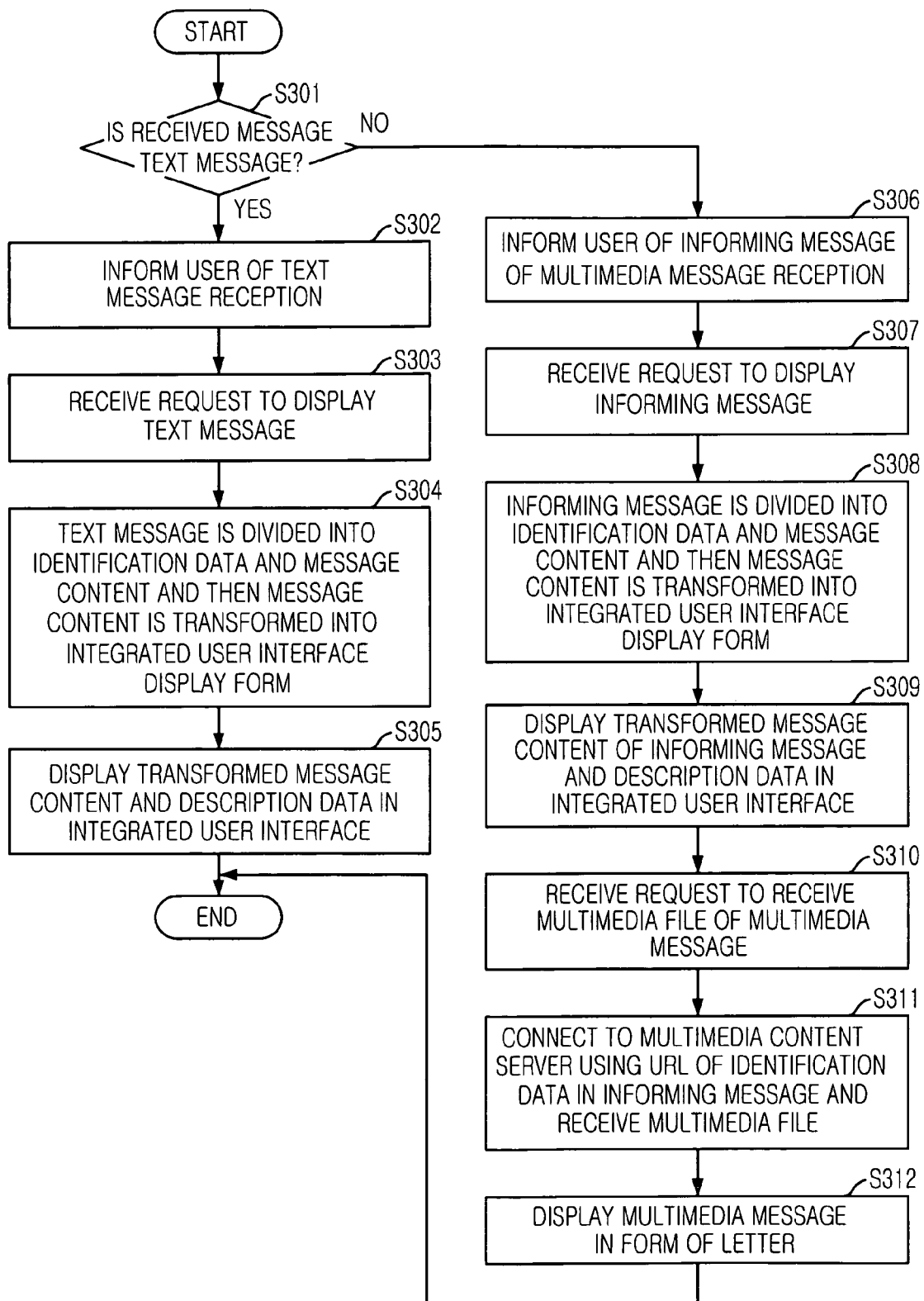


FIG. 4A

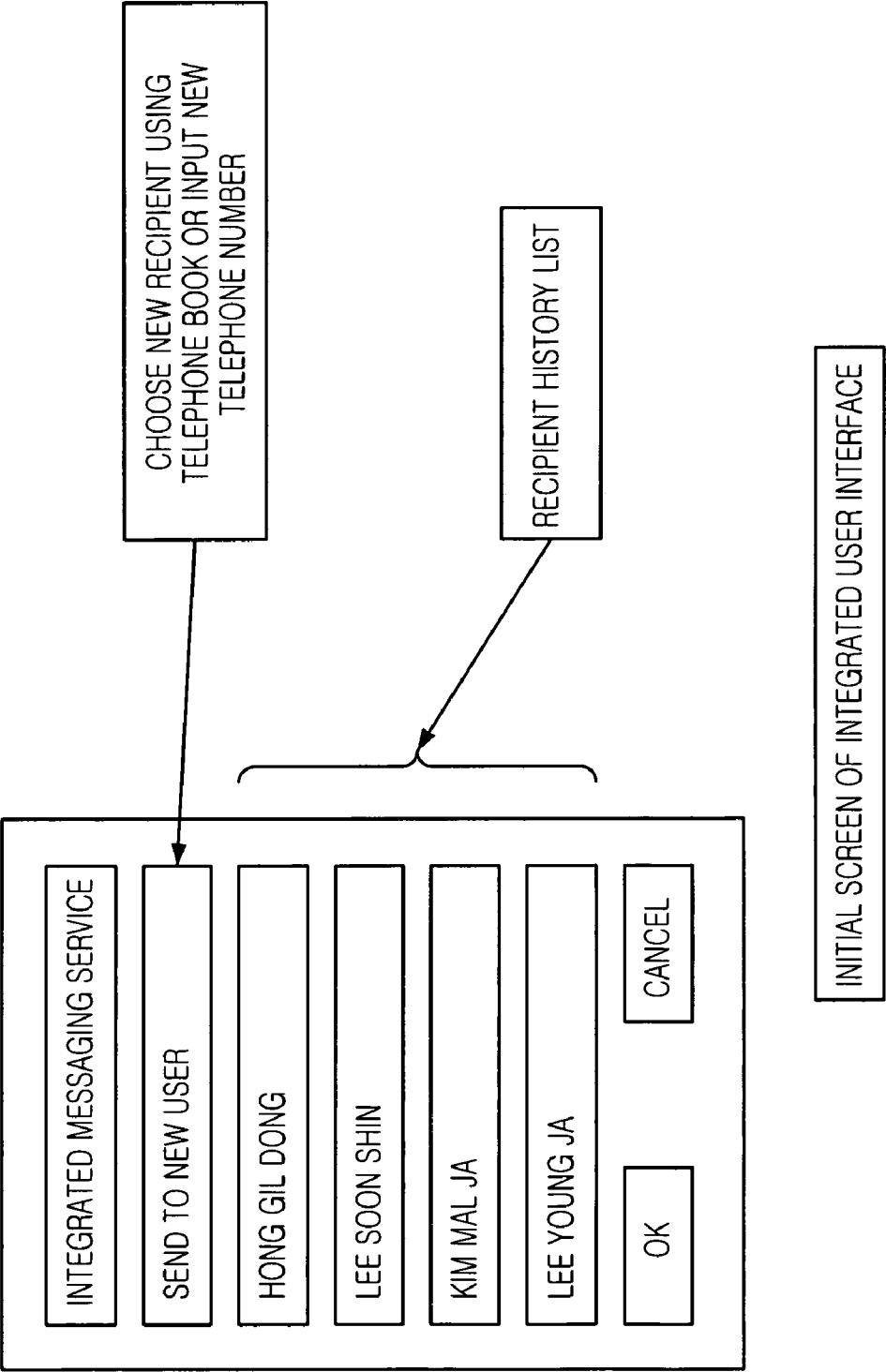
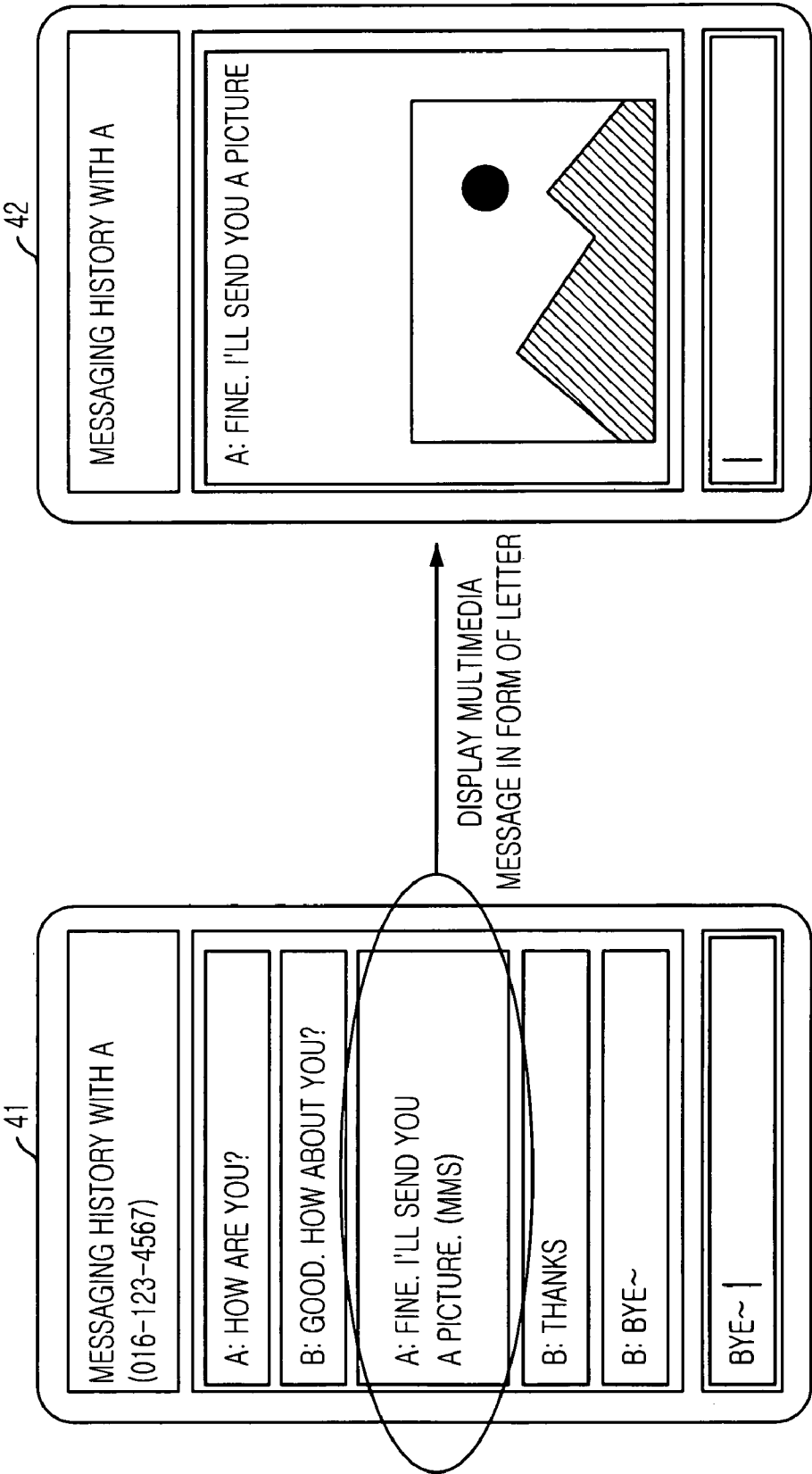


FIG. 4B



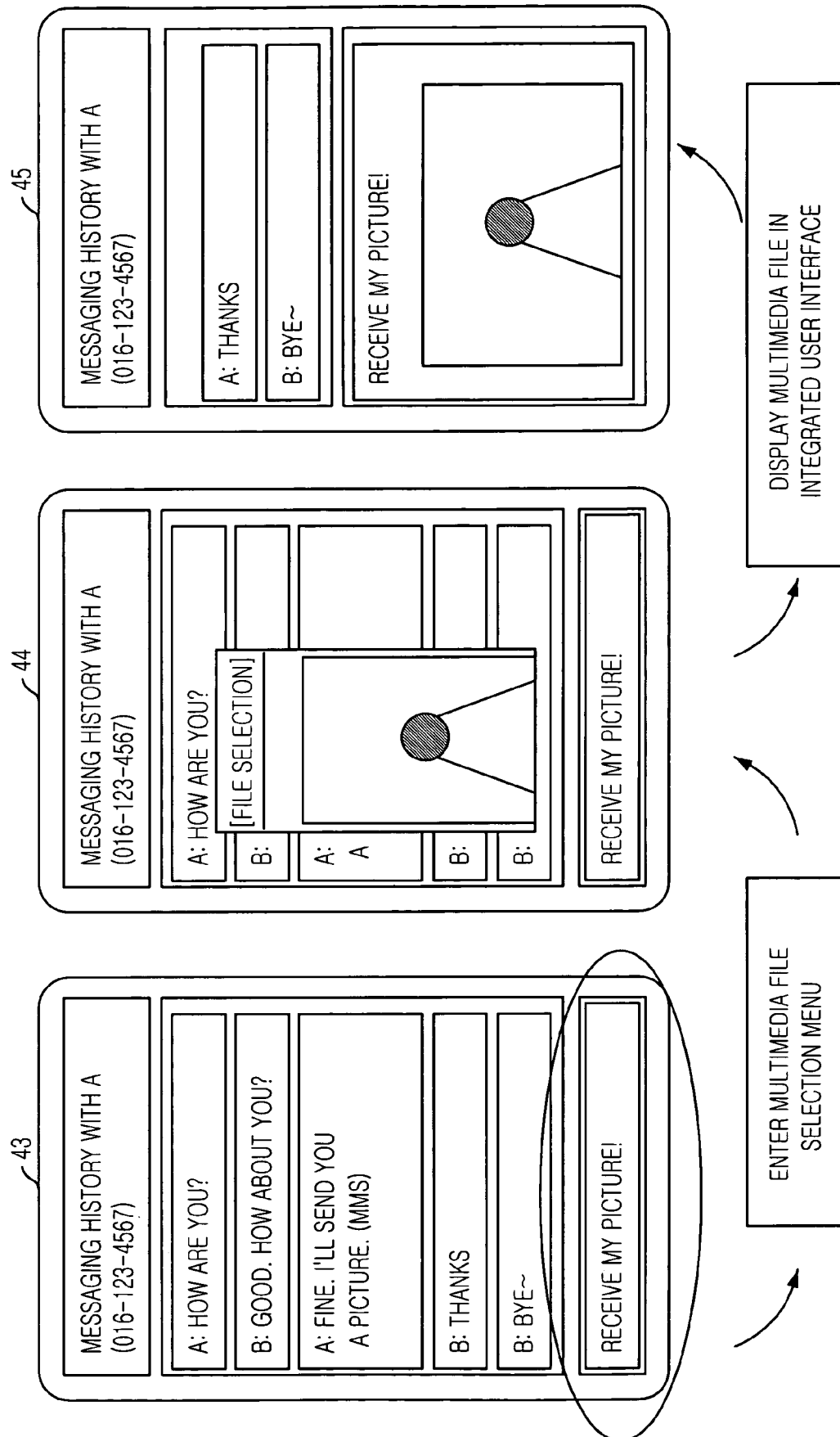
U.S. Patent

Oct. 16, 2007

Sheet 6 of 6

US 7,283,839 B2

FIG. 4C



US 7,283,839 B2

1

WIRELESS COMMUNICATING TERMINAL FOR PROVIDING INTEGRATED MESSAGING SERVICE AND METHOD THEREOF

FIELD OF THE INVENTION

The present invention relates to a wireless communication terminal having a function of providing an integrated messaging service; and, more particularly, to a wireless communication terminal and a method for transmitting and receiving various kinds of messages, e.g., a text message and a multimedia message, by using an integrated messaging service program without changing a transmission protocol or a network.

DESCRIPTION OF RELATED ART

A wireless communication terminal includes a mobile communication terminal, a Personal Communication Station (PCS), a Personal Digital Assistance (PDA), a smart phone, an International Mobile Telecommunication (IMT)-2000 terminal and a wireless Local Area Network (LAN) terminal capable of transmitting and receiving multimedia contents, e.g., text data, voice data, images, and moving pictures.

The wireless communication terminal provides functions of voice communications and a text messaging. Recently, the mobile terminal is provided with a multimedia message transceiving service including text data, voice data, images, and moving pictures.

A conventional wireless communication terminal provides messaging services in different user interfaces according to the kind of messages e.g., a text message and a multimedia message.

Therefore, in the conventional method, a user should use a different interface according to the message kind to transmit and receive the text message or the multimedia message.

Also, although the user does not need to know each technology used for each message type, the conventional wireless terminal provides different terms for each of messaging menus. Therefore, there is a problem that the user should use the various messaging services frequently in the conventional method.

The conventional wireless communication terminal manages incoming/outgoing messages in an in-box and an out-box based on a concept that the message is a kind of a letter. The conventional messaging service provides late response in a communication, compared to an Internet instant messenger.

SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to provide a wireless communication terminal and a method for transmitting and receiving different kinds of messages, e.g., a text message and a multimedia message in an integrated user interface by using an integrated messaging service program in order to provide an easy and user-friendly interface without modifying a transmission protocol or a network.

In accordance with an aspect of the present invention, there is provided a wireless communication terminal having a function of providing an integrated messaging service, the wireless communication terminal including: a wireless transceiver for transceiving a message to/from an outside

2

device through a wireless network; a storage for storing an integrated messaging service program and messages in order to provide an integrated user interface (IUI); a keypad for receiving a message content and a menu selecting signal in the IUI; a displayer for displaying the message content and description data in the IUI; and a controller for providing the IUI to the keypad and the displayer by operating the integrated messaging service program, determining a message kind of the message to be transmitted which is inputted in the IUI, generating an outgoing message including identification data corresponding to the message kind, transmitting the outgoing message, displaying the message content and the description data of the outgoing message in the IUI, determining a message kind of a received message, dividing the received message into a message content and description data, displaying the message content and the description data in the IUI, and controlling elements in the wireless communication terminal.

In accordance with another aspect of the present invention, there is provided a method for transmitting a message in a wireless communication terminal for providing an integrated messaging service, the method including the steps of: inputting a message content in an IUI; determining a message kind of the message content; generating an outgoing message including identification data; transmitting the outgoing message to a receiving terminal; and displaying the message content with description data in the IUI.

In accordance with another aspect of the present invention, there is provided a method for receiving a message in a wireless communication terminal for providing an integrated message service, the method including the steps of: determining a message kind of an incoming message; informing of the incoming message to a user; when a display form transformation request is received, dividing the incoming message into a message content and identification data and transforming the message content into a display form of an IUI; and displaying the transformed message content and description data in the IUI.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects and features of the present invention will become apparent from the following description of the preferred embodiments given in conjunction with the accompanying drawings, in which:

FIG. 1 is a block diagram showing a wireless communication terminal having a function of providing an integrated message service in accordance with a preferred embodiment of the present invention;

FIG. 2 is a flowchart describing a method for transmitting a message in a wireless communication terminal having a function of providing an integrated message service in accordance with a preferred embodiment of the present invention;

FIG. 3 is a flowchart describing a method for receiving a message of a wireless communication terminal having a function of providing an integrated message service in accordance with a preferred embodiment of the present invention; and

FIGS. 4A to 4C are block diagrams showing an integrated user interface in a wireless communication terminal having a function of providing an integrated message service in accordance with a preferred embodiment of the present invention.

US 7,283,839 B2

3

DETAILED DESCRIPTION OF THE
INVENTION

Hereinafter, a wireless communication terminal and the method for providing the integrated messaging service will be described in detail with reference to the accompanying drawings.

The wireless communication terminal in accordance with the present invention can transmit/receive various kinds of messages such as a text message and a multimedia message.

FIG. 1 is a block diagram showing the wireless communication terminal having a function of providing an integrated message service in accordance with a preferred embodiment of the present invention.

As shown, the wireless communication terminal having a function of providing an integrated messaging service includes a wireless transceiver 11, a storage 12, a CODEC 13, a controller 14, a speaker 15, a keypad 16, a display 17 and a microphone 18.

The wireless transceiver 11 transmits/receives a text message and an informing message of a multimedia message to/from another terminal through a wireless network and transmits/receives the multimedia message including a multimedia file to/from a multimedia contents server.

The storage 12 stores an integrated messaging program, a phone book, wherein the integrated messaging program provides an integrated user interface (IUI) for transmitting/receiving messages regardless of a message kind and the phone book includes a telephone number and a nick name of another terminal.

The CODEC 13 converts a voice signal received from the wireless communication terminal into voice and outputs the voice to the speaker 15. Also, the CODEC 13 converts the voice received from the microphone 18 into the voice signal and then transmits the voice signal to the controller 14 so that the voice signal is released through the wireless transceiver 11 under the control of the controller 14.

The controller 14 provides the IUI to the inputting unit 16 and the display 17 by operating the integrated messaging program stored in the storage 12. When the wireless communication terminal transmits a message (hereinafter, which is referred to as an outgoing message), the controller 14 determines the message kind of an outgoing message based on whether a multimedia file is included in the message content or not; generates the outgoing message provided with identification data of a determined message kind and transmits the outgoing message; and displays the message content and the identification data of the outgoing message in the IUI. When the wireless communication terminal receives a message (hereinafter, which is referred to as an incoming message), the controller 14 determines the message kind of the incoming message based on the identification data of the incoming message; divides the incoming message into message content and the identification data and transforms the message content according to a display form of the IUI; displays the message content and description data; and controls other elements included in the wireless communication terminal.

The speaker 15 receives the voice from the CODEC 13 and outputs the voice.

The inputting unit 16 receives the message content of the outgoing message and a menu selection signal from the user in the integrated user interface.

The display 17 displays the message content of the incoming and outgoing message and the description data.

The microphone 18 receives the voice and transmits the voice to the CODEC 13.

4

FIG. 2 is a flowchart describing a method for transmitting a message in the wireless communication terminal having a function of providing an integrated message service in accordance with a preferred embodiment of the present invention.

A message content of the outgoing message is inputted by a user in the IUI at step S201. Because the IUI is one of main menus of the wireless communication terminal, the integrated messaging service is operated automatically by the controller 14 to provide the IUI when the power of the wireless communication terminal is turned on. Therefore, the IUI can be used without an additional request for operating the integrated messaging service.

The controller 14 determines the kind of a message according to whether a multimedia file is included in the message content or not at step S202. If the message content include only texts, the kind of the message content is determined as a text message. If the message content include a multimedia file, the kind of a message is determined as a multimedia message.

The multimedia file means a file including text, image, voice and/or moving pictures. The multimedia file must be transmitted to a receiving terminal through the multimedia contents server differently from the text that is transmitted to the receiving terminal directly.

If the message kind of the outgoing message is the text message, the identification data for the text message is generated at step S203. The identification data include caller information such as a telephone number and a name and time information such as transmission time.

The outgoing message which is a text message (hereinafter, which will be referred to as an outgoing text message) provided with the message content and the identification data are generated at step S204, and the outgoing text message is transmitted to the receiving terminal at step S205.

The identification data identify the kind of the outgoing message. The text message and the multimedia message are transmitted to the receiving terminal in different routes. Therefore, the identification data of the text message are different from the identification data of the multimedia message.

The message content of the outgoing text message, i.e., the text is transformed into a display form of the IUI and displayed with description data in the IUI at step S206.

The description data present the description of the incoming/outgoing messages in the IUI on the display. The description data include incoming/outgoing description data for indicating the incoming message or the outgoing message and file description data, which are applied to only multimedia messages, for indicating a kind of multimedia files such as images, voice and moving images.

For example, the incoming/outgoing description data can be a sender/recipient name, a nickname, a telephone number or an icon, and the incoming/outgoing description data are displayed on a side of the message content. Also, the file description data can be icons, thumbnails or snapshots of the moving pictures and the file description data are displayed to inform that the multimedia files are included in the messages.

At the step S206, the description data for the outgoing text message includes the outgoing description data.

If the message kind of the outgoing message is the multimedia message, the identification data for the multimedia message are generated at step S203. The identification data for the multimedia messages include the caller infor-

US 7,283,839 B2

5

mation such as a telephone number and a name, the time information such as transmission time, and multimedia file information at step S207.

The multimedia message including the multimedia file and the informing message of the multimedia message are generated at step S208. The informing message is a text message for informing multimedia message transmission and it includes the message content except the multimedia file and the identification data generated at step S207.

The informing message is transmitted to the receiving terminal at step S209 and the multimedia message is transmitted to the multimedia contents server so that the receiving terminal can access to the multimedia contents server to receive the multimedia message with the multimedia file at step S210.

The message content is transformed into the display form of the IUI and displayed with the description data, wherein the description data include the outgoing description data and the multimedia file data.

FIG. 3 is a flowchart describing a method for receiving a message of a wireless communication terminal having a function of providing an integrated message service in accordance with a preferred embodiment of the present invention.

The message kind of the message received from a transmitting terminal (hereinafter, which is referred to as an incoming message) is determined based on the identification data included in the incoming message at step S301.

If the incoming message is a text message, reception of the incoming message is informed to the user by using an icon, sound or vibration at step S302.

When a request signal for displaying the text message is received through the inputting unit at step S303, the text message is divided into the message content and the identification data at step S304 and the message content is transformed into the display form of the IUI at step S304.

The message content of the text message and the description data are displayed in the IUI at step S305.

If the incoming message is an informing message, reception of the incoming message which is a multimedia message is informed to the user by using an icon, sound or vibration at step S306.

When a request signal for displaying the multimedia message is received through the inputting unit 17 at step S307, the informing message is divided into the identification data and the message content and then the message content is transformed into the display form of the IUI at step S308.

The message content of the informing message and the description data are displayed in the IUI at step S309, wherein the description data include the incoming description data and the file description data. The file description data can be obtained based on the identification data.

When a request signal for receiving the multimedia message is received through the inputting unit 17 at step S307, the receiving terminal accesses to the multimedia contents server having a Uniform Resource Locator (URL) of the identification data in the informing message and receives the multimedia message with the multimedia file at step S311.

The displayer 16 displays the multimedia message in a display form of a letter supported the conventional wireless communication terminal at step S312.

When a user uses a messaging service in the initial time, the user selects an IUI menu in an initial menu screen to transmit/receive a message in the IUI. On other hand, if a new message is transmitted or received when the user uses the messaging service in the IUI, a message list is scrolled

6

on the displayer so that the oldest message disappears in the message list and the new message is displayed in the message list in a sequence of message reception/transmission. The oldest message can be back to be displayed again upon a user request.

FIGS. 4A and 4C are diagrams illustrating integrated user interface of the wireless communication terminal having an integrated messaging service in accordance with an embodiment of the present invention.

FIG. 4A shows an initial screen display of the integrated user interface outputted to provide the integrated messaging service upon a menu selecting signal from the user in accordance with an embodiment of the present invention. Prior to regular message transmission/reception, a user selects a message receiving part to receive a message on the integrated user interface by searching the telephone book, inputting a telephone number directly, or selecting a particular person in the recent call record, which is a list containing recent message transmitting/receiving parts who have transmitted/received messages through the integrated user interface.

FIG. 4B presents an example of messages transmitted and received between a user A and a current user B of the wireless communication terminals. To identify transmitted/received message, 'A' and 'B,' which mean two users, are used as transmitting/receiving identifying information. Also, 'MMS' is used as data classifying information to distinguish the data type of a multimedia message. Also, it is possible to realize the data classifying information in forms of icons, thumbnail preview images, and miniaturized images from the first scene of video in order to distinguish the data type more in detail.

As shown in a display image 41 of FIG. 4B, short messages transmitted/received between the users A and B and an informing message of a multimedia message transmitted from the user A are outputted onto the integrated user interface in the transmitted/received order. Herein, the messages outputted onto the integrated user interface can be displayed in a plurality of lines or they can be displayed in the form of a letter supported in the conventional wireless communication terminal by selecting a particular message with a cursor or an item selecting signal. Then, a message outputted upon the selection can be converted into an output form of the integrated user interface, i.e., a messenger form. For example, when a short message is selected with a cursor, a full text message is outputted in a plurality of lines. Before the selection, only part of the text message is displayed. When the short message selected with the cursor is selected again by using an item selecting signal, it can be outputted in a letter form, which is supported in the conventional wireless communication terminal, on the entire screen, instead of being outputted in the output form of the integrated user interface.

An image 42 of FIG. 4B shows a display outputted when an informing message of the multimedia message shown in the image 41 is selected by using the item selecting signal. The wireless communication terminal accesses to a multimedia contents server based on the URL of identifying information included in the informing message, receives the multimedia message, i.e., a multimedia file, and outputs it in a letter form of the integrated user interface supported in the conventional wireless communication terminal. It is also possible to convert the output form from the letter form to the integrated user interface upon a request from the user.

As described above, an entire message can be outputted in the integrated user interface by selecting the cursor and an item selecting signal, and it can be also outputted in the

US 7,283,839 B2

7

output form of the integrated user interface in the letter form supported by the conventional wireless communication terminal compatibly.

Meanwhile, referring to images 43 and 45 of FIG. 4C, a multimedia message is authored by the user B on an input window of the integrated user interface.

That is, after the text content to be included in the multimedia message is inputted (to be more precise, after the text content is included in an informing message and transmitted), which is shown in the image 43 of FIG. 4C, the user B enters the file selecting menu by inputting a predetermined key and selects a multimedia file to be transmitted to another user, such as an image file, which is shown in an image 44 of FIG. 4C. Herein, the predetermined key means a predetermined menu key, a side key, or a soft key. The key can be embodied in diverse methods. The multimedia file selected by the user B is converted to conform to the output form of the integrated user interface and displayed on the input window and, thus, previously transmitted and received messages are scrolled up and not shown on the monitor, which is illustrated in an image 45 of FIG. 4C.

Also, the image 45 of FIG. 4C shows that the size of the input window is changed, as the size of the message inputted by the user B becomes large. For example, in case where the content of the text message is long, the size of the input window becomes large. If a multimedia file is attached, the input window becomes small to show the file. Herein, data classification information can be used to inform the user of the attachment of the multimedia file, instead of outputting the file itself.

As described above, the present invention provides an integrated user interface for transmitting/receiving diverse kinds of messages through one integrated user interface by using an integrated messaging service program.

The present invention provides a wireless communication terminal and a method for transmitting and receiving messages of various kinds, e.g., a text message and a multimedia message, by using an integrated messaging service program without changing a transmission protocol or a network to thereby provide a user-friendly interface to a user.

The present invention provides user-friendly interface of the messaging service so that the user can use multimedia messaging service frequently and provides an instant messenger-like interface that can be compared with the conventional messaging service so that the user can exchange responses fast using the integrated messaging service.

Since the present invention can be embodied without changing the conventional protocol or the network, it does not require additional expense for it.

The present application contains subject matter related to Korean patent application Nos. 2004-25882 and 2004-83073, filed in the Korean intellectual Property Office on Apr. 14, 2004, and Oct. 18, 2004, respectively, the entire contents of which being incorporated herein by reference.

While the present invention has been described with respect to certain preferred embodiments, it will be apparent to those skilled in the art that various changes and modifications may be made without departing from the scope of the invention as defined in the following claims.

8

What is claimed is:

1. A wireless communication terminal having a function of providing an integrated messaging service, the wireless communication terminal comprising:

- a wireless transceiver for transceiving a message to/from an outside device through a wireless network;
- a storage for storing an integrated messaging service program and messages in order to provide an integrated user interface (IUI);
- a keypad for receiving a message content and a menu selecting signal in the IUI;
- a displayer for displaying the message content and description data in the IUI; and
- a controller for providing the IUI to the keypad and the displayer by operating the integrated messaging service program, determining a message kind of the message to be transmitted which is inputted in the IUI, generating an outgoing message including identification data corresponding to the message kind, transmitting the outgoing message, displaying the message content and the description data of the outgoing message in the IUI, determining a message kind of a received message, dividing the received message into a message content and description data, displaying the message content and the description data in the IUI, and controlling elements in the wireless communication terminal.

2. The wireless communication terminal as recited in claim 1, wherein the description data include incoming/outgoing description data in order to present whether the message is transmitted or received.

3. The wireless communication terminal as recited in claim 1, wherein the controller generates a multimedia message including a multimedia file and transmits the multimedia message to a multimedia contents server so that a wireless communication terminal of a receiving part accesses to the multimedia contents server and receives the multimedia message when the outgoing message is a multimedia message; and

the controller accesses to the multimedia contents server based on a Uniform Resource Locator (URL) included in an informing message and receives the multimedia message including the multimedia file to thereby display the multimedia message in the IUI when an incoming message is an informing message of the multimedia message.

4. The wireless communication terminal as recited in claim 3, wherein the outgoing/incoming message is displayed with incoming/outgoing description data to indicate whether the message is transmitted or received and file description data to present a file kind included in the message content.

5. The wireless communication terminal as recited in claim 3, wherein when a display form transformation request is received, an IUI display form is transformed into a conventional display form or the conventional display form into the IUI display form, and the message content is displayed on the displayer.

* * * * *

EXHIBIT 7



US009575631B2

(12) **United States Patent**
Choi et al.

(10) **Patent No.:** **US 9,575,631 B2**

(45) **Date of Patent:** ***Feb. 21, 2017**

(54) **METHOD FOR SELECTING AND CONTROLLING SECOND WORK PROCESS DURING FIRST WORK PROCESS IN MULTITASKING MOBILE TERMINAL**

(2013.01); *G06F 3/048* (2013.01); *G06F 3/0481* (2013.01); *G06F 3/04817* (2013.01); *G06F 3/04842* (2013.01); *G06F 3/162* (2013.01); *G06F 3/167* (2013.01); *G06F 9/4443* (2013.01);

(71) Applicant: **PANTECH CO., LTD.**, Seoul (KR)

(Continued)

(72) Inventors: **Seul Ki Choi**, Ansan-si (KR); **Sang Jin Yoon**, Anyang-si (KR)

(58) **Field of Classification Search**

None

See application file for complete search history.

(73) Assignee: **Pantech Inc.**, Seoul (KR)

(56)

References Cited

U.S. PATENT DOCUMENTS

5,075,675 A 12/1991 Barker et al.
5,859,639 A 1/1999 Ebrahim

(Continued)

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

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **15/010,629**

(22) Filed: **Jan. 29, 2016**

(65) **Prior Publication Data**

US 2016/0147392 A1 May 26, 2016

Related U.S. Application Data

(63) Continuation of application No. 14/840,844, filed on Aug. 31, 2015, now Pat. No. 9,250,957, which is a (Continued)

(30) **Foreign Application Priority Data**

Aug. 11, 2005 (KR) 10-2005-0073877
Oct. 28, 2005 (KR) 10-2005-0102198

(51) **Int. Cl.**
G06F 9/46 (2006.01)
G06F 3/00 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC *G06F 3/0482* (2013.01); *G06F 3/0346*

OTHER PUBLICATIONS

Nokia Corp., "User's Guide for Nokia 5110", Copyright 2004, Nokia Mobile Phones, Finland.

(Continued)

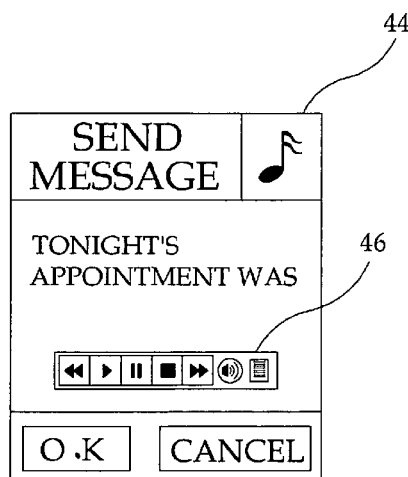
Primary Examiner — Charles Swift

(74) *Attorney, Agent, or Firm* — H.C. Park & Associates, PLC

(57) **ABSTRACT**

Provided is a method for controlling a plurality of work processes in a multitasking mobile terminal, and more particularly, a method for selecting a second work process during a first work process and controlling a predetermined function of the selected second work process. In the controlling method, icons corresponding to the respective work processes are displayed in response to a user command, and a desired work process is selected through the displayed icons. A predetermined function of the selected work process is controlled through a pop-up menu activated in response to the user command.

20 Claims, 10 Drawing Sheets



US 9,575,631 B2

Page 2

Related U.S. Application Data

continuation of application No. 11/495,863, filed on
Jul. 28, 2006, now Pat. No. 9,122,518.

(51) **Int. Cl.**

G06F 3/048 (2013.01)
G06F 3/14 (2006.01)
G06F 3/0482 (2013.01)
G06F 3/0481 (2013.01)
G06F 9/44 (2006.01)
G06F 9/48 (2006.01)
G06F 3/0346 (2013.01)
G06F 3/0484 (2013.01)
G06F 3/16 (2006.01)

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

CPC **G06F 9/48** (2013.01); **G06F 9/485**
(2013.01); **G06F 9/4806** (2013.01); **G06F**
9/4843 (2013.01); **G06F 9/4881** (2013.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,388,686	B1	5/2002	Hetherington et al.
6,546,263	B1	4/2003	Petty et al.
7,123,945	B2	10/2006	Kokubo
7,222,304	B2	5/2007	Beaton et al.
7,546,188	B2	6/2009	Nezu et al.
7,623,119	B2	11/2009	Autio et al.
8,106,877	B2	1/2012	Park et al.
2002/0080186	A1	6/2002	Frederiksen
2003/0011638	A1	1/2003	Chung

2003/0013483	A1	1/2003	Ausems et al.
2003/0016251	A1	1/2003	Kondo
2004/0229200	A1	11/2004	McKeon et al.
2005/0086611	A1	4/2005	Takabe et al.
2005/0120306	A1	6/2005	Klassen et al.
2005/0183017	A1	8/2005	Cain
2005/0229103	A1	10/2005	King
2006/0075347	A1	4/2006	Rehm
2006/0107227	A1	5/2006	Kiljander
2006/0236266	A1	10/2006	Majava
2006/0247851	A1	11/2006	Morris
2007/0003224	A1	1/2007	Krikorian et al.
2007/0192741	A1	8/2007	Yoritate et al.

OTHER PUBLICATIONS

Non-Final Office Action issued on Aug. 31, 2010, in U.S. Appl. No. 11/495,683.

Final Office Action issued on Mar. 16, 2011, in U.S. Appl. No. 11/495,683.

Non-Final Office Action issued on Oct. 22, 2012, in U.S. Appl. No. 11/495,683.

Final Office Action issued on Mar. 28, 2013, in U.S. Appl. No. 11/495,683.

Non-Final Office Action issued on Jul. 10, 2013, in U.S. Appl. No. 11/495,683.

Final Office Action issued on Dec. 4, 2013, in U.S. Appl. No. 11/495,683.

Non-Final Office Action issued on Sep. 23, 2014, in U.S. Appl. No. 11/495,683.

Notice of Allowance issued on Apr. 22, 2015, in U.S. Appl. No. 11/495,683.

Notice of Allowance issued on Sep. 25, 2015, in U.S. Appl. No. 14/840,844.

FIG. 1
(PRIOR ART)

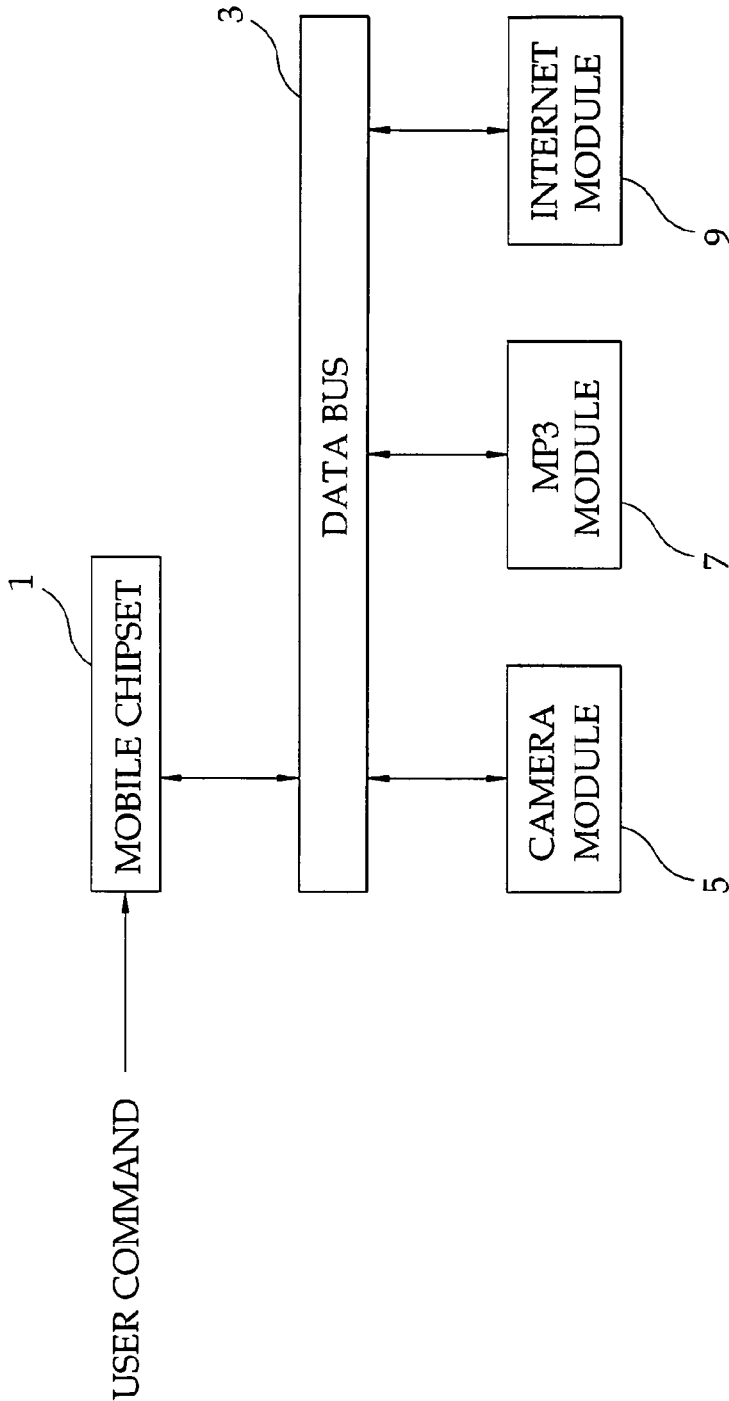


FIG. 2
(PRIOR ART)

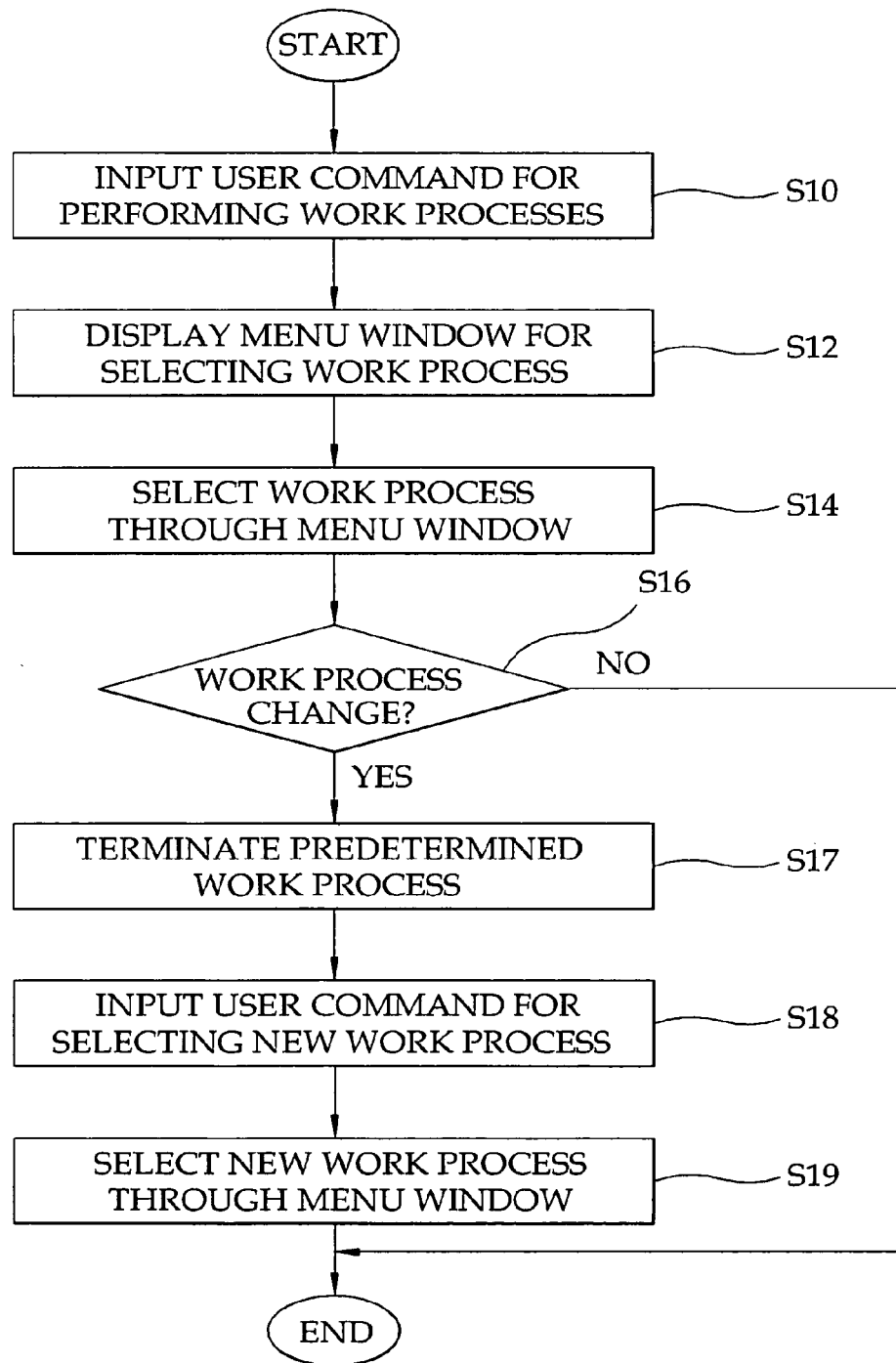


FIG. 3
(PRIOR ART)

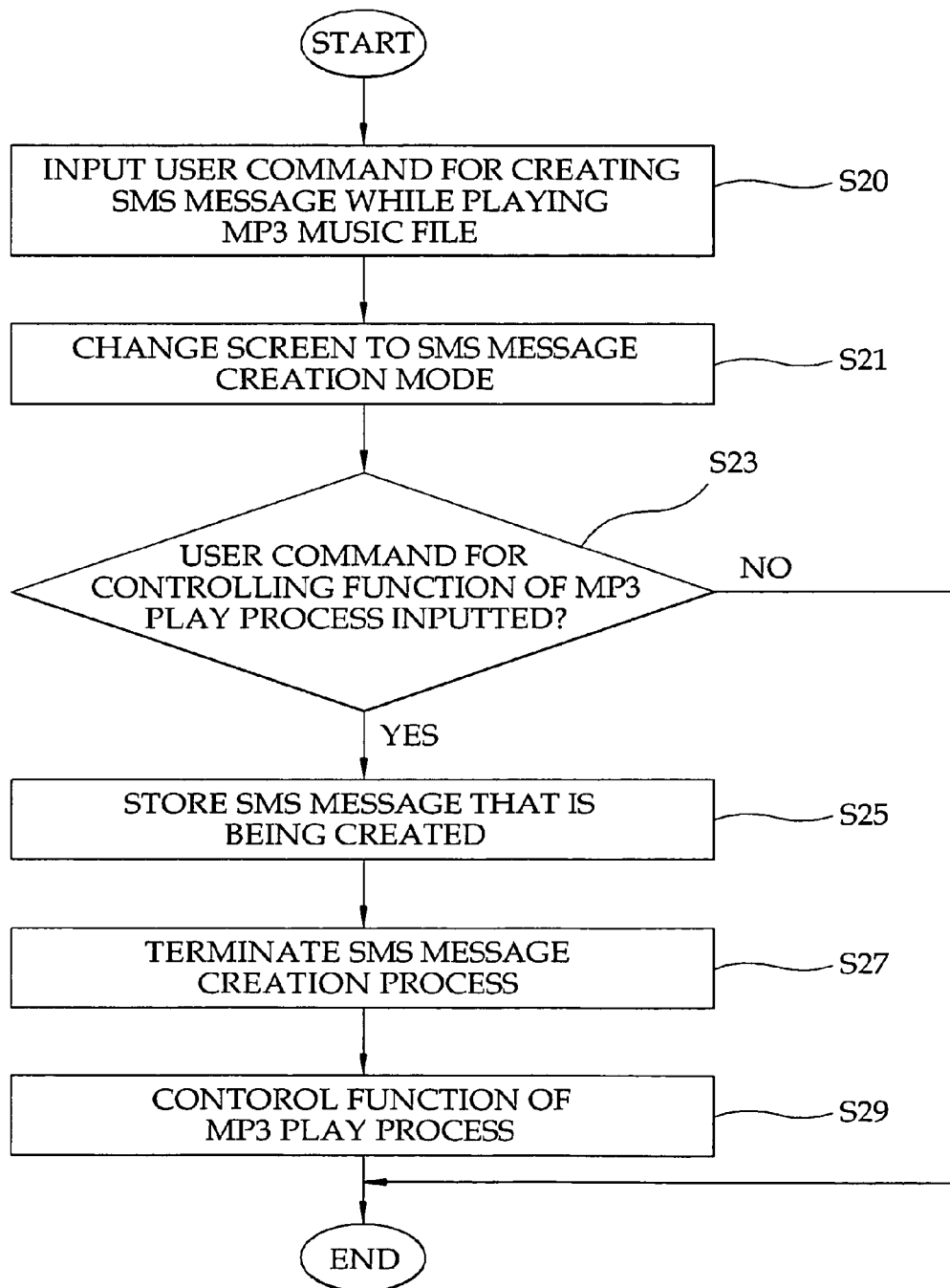


FIG. 4

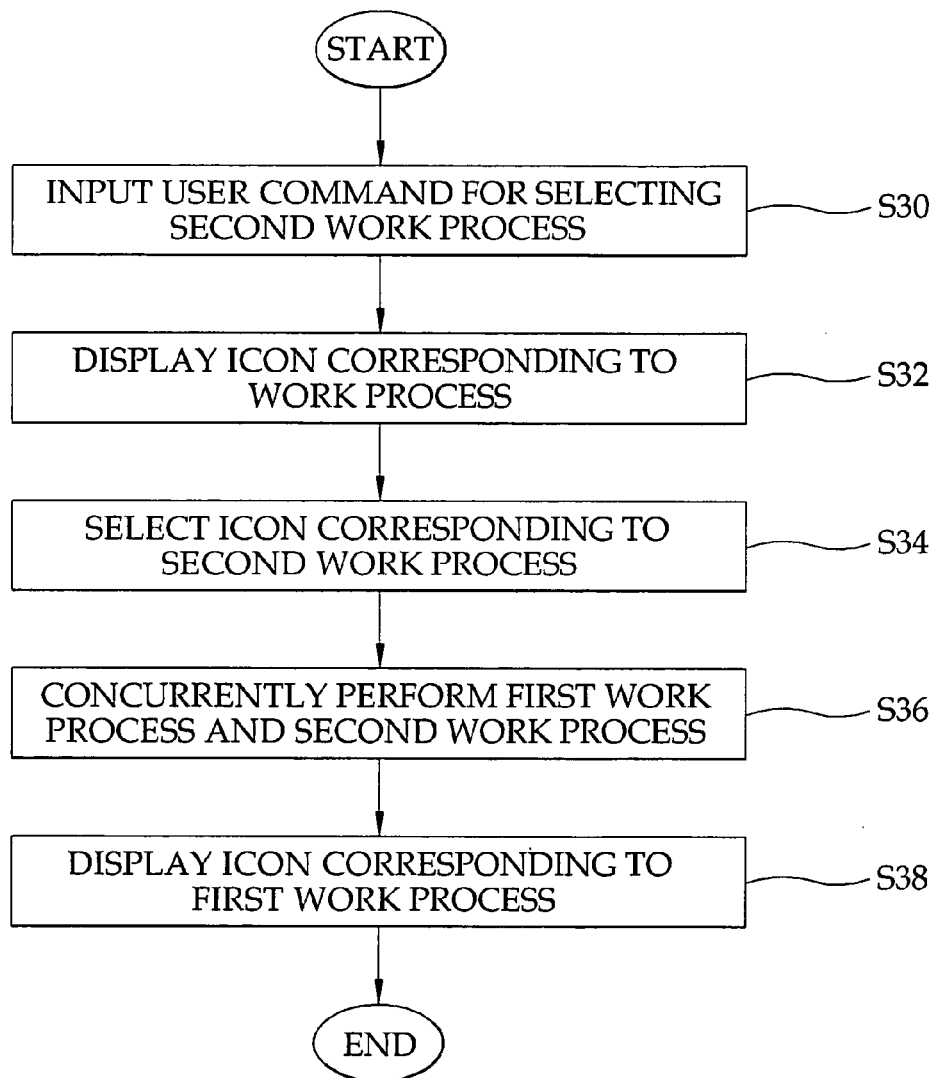


FIG. 5A

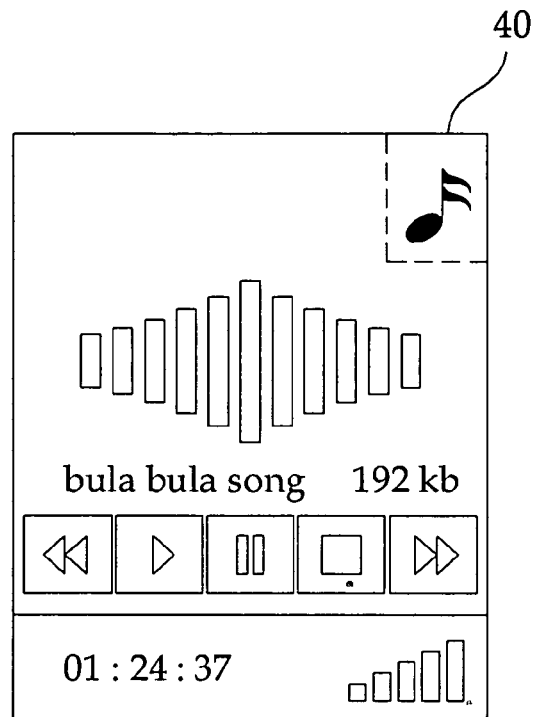


FIG. 5B

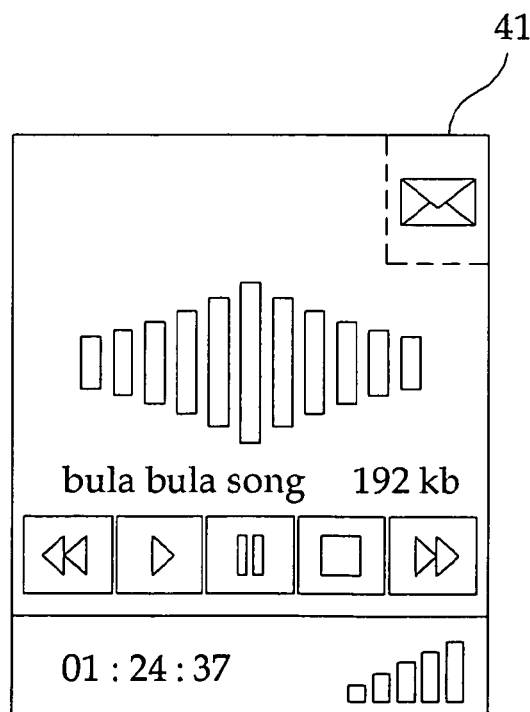


FIG. 5C



FIG. 5D



FIG. 6

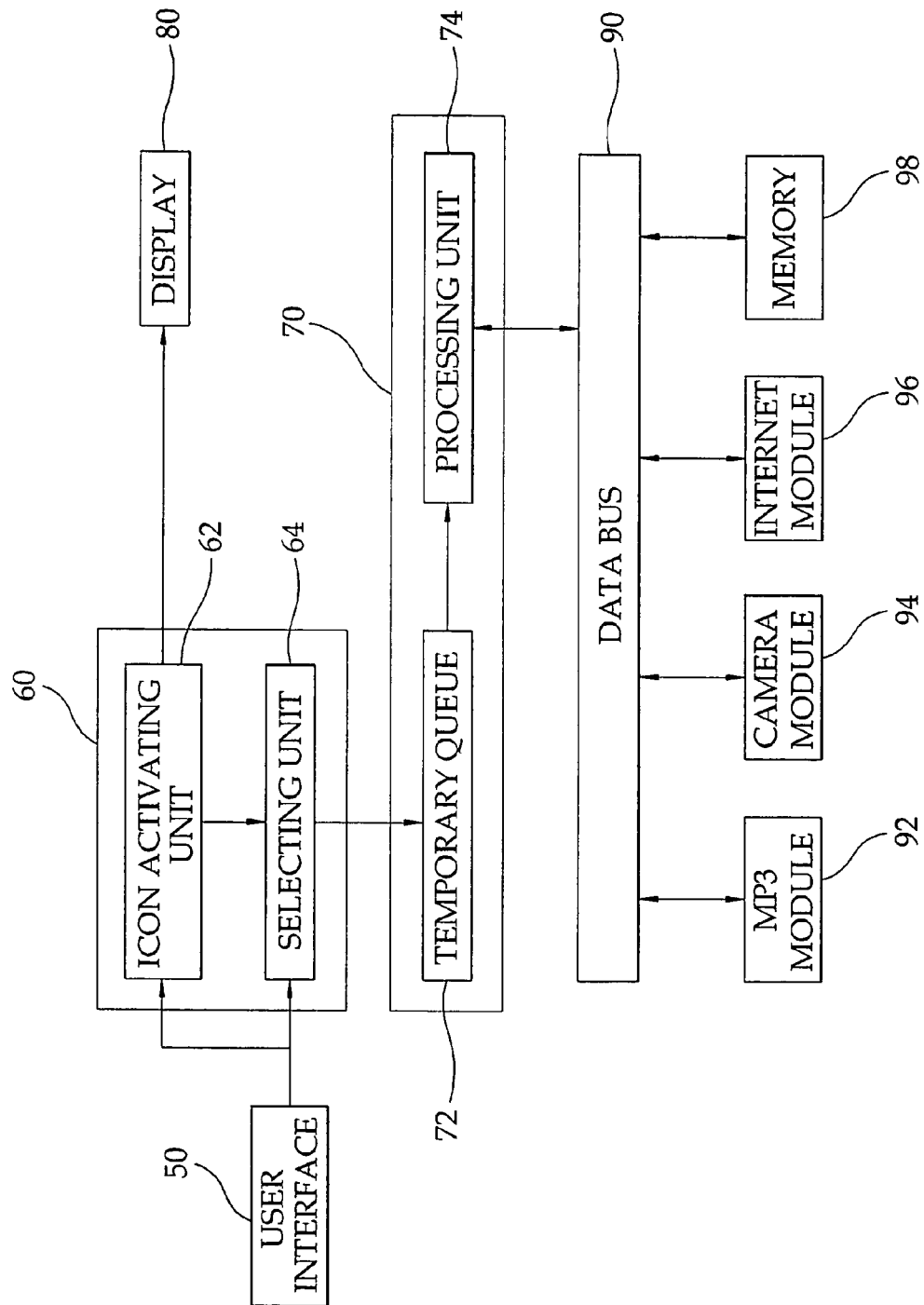


FIG. 7

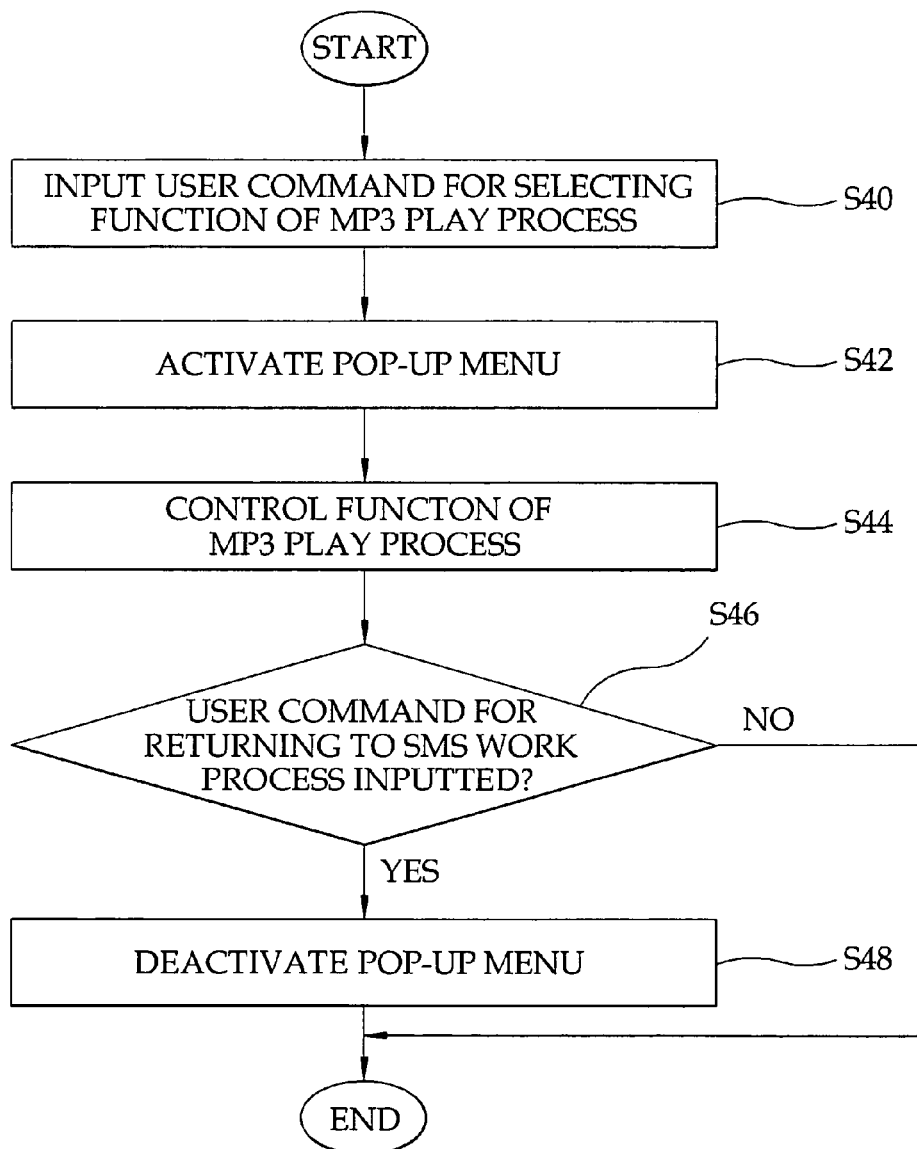


FIG. 8A

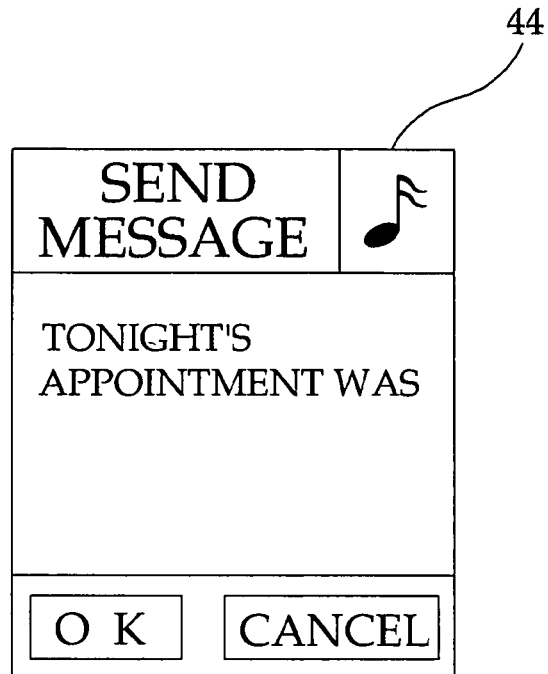


FIG. 8B

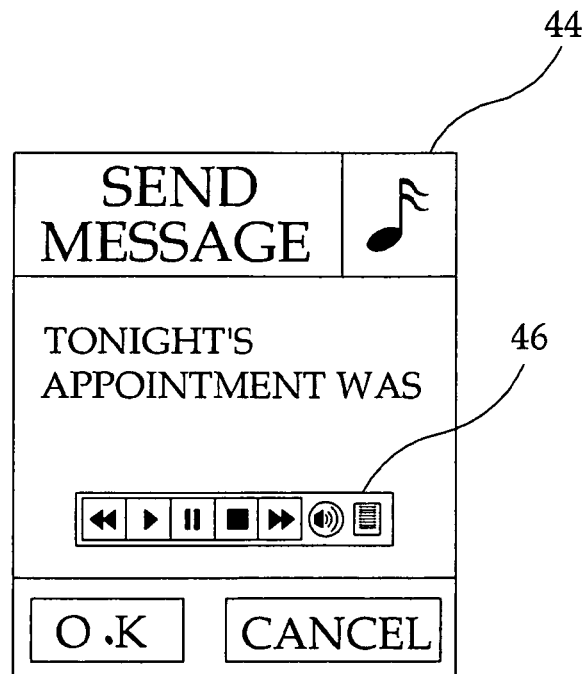
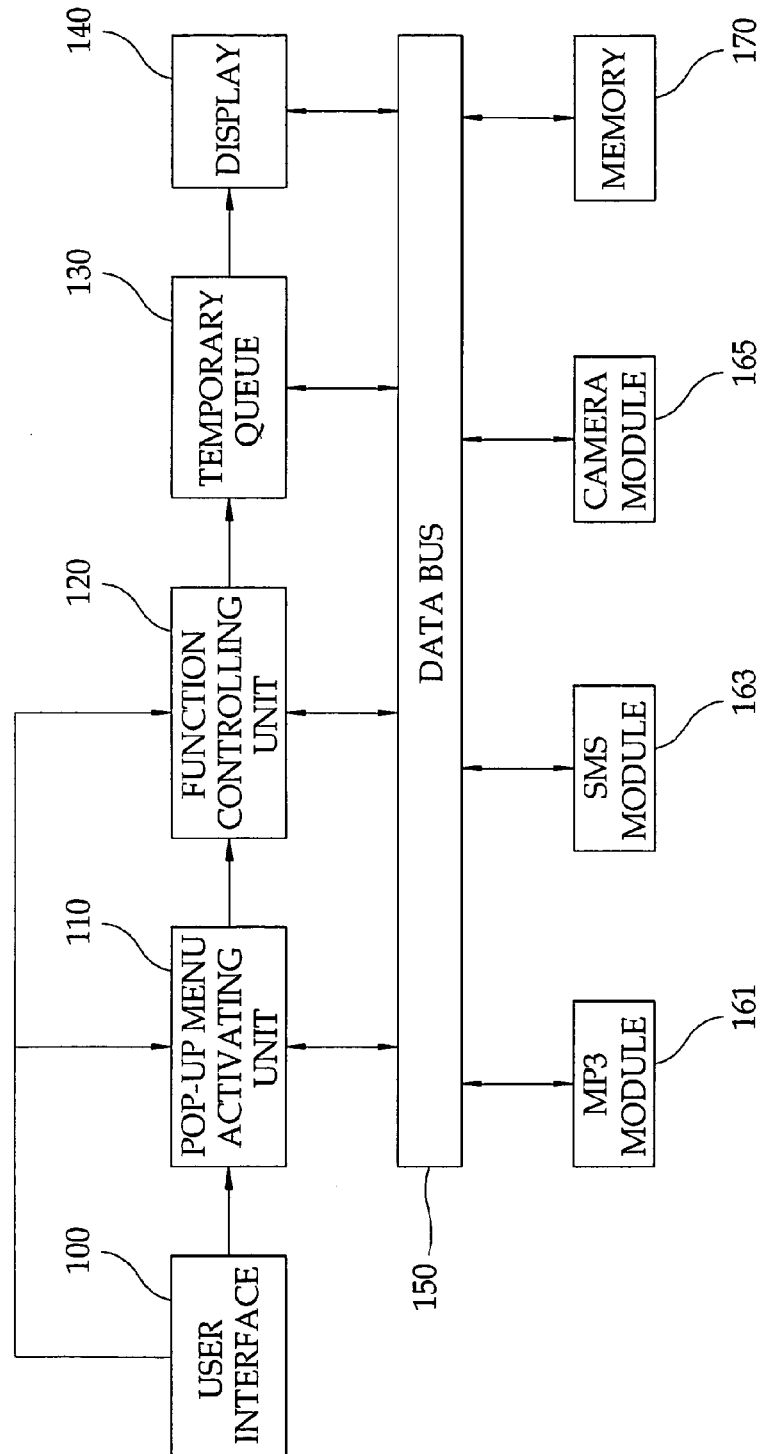


FIG. 9



US 9,575,631 B2

1

METHOD FOR SELECTING AND CONTROLLING SECOND WORK PROCESS DURING FIRST WORK PROCESS IN MULTITASKING MOBILE TERMINAL

CROSS-REFERENCE TO RELATED PATENT APPLICATIONS

This application is a Continuation of U.S. patent application Ser. No. 14/840,844, filed on Aug. 31, 2015, which is a Continuation of U.S. patent application Ser. No. 11/495,863, filed on Jul. 28, 2006, now U.S. Pat. No. 9,122,518, and claims priority from and the benefit of Korean Patent Application No. 10-2005-0073877 filed on Aug. 11, 2005, and Korean Patent Application No. 10-2005-0102198 filed on Oct. 28, 2005, each of which is hereby incorporated by reference for all purpose as if fully set forth herein.

BACKGROUND

Field

The present invention relates to a method for controlling a plurality of work processes in a multitasking mobile terminal, and more particularly, to a method for selecting a second work process during a first work process and controlling a predetermined function of the selected second work process.

Discussion of the Background

With the recent advance of mobile communication technology, various kinds of mobile terminals such as hand-held phones and personal digital assistants (PDAs) are commercially available. The mobile terminals have a wireless communication function, a camera function, a multimedia play function, an Internet connection function, and the like. Also, as the performance of microprocessors built in the mobile terminals is improved, a plurality of work processes can be performed concurrently. For example, an MP3 music file can be played during a phone call, or a short message service (SMS) message can be sent while an MP3 music file is played.

FIG. 1 is a functional block diagram of a conventional multitasking mobile terminal that concurrently performs a plurality of work processes. A mobile chipset 1 controls an overall operation of the mobile terminal according to user commands. The mobile chipset 1 transmits a control signal through a data bus 3 to a camera module 5, an MP3 module 7, and an Internet module 9 according to the user commands. Work processes of the camera module 5, the MP3 module 7, and the Internet module 9 are concurrently performed according to the control signal.

FIG. 2 is a flowchart illustrating a conventional method for selecting a second work process during a first work process in a multitasking mobile terminal that concurrently performs a plurality of work processes. In step S10, while a first work process is performed, a user command for a second work process is inputted. In step S12, a menu window for selecting a new work process is displayed on a display of the mobile terminal in response to the user command. In step S14, the user selects a desired new work process through the displayed menu window. In steps S16 and S17, when the user wants to change the selected process into another new process, the selected work process is terminated. In step S18, a user command for selecting the another new work process is inputted. In step S19, the another new work process is selected through the displayed menu window in response to the user command.

2

FIG. 3 is a flowchart illustrating a conventional method for controlling a predetermined function of a second work process during a first work process in a multitasking mobile terminal that concurrently performs a plurality of work processes.

In step S20, assuming that the first work process is an MP3 play process and the second work process is an SMS message creation process, a first command of user for the SMS message creation process is inputted while an MP3 music file is played. In step S21, a screen for the SMS message creation process is displayed in response to the first command of user, and the SMS message creation process is performed while the MP3 music file is played. In step S23, it is determined whether or not a second command of user for controlling a function of the MP3 play process is inputted while an SMS message is created. In steps S25 and S27, when the second command of user is inputted, the SMS message that is being created is stored in the memory and the SMS message creation process is terminated. In step S29, after the termination of SMS message creation process, the function of the MP3 play process is controlled. When the SMS message creation process is terminated, a screen for the MP3 play process is again displayed, and a third command of user for controlling the function of the MP3 play process is inputted. A control signal corresponding to the third command of user is generated and the function of the MP3 play process is controlled.

SUMMARY

In the conventional method for selecting the work process, when selecting a work process that is concurrently performed, the user has to select a new work process through a displayed menu window. Also, in order to terminate a predetermined work process among a plurality of work processes that are concurrently performed and select a new work process, the user has to select the new work process through the menu window.

Also, in the conventional method for controlling a function of the work process, the user has to terminate an SMS message creation process so as to control a function of an MP3 play process (e.g., volume control, list selection of MP3 music files) while creating an SMS message. In case where the SMS message creation process is terminated, the SMS message that is being created is deleted or stored in a predetermined memory space such as a temporary mailbox. Consequently, the conventional method is inconvenient in that the user has to again select the SMS message creation process and create the SMS message or reload the SMS message stored in the temporary mailbox.

The present invention provides a method for selecting a work process of a multitasking mobile terminal through an icon corresponding to the work process.

The present invention also provides a method for controlling a function of a work process through an activated pop-up menu in a multitasking mobile terminal that concurrently performs a plurality of work processes.

According to an aspect of the present invention, there is provided a method for selecting a second work process during a first work process in a multitasking mobile terminal that concurrently performs the first work process and the second work process. The selecting method includes: inputting a user command for selecting the second work process; and displaying an icon corresponding to the second work process in response to the user command, and selecting the second work process based on the displayed icon.

US 9,575,631 B2

3

According to another aspect of the present invention, there is provided a method for controlling a predetermined function of a second work process during a first work process in a multitasking mobile terminal that concurrently performs the first work process and the second work process. The controlling method includes: inputting a first command of user for selecting a predetermined function of the second work process; activating a pop-up menu for controlling the predetermined function of the second work process in response to the first command of user; and controlling the predetermined function of the second work process through the activated pop-up menu.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other features and advantages of the present invention will become more apparent by describing in detail exemplary embodiments thereof with reference to the attached drawings in which:

FIG. 1 is a functional block diagram of a conventional multitasking mobile terminal that concurrently performs a plurality of work processes;

FIG. 2 is a flowchart illustrating a conventional method for selecting a second work process during a first work process in a multitasking mobile terminal that concurrently performs a plurality of work processes;

FIG. 3 is a flowchart illustrating a conventional method for controlling a function of a second work process during a first work process in a multitasking mobile terminal that concurrently performs a plurality of work processes;

FIG. 4 is a flowchart illustrating a method for selecting a second work process in a multitasking mobile terminal that concurrently performs a first work process and the second work process;

FIGS. 5A, 5B, 5C, and 5D illustrate the displayed icons of the work processes according to an embodiment of the present invention;

FIG. 6 is a functional block diagram of an apparatus for selecting a work process of a multitasking mobile terminal that concurrently performs a first work process and a second work process according to an embodiment of the present invention;

FIG. 7 is a flowchart illustrating a method for controlling a function of an MP3 play process during the creation of an SMS message in a multitasking mobile terminal that concurrently performs the MP3 play process and the SMS message creation process;

FIGS. 8A and 8B illustrate the displayed pop-up menus according to an embodiment of the present invention; and

FIG. 9 is a functional block diagram of an apparatus for controlling a function of the MP3 play process in the multitasking mobile terminal that concurrently performs the MP3 play process and the SMS message creation process according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

Hereinafter, a method for selecting a second work process during a first work process and controlling a function of the selected second work process according to the present invention will be described in detail with reference to the accompanying drawings.

FIG. 4 is a flowchart illustrating a method for selecting a second work process in a multitasking mobile terminal that concurrently performs a first work process and the second work process according to an embodiment of the present

4

invention. Referring to FIG. 4, in step S30, a user command for selecting the second work process is inputted. In step S32, while the first work is processed through the first work process of the mobile terminal, a first command of user for multitasking of the second work process together with the first work is inputted. Icons corresponding to the work processes are displayed in response to the first user command. The icons are previously designated with respect to all work processes of the mobile terminal. Every when the first command of user is inputted, the icons are displayed in turn.

In step S34, when an icon corresponding to the second work process the user wants to select is displayed, a second command of user for selecting the displayed icon is inputted. In step S36, the first work of the first work process and the second work of the second work process are concurrently processed in response to the second command of user. For example, when the user intends to send an SMS message while an MP3 music file is played, an MP3 play process and an SMS message send process are divided in quantum units and alternately processed at regular time intervals.

In step S38, an icon corresponding to the first work process is preferably displayed together with an activated screen image of the second work process. The user can know from the displayed icon that the first work process is concurrently performed in the second work process.

FIG. 5A, FIG. 5B, FIG. 5C, and FIG. 5D illustrate the displayed icons of the work processes according to an embodiment of the present invention.

Referring to FIG. 5A, an icon indicating an MP3 play process is displayed in a first portion of a display 40, while an MP3 music file is played.

Referring to FIG. 5B, when a first command of user for sending an SMS message is inputted while an MP3 music file is played, an icon indicating an SMS message creation process is displayed in a first portion of a display 41.

Referring to FIG. 5C, when a second command of user for selecting a displayed SMS icon is inputted, an SMS message creation process is activated, and an MP3 play process and the SMS message creation process are performed concurrently. Preferably, an icon corresponding to the MP3 play process that is performed concurrently is displayed in a first portion of a display 42 together with a screen of the SMS message creation process.

Referring to FIG. 5D, when a first command of user for selecting a new work process of a camera mode is inputted, an icon corresponding to a camera mode work process is displayed in a first portion of a display 43 in response to the first user command. By selecting the displayed camera mode icon, the work process for sending an SMS message is changed to the camera mode work process.

FIG. 6 is a functional block diagram of an apparatus for selecting the work process of the multitasking mobile terminal that concurrently performs the first work process and the second work process. Referring to FIG. 6, the apparatus according to the present invention includes a user interface 50, a second work process selecting unit 60, a multiprocessing unit 70, a display 80, a data bus 90, and a plurality of application units 92, 94 and 96. The plurality of application units 92, 94 and 96 are controlled via the data bus 90 by the multiprocessing unit 70.

A user commands for changing the work process of the mobile terminal is inputted through the user interface 50. The user interface 50 may be a voice recognition unit for recognizing user's voice, or a motion recognition unit for recognizing a motion of the mobile terminal.

US 9,575,631 B2

5

A first command of user for selecting the second work process that is concurrently performed together with the first work process of the mobile terminal is inputted through the user interface 50 to the second work process selecting unit 60. The second work process selecting unit 60 includes an icon activating unit 62 and a selecting unit 64. Every when the first command of user is inputted, the icon activating unit 62 sequentially displays icons corresponding to the respective work processes of the mobile terminal through the display 80. A second command of user is inputted through the user interface 50 to the selecting unit 64 so as to select the second work process concurrently performed together with the first work process among the sequentially displayed icons. The selecting unit 64 provides the work process corresponding to the selected icon to the multiprocessing unit 70 in response to the second user command.

The multiprocessing unit 70 includes a temporary queue 72 and a processing unit 74. The temporary queue 72 stores the first work process and the second work process, which are provided from the selecting unit 64 and performed concurrently. The processing unit 74 generates a control signal for alternately performing the first work process and the second work process, which are stored in the temporary queue 72, at regular time intervals. The processing unit 74 is connected through the data bus 90 to the MP3 module 92, the camera module 94, and the Internet module 96. The MP3 module 92, the camera module 94, and the Internet module 96 perform a work process of an MP3 play mode, a work process of a camera mode, and a work process of an Internet connection mode in response to the control signal outputted from the processing unit 74, respectively. Other applications can be further added to the mobile terminal according to the fields to which the present invention is applied. It is apparent to those skilled in the art that these embodiments will fall within the scope of the present invention.

FIG. 7 is a flowchart illustrating a method for controlling a function of the MP3 play process, while the SMS message is created, according to an embodiment of the present invention.

Referring to FIG. 7, in step S40, a first command of user is inputted so as to control the function of the MP3 play process while the SMS message is created. In step S42, a pop-up menu for controlling the function of the MP3 play process is activated in the display of the mobile terminal in response to the first command of user.

In step S44, when the pop-up menu is activated, a second command of user is inputted for controlling the function of the MP3 play process, and the function of the MP3 play process is controlled in response to the second command of user. When the pop-up menu is activated, a pop-up process for controlling the function of the MP3 play process is assigned to a temporary queue by using the activated pop-up menu, and the pop-up process is concurrently performed together with the creation of the SMS message.

That is, the pop-up process and the SMS message creation process are divided in quantum units, and the pop-up process and the SMS message send process are alternately performed at regular time intervals. When the second command of user is inputted, the pop-up process generates the control signal corresponding to the second command of user and provides the generated control signal to the MP3 play process. The MP3 play process controls the function of the MP3 play process in response to the control signal.

In step S46, it is determined whether or not a third command of user for returning to the SMS message creation process is inputted. In step S48, when the third command of user is inputted after the control of the function of the MP3

6

play process is completed, the activated pop-up menu is deactivated. Even though the pop-up menu is deleted from the temporary queue and the pop-up process is terminated, the MP3 play process and the SMS message creation process continue to be performed and the user can keep on creating the SMS message while listening to the MP3 music.

Preferably, the first to third commands of user may be inputted through a predetermined key arranged at a keypad of the mobile terminal, a user's voice, a motion of the mobile terminal, and the like.

Preferably, the first and third commands of user may be inputted through the identical key of the mobile terminal.

FIG. 8A and FIG. 8B illustrate the displayed pop-up menus according to an embodiment of the present invention.

FIG. 8A illustrates a pop-up menu displayed when the MP3 play process and the SMS message creation process are concurrently performed. Preferably, an icon 44 indicating the MP3 play process concurrently performed together with the SMS message creation process is also displayed in a portion of a display.

FIG. 8B illustrates a pop-up menu displayed in response to the first command of user. The pop-up menu 46 has a predetermined format, and image information for the pop-up menu 46 displayed is stored in the memory of the mobile terminal. Preferably, in response to the first command of user, the pop-up menu 46 may be displayed brightly and clearly, while the screen corresponding to the SMS message process may be displayed darkly and unclearly.

FIG. 9 is a functional block diagram of an apparatus for controlling the function of the MP3 play process in the multitasking mobile terminal that concurrently performs the MP3 play process and the SMS message creation process according to an embodiment of the present invention. Referring to FIG. 9, the apparatus according to the present invention includes a user interface 100, a pop-up menu activating unit 110, a function controlling unit 120, a temporary queue 130, a display 140, a data bus 150, a plurality of application modules 161, 163 and 165, and a memory 170.

A first command of user is inputted through the user interface 100. The pop-up menu activating unit 110 acquires image information of a pop-up menu stored in the memory 170 in a predetermined format through the data bus 150, and activates the pop-up menu on the display 140. Meanwhile, the temporary queue 130 stores a pop-up process.

A second command of user for controlling the function of the MP3 play process is inputted through the user interface 100, and the function controlling unit 120 generates a first control signal for controlling the pop-up menu in response to the second command of user. The MP3 play process, the SMS message creation process, and the pop-up process, which are stored in the temporary queue 130, are alternately performed at regular time intervals. The generated first control signal is transferred through the data bus 150 to the MP3 module, and the function of the MP3 play process is controlled.

A third command of user for terminating the pop-up process is inputted through the user interface 100. The function controlling unit 120 generates a second control signal for deactivating the pop-up menu in response to the third command of user. The generated second control signal is transferred through the data bus 150 to the temporary queue 130. The temporary queue 130 deletes the pop-up process in response to the second control signal, thus terminating the pop-up process.

The embodiments of the present invention can be written as computer programs and can be implemented in general-

US 9,575,631 B2

7

use digital computers that execute the programs using a computer readable recording medium. Examples of the computer readable recording medium include magnetic storage media (e.g., ROM, floppy disks, hard disks), optical recording media (e.g., CD-ROMs, or DVDs), and storage media such as carrier waves (e.g., transmission through the Internet).

The above-mentioned method for selecting the second work process according to the present invention can simply select the second work process by selecting the icons sequentially displayed while the first work process is performed.

Also, the above-described method for controlling the function of the second work process according to the present invention can simply control the function of the MP3 play process during the creation of the SMS message by controlling the function of the MP3 play process through the pop-up menu in the multitasking mobile terminal that concurrently performs the MP3 play process and the SMS message creation process.

Further, the above-described method for controlling the function of the second work process according to the present invention can continuously create the SMS message after controlling the function of the MP3 play process by controlling the function of the MP3 play process through the pop-up menu in the multitasking mobile terminal that concurrently the MP3 play process and the SMS message creation process.

While the present invention has been particularly shown and described with reference to exemplary embodiments thereof, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the present invention as defined by the following claims.

What is claimed is:

1. A method for controlling a predetermined function of a second work process during a first work process in a multitasking mobile terminal that performs the first work process and the second work process, the method comprising:

displaying one icon in a designated portion of a display, wherein the displayed icon corresponds to the first work process;

if the displayed icon corresponding to the first work process is selected, displaying a screen of the first work process in the display;

in response to a first command for sequentially displaying icons, performing sequential display of icons such that an icon corresponding to the second work process is displayed, wherein the icon corresponding to the second work process is displayed in the designated portion of the display;

in response to a second command for changing to the second work process, replacing the screen of the first work process with a screen of the second work process; controlling the multitasking of the second work process and the first work process;

in response to a third command for activating a control menu for controlling a predetermined function of the first work process, activating the control menu for controlling the predetermined function of the first work process; and

in response to a fourth command for controlling the predetermined function of the first work process through the activated control menu, controlling the predetermined function of the first work process through the activated control menu.

8

2. The method of claim 1, wherein the controlling the predetermined function of the first work process comprises: generating a control signal for controlling the predetermined function of the first work process in response to the fourth command; and

controlling the predetermined function of the first work process in response to the generated control signal.

3. The method of claim 1, further comprising: in response to a fifth command for deactivating the activated control menu, deactivating the activated control menu.

4. The method of claim 1, wherein the first work process is an MP3 play process.

5. The method of claim 1, wherein an item of the first work process is displayed relatively brighter or clearer than the screen of the first work process.

6. The method of claim 1, wherein an item of the second work process is displayed relatively brighter or clearer than an item or a screen of a work process other than the second work process.

7. The method of claim 3, wherein the third command and the fifth command are inputted through at least one of a predetermined key, a user's voice, and a motion of the mobile terminal.

8. The method of claim 1, wherein, in response to a repetition of the first command, performing sequential display of icons such that a displayed icon disappears from a screen of the mobile terminal and an icon appears on the screen of the mobile terminal.

9. The method of claim 1, wherein an icon to be displayed in the designated portion is replaced with an icon that is different from the icon corresponding to the second work process in response to the first command.

10. The method of claim 1, wherein the displayed icon is displayed together with at least a part of a screen image of a work process in the display.

11. A method for selecting a second work process during a first work process in a multitasking mobile terminal that performs the first work process and the second work process in a multitasking environment, the method comprising:

displaying one icon in a designated portion of a display, wherein the displayed icon corresponds to the first work process;

if the displayed icon corresponding to the first work process is selected, displaying a screen of the first work process in the display;

in response to a first command for sequentially displaying icons, performing sequential display of icons such that an icon corresponding to the second work process is displayed, wherein the icon corresponding to the second work process is displayed in the designated portion of the display;

in response to a second command for changing to the second work process, replacing the screen of the first work process with a screen of the second work process; and

controlling the multitasking of the second work process and the first work process,

wherein an item of the second work process is displayed relatively brighter or clearer than an item or a screen of a work process other than the second work process.

12. The method of claim 11, wherein, in response to a repetition of the first command, performing sequential display of icons such that a displayed icon disappears from a screen of the mobile terminal and an icon appears on the screen of the mobile terminal.

US 9,575,631 B2

9

13. The method of claim 11, wherein an icon to be displayed in the designated portion is replaced with an icon that is different from the icon corresponding to the second work process in response to the first command.

14. The method of claim 11, wherein the first command and the second command are inputted through at least one of a predetermined key, a user's voice, and a motion of the mobile terminal, and

wherein the displayed icon is displayed together with at least a part of a screen image of a work process in the display.

15. The method of claim 11, wherein the screen of the first work process is displayed together with sequentially displayed icons corresponding to respective work processes of the mobile terminal.

16. A method for selecting a second work process during a first work process in a multitasking mobile terminal that performs the first work process and the second work process in a multitasking environment, the method comprising:

displaying one icon in a designated portion of a display, wherein the displayed icon corresponds to the first work process;

if the displayed icon corresponding to the first work process is selected, displaying a screen of the first work process in the display;

in response to a first command for sequentially displaying icons, performing sequential display of icons such that an icon corresponding to the second work process is displayed, wherein the icon corresponding to the second work process is displayed in the designated portion of the display;

10

in response to a second command for changing to the second work process, replacing the screen of the first work process with a screen of the second work process; and

controlling the multitasking of the second work process and the first work process,

wherein an item of the first work process is displayed relatively brighter or clearer than the screen of the first work process.

17. The method of claim 16, wherein, in response to a repetition of the first command, performing sequential display of icons such that a displayed icon disappears from a screen of the mobile terminal and an icon appears on the screen of the mobile terminal.

18. The method of claim 16, wherein an icon to be displayed in the designated portion is replaced with an icon that is different from the icon corresponding to the second work process in response to the first command.

19. The method of claim 16, wherein the first command and the second command are inputted through at least one of a predetermined key, a user's voice, and a motion of the mobile terminal, and

wherein the displayed icon is displayed together with at least a part of a screen image of a work process in the display.

20. The method of claim 16, wherein the screen of the first work process is displayed together with sequentially displayed icons corresponding to respective work processes of the mobile terminal.

* * * * *