UNITED STATES DISTRICT COURT
DISTRICT OF DELAWARE

EVOLVED WIRELESS, LLC,	)	
Plaintiff,	)	
v.	)	
	)	Case No. _____
APPLE, INC.,	)	
	)	**JURY TRIAL DEMANDED**
Defendant.	)	

COMPLAINT FOR PATENT INFRINGEMENT

Plaintiff Evolved Wireless, LLC ("Evolved Wireless"), for its causes of action against Defendant Apple, Inc. ("Apple"), states and alleges on knowledge and information and belief as follows:

PARTIES

1. Plaintiff Evolved Wireless is a limited liability company organized and existing under the laws of the State of Delaware with its principal place of business at 805 Las Cimas Parkway, Suite 240, Austin, Texas 78746.

2. On information and belief, Defendant Apple, Inc. is a California corporation with its principal place of business at 1 Infinite Loop, Cupertino, California 95014.

JURISDICTION

3. This Court has subject matter jurisdiction over this action pursuant to 28 U.S.C. §§ 1331 and 1338(a), in that this action arises under the federal patent statutes, 35 U.S.C. §§ 271 and 281-285.

4. This Court has personal jurisdiction over Apple. Upon information and belief, Apple has committed and continues to commit acts giving rise to this action within Delaware and within this judicial district and Apple has established minimum contacts within the forum such that the exercise of jurisdiction over Apple would not offend traditional notions of fair play and substantial justice. For example, Apple has committed and continues to commit acts of infringement in this District, by among other things, offering to sell and selling products that infringe Evolved Wireless's LTE Patent Portfolio, as defined below, including smartphones, tablets, and other mobile devices. In conducting its business in Delaware and this judicial district, Apple derives substantial revenue from infringing products being sold, used, imported, and/or offered for sale or providing service and support to Apple's customers in Delaware and this District, and will continue to do so unless enjoined by this Court.

VENUE

5. Venue in the District of Delaware is proper pursuant to 28 U.S.C. §§ 1391(b) and (c) and 1400(b) because Apple has committed acts within this judicial district giving rise to this action, and Apple has and continues to conduct business in this judicial district, including one or more acts of selling, using, importing, and/or offering for sale infringing products or providing service and support to Apple's customers in this District.

6. Venue in the District of Delaware is further proper because Evolved Wireless is incorporated in the state of Delaware.

BACKGROUND

7. The Third Generation Partnership Project ("3GPP") develops standards for globally-applicable commercial cellular systems. The Organizational Partners of 3GPP are major telecommunications standards developing organizations from around the world, including the

European Telecommunications Standards Institute ("ETSI"), the North American Alliance for Telecommunication Industry Solutions, the Telecommunications Technology Association of Korea, and a few others. Companies participate in 3GPP via their membership in one of the Organizational Partners. Apple and LG Electronics, Inc. are members of at least one Organizational Partner, either directly or through their subsidiaries.

8. Global standards establish precise specifications for the essential components of telecommunications systems and are fundamental in allowing products and services from unrelated competitors to be compatible and operate seamlessly with a telecommunications network.

9. The 3GPP standards for cellular wireless communications are known as Releases. Release 8 describes the first version of the Long Term Evolution ("LTE") standard. The LTE standard network includes Evolved Universal Terrestrial Access Network ("E-UTRAN") and a Core Network called Evolved Packet Core.

10. Each Release consists of a series of technical specifications ("TS"). The 3GPP 36 series of technical specifications covers the E-UTRAN, including at least TS 36.211, .300, .321, .331, and .423. Starting with Release 8, LTE has been commercially available in the United States since around 2010.

11. Developing these standards is an iterative process in which industry players compete to find novel solutions to the standard's technical challenges and goals, including increased data rates and throughput, reduced latency, and higher reliability. The member companies participate in 3GPP Working Groups to discuss, vote, and select the most appropriate technology among competing proposals to provide each individual function within the standard. Therefore, technologies patented by the members become part of the 3GPP standards.

12. 3GPP participants must abide by the intellectual property rights ("IPR") policy of the Organizational Partners to which they belong. These IPR policies, such as the ETSI IPR policy, are intended to strike "a balance between the needs of standardization for public use in the field of telecommunications and the rights of the owners of IPRs."[1] "IPR holders whether members of ETSI and their AFFILIATES or third parties, should be adequately and fairly rewarded for the use of their IPRs in the implementation of STANDARDS and TECHNICAL SPECIFICATIONS."[2]

13. 3GPP participants are required to disclose intellectual property (including patents and patent applications) owned by them which they believe are or are likely to become essential, or might be essential, to any 3GPP standard, including LTE. Companies are also required by IPR policies to license their intellectual property on terms that are fair, reasonable, and non-discriminatory ("FRAND").[3] These policies bind all successors-in-interest to license essential intellectual property on FRAND terms.[4]

EVOLVED WIRELESS

14. Evolved Wireless restates and realleges each of the allegations set forth above and incorporates them herein.

15. Evolved Wireless owns, through assignments originating with LG Electronics, Inc. ("LG"), a standard-essential patent portfolio relating to LTE wireless communication systems. The portfolio, which includes United States Patent Nos. 7,746,916, 7,768,965, 7,809,373, 7,881,236, and 8,218,481 (collectively referred to herein as "LTE Patent Portfolio"),

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[1] ETSI Rules of Procedure, Annex 6: ETSI Intellectual Property Rights Policy § 3.1 (2014), *available at* http://www.etsi.org/images/files/IPR/etsi-ipr-policy.pdf.
[2] *Id*. § 3.2.
[3] *Id*. § 6.1.
[4] *Id*. § 6.1bis.

is essential to the 3GPP 36 Series technical specifications, including at least TS 36.211, .300, .321, .331, and .423.

16. As an ETSI member, LG extensively participated in 3GPP Working Group meetings to develop the LTE standards. LG submitted numerous proposals for incorporation into the standards, and LG's research and development efforts solved significant technical challenges facing the standards. The LTE Patent Portfolio claims several of LG's technical solutions that solve technical challenges in wireless telecommunications technology.

17. Evolved Wireless continues to innovate and contribute additional inventions to the LTE wireless communication system.

OVERVIEW OF MOBILE TELECOMMUNICATIONS

18. Mobile (cellular) phones and devices allow users to make or receive telephone calls and transmit and receive data wirelessly over a wide geographical area.

19. Around 1980, first generation ("1G") mobile phones were introduced to the public. These phones used analog modulation techniques, specifically frequency division multiple access, to transmit voice calls.

20. In the 1990s, second generation ("2G") phones emerged. These phones used digital technology, which permitted more efficient use of the radio spectrum than their 1G predecessor. While second generation systems were originally designed only for voice, they were later enhanced to include data transmission, but could only achieve low data rates.

21. During the same time period of growth for 2G communications systems, overall use of the Internet also increased. In response to user demand for higher data rates, third generation ("3G") phones emerged.

22. While voice calls traditionally dominated the traffic in mobile communications, the increasing number of mobile devices and the advancement of mobile device technology with increased features and data-hungry applications drove demand for faster and more reliable data transmissions. Data traffic over cellular networks has therefore increased dramatically since the mid to late 2000s.

23. Given the increased demand for data, coupled with limited available radio spectrum, mobile communication developers were required to create a standard that, compared with 3G, offered much higher data rates, lower latency, and improved overall user experience. LTE is the result of this development.

EVOLVED WIRELESS'S STANDARD-ESSENTIAL LTE PATENT PORTFOLIO

24. Evolved Wireless's LTE Patent Portfolio is rooted in mobile telecommunications technology and solves particular problems arising in wireless cellular communications between mobile devices and cellular networks.

25. The above-mentioned benefits of LTE, such as higher throughput and lower latency, could be achieved only after significant challenges were overcome. These challenges included at least interference management and signal processing. The LTE Patent Portfolio addresses some of these challenges and offers specific solutions to improve mobile device functionality over the prior art with faster, more reliable, and more efficient voice and data transmissions.

UNITED STATES PATENT NO. 7,746,916 ("THE '916 PATENT")

26. United States Patent No. 7,746,916 ("the '916 Patent"), entitled "Method and Apparatus for Generating and Transmitting Code Sequence in a Wireless Communication

System," was issued on June 29, 2010. Evolved Wireless is the owner and assignee of the '916 Patent.

27. On November 29, 2006, the '916 Patent inventors assigned the entire right, title, and interest of the '916 Patent to LG, which was duly recorded in the U.S. Patent and Trademark Office ("USPTO") on March 15, 2007. LG assigned the entire right, title, and interest of the '916 Patent to TQ Lambda LLC on February 7, 2014, which was duly recorded in the USPTO on March 4, 2014. On September 26, 2014, TQ Lambda LLC assigned the entire right, title, and interest of the '916 Patent to Evolved Wireless, which was duly recorded in the USPTO on October 27, 2014.

28. The '916 patented technology relates to a technique for obtaining a plurality of code sequences with certain properties that results in an improved telecommunication system to overcome limitations rooted in prior art telecommunication system technology. Obtaining code sequences in the way claimed by the '916 Patent is fundamental to the operation of LTE and is used in several aspects, including random access preambles and uplink reference signals.

29. Among other limitations, the method for sequence generation in 3G systems resulted in a limited number of different code sequences. Because the number of code sequences was limited, telecommunication systems either had a higher level of interference or were only able to serve a limited number of mobile phones for a particular base station. This shortcoming is addressed by the '916 patented technology.

30. The '916 Patent describes the state of the art where "a pilot signal or preamble of a wireless communication system is referred to as a reference signal used for initial synchronization, cell search, and channel estimation. Further, the preamble is comprised of a

code sequence, and the code sequence is further comprised of orthogonal or quasi-orthogonal [codes] which represent good correlation properties." (Ex. 1, 1:20-26.)

31. The '916 Patent further describes the problems associated with prior art code sequences. "Although the [Hadamard] code sequence and a poly-phase Constant Amplitude Zero Auto-Correlation (CAZAC) code sequence are orthogonal codes, [the] number of codes used to maintain orthogonality is limited." (*Id*. at 1:31-34.)

32. Thus, the '916 Patent solved at least one particular problem arising from synchronizing mobile devices to cell towers using code sequences. "Accordingly, the ['916 Patent] is directed to a method and apparatus for generating and transmitting code sequence in a wireless communication system that substantially obviates one or more problems due to limitations and disadvantages of the related art." (*Id*. at 1:51-55.)

UNITED STATES PATENT NO. 7,768,965 ("THE '965 PATENT")

33. United States Patent No. 7,768,965 ("the '965 Patent"), entitled "Method for Transmitting and Receiving Signals Based on Segmented Access Scheme and Method for Allocating Sequence for the Same," was issued August 3, 2010. Evolved Wireless is the owner and assignee of the '965 Patent.

34. On March 2 and March 9, 2009, the '965 Patent inventors assigned the entire right, title, and interest of the '965 Patent to LG, which was duly recorded in the USPTO on March 13, 2009. LG assigned the entire right, title, and interest of the '965 Patent to TQ Lambda LLC on February 7, 2014, which was duly recorded in the USPTO on March 4, 2014. On September 26, 2014, TQ Lambda LLC assigned the entire right, title, and interest of the '965 Patent to Evolved Wireless, which was duly recorded in the USPTO on October 27, 2014.

35. The ’965 patented technology is directed generally to an apparatus and method for transmitting and receiving codes used by mobile devices.

36. In prior art telecommunications systems, as cell size increased, longer preambles were required to accommodate mobile devices farther away from the cell tower. Mobile devices close to the cell tower also used the same longer preamble length. This in part resulted in increased overhead to telecommunications systems. “For instance, in case that 1 subframe is used as an RACH or a ranging channel in 3GPP LTE system, the system uses $^{1}/_{20}$ of overhead as the RACH or the ranging channel. Yet, if 5 subframes need to be used due to an increased cell size, the overhead increases 5 times to considerably affect overall system performance.” (Ex. 2, 3:15-20.)

37. The ’965 patented technology addressed this problem by providing a method according to which different mobile devices can use preambles of different length based at least in part on their location within a cell, rather than the size of the cell area. The ’965 recognizes that a short sequence can be used by mobile devices in the center of a cell, and a long sequence can be used by mobile devices at the edge of a cell. This reduced the overhead experienced by the telecommunication system while reducing the probability of collision with other mobile devices within a cell.

38. The ’965 Patent describes collision as one aspect of the technical problems associated with larger cell sizes: when mobile devices (user equipment) “within a large cell use an identically specified sequence, probability of collision in an RACH or ranging channel slot can be raised in proportion to an increasing number of user equipment[] within the corresponding cell.” (*Id*. at 3:28-32.) Thus, “the demand for a technology in reducing probability of collision

occurrence in the same RACH or ranging channel slot and [reducing] overhead attributed to an RACH or a ranging channel in a large cell has risen." (*Id*. at 3:33-36.)

39. The '965 Patent claims at least one technical solution to this particular prior art problem. "An object of the present invention is to reduce probability of collision possible in using an identical sequence by entire user equipment[] within a cell in a manner of providing a sequence set differently allocated according to a location of a user equipment within a cell." (*Id*. at 4:1-5.)

UNITED STATES PATENT NO. 7,809,373 ("THE '373 PATENT")

40. United States Patent No. 7,809,373 ("the '373 Patent"), entitled "Method of Transmitting and Receiving Radio Access Information in a Wireless Mobile Communication System," was issued on October 5, 2010. Evolved Wireless is the owner and assignee of the '373 Patent.

41. On September 7, 2006, the '373 Patent inventors assigned the entire right, title, and interest of the '373 Patent to LG, which was duly recorded in the USPTO on November 2, 2006. LG assigned the entire right, title, and interest of the '373 Patent to TQ Lambda LLC on February 7, 2014, which was duly recorded in the USPTO on March 4, 2014. On September 26, 2014, TQ Lambda LLC assigned the entire right, title, and interest of the '373 Patent to Evolved Wireless, which was duly recorded in the USPTO on October 27, 2014.

42. The '373 patented technology is directed generally to the handover of a mobile device from one cell tower base station (the source base station) to another cell tower base station (the target base station). Handovers are fundamental to the cellular architecture of wireless telecommunication systems.

43. When a mobile device moves to the coverage area of a new base station, the mobile device must send a signal to establish synchronization and make scheduling requests. The signal includes a random access preamble selected randomly for a limited number of signatures. Problems arise with this prior art handover method. Specifically, the random access message is susceptible to collision and disruption during the handover from, among other things, multiple devices using the same preamble message. As more and more devices enter and leave the cell area, the likelihood of collision increases. Any collisions will increase service interruption, ultimately reducing the quality and/or availability of service.

44. The ’373 patented technology addresses problems specifically arising out using a limited number of preambles in a random access process to access a base station as the number of mobile devices within the cell increases. The ’373 Patent discloses a mobile device that receives a dedicated preamble supplied by the target base station by means of the source base station. The mobile device uses the dedicated preamble after the handover process to eliminate the likelihood of collision, which can reduce handover processing time and in turn result in a faster and more efficient method of accessing the target base stations.

45. More specifically, the ’373 Patent describes at least one technical problem existing in prior art methods to handover mobile devices (mobile terminals) from one cell tower to another. “In the related art, when the mobile terminal moves from a source cell to a target cell, the mobile terminal uses a RACH to transmit a cell update message to the target cell. However, because of a possibility of RACH collision (i.e. the same signature is being selected from multiple terminals that use of the RACH), the processing time for the handover process may be delayed.” (Ex. 3, 5:51-57.)

46. With this particular prior art problem in mind, the ’373 Patent claims at least one technical solution for providing the mobile device with handover information prior to the actual handover in order to reduce handover processing time. “In contrast [to the prior art], the features of the present invention provide that the terminal receives necessary information from a source cell in advance (i.e., before the terminal transmits a RACH setup request to a network) in order to utilize the RACH in a later step. As a result, the terminal can connect with the target cell with minimal delays.” (*Id*. at 5:58-63.)

UNITED STATES PATENT NO. 7,881,236 (“THE ’236 PATENT”)

47. United States Patent No. 7,881,236 (“the ’236 Patent”), entitled “Data Transmission Method and User Equipment for the Same,” was issued on February 1, 2011. Evolved Wireless is the owner and assignee of the ’236 Patent.

48. On July 29, 2009, the ’236 Patent inventors assigned the entire right, title, and interest of the ’236 Patent to LG, which was duly recorded in the USPTO on August 13, 2009. LG assigned the entire right, title, and interest of the ’236 Patent to TQ Lambda LLC on February 7, 2014, which was duly recorded in the USPTO on March 4, 2014. On September 26, 2014, TQ Lambda LLC assigned the entire right, title, and interest of the ’236 Patent to Evolved Wireless, which was duly recorded in the USPTO on October 27, 2014.

49. The ’236 Patent avoids problems arising from transmission errors when data stored in a mobile device’s Msg3 buffer is transmitted regardless of the reception mode of the Uplink Grant signal. The ’236 Patent describes that problems occur “if the data stored in the Msg**3** buffer is transmitted in correspondence with the reception of *all* UL Grant signals.” (Ex. 4, 4:30-32 (emphasis added).)

50. The ’236 Patent claims at least one technical solution to this particular problem arising in mobile device uplink grants. “An object of the present invention is to provide a data transmission method and a user equipment for the same, which is capable of solving a problem which may occur when data stored in a message **3** (Msg**3**) buffer is transmitted according to a reception mode of an Uplink (UL) Grant signal.” (*Id*. at 4:42-47.)

UNITED STATES PATENT NO. 8,218,481 (“THE ’481 PATENT”)

51. United States Patent No. 8,218,481 (“the ’481 Patent”), entitled “Method of Transmitting Data in a Mobile Communication System,” was issued on July 10, 2012. Evolved Wireless is the owner and assignee of the ’481 Patent.

52. On June 30 and July 6, 2010, the ’481 Patent inventors assigned the entire right, title, and interest of the ’481 Patent to LG, which was duly recorded in the USPTO on July 7, 2010. LG assigned the entire right, title, and interest of the ’481 Patent to TQ Lambda LLC on February 7, 2014, which was duly recorded in the USPTO on March 4, 2014. On September 26, 2014, TQ Lambda LLC assigned the entire right, title, and interest of the ’481 Patent to Evolved Wireless, which was duly recorded in the USPTO on October 27, 2014.

53. The ’481 patented technology is directed generally to an apparatus and method for creating the preamble of a random access signal so as to address the limitations rooted in the prior art. In prior art systems, a preamble of fixed length was used, limiting flexibility under different cell sizes. The ’481 patented technology addresses this problem by providing an apparatus and method where a specific sequence is repeated multiple times and a cyclic prefix is added. The resulting preambles are less susceptible to “noise or channel change.” (Ex. 5, 2:49.) The ’481 Patent improves the probability of preamble reception by base stations and in turn provides more efficient and reliable cellular connections than prior art systems and methods.

54. The ’481 Patent describes a telecommunication system wherein “[a] user equipment uses a random access channel (RACH) to access a network in a state that the user equipment is not uplink synchronized with a base station. A signal having repetitive characteristic in a time domain is used in the random access channel, so that a receiver easily searches a start position of a transmission signal. In general, the repetitive characteristic is realized by repetitive transmission of a preamble.” (*Id*. at 1:24-30.)

55. Further, “[a] representative example of a sequence for realizing the preamble includes a CAZAC (Constant Amplitude Zero Auto Correlation) sequence. . . . [which] has excellent transmission characteristics. However, the CAZAC sequence has limitation[s] in that maximum N-1 number of sequences can be used for a sequence having a length of N.” (*Id*. at 1:32-40.)

56. The ’481 Patent describes five prior art methods and the associated problems for “transmitting data from a random access channel by using the CAZAC sequence.” (*Id.* at 1:45-46; *see also* 1:46-2:33.) “[T]he first method is to directly interpret CAZAC sequence ID to message information.” (*Id.* at 1:46-47.) Problems occur, however, because “there is difficulty in realizing a sufficient number of CAZAC sequence sets, and the costs required for search of a receiver increases.” (*Id*. at 1:52-56.)

57. The second and third prior art methods involve either simultaneously transmitting a CAZAC sequence with a Walsh sequence or mixing a CAZAC sequence with a Walsh sequence. (*Id*. at 1:57-59, 2:1-3.) The second method is still limited, however, because “bits of message[s] that can additionally be obtained are only $\log_2 N$ bits when the Walsh sequence has a length of N.” (*Id*. at 1:66-67.) Further, the third method encounters problems

where "the Walsh sequence acts as noise in detection of the CAZAC sequence [and] cause[s] difficulty in detecting sequence ID." (*Id.* at 2:8-10.)

58. The fourth prior art method involves modifying the code sequence by either "multiplying an exponential term by a CAZAC sequence or directly apply[ing] data modulation," (*Id*. at 2:15-17.), and the fifth method involves "attaching a message part to the CAZAC sequence." (*Id*. at 2:25-26.) These methods "have a problem in that they are susceptible to change of channel condition." (*Id.* at 31-33.)

59. The '481 Patent claims at least one technical solution for solving limitations with CAZAC sequences existing in the prior art. "[T]he present invention has been suggested to substantially obviate one or more problems due to limitations and disadvantages of the related art, and an object of the present invention is to provide a method of transmitting and receiving message[s] between a user equipment and a base station by using a long sequence to maximize time/frequency diversity and alleviat[e] performance attenuation due to channel." (*Id*. at 2:37-44.)

60. "Another object of the present invention is to provide a method of transmitting data through a code sequence in a mobile communication system, in which the quantity of data can be increased and the transmitted data becomes robust to noise or channel change." (*Id*. at 2:45-49.)

APPLE

61. Apple sells phones, smartphones, tablets, and other wireless devices. Products sold by Apple include, but are not limited to, the devices listed in Appendix A.

62. Apple sells, manufactures, imports, and uses certain devices that practice the LTE standards established by ETSI and 3GPP. Indeed, Apple markets to the public that certain devices are compliant with the LTE standard. (*See* Ex. 6, iPhone User Guide, at 188.)

63. Apple, or its subsidiaries, is a member of ETSI, and was a member during the relevant period when LG declared the LTE Patent Portfolio to ETSI.

64. The 3GPP Working Group meetings evaluated competing technologies that could best serve the essential functions necessary to standardize wireless communications. Upon information and belief, Apple has not participated in the 3GPP Working Group meetings, although Apple has taken advantage of the system and has been successful in the LTE device market.

LICENSING EFFORTS

65. On November 4, 2014, Evolved Wireless sent Jayna Whitt, Director of IP Transactions at Apple, a letter offering to engage in licensing discussions on FRAND terms for Evolved Wireless's LTE Patent Portfolio. Evolved Wireless further sent e-mails on November 4 and November 13, 2014 to open up licensing discussions. Jayna Whitt responded on November 13, 2014 identifying Heather Mewes as the point of contact.

66. Apple has not entered into a license agreement with Evolved Wireless for the LTE Patent Portfolio.

COUNT I

INFRINGEMENT OF U.S. PATENT NO. 7,746,916

67. Evolved Wireless restates and realleges each of the allegations set forth above and incorporates them herein.

68. Apple has infringed, induced infringement, and/or contributed to infringement of the ’916 Patent by making, using, selling, offering for sale, or importing into the United States, or by intending that others make, use, import into, offer for sale, or sell in the United States, products and/or methods covered by one or more claims of the ’916 Patent, including but not limited to cellular telephones, tablet computers, and/or other devices with LTE capabilities and that comply with the LTE standards, including at least TS 36.211, .300, .321, .331, and .423.

69. On information and belief, Apple has actively induced and is actively inducing third parties, such as Apple’s customers, to directly infringe the ’916 Patent in this District and elsewhere in the United States in violation of 35 U.S.C. § 271(b). On information and belief, Apple and/or its distributors or representatives have sold or otherwise provided cellular telephones, tablet computers, and/or other devices with LTE capabilities and that comply with the LTE standards to third parties, such as Apple’s customers. Apple’s customers, on information and belief, have directly infringed and are directly infringing the ’916 Patent. Moreover, Apple specifically intends for and encourages its customers to use their products in violation of the ’916 Patent. For example, by marketing and selling its cellular telephones, tablet computers, and/or other devices with LTE capabilities and that comply with the LTE standards, Apple has encouraged and is encouraging its customers to use the products to directly infringe the ’916 Patent.

70. Further, on information and belief, Apple has also contributed to and is contributing to direct infringement of the ’916 Patent by third parties, such as Apple’s customers, in this District and elsewhere in the United States in violation of 35 U.S.C. § 271(c). On information and belief, Apple and/or its distributors or representatives have sold or otherwise provided cellular telephones, tablet computers, and/or other devices with LTE capabilities and

that comply with the LTE standards to third parties, such as Apple's customers. Apple's customers, on information and belief, have directly infringed and are directly infringing the '916 Patent. Moreover, because the '916 Patent is essential to the LTE standards, Apple's cellular telephones, tablet computers, and/or other devices with LTE capabilities and that comply with the LTE standards are material in practicing the '916 Patent, are especially made to infringe the '916 Patent, and have no substantial non-infringing uses.

71. Apple's LTE devices that infringe the '916 Patent include, but are not limited to, at least the devices listed in Appendix A.

72. At least as early as the service of this Complaint, Apple has notice of the '916 Patent and the infringement alleged herein.

73. At least as early as the service of this Complaint, Apple has knowingly induced others to directly infringe the '916 Patent.

74. At least as early as the service of this Complaint, Apple has knowingly contributed to the infringement of the '916 Patent.

75. At least as early as the service of this Complaint, Apple has willfully infringed the '916 Patent.

76. Apple does not have a license or permission to use the claimed subject matter in the '916 Patent.

77. Apple will continue to infringe the '916 Patent without a license unless otherwise ordered by this Court. As a result of Apple's infringement of the '916 Patent, Evolved Wireless has suffered damages and is entitled to monetary relief to compensate for the infringement, but in no event less than a reasonable royalty for the use made of the invention by Apple, together with interest and costs as fixed by the Court.

COUNT II

INFRINGEMENT OF U.S. PATENT NO. 7,768,965

78. Evolved Wireless restates and realleges each of the allegations set forth above and incorporates them herein.

79. Apple has infringed, induced infringement, and/or contributed to infringement of the ’965 Patent by making, using, selling, offering for sale, or importing into the United States, or by intending that others make, use, import into, offer for sale, or sell in the United States, products and/or methods covered by one or more claims of the ’965 Patent, including but not limited to cellular telephones, tablet computers, and/or other devices with LTE capabilities and that comply with the LTE standards, including at least TS 36.211, .300, .321, .331, and .423.

80. On information and belief, Apple has actively induced and is actively inducing third parties, such as Apple’s customers, to directly infringe the ’965 Patent in this District and elsewhere in the United States in violation of 35 U.S.C. § 271(b). On information and belief, Apple and/or its distributors or representatives have sold or otherwise provided cellular telephones, tablet computers, and/or other devices with LTE capabilities and that comply with the LTE standards to third parties, such as Apple’s customers. Apple’s customers, on information and belief, have directly infringed and are directly infringing the ’965 Patent. Moreover, Apple specifically intends for and encourages its customers to use their products in violation of the ’965 Patent. For example, by marketing and selling its cellular telephones, tablet computers, and/or other devices with LTE capabilities and that comply with the LTE standards, Apple has encouraged and is encouraging its customers to use the products to directly infringe the ’965 Patent.

81. Further, on information and belief, Apple has also contributed to and is contributing to direct infringement of the ’965 Patent by third parties, such as Apple’s customers, in this District and elsewhere in the United States in violation of 35 U.S.C. § 271(c). On information and belief, Apple and/or its distributors or representatives have sold or otherwise provided cellular telephones, tablet computers, and/or other devices with LTE capabilities and that comply with the LTE standards to third parties, such as Apple’s customers. Apple’s customers, on information and belief, have directly infringed and are directly infringing the ’965 Patent. Moreover, because the ’965 Patent is essential to the LTE standards, Apple’s cellular telephones, tablet computers, and/or other devices with LTE capabilities and that comply with the LTE standards are material in practicing the ’965 Patent, are especially made to infringe the ’965 Patent, and have no substantial non-infringing uses.

82. Apple’s LTE devices that infringe the ’965 Patent include, but are not limited to, at least the devices listed in Appendix A.

83. At least as early as the service of this Complaint, Apple has notice of the ’965 Patent and the infringement alleged herein.

84. At least as early as the service of this Complaint, Apple has knowingly induced others to directly infringe the ’965 Patent.

85. At least as early as the service of this Complaint, Apple has knowingly contributed to the infringement of the ’965 Patent.

86. At least as early as the service of this Complaint, Apple has willfully infringed the ’965 Patent.

87. Apple does not have a license or permission to use the claimed subject matter in the ’965 Patent.

88. Apple will continue to infringe the ’965 Patent without a license unless otherwise ordered by this Court. As a result of Apple’s infringement of the ’965 Patent, Evolved Wireless has suffered damages and is entitled to monetary relief to compensate for the infringement, but in no event less than a reasonable royalty for the use made of the invention by Apple, together with interest and costs as fixed by the Court.

COUNT III

INFRINGEMENT OF U.S. PATENT NO. 7,809,373

89. Evolved Wireless restates and realleges each of the allegations set forth above and incorporates them herein.

90. Apple has infringed, induced infringement, and/or contributed to infringement of the ’373 Patent by making, using, selling, offering for sale, or importing into the United States, or by intending that others make, use, import into, offer for sale, or sell in the United States, products and/or methods covered by one or more claims of the ’373 Patent, including but not limited to cellular telephones, tablet computers, and/or other devices with LTE capabilities and that comply with the LTE standards, including at least TS 36.211, .300, .321, .331, and .423.

91. On information and belief, Apple has actively induced and is actively inducing third parties, such as Apple’s customers, to directly infringe the ’373 Patent in this District and elsewhere in the United States in violation of 35 U.S.C. § 271(b). On information and belief, Apple and/or its distributors or representatives have sold or otherwise provided cellular telephones, tablet computers, and/or other devices with LTE capabilities and that comply with the LTE standards to third parties, such as Apple’s customers. Apple’s customers, on information and belief, have directly infringed and are directly infringing the ’373 Patent. Moreover, Apple specifically intends for and encourages its customers to use their products in violation of the ’373

Patent. For example, by marketing and selling its cellular telephones, tablet computers, and/or other devices with LTE capabilities and that comply with the LTE standards, Apple has encouraged and is encouraging its customers to use the products to directly infringe the ’373 Patent.

92. Further, on information and belief, Apple has also contributed to and is contributing to direct infringement of the ’373 Patent by third parties, such as Apple’s customers, in this District and elsewhere in the United States in violation of 35 U.S.C. § 271(c). On information and belief, Apple and/or its distributors or representatives have sold or otherwise provided cellular telephones, tablet computers, and/or other devices with LTE capabilities and that comply with the LTE standards to third parties, such as Apple’s customers. Apple’s customers, on information and belief, have directly infringed and are directly infringing the ’373 Patent. Moreover, because the ’373 Patent is essential to the LTE standards, Apple’s cellular telephones, tablet computers, and/or other devices with LTE capabilities and that comply with the LTE standards are material in practicing the ’373 Patent, are especially made to infringe the ’373 Patent, and have no substantial non-infringing uses.

93. Apple’s LTE devices that infringe the ’373 Patent include, but are not limited to, at least the devices listed in Appendix A.

94. At least as early as the service of this Complaint, Apple has notice of the ’373 Patent and the infringement alleged herein.

95. At least as early as the service of this Complaint, Apple has knowingly induced others to directly infringe the ’373 Patent.

96. At least as early as the service of this Complaint, Apple has knowingly contributed to the infringement of the ’373 Patent.

97. At least as early as the service of this Complaint, Apple has willfully infringed the ’373 Patent.

98. Apple does not have a license or permission to use the claimed subject matter in the ’373 Patent.

99. Apple will continue to infringe the ’373 Patent without a license unless otherwise ordered by this Court. As a result of Apple’s infringement of the ’373 Patent, Evolved Wireless has suffered damages and is entitled to monetary relief to compensate for the infringement, but in no event less than a reasonable royalty for the use made of the invention by Apple, together with interest and costs as fixed by the Court.

COUNT IV

INFRINGEMENT OF U.S. PATENT NO. 7,881,236

100. Evolved Wireless restates and realleges each of the allegations set forth above and incorporates them herein.

101. Apple has infringed, induced infringement, and/or contributed to infringement of the ’236 Patent by making, using, selling, offering for sale, or importing into the United States, or by intending that others make, use, import into, offer for sale, or sell in the United States, products and/or methods covered by one or more claims of the ’236 Patent, including but not limited to cellular telephones, tablet computers, and/or other devices with LTE capabilities and that comply with the LTE standards, including at least TS 36.211, .300, .321, .331, and .423.

102. On information and belief, Apple has actively induced and is actively inducing third parties, such as Apple’s customers, to directly infringe the ’236 Patent in this District and elsewhere in the United States in violation of 35 U.S.C. § 271(b). On information and belief, Apple and/or its distributors or representatives have sold or otherwise provided cellular

telephones, tablet computers, and/or other devices with LTE capabilities and that comply with the LTE standards to third parties, such as Apple's customers. Apple's customers, on information and belief, have directly infringed and are directly infringing the '236 Patent. Moreover, Apple specifically intends for and encourages its customers to use their products in violation of the '236 Patent. For example, by marketing and selling its cellular telephones, tablet computers, and/or other devices with LTE capabilities and that comply with the LTE standards, Apple has encouraged and is encouraging its customers to use the products to directly infringe the '236 Patent.

103. Further, on information and belief, Apple has also contributed to and is contributing to direct infringement of the '236 Patent by third parties, such as Apple's customers, in this District and elsewhere in the United States in violation of 35 U.S.C. § 271(c). On information and belief, Apple and/or its distributors or representatives have sold or otherwise provided cellular telephones, tablet computers, and/or other devices with LTE capabilities and that comply with the LTE standards to third parties, such as Apple's customers. Apple's customers, on information and belief, have directly infringed and are directly infringing the '236 Patent. Moreover, because the '236 Patent is essential to the LTE standards, Apple's cellular telephones, tablet computers, and/or other devices with LTE capabilities and that comply with the LTE standards are material in practicing the '236 Patent, are especially made to infringe the '236 Patent, and have no substantial non-infringing uses.

104. Apple's LTE devices that infringe the '236 Patent include, but are not limited to, at least the devices listed in Appendix A.

105. At least as early as the service of this Complaint, Apple has notice of the '236 Patent and the infringement alleged herein.

106. At least as early as the service of this Complaint, Apple has knowingly induced others to directly infringe the ’236 Patent.

107. At least as early as the service of this Complaint, Apple has knowingly contributed to the infringement of the ’236 Patent.

108. At least as early as the service of this Complaint, Apple has willfully infringed the ’236 Patent.

109. Apple does not have a license or permission to use the claimed subject matter in the ’236 Patent.

110. Apple will continue to infringe the ’236 Patent without a license unless otherwise ordered by this Court. As a result of Apple’s infringement of the ’236 Patent, Evolved Wireless has suffered damages and is entitled to monetary relief to compensate for the infringement, but in no event less than a reasonable royalty for the use made of the invention by Apple, together with interest and costs as fixed by the Court.

COUNT V

INFRINGEMENT OF U.S. PATENT NO. 8,218,481

111. Evolved Wireless restates and realleges each of the allegations set forth above and incorporates them herein.

112. Apple has infringed, induced infringement, and/or contributed to infringement of the ’481 Patent by making, using, selling, offering for sale, or importing into the United States, or by intending that others make, use, import into, offer for sale, or sell in the United States, products and/or methods covered by one or more claims of the ’481 Patent, including but not limited to cellular telephones, tablet computers, and/or other devices with LTE capabilities and that comply with the LTE standards, including at least TS 36.211, .300, .321, .331, and .423.

113. On information and belief, Apple has actively induced and is actively inducing third parties, such as Apple's customers, to directly infringe the '481 Patent in this District and elsewhere in the United States in violation of 35 U.S.C. § 271(b). On information and belief, Apple and/or its distributors or representatives have sold or otherwise provided cellular telephones, tablet computers, and/or other devices with LTE capabilities and that comply with the LTE standards to third parties, such as Apple's customers. Apple's customers, on information and belief, have directly infringed and are directly infringing the '481 Patent. Moreover, Apple specifically intends for and encourages its customers to use their products in violation of the '481 Patent. For example, by marketing and selling its cellular telephones, tablet computers, and/or other devices with LTE capabilities and that comply with the LTE standards, Apple has encouraged and is encouraging its customers to use the products to directly infringe the '481 Patent.

114. Further, on information and belief, Apple has also contributed to and is contributing to direct infringement of the '481 Patent by third parties, such as Apple's customers, in this District and elsewhere in the United States in violation of 35 U.S.C. § 271(c). On information and belief, Apple and/or its distributors or representatives have sold or otherwise provided cellular telephones, tablet computers, and/or other devices with LTE capabilities and that comply with the LTE standards to third parties, such as Apple's customers. Apple's customers, on information and belief, have directly infringed and are directly infringing the '481 Patent. Moreover, because the '481 Patent is essential to the LTE standards, Apple's cellular telephones, tablet computers, and/or other devices with LTE capabilities and that comply with the LTE standards are material in practicing the '481 Patent, are especially made to infringe the '481 Patent, and have no substantial non-infringing uses.

115. Apple's LTE devices that infringe the '481 Patent include, but are not limited to, at least the devices listed in Appendix A.

116. At least as early as the service of this Complaint, Apple has notice of the '481 Patent and the infringement alleged herein.

117. At least as early as the service of this Complaint, Apple has knowingly induced others to directly infringe the '481 Patent.

118. At least as early as the service of this Complaint, Apple has knowingly contributed to the infringement of the '481 Patent.

119. At least as early as the service of this Complaint, Apple has willfully infringed the '481 Patent.

120. Apple does not have a license or permission to use the claimed subject matter in the '481 Patent.

121. Apple will continue to infringe the '481 Patent without a license unless otherwise ordered by this Court. As a result of Apple's infringement of the '481 Patent, Evolved Wireless has suffered damages and is entitled to monetary relief to compensate for the infringement, but in no event less than a reasonable royalty for the use made of the invention by Apple, together with interest and costs as fixed by the Court.

DEMAND FOR TRIAL BY JURY

Evolved Wireless demands a jury trial on all issues so triable, pursuant to Rule 38 of the Federal Rules of Civil Procedure.

PRAYER FOR RELIEF

WHEREFORE, Plaintiff Evolved Wireless prays for the following relief:

1. A declaration that Apple has infringed and is infringing at least one claim in Evolved Wireless's LTE Patent Portfolio;

2. An order further entering a permanent injunction under 35 U.S.C. § 283 enjoining Apple and its officers, directors, agents, servants, affiliates, employees, divisions, branches, subsidiaries, parents, and all others acting in active concert or participation with it, from infringement of all claims in Evolved Wireless's LTE Patent Portfolio for which it is determined that Apple has and/or does infringe;

3. If a permanent injunction is not granted, a judicial determination of the conditions for future infringement such as an ongoing royalty;

4. An award of damages, including costs, expenses, pre-judgment and post-judgment interest, in an amount adequate to compensate Evolved Wireless for Apple's infringement of all claims in Evolved Wireless's LTE Patent Portfolio for which it is determined that Apple has and/or does infringe;

5. An equitable accounting of damages owed by Apple for the period of infringement of Evolved Wireless's LTE Patent Portfolio, following the period of damages established by Evolved Wireless at trial;

6. An award of enhanced damages, including that the damages be trebled pursuant to 35 U.S.C. § 284, for Apple's willful infringement of all claims in Evolved Wireless's LTE Patent Portfolio for which it is determined that Apple has and/or does infringe;

7. A finding that this case is exceptional and an award of attorneys' fees pursuant to 35 U.S.C. § 285;

8. An award of costs, expenses, and disbursements; and

9. Such other and further relief that Evolved Wireless may be entitled to in law and equity.

Dated: June 25, 2015

Respectfully submitted,

FARNAN LLP

/s/ Brian E. Farnan

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Counsel for Plaintiff Evolved Wireless, LLC

EXHIBIT 1

US007746916B2

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

(10) **Patent No.: US 7,746,916 B2**
(45) **Date of Patent: Jun. 29, 2010**

(54) **METHOD AND APPARATUS FOR GENERATING AND TRANSMITTING CODE SEQUENCE IN A WIRELESS COMMUNICATION SYSTEM**

(75) Inventors: **Seung Hee Han**, Seoul (KR); **Min Seok Noh**, Seoul (KR); **Yeon Hyeon Kwon**, Suwon-si (KR); **Hyun Hwa Park**, Anyang-si (KR); **Hyun Woo Lee**, Anyang-si (KR); **Dong Cheol Kim**, Uiwang-si (KR)

(73) Assignee: **LG Electronics Inc.**, Seoul (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 580 days.

(21) Appl. No.: **11/563,909**

(22) Filed: **Nov. 28, 2006**

(65) **Prior Publication Data**

US 2007/0177682 A1 Aug. 2, 2007

(30) **Foreign Application Priority Data**

Nov. 28, 2005 (KR) 10-2005-0114306
Jul. 4, 2006 (KR) 10-2006-0062467
Jul. 7, 2006 (KR) 10-2006-0064091

(51) **Int. Cl.**
H04B 1/00 (2006.01)

(52) **U.S. Cl.** **375/142**; 370/203; 370/208; 375/131; 375/140; 375/146; 375/148

(58) **Field of Classification Search** 370/203; 375/131, 142
See application file for complete search history.

(56) **References Cited**

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WO	WO 03/075500	9/2003
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Texas Instruments "On allocation of Uplink Pilot Sub-Channels in Eutra SC-FDMA", 3GPP TSG-RAN WG1, E1-050922, Aug. 29, 2005.

* cited by examiner

Primary Examiner—David C Payne
Assistant Examiner—Adolf Dsouza
(74) *Attorney, Agent, or Firm*—Lee, Hong, Degerman, Kang & Waimey

(57) **ABSTRACT**

A method of generating a code sequence in a wireless communication system is disclosed. More specifically, the method includes recognizing a desired length of the code sequence, generating a code sequence having a length different from the desired length, and modifying the length of the generated code sequence to equal the desired length. Here, the step of modifying includes discarding at least one element of the generated code sequence or inserting at least one null element to the generated code sequence.

11 Claims, 18 Drawing Sheets

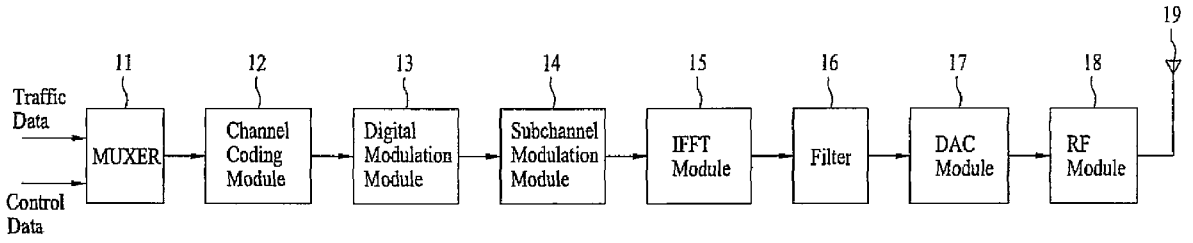


FIG. 1

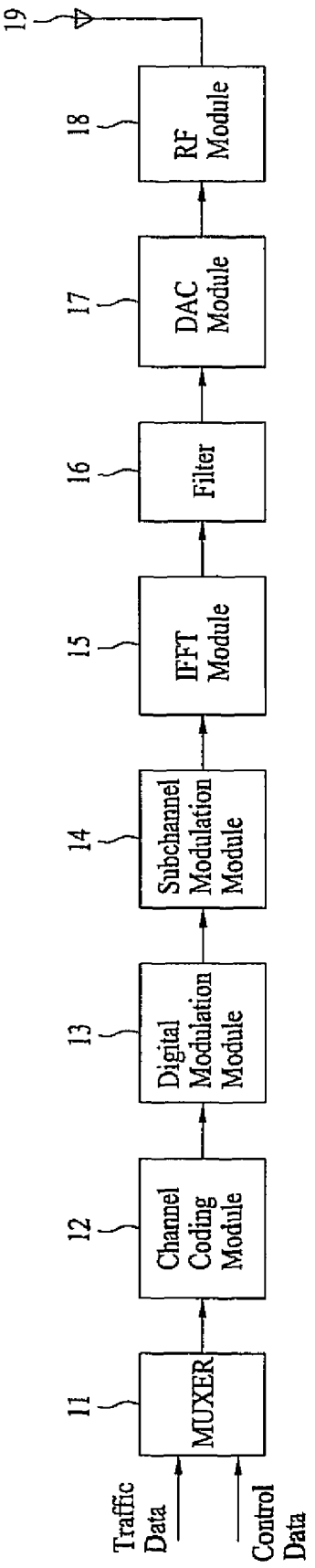

Traffic Data
Control Data
11
MUXER
12
Channel Coding Module
13
Digital Modulation Module
14
Subchannel Modulation Module
15
IFFT Module
16
Filter
17
DAC Module
18
RF Module
19

FIG. 2

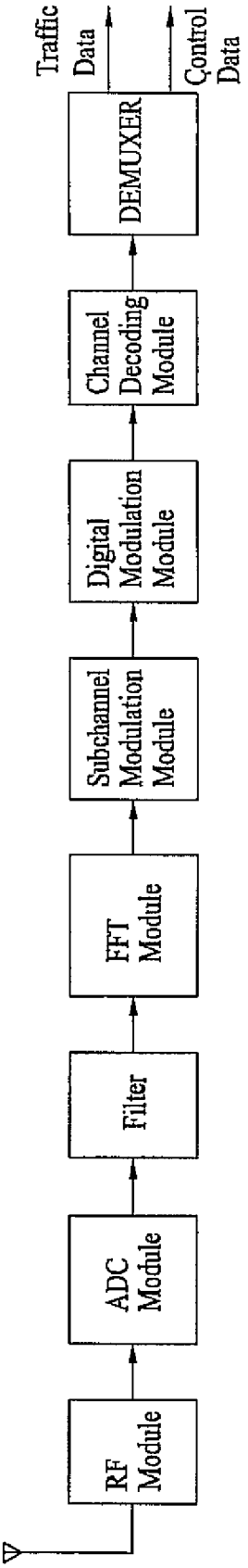

RF Module
ADC Module
Filter
FFT Module
Subchannel Modulation Module
Digital Modulation Module
Channel Decoding Module
DEMUXER
Traffic Data
Control Data

FIG. 3

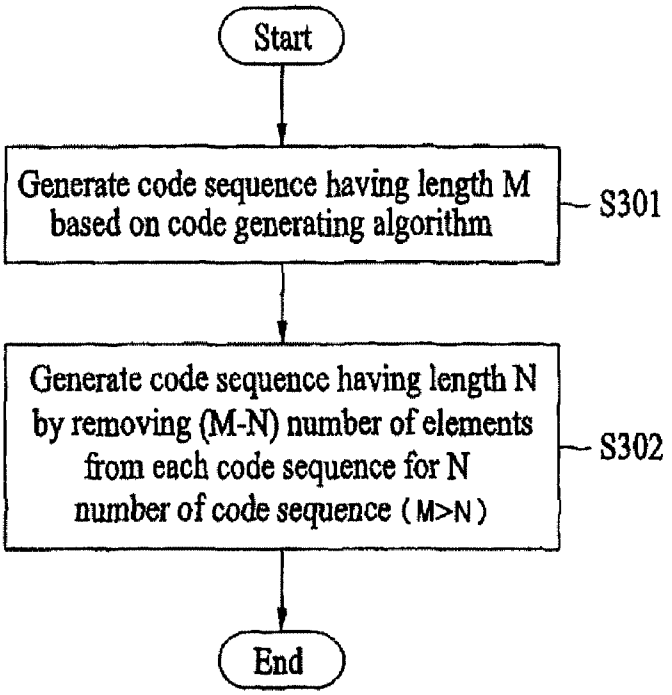

Start
Generate code sequence having length M based on code generating algorithm
S301
Generate code sequence having length N by removing (M-N) number of elements from each code sequence for N number of code sequence (M>N)
S302
End

FIG. 4

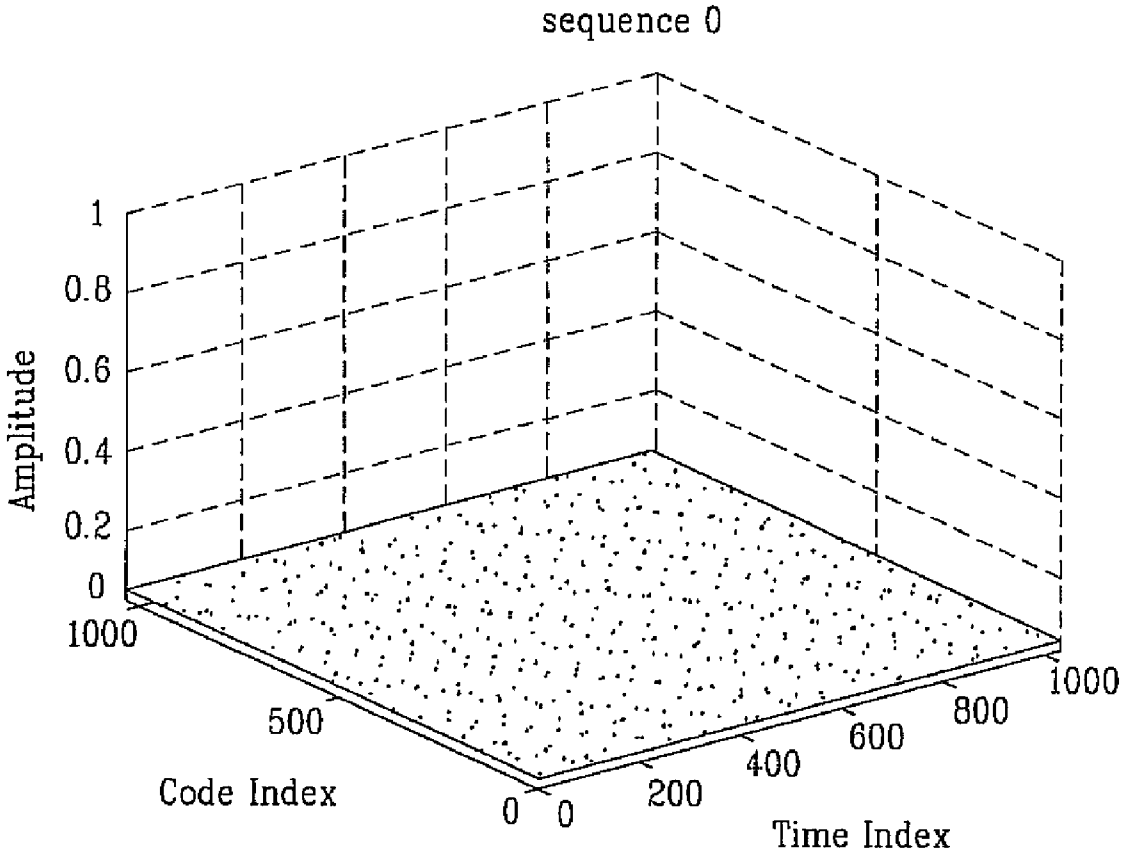

sequence 0
Amplitude
1
0.8
0.6
0.4
0.2
0
1000
500
0
Code Index
0
200
400
600
800
1000
Time Index

FIG. 5

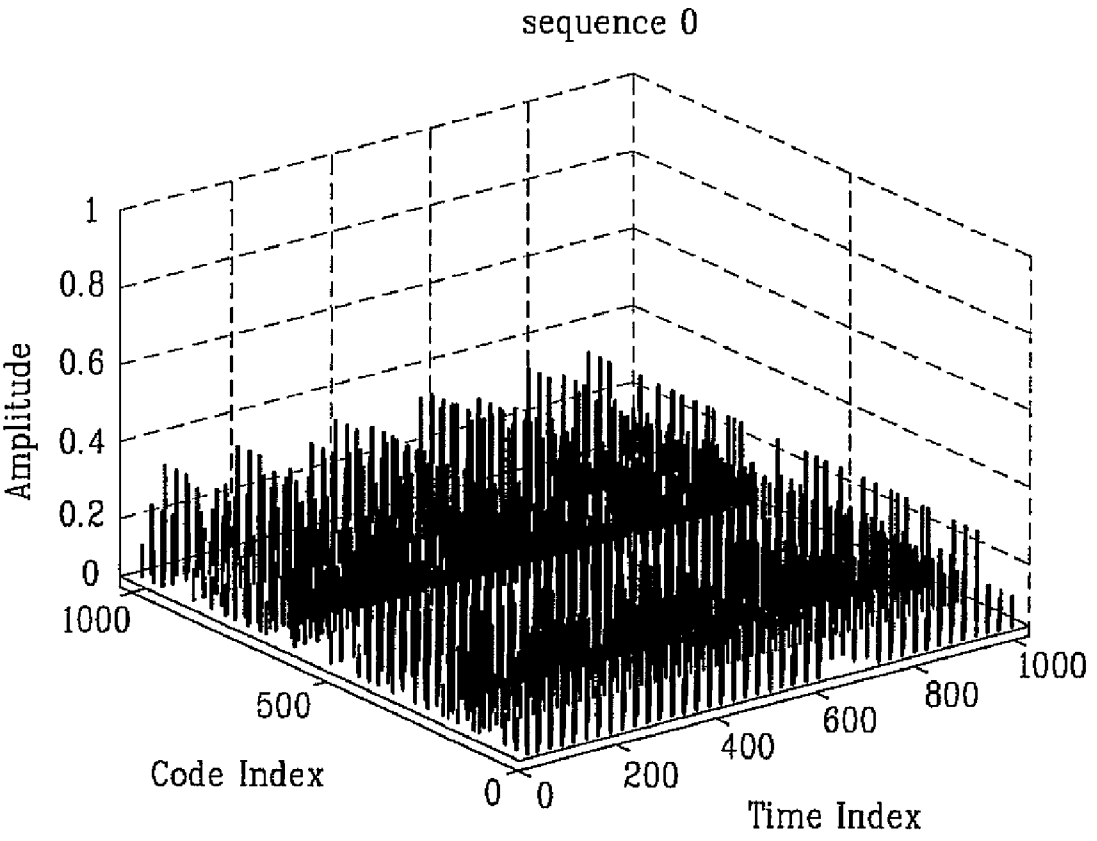

sequence 0
Amplitude
1
0.8
0.6
0.4
0.2
0
1000
500
0
Code Index
0
200
400
600
800
1000
Time Index

FIG. 6

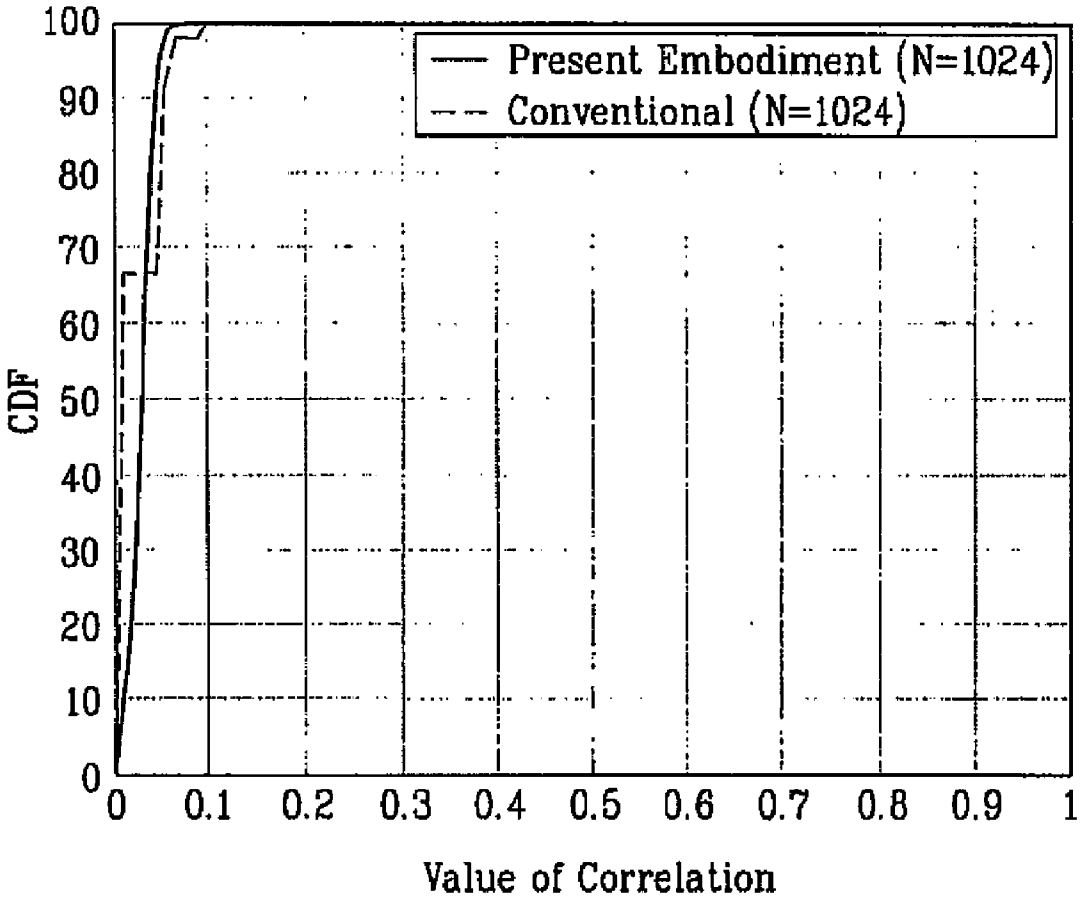

Present Embodiment (N=1024)
Conventional (N=1024)
CDF
100
90
80
70
60
50
40
30
20
10
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Value of Correlation

FIG. 7

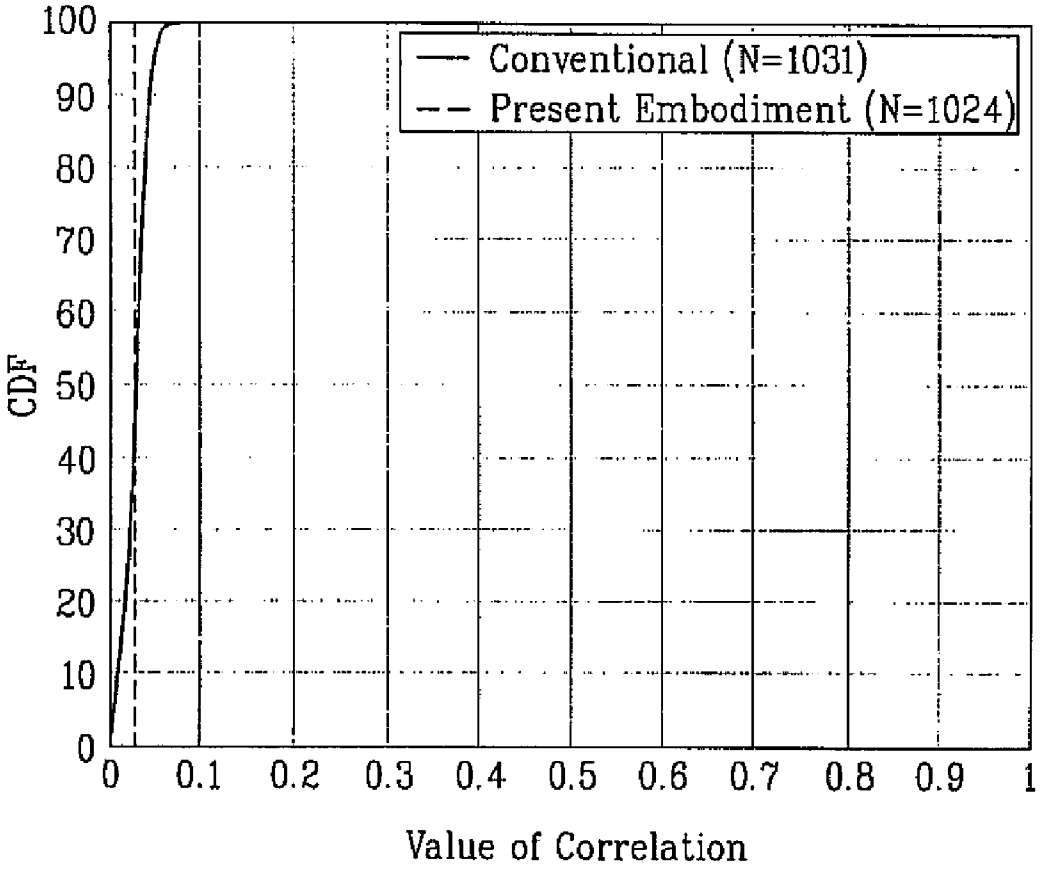

Conventional (N=1031)
Present Embodiment (N=1024)
CDF
100
90
80
70
60
50
40
30
20
10
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Value of Correlation

FIG. 8

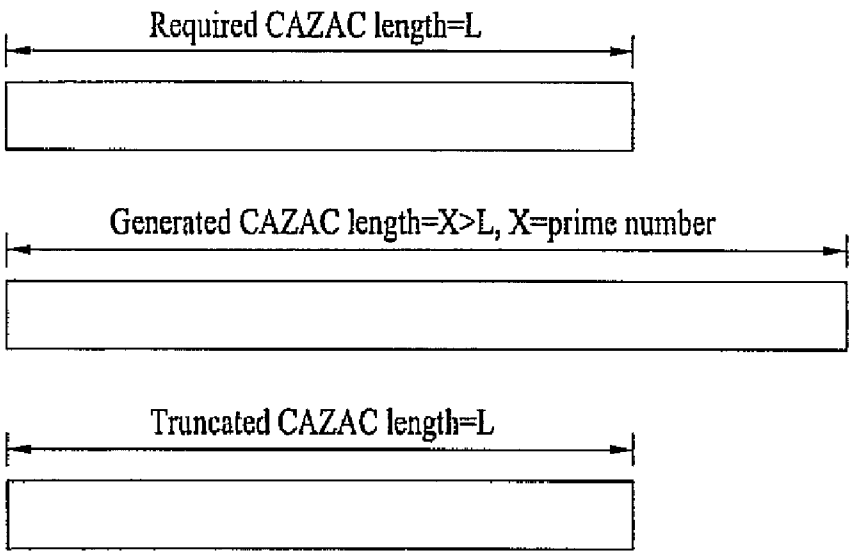

Required CAZAC length=L
Generated CAZAC length=X>L, X=prime number
Truncated CAZAC length=L

FIG. 9

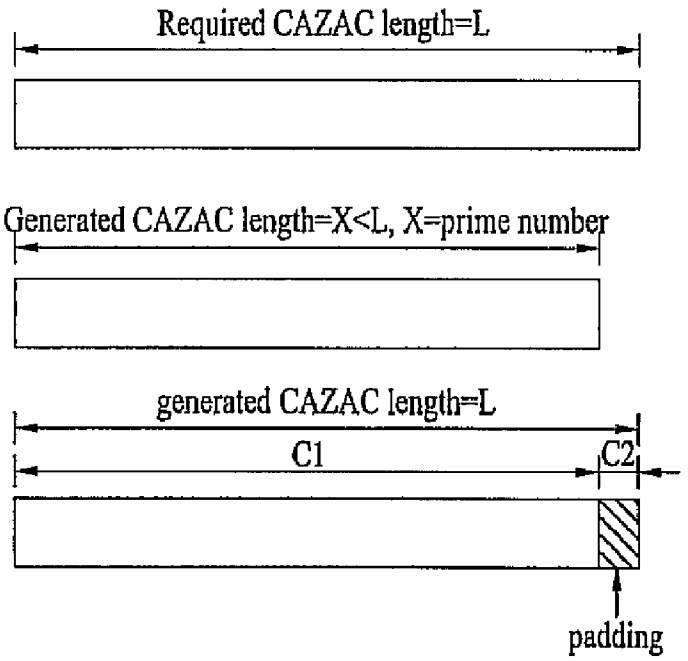

Required CAZAC length=L
Generated CAZAC length=X<L, X=prime number
generated CAZAC length=L
C1
C2
padding

FIG. 10

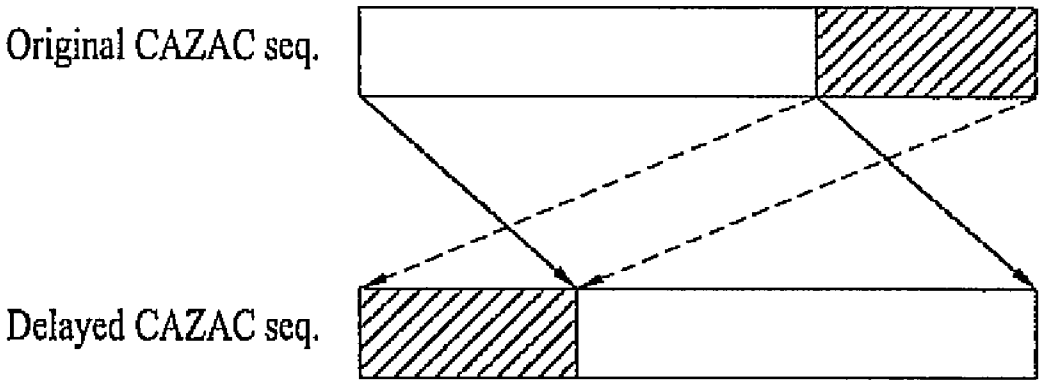


FIG. 11

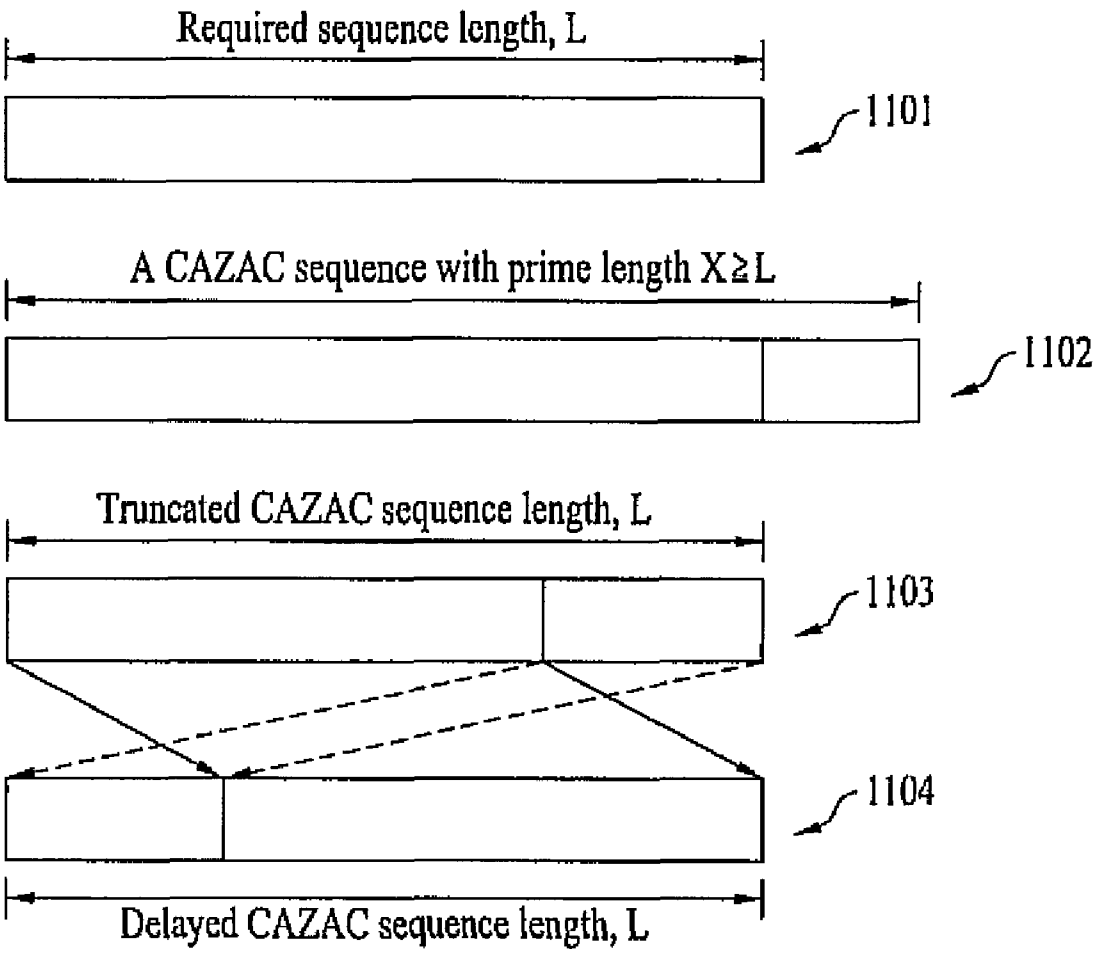

Required sequence length, L
1101
A CAZAC sequence with prime length X≥L
1102
Truncated CAZAC sequence length, L
1103
1104
Delayed CAZAC sequence length, L

FIG. 12

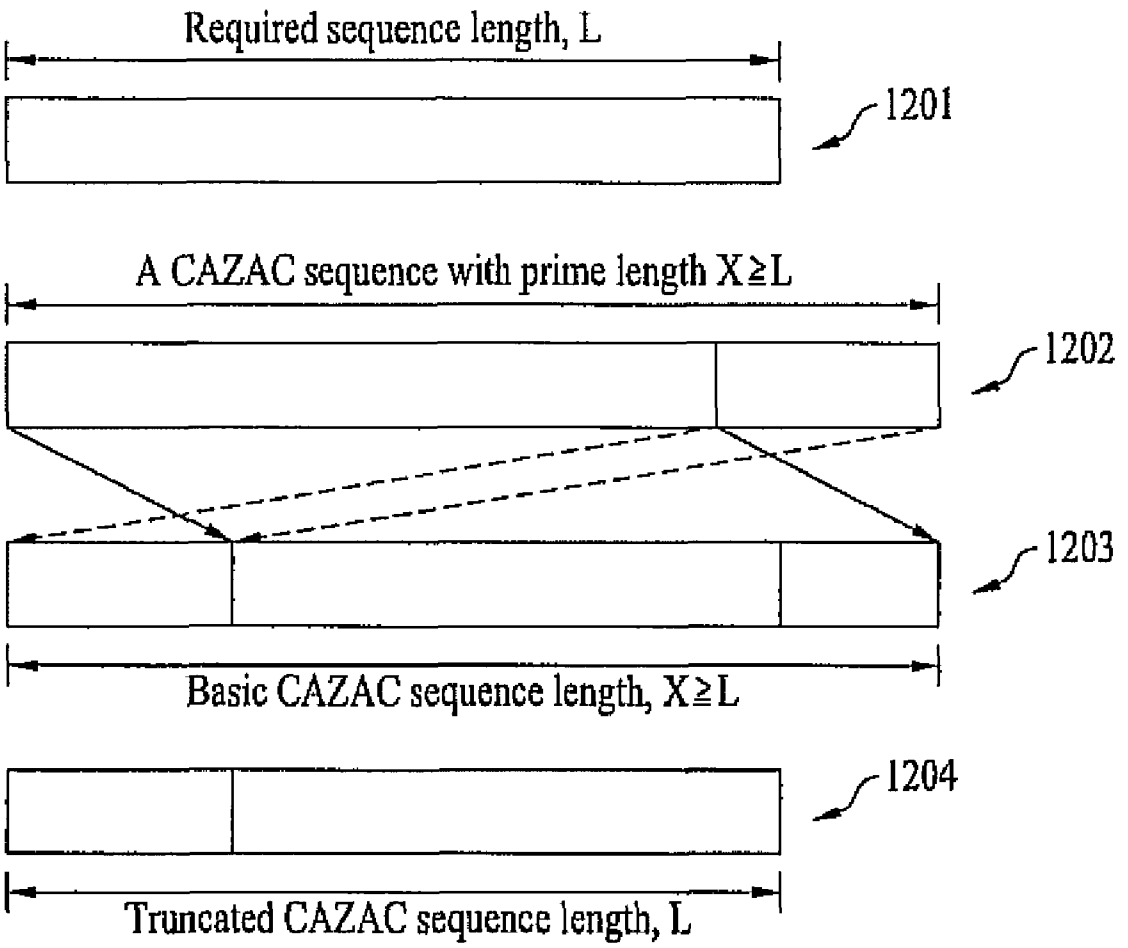

Required sequence length, L
1201
A CAZAC sequence with prime length X≧L
1202
1203
Basic CAZAC sequence length, X≧L
1204
Truncated CAZAC sequence length, L

FIG. 13

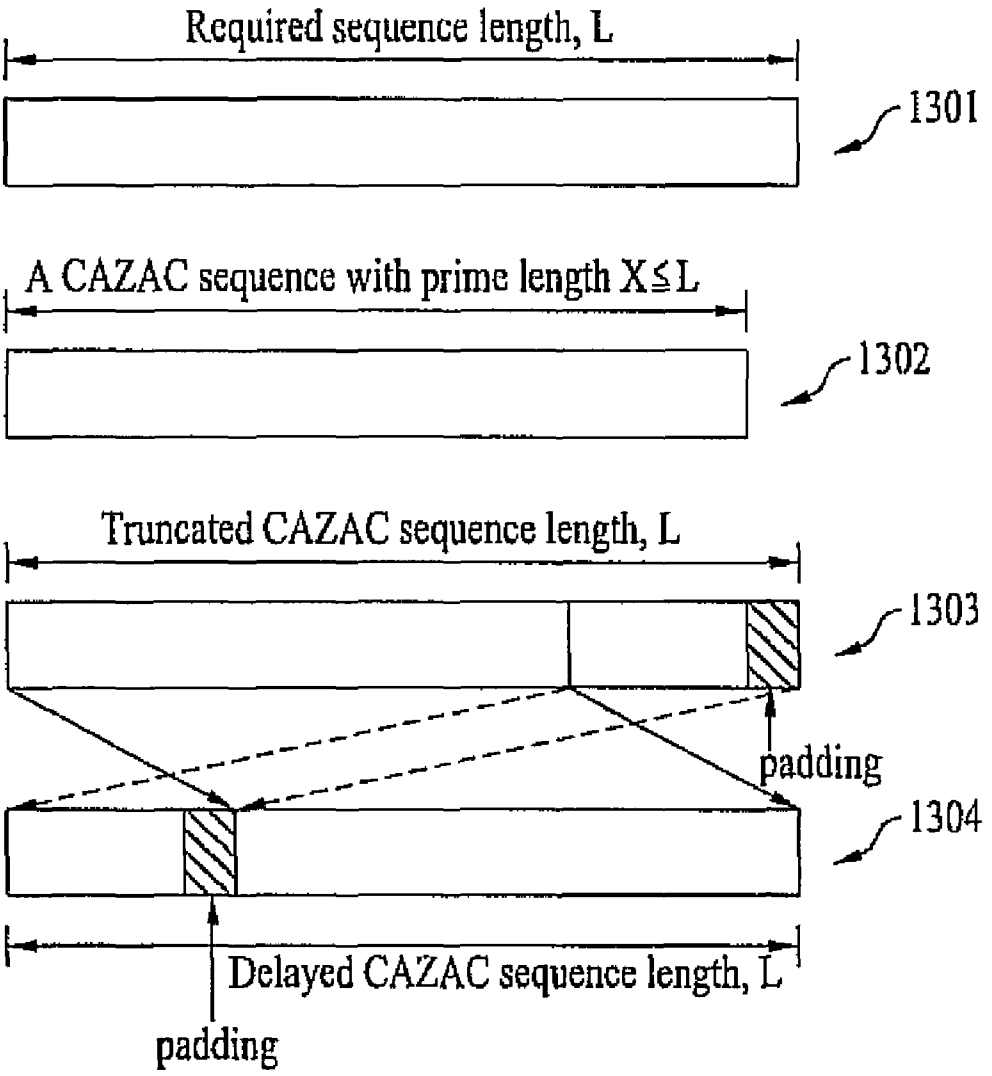

Required sequence length, L
1301
A CAZAC sequence with prime length X≤L
1302
Truncated CAZAC sequence length, L
1303
padding
1304
Delayed CAZAC sequence length, L
padding

FIG. 14

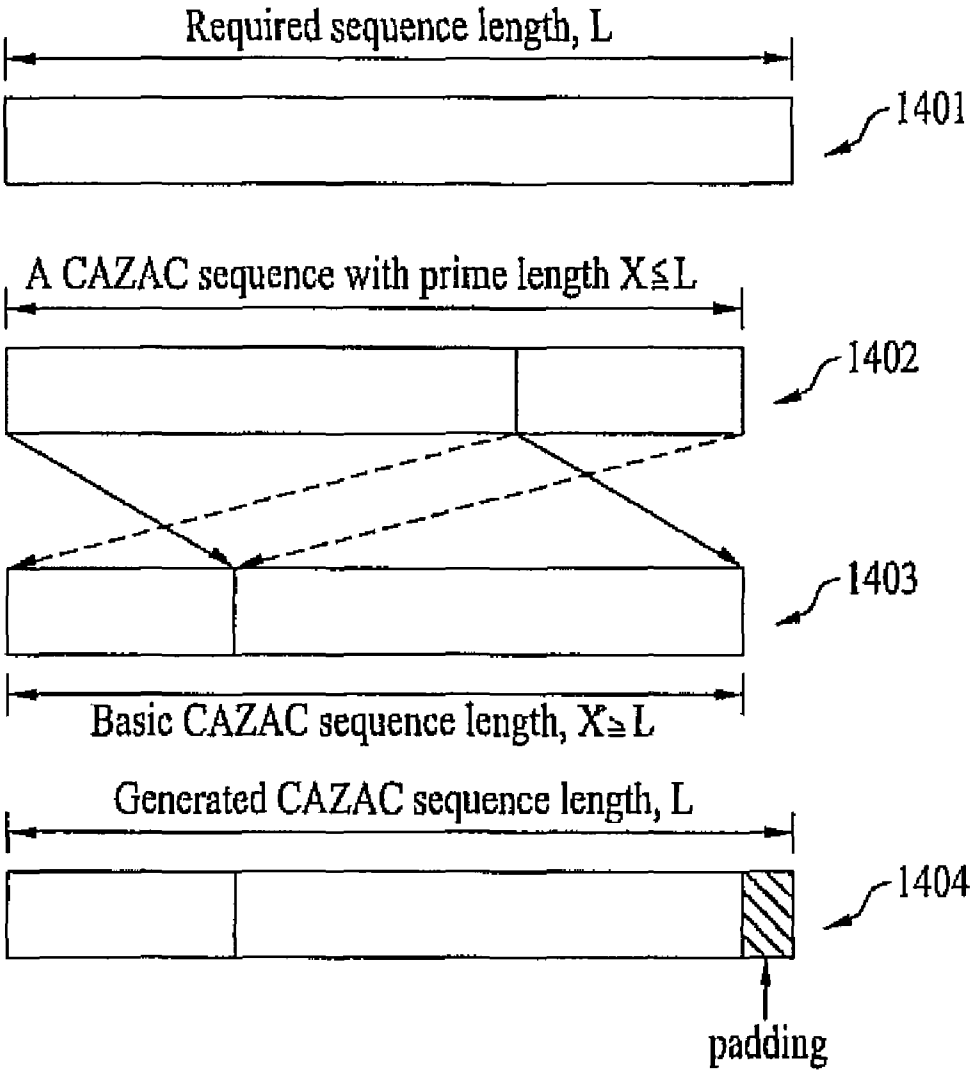

Required sequence length, L
1401
A CAZAC sequence with prime length X≦L
1402
1403
Basic CAZAC sequence length, X≧L
Generated CAZAC sequence length, L
1404
padding

FIG. 15

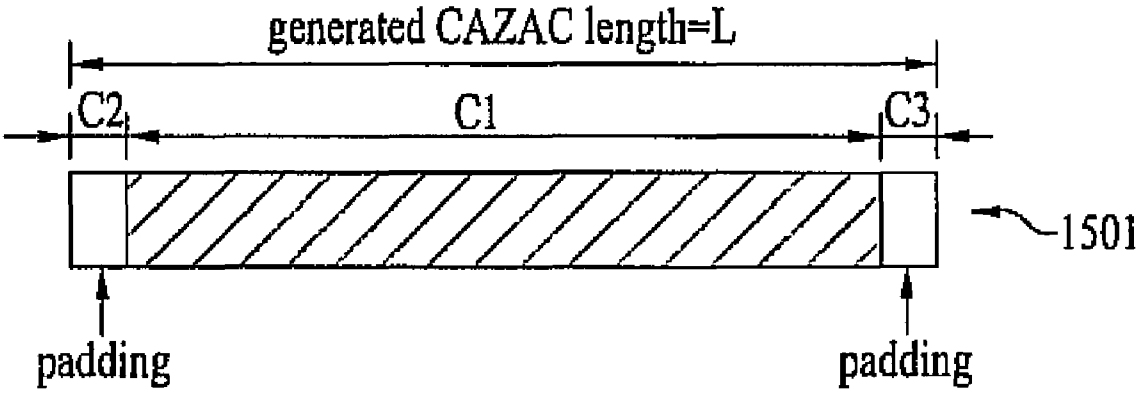


FIG. 16

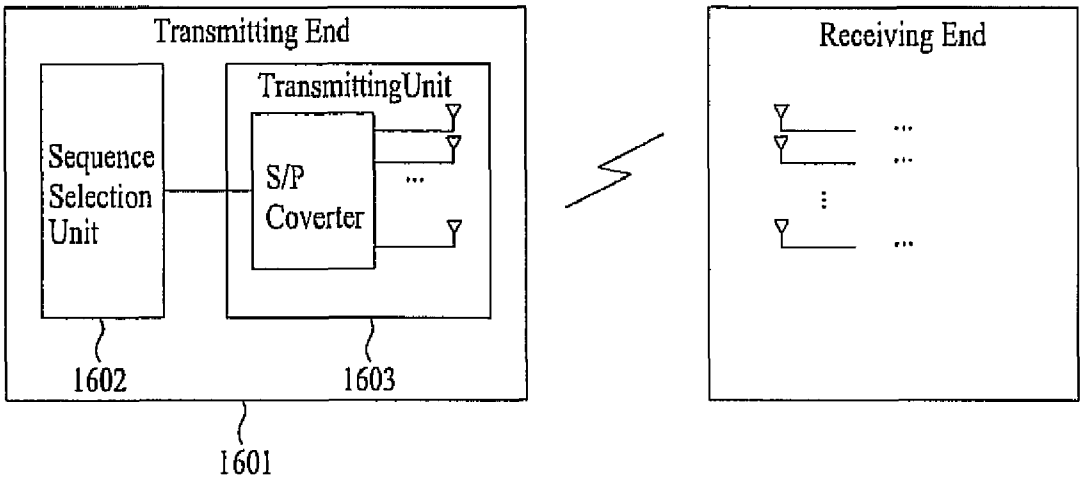

Transmitting End
TransmittingUnit
Sequence Selection Unit
S/P Coverter
1602
1603
1601
Receiving End

FIG. 17

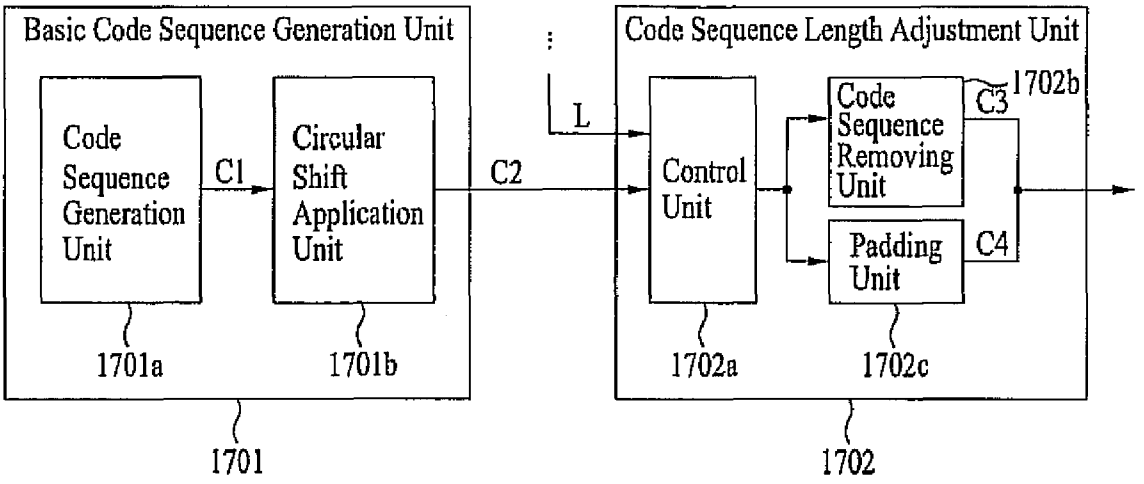

Basic Code Sequence Generation Unit
Code Sequence Generation Unit
C1
Circular Shift Application Unit
C2
L
Code Sequence Length Adjustment Unit
Control Unit
Code Sequence Removing Unit
C3
1702b
Padding Unit
C4
1701a
1701b
1702a
1702c
1701
1702

FIG. 18

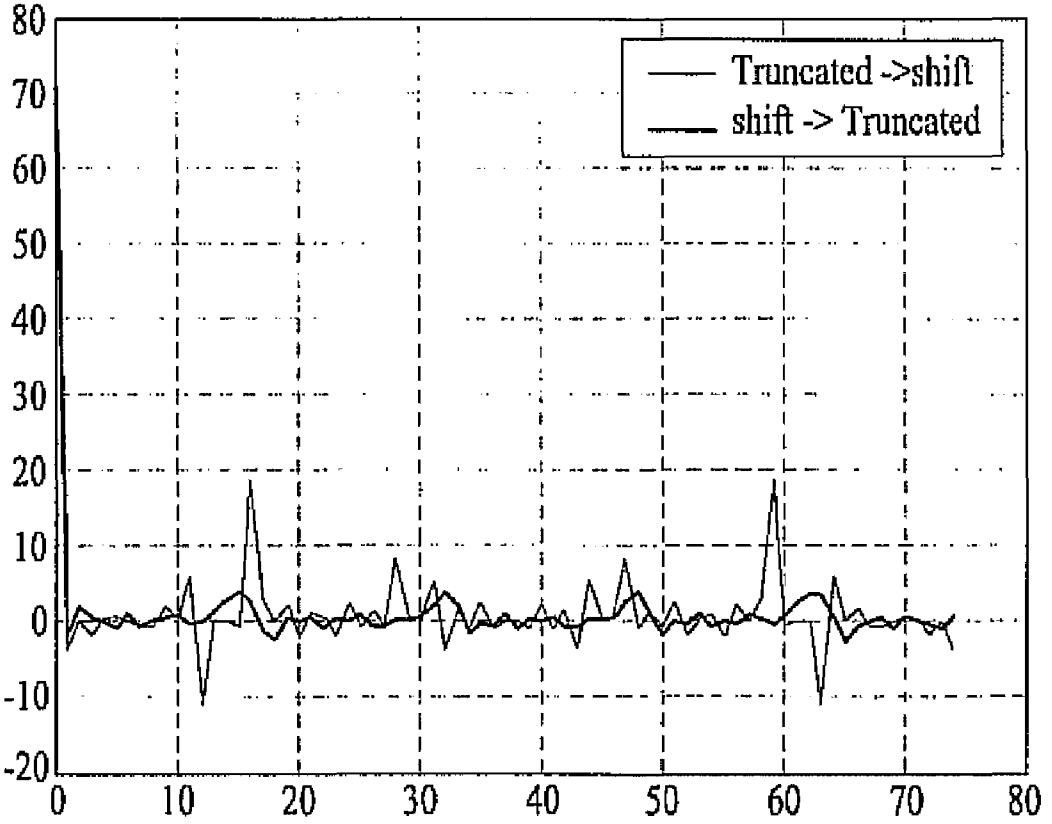

Truncated ->shift
shift -> Truncated
80
70
60
50
40
30
20
10
0
-10
-20
0
10
20
30
40
50
60
70
80

FIG. 19

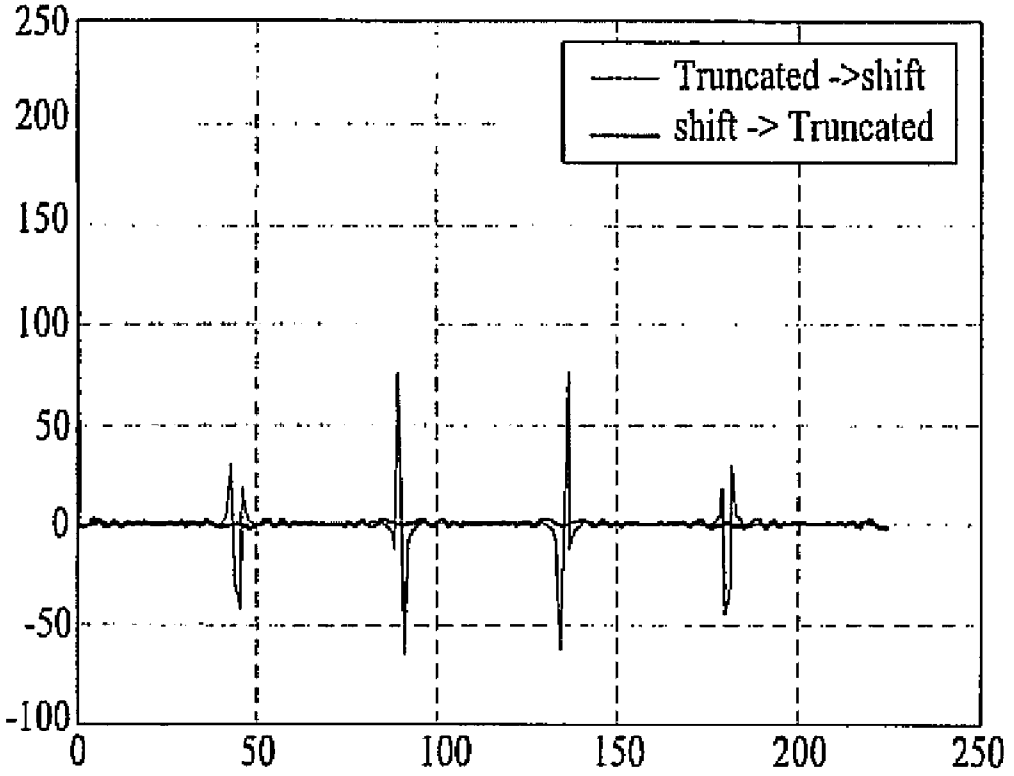
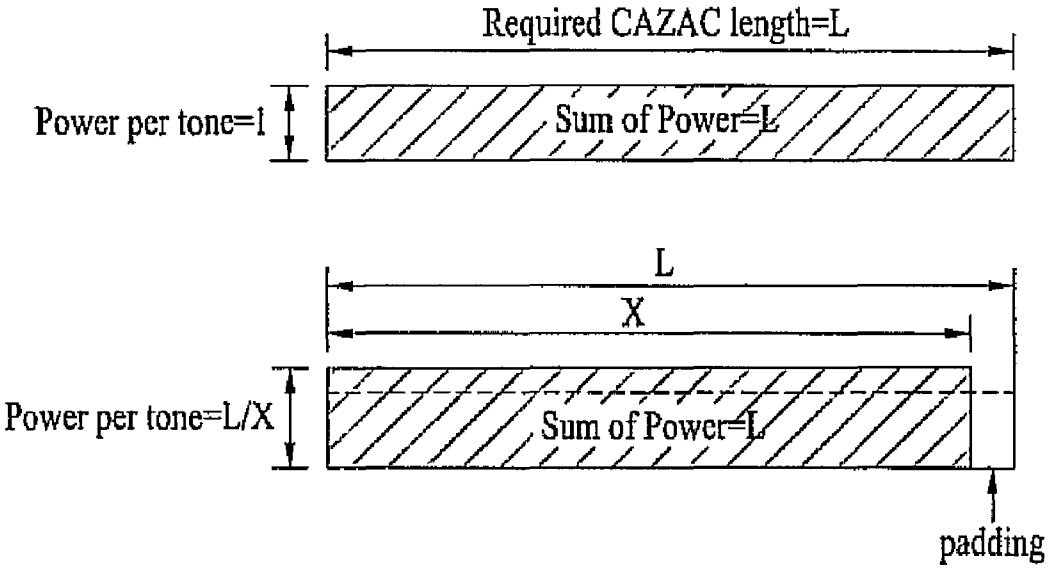

Truncated ->shift
shift -> Truncated
250
200
150
100
50
0
-50
-100
0
50
100
150
200
250

FIG. 20


Required CAZAC length=L
Power per tone=1
Sum of Power=L
L
X
Power per tone=L/X
Sum of Power=L
padding

METHOD AND APPARATUS FOR GENERATING AND TRANSMITTING CODE SEQUENCE IN A WIRELESS COMMUNICATION SYSTEM

This application claims the benefit of Korean Application No. P2005-114306, filed on Nov. 28, 2005, Korean Application No. P2006-62467, filed on Jul. 4, 2006, and Korean Application No. P2006-64091, filed on Jul. 7, 2006, which are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method of generating and transmitting code sequence, and more particularly, to a method and apparatus for generating and transmitting code sequence in a wireless communication system.

2. Discussion of the Related Art

Usually, a pilot signal or a preamble of a wireless communication system is referred to as a reference signal used for initial synchronization, cell search, and channel estimation. Further, the preamble is comprised of a code sequence, and the code sequence is further comprised of orthogonal or quasi-orthogonal which represent good correlation properties.

For example, a Hadamard matrix of 128×128 is used in a portable internet (PI) to insert the code sequence to the frequency domain. In so doing, 127 types of code sequences are used.

Although the Hadmard code sequence and a poly-phase Constant Amplitude Zero Auto-Correlation (CAZAC) code sequence are orthogonal codes, a number of codes used to maintain orthogonality is limited. For example, a number of N orthogonal codes in a N×N Hadamard matrix is N, and a number of N orthogonal codes that can be expressed by the CAZAC codes is N and a prime number smaller than N (David C. Chu, "Polyphase Codes with Good Periodic Correlation Properties," *Information Theory IEEE Transaction on*, vol. 18, issue 4, pp. 531-532, July 1972). With respect to CAZAC sequence types, GCL CAZAC and Zadoff-Chu CAZAC are often used.

If the code sequence is generated using the Hadamard codes, N number of sequence types corresponding to the entire length of the codes is generated. However, the if the code sequence is generated using the CAZAC codes, only half or N/2 number of sequence types are generated.

SUMMARY OF THE INVENTION

Accordingly, the present invention is directed to a method and apparatus for generating and transmitting code sequence in a wireless communication system that substantially obviates one or more problems due to limitations and disadvantages of the related art.

An object of the present invention is to provide a method of generating a code sequence in a wireless communication system.

Another object of the present invention is to provide an apparatus for generating a code sequence in a wireless communication system.

Additional advantages, objects, and features of the invention will be set forth in part in the description which follows and in part will become apparent to those having ordinary skill in the art upon examination of the following or may be learned from practice of the invention. The objectives and other advantages of the invention may be realized and

attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

To achieve these objects and other advantages and in accordance with the purpose of the invention, as embodied and broadly described herein, a method of generating a code sequence in a wireless communication system includes recognizing a desired length of the code sequence, generating a code sequence having a length different from the desired length, and modifying the length of the generated code sequence to equal the desired length. Here, the step of modifying includes discarding at least one element of the generated code sequence or inserting at least one null element to the generated code sequence.

In another aspect of the present invention, method of generating a code sequence in a wireless communication system includes a recognizing a desired length of a first code sequence, generating a second code sequence having a length different from the desired length of the first code sequence, and modifying the length of the second code sequence to equal the desired length of the first code sequence. Here, the step of modifying includes discarding at least one element of the modified code sequence if the length of the modified code sequence is longer than the desired length of the first code sequence or inserting at least one null element to the modified code sequence if the length of the modified second code sequence is shorter than the desired length of the first code sequence.

In a further aspect of the present invention, an apparatus for generating a code sequence in a wireless communication system includes a sequence selection unit for recognizing a desired length of the code sequence, generating a code sequence having a length different from the desired length, and modifying the length of the generated code sequence to equal the desired length, wherein the sequence selection unit discards at least one element of the generated code sequence or inserts at least one null element to the generated code sequence in modifying the length of the generated code sequence, and a transmitting unit for transmitting the modified generated code sequence via at least one antenna.

It is to be understood that both the foregoing general description and the following detailed description of the present invention are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this application, illustrate embodiment(s) of the invention and together with the description serve to explain the principle of the invention. In the drawings;

FIG. **1** illustrates a structure of an apparatus for transmitting data using Orthogonal Frequency Division Multiplexing (OFDM) or OFDM Access (OFDMA) scheme;

FIG. **2** illustrates a structure of an apparatus for receiving data using OFDM/OFDMA scheme;

FIG. **3** is a flow diagram illustrating adjusting a code sequence;

FIG. **4** illustrates cross-correlation properties of the generated code sequence;

FIG. **5** illustrates a generated CAZAC sequence

$a_{N_{seq\_N}xN}$

using N (=1024);

FIG. **6** illustrates a cross-correlation properties cumulative distribution function (CDF) of the code sequences that can be generated according to the code sequence

$a_{N_{seq\_M}xN}$

and the CAZAC sequence

$a_{N_{seq\_N}xN}$

when N=1024;

FIG. **7** illustrates the cross-correlation properties CDF of the code sequences that can be generated based on the CAZAC sequence generated using the prime number of N=1031 and a code sequence set

$a_{N_{seq\_M}xN}$

having length of 1024 (seven (7) elements removed);

FIG. **8** illustrates a method of generating CAZAC sequence using a length required by a communication system;

FIG. **9** illustrates a method of generating a CAZAC sequence using a padding portion;

FIG. **10** illustrates an exemplary application of circular shift;

FIG. **11** is an exemplary diagram illustrating application of circular shift to the generated code sequence after the elements of the code sequence are removed;

FIG. **12** is an exemplary diagram illustrating application of circular shift to the generated code sequence prior to removing the elements of the code sequence;

FIG. **13** is an exemplary diagram illustrating application of circular shift to the generated code sequence after a padding portion is attached;

FIG. **14** is an exemplary diagram illustrating application of circular shift to the generated code sequence prior to attaching a padding portion;

FIG. **15** is an exemplary diagram of a padding portion of the code sequence in which the padding portion is used as a lower bandwidth guard interval;

FIG. **16** is a structural diagram for transmitting the code sequence. Depending on whether the transmission of the code sequence is made in a downlink direction or an uplink direction, the structure can be in different form;

FIG. **17** is a structural diagram illustrating a basic code sequence generation unit and a code sequence length adjustment unit;

FIG. **18** illustrates cross-correlation characteristics of the code sequence;

FIG. **19** illustrates cross-correlation characteristics of the code sequence; and

FIG. **20** is an exemplary diagram illustrating boosting the power of the generated code sequence.

DETAILED DESCRIPTION OF THE INVENTION

Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

FIG. **1** illustrates a structure of an apparatus for transmitting data using Orthogonal Frequency Division Multiplexing (OFDM) or OFDM Access (OFDMA) scheme. FIG. **2** illustrates a structure of an apparatus for receiving data using OFDM/OFDMA scheme.

In FIG. **1**, traffic data and control data are multiplexed at a muxer **11**. Here, the traffic data is used to provide service from a transmitting end to a receiving end, and the control data is used to facilitate transmission from the transmitting end to the receiving end. The discussion relating to the present invention regarding the code sequence which relates to a type of a code sequence of the control data. The code sequence can be used for initial synchronization, cell search, or channel estimation.

Depending on the communication system, the code sequence can be used in various forms. For example, the code sequence in an IEEE 802.16 wideband wireless access system can be used in a preamble or a pilot signal format, and in a multi-input, multi-output (MIMO) system, the code sequence can be used as a midamble format.

After being processed at the muxer **11**, the multiplexed traffic and control data is then channel coded by a channel coding module **12**. Channel coding is used to allow the receiving end to correct error that can occur during transmission by adding parity bits. Examples of channel coding include convolution coding, turbo coding, and low density parity check (LDPC) coding.

Thereafter, the channel coded data is modulated by a digital modulation module **13** in which data symbols are mapped using algorithms such as a quadrature phase shift keying (QPSK) or a 16-quadrature amplitude modulation (16 QAM). The mapped data symbols are then processed by a subchannel modulation module **14** through which the data symbols are mapped to each subcarrier of the OFDM system or OFDMA system. Then, the data symbols mapped to subcarriers are processed by an inverse fast Fourier transform (IFFT) module **15** which transform the data symbols into a signal in a time domain. The transformed data symbols are then processed through a filter **16** and further processed through a digital-to-analog conversion (DAC) module **17** where the filtered data symbols are converted to analog signals. Lastly, the analog signals are converted into a radio frequency (RF) by a RF module **18** which is then transmitted via an antenna **19** to the receiving end.

Based on the type of generated code (e.g., CAZAC code), the steps of channel coding and/or symbol mapping can be omitted. FIG. **2** illustrates a receiving end whose processes are inverse to those of the transmitting end.

A code sequence is used for transmitting control information, which includes identification (ID) and synchronization information, to classify types of sequences in a communication system. In order for more effective reception of the control information using code sequence, the code sequence can be adjusted or modified. Further, the code sequence can be applied to all of the channels that use code sequence for control signaling such as a random access channel (RACH),

downlink/uplink reference symbol, channel quality information (CQI), and Acknowledgement (ACK)/Negative Acknowledgement (NACK).

FIG. **3** is a flow diagram illustrating adjusting a code sequence. More specifically, a length of the code sequence is defined as N, a number of codes in the code sequence is defined as N_{seq_N}, and a code sequence set defined as

$$a_{N_{\text{seq\_N}}xN}.$$

In operation, the code sequence set

$$a_{N_{\text{seq\_N}}xN}$$

having N_{seq_N} number of codes can be extended to a code sequence set

$$a_{N_{\text{seq\_M}}xN}$$

having N_{seq_M} number of codes.

Equation

$$a_{N_{\text{seq\_N}}xN}$$

is a matrix of N_{seq_N}×N of

$$a_{N_{\text{seq\_N}}xN} = \left[a^0_{N_{\text{seq\_N}}xN}\, a^1_{N_{\text{seq\_N}}xN} \ldots a^{N_{seq}-1}_{N_{\text{seq\_N}}xN}\right]^T, \text{ and } a^k_{N_{\text{seq\_N}}xN}$$

is a row vector of

$$a^k_{N_{\text{seq\_N}}xN} = \left\lfloor a^k_{N_{\text{seq\_N}}xN}(0)\, a^k_{N_{\text{seq\_N}}xN}(1) \ldots a^k_{N_{\text{seq\_N}}xN}(N-1)\right\rfloor.$$

Furthermore,

$$a^k_{N_{\text{seq\_N}}xN}(n)$$

indicates n(=0, 1, 2, . . . , N−1) element of k(=0, 1, 2, N_{seq_N}−1) code sequence.

Referring to FIG. **3**, a code sequence set

$$a_{N_{\text{seq\_M}}xM},$$

having N_{seq_M} number of code sequence(s) where each code sequence has length M, can be generated based on the code generation algorithm based on code type in which a value of length M is a natural number greater than a value of length N (S**301**). Here, the code types include Hadamard code, Pseudo Noise (PN) code, and a Constant Amplitude Zero Auto-Correlation (CAZAC) code, among others to be used for initial synchronization, cell search, and channel estimation in the wireless communication system. The code sequence set having length M per each code type can be generated by various schemes as discussed. As for the CAZAC code, the value of length M is a smallest prime number greater than the value of length N, preferably.

Subsequently, a code sequence set

$$a_{N_{\text{seq\_M}}xN},$$

having N_{seq_M} number of code sequences, can be generated where a resulting length of the code sequence is length N. More specifically, the code sequence set

$$a_{N_{\text{seq\_M}}xM},$$

having N_{seq_M} number of code sequences where each code sequence has length M (from step S**301**), can have elements of the code sequence removed. That is, elements which comprise each code sequence can be removed from the code sequence allowing the length of the code sequence to be adjusted or shortened. Here, M−N number of elements can be removed from the code sequence whose length corresponds to length M. By removing elements from the code sequence with length M, a code sequence having length N can be generated. As discussed, N is smaller than M. Consequently, a code sequence set

$$a_{N_{\text{seq\_M}}xN},$$

having N_{seq_M} number of code sequences in which each code sequence has length N, can be generated (S**302**).

A code sequence is used for transmitting control information, which includes identification (ID) and synchronization information, to classify types of sequences in a communication system. Currently in 3rd Generation Partnership Project (3GPP) Long Term Evolution (LTE), a CAZAC sequence is being considered.

The CAZAC sequence can be used by channels to output various IDs and information. The channels include channels for downlink synchronization (e.g., primary synchronization channel, secondary synchronization channel, and broadcast channel), uplink synchronization (e.g., random access channel), and pilot channels (e.g., data pilot and channel quality pilot). Further, the CAZAC sequence can be used in scrambling as well as channels that use code sequence such as RACH.

Although there are various types of the CAZAC sequences, there are two types of often used CAZAC sequences—GCL CAZAC and Zadoff-Chu CAZAC. The Zadoff-Chu CAZAC sequence can be defined by the following equations.

$$c(k; N, M) = \exp\left(\frac{j\pi Mk(k+1)}{N}\right) (\text{for odd } N) \qquad \text{[Equation 1]}$$

-continued

$$c(k; N, M) = \exp\left(\frac{j\pi Mk^2}{N}\right) \text{ (for even } N) \quad \text{[Equation 2]}$$

Here, k denotes sequence index, N denotes a length of CAZAC to be generated, and M denotes sequence ID.

If the Zadoff-Chu CAZAC sequence and the GCL CAZAC sequence are expressed by c(k;N,M) as shown in Equations 1 and 2, then the sequences have the following three (3) characteristics as presented in following equations.

$$|c(k; N, M)| = 1 \text{ (for all } k, N, M) \quad \text{[Equation 3]}$$

$$R_{M;N}(d) = \begin{cases} 1, & \text{(for } d = 0) \\ 0, & \text{(for } d \neq 0) \end{cases} \quad \text{[Equation 4]}$$

$$R_{M_1,M_2;N}(d) = p \text{ (for all } M_1, M_2 \text{ and } N) \quad \text{[Equation 5]}$$

According to Equation 3, the CAZAC sequence always has a size of 1, and the CAZAC sequence of Equation 4 has an auto-correlation function denoted by a delta function. Here, the auto-correlation is based on circular correlation. Further, Equation 5 is a cross-correlation which is constant if N is a prime number,

If the length to be applied in the wireless communication system for generating the CAZAC sequence is denoted by L, a method for generating the CAZAC sequence sets N of Equations 1 and 2 to equal L (N=L)—identified as step (1). Step (2) can be identified by a method where a value of N is set to be a prime number greater than a value of length L for generating the CAZAC sequence.

Referring to the characteristics of the generated CAZAC sequence having a specified length of L, if L is not a prime number, the generated CAZAC sequence can include M=1, 2, . . . L−1 number of codes, some of which are repeated codes. In other words, the number of different codes is less than L−1 number of codes. On the contrary, if L is a prime number, there is L−1 number of different codes. The above descriptions may also be applied to other types of code sequences and are not limited to Zadoff-Chu CAZAC sequence.

Further, the following technique has been considered. More specifically, if the length of code to be applied to the system is not a prime number, and there are a large number of codes to be used, a smallest prime number greater than L was selected. Using the selected prime number, the CAZAC sequence was generated, and discards or removes at least one element of the generated CAZAC sequence for use. This technique is different than the technique introduced with respect to step 1.

For example, assume that a number of codes of a CAZAC code sequence (N) is 1024. The following equation can be used to express an algorithm for generating a Zadoff-Chu CAZAC code.

$$a^{index(A)}(n) = \begin{cases} \exp\left(i\frac{A\pi n(n+1)}{M}\right), \text{ when } M \text{ is odd} \\ \exp\left(i\frac{A\pi n^2}{M}\right), \text{ when } M \text{ is even} \end{cases} \quad \text{[Equation 6]}$$

where $n = 0, 1, 2, \ldots, M-1$

In Equation 6, A and M are natural numbers, and index(A) (=0, 1, 2, . . . , N_{seq_M}−1) is an index of A in ascending order. In order to extend the CAZAC sequence where N=1024, a smallest prime number greater than 1024 is used. That is, the smallest prime number greater than 1024 is 1031. As such, the code sequence set

$$a_{N_{\text{seq\_M}}xM}$$

where M=1031 is applied to Equation 6.

Since M (=1031) is a prime number, N_{seq_M}=1030. Furthermore, A can be referred to as a seed value used to generate a code sequence maintaining CAZAC properties. If M is a prime number, a total of M−1 number of code sequences can be generated. In other words, for example, if M=1024, a total of 512 (=1024/2 or N/2) number of code sequences are generated. However, if M=1031, a total of 1030 number of code sequences (M−1) are generated. Moreover, the cross-correlation properties of the generated code sequence are better if M is a prime number than a composite number.

In order to adjust or modify the CAZAC code sequence set

$$a_{N_{\text{seq\_M}}xM}$$

where M=1031 to a code sequence set

$$a_{N_{\text{seq\_M}}xM}$$

whose length is N=1024, M−N number of elements can be removed from index n=N, . . . , M−1, generating a code sequence set

$$a_{N_{\text{seq\_M}}xN},$$

In determining the value of M, although the number of code sequences can increase with increase in value of N, it is preferable to determine the value of M based on the code sequence whose length is N that promotes maintenance of good correlation properties. In case of the CAZAC code, optimum correlation properties can be attained if the value of length M is the smallest prime number greater than the value of length N.

If the code sequence set

$$a_{N_{\text{seq\_M}}xN}$$

generated using length N=1024 is compared with the code sequence set

$$a_{N_{\text{seg\_M}}xN},$$

a total number code sequences of the former can be represented by N/2 or 512 (=1024/2) code sequences having an

index 0, 1, 2, . . . , N/2−1(N=1024), and a total number of code sequences of the latter can be represented by M−1 or 1030 having an index 0, 1, 2, . . . , M−2 (M=1031).

FIG. **4** illustrates cross-correlation properties of the generated code sequence. More specifically, the cross-correlation properties of

$$a^{k}_{N_{\text{seq\_M}}xN}(k = 1, 2, \cdots, N_{\text{seq\_M}} - 1)$$

associated with the remaining N_{seq_M}(1029) code sequences for

$$a^{0}_{N_{\text{seq\_M}}xN}$$

code sequence of the code sequence set

$$a_{N_{\text{seq\_M}}xN}.$$

The figure illustrates this with respect to amplitude, code index, and time index.

Further, FIG. **5** illustrates a generated CAZAC sequence

$$a_{N_{\text{seq\_N}}xN}$$

using N(=1024). More specifically, the figures illustrate cross-correlation properties of

$$a^{k}_{N_{\text{seq\_M}}xN}(k = 1, 2, \cdots, N_{\text{seq\_M}} - 1)$$

regarding the remaining N_{seq_N}(511) code sequences. The figure illustrates this with respect to amplitude, code index, and time index. Between FIG. **4** and FIG. **5**, the cross-correlation properties of the generated code sequence of FIG. **4** are better.

FIG. **6** illustrates a cross-correlation properties cumulative distribution function (CDF) of the code sequences that can be generated according to the code sequence

$$a_{N_{\text{seq\_M}}xN}$$

and the CAZAC sequence

$$a_{N_{\text{seq\_N}}xN}$$

when N=1024.

FIG. **7** illustrates the cross-correlation properties CDF of the code sequences that can be generated based on the CAZAC sequence generated using the prime number of N=1031 and a code sequence set

$$a_{N_{\text{seq\_M}}xN}$$

having length of 1024 (seven (7) elements removed). The performance lines of FIGS. **4-7** indicate that the code sequence set with seven (7) elements removed has equivalent cross-correlation properties compared to the original code sequence set.

As discussed, the codes in addition to the CAZAC code are available, such as the PN code and the Hadamard code. The discussion with respect to the CAZAC code sequence can also be applied to the PN code and the Hadamard code. With respect to the PN code, a modular shift register generator is used to generate the code sequences. If a number of shift registers generated is represented by N, a code sequence having a length of 2^N-1 is generated. Thereafter, a value "1" is added to the shift register, resulting in a length $2^{N+1}-1$, and then, adjust the length to equal 2^N.

With respect to the Hadamard codes, a number of code sequences, which equal the length of the code sequence, make up a code sequence. However, for example, if M number of code sequences having length N is required (M>N), then M number of code sequences having length M are generated, followed by removing a specified number of elements to make the length of the code sequence equal length N.

FIG. **8** illustrates a method of generating CAZAC sequence using a length required by a communication system. That is, the required (or desired) length of the CAZAC sequence can be represented by length L. Further, the codes types can be extended. However, since a generated code sequence can be truncated or have elements discarded to correspond to the desired length L, the auto-correlation and cross-correlation properties of the truncated code sequence can experience deterioration. Similarly, even if a code sequence portion is added/attached to the generated code sequence (e.g., zero-padding or cyclic prefix) to correspond to the desired length L, the auto-correlation and cross-correlation properties can experience deterioration. Here, auto-correlation properties relate to the auto-correlation value being 1 when the delay is 0. Otherwise, the auto-correlation value is 0 when the delay is a value other than 0. Further, the cross-correlation properties having a constant value is negatively affected.

Assuming that the code sequence having poor auto-correlation and cross-correlation properties are removed, the remaining number of code sequences may be less than L−1.

In order to attain a desired length and a maximum number of CAZAC sequence types corresponding to the desired length, a smallest prime number, X, greater than the desired length, L, (X>L) can be selected. Although the CAZAC sequence can be generated using X, due to deterioration of the correlation properties, the correlations properties of CAZAC sequence as shown in Equations 4 and 5 cannot be attained. Further, when selecting a length of the generated code sequence, the length that is nearest to the desired length L which is between a smallest prime number larger than the desired length or a largest prime number smaller than the desired length can be selected.

Referring to FIG. **8**, the generated CAZAC sequence has length X. Thereafter, the generated CAZAC sequence having length X has elements of the code sequence removed (or truncated) so as to make the length of the generated CAZAC sequence correspond to the desired length L.

FIG. **9** illustrates a method of generating a CAZAC sequence using a padding portion. As discussed, the gener-

ated CAZAC sequence is truncated. With respect to auto-correlation and cross correlation properties, delay of 0 indicates an auto-correlation value of 1, as shown in Equation 4, and a delay not equaling 0 indicates a value of 0. Moreover, the properties where the cross-correlation value is always a prime number is not deteriorated whereby effective correlation is maintained. Further, additional control information can be transmitted by using the information inputted to the fading unit.

Referring to FIG. **9**, the generated CAZAC sequence has length X. Here, the value of X is a largest prime number less than the value of L. In other words, X is a prime number less than L. Thereafter, the generated CAZAC sequence having length X has elements added or a padding portion added to the CAZAC sequence in order to make the length of the generated CAZAC sequence corresponding to the desired length L. Here, C**1** represents the length of the CAZAC sequence having length X, and C**2** represents the padding portion. By combining C**1** and C**2** (C**1**+C**2**), the generated CAZAC sequence can have a length corresponding to the desired length L.

FIG. **10** illustrates an exemplary application of circular shift. The circular shift is typically applied to increase an amount of control information transmitted to the communication system. For example, a back portion of the sequence is re-allocated to a front portion of the sequence, and the remaining sequence is shifted in the direction of the back portion of the sequence in an amount (or length) corresponding to the re-allocated back portion, as illustrated in FIG. **10**. Further, if specified control information is applied the circular shift as described above, the amount of control information that can be transmitted via a corresponding sequence increases.

Discussions of above relate to the methods of generating the sequence using the desired length L, and of increasing transmitted control information using the circular shift. If these methods are applied in generating the sequence, the following processes take place. First, select a smallest prime number greater than L or a largest prime number less than L, which is referred to as X. Second, remove or add a sequence unit having a length corresponding to X−L or L−X. Third, apply the circular shift to the resulting sequence.

FIG. **11** is an exemplary diagram illustrating application of circular shift to the generated code sequence after the elements of the code sequence are removed. Referring to FIG. **11**, the code sequence **1102** is generated based on length X which is the smallest prime number greater than length L. In other words, the generated code sequence **1102** has a length equaling length X which is longer than the desired length L. From the generated code sequence **1102**, a portion having a length corresponding to length X−L is removed, resulting in a code sequence having length L **1103**. Thereafter, the result of the generated code sequence **1103** having length L is applied circular shift thereto, resulting in the code sequence **1104**.

FIG. **12** is an exemplary diagram illustrating application of circular shift to the generated code sequence prior to removing the elements of the code sequence. In other words, circular shift is performed to the generated CAZAC sequence having length X; and after circular shift is performed, the elements of the code sequence are removed.

Referring to FIG. **12**, the code sequence **1202** is generated based on length X which is the smallest prime number greater than length L. In other words, the generated code sequence **1202** has a length equaling length X which is longer than the desired length L. A circular shift is then performed to the generated code sequence **1203** having length X. Thereafter, a portion of the generated code sequence having a length corresponding to length X−L is removed, resulting in a code sequence **1204** having length L.

Equation 8 is used to acquire cross-correlation value(s) of a code sequence whose ID is M_2, from the received code sequence whose sequence ID is M_1. Through the acquired value, synchronization can be achieved.

Typically, if the wireless communication system is a synchronous network, auto-correlation is used to acquire synchronization information, and if the system is an asynchronous network, cross-correlation is used to acquire synchronization information. However, according to the embodiments of the present invention, synchronization information can be acquired using any one or at least one of the correlation schemes.

After the synchronization information of the received code sequence is acquired, the receiving end analyzes the received code sequence to acquire the sequence ID, as shown in Equations 9 and 10.

$$\sigma c(k; M, X) = c(k+1; M, X) \cdot c^*(k; M, X) \text{ (for } k = 0, 1, \ldots, L-1) \quad \text{[Equation 9]}$$

$$\sigma c(k; M, X) = c(k+1; M, X) \cdot c^*(k; M, X) \text{ (for } k = 0, 1, \ldots, X-1) \quad \text{[Equation 10]}$$

In Equations 9 and 10, σc(k;M,X) denotes difference sequence of the received sequences. Equation 9 is used to acquire the ID information of the received sequence using the differential sequence corresponding to the total length of the received sequence. Equation 9 can also be used to acquire the ID information of the code sequence which has been generated with the cyclic prefix/postfix padded portion. Equation 10 is used

FIG. **13** is an exemplary diagram illustrating application of circular shift to the generated code sequence after a padding portion is attached. Referring to FIG. **13**, the code sequence **1302** is generated based on length X which is the largest prime number smaller than the value of length L. To the generated CAZAC sequence **1302**, a padding portion is added **1303**. The length of the padding portion corresponds to a length L−X. As discussed, the padding portion can be comprised of zeroes or cyclic prefix/postfix. With the addition of the padding portion, the length of the CAZAC sequence equals the desired length L. Thereafter, the result of the generated code sequence having length L **1303** is applied circular shift thereto, resulting in the CAZAC sequence **1304**.

FIG. **14** is an exemplary diagram illustrating application of circular shift to the generated code sequence prior to attaching a padding portion. In other words, circular shift is performed to the generated CAZAC sequence having length X, and after circular shift is performed, the padding portion is attached.

Referring to FIG. **14**, the code sequence **1402** is generated based on length X which is the largest prime number smaller than the value of the desired length L. To the generated CAZAC sequence **1402**, circular shift is performed. The circularly-shifted CAZAC sequence **1403** still has length X. To the CAZAC sequence **1403**, a padding portion is added, resulting in the CAZAC sequence **1404**. The length of the padding portion corresponds to a length L−X. As discussed, the padding portion can be comprised of zeroes or cyclic prefix/postfix. With the addition of the padding portion, the length of the CAZAC sequence **1404** equals the desired length L.

Between FIGS. **11** and **12**, the difference is that circular shift is performed either before or after the elements of the CAZAC sequence are removed, By performing circular shift before removing the elements (or adjusting the length to equal the desired length), correlation deterioration can be reduced. To put differently, the CAZAC sequence does not have discontinuous codes.

Between FIGS. **13** and **14**, the difference is that circular shift is performed either before or after the padding portion is added to the generated CAZAC sequence. By attaching the padding portion after performing circular shift, better correlation properties can be attained, especially since the padding portion is placed at the end of the code sequence.

Further, according to the discussion above, the desired length L (or required length) is first recognized. As illustrated with respect to FIGS. **11-14**, the generated code sequence is adjusted/modified based on the desired length L. Based on that, after the desired length L recognized, a determination can be made as to whether the generated length X should be shortened or extended. In other words, the determination can be made whether to remove or discard at least one element of the generated code sequence or to add or insert at least one element to the generated code sequence. As discussed, the elements to be inserted can be a null (0) element (e.g., zero padding) or cyclic prefix/postfix, for example. In order to make the determination between discarding the element(s) or adding the element(s), the system can choose to select the length closest to the desired length L.

For example, if the desired length L is 75, the value of the smallest prime number greater than 75 is 79, and the value of the largest prime number smaller than the 75 is 73. Here, the prime number 73 can be selected since 73 is closer to 75 than 79 is to 75.

Although the illustration above selects the prime number closest to the desired length L, selection regarding removal or addition of the element(s) is not limited to the example of above and other implementations may be applied.

Regarding padding, there are five (5) schemes by which padding can be accomplished. As a first padding scheme, the padding portion can be comprised of a constant number (e.g., 0s). Although the padding portion is used to fill the portion of the code sequence so that the length of the code sequence coincides with the desired length, it is possible for the padding portion to be less then completely full. In other words, it is possible for that the length of the code sequence with padded portion is not equal to or is shorter than the code sequence with the desired length. That is, when the code sequence is used for functions deemed less important, such as for cell search or random access, it is not necessary to use the entire length of the code sequence, and as such, the padding portion does not need to be completely occupied to correspond to the desired length of the code sequence.

As a second padding scheme, the padding portion can be comprised of a repeated portion. In other words, the portion corresponding to L−X of the code sequence **1204** can be duplicated and inserted/attached to the end of the code sequence **1204**. This can be referred to as cyclic postfix. Here, the code sequence uses the entire length L. When determining the identification (ID) of the code sequence, the entire length L is used to facilitate identifying of the code sequence ID. At the same time, the generated code sequence does not experience distortion by using the entire length L. In the discussion above, the cyclic postfix is used. Alternatively, cyclic prefix can also be used.

As a third padding scheme, the padding portion can be comprised of additional information through which different messages can be delivered. More specifically, the desired length L of the code sequence can be used to generate a supplemental code sequence whose length equals the desired length L (N=L). The code sequence portion corresponding to L−X is extracted from the supplemental code sequence and inserted/attached to the generated code sequence as the padded portion.

As a fourth padding scheme, a portion corresponding to length L−X is extracted from the code sequence and inserted as the padding portion. Here, the code sequence inserted to the padding portion may be a different code sequence than the code sequence **1204**. Put differently, the code sequence inserted to the padding portion may be a CAZAC sequence having a length of M, for example, which is different from the code sequence **1204** having a length of L. Further, the code sequence inserted to the padding portion can be a different code sequence other than the CAZAC sequence. By using different code sequence, additional information can be delivered including information related to type of code sequence adjustments.

As a fifth padding scheme, the padding portion can be used as lower bandwidth guard interval. During transmission of control information using a prescribed sequence, the following possible scenarios can occur such as transmitting data without establishing synchronization with an access channel, transmitting data by a plurality of users within a communication system, and distortion of frequency of the received data.

Furthermore, the padding portions can be placed at both ends of the code sequence to use the padding portions as guard intervals of the lower bandwidth. Consequently, a more reliable acquisition of control information from the received data can take place despite distorted frequency signals. In the padding portions used as guard intervals, constant numbers (e.g., 0s) can be used or cyclic prefix or postfix of the generated code sequence can be used.

If the padding portions are placed at both ends of the code sequence and used as guard intervals of the lower bandwidth, the code sequences can be protected from frequency signal distortions. Moreover, if 0s are inserted between the guard intervals or put differently, within the code sequence, interference to neighboring codes can be reduced. Alternatively, if cyclic prefix/postfix is used as guard intervals, the code sequences can be protected from frequency distortions and can be used to transmit the control information containing the sequence ID if there is no frequency distortion.

FIG. **15** is an exemplary diagram of a padding portion of the code sequence in which the padding portion is used as a lower bandwidth guard interval. Referring to FIG. **15**, the code sequence **1501** can be divided into three (3) parts—a portion (C**1**), which is generated based on length X and the other two portions (C**2** and C**3**) are attached to both ends of the code sequence **1501**.

In the discussions above, five (5) padding schemes are introduced. However, the padding schemes are not limited to the discussed schemes, and there can be other types of padding schemes,

Besides the first padding scheme in which no information is inserted, the other four padding schemes insert additional information in the padding portions to allow expansion of the code sequence and/or transmission of message(s). Various information can be inserted into the padding portion including, for example, initial access information, timing update information, resource request information, user ID information, channel quality information (CQI), user group ID information related to a random access channel (RACH). Furthermore, the information can include cell ID information, multi-input multi-output (MIMO) information, and

synchronization channel information of a synchronization channel (SCH), for example. In addition, the padding portion can be used for transmitting data for message transmission as well as arbitrary information using a code sequence having a length of L−X.

FIG. **16** is a structural diagram for transmitting the code sequence. Depending on whether the transmission of the code sequence is made in a downlink direction or an uplink direction, the structure can be in different form. With that, FIG. **16** is described with respect to a general transmitting end for transmitting the control signal.

Referring to FIG. **16**, the transmitting end **1601** comprises a sequence selection unit **1602** and a transmitting unit **1603**. The sequence selection unit **1602** is used to generate the code sequence for transmitting the control information. More specifically, the sequence selection unit **1602** performs an operation to select a code sequence having a desired length of L. In other words, the sequence selection unit **1602** stores the value of the desired length L, and then selects an appropriate code sequence for expressing the control information to be transmitted where the code sequence has a length of L.

The code sequence that can be selected by the sequence selection unit **1602** has a length of L as illustrated in FIGS. **12** and **14** (e.g., code sequence **1204** and code sequence **1404**). Moreover, the code sequence is applied circular shift (e.g., code sequences **1203** and **1403**) to which a padded portion corresponding to lengths L−X or X−L is removed or inserted/added. As a result, discontinuous parts are not formed within or in the code sequence to promote superior correlation characteristics.

Although it is preferable to use length X which is a smallest prime number greater than the length of L or a largest prime number smaller than the length of L, as long as the value of length X is a prime number, different or other prime numbers can be used as the value of length X.

FIG. **17** is a structural diagram illustrating a basic code sequence generation unit and a code sequence length adjustment unit. In FIG. **17**, the basic code sequence generation unit **1701** further comprises a code sequence generation unit **1701***a* and a circular shift application unit **1701***b*. The code sequence generation unit **1701***a* is used to generate a first code sequence (C**1**). Here, C**1** can be defined as a code sequence having a length of X where the value of length X is a smaller prime number larger than the value of length L or a code sequence having a length of X where the value of length X is a larger prime number smaller than the value of length L. C**1** is then applied circular shift by the circular shift application unit **1701***b*. More specifically, the circular shift application unit **1701***b* receives C**1** having length of X, applies circular shift, and outputs a second code sequence (C**2**) to the code sequence length adjustment unit **1702**.

The code sequence length adjustment unit **1702** further comprises a control unit **1702***a*, a code sequence removing unit **1702***b*, and a padding unit **1702***c*. More specifically, the control unit **1702***a* receives C**2** as well as the value of length L. The control unit **1702***a* determines whether to remove a portion/section of C**2** or insert/add a portion/section to C**2**. Based on the determination from the control unit **1702***a*, C**2** is delivered to the sequence removing unit **1702***b* in which a portion/section of C**2** corresponding to a length of X−L is removed. Alternatively, C**2** can be delivered to the padding unit **1702***c* for inserting/adding a portion/section of C**2** whose length corresponds to the length of L−X.

If C**2** and the value of length L are provided to the control unit **1702***a*, the control unit **1702***a* compares the value of length X which identifies the length of C**2** with the value of the length L. Here, if X is greater than L, then C**2** is inputted into the sequence removing unit **1702***b*. From C**2**, the portion length of C**2** corresponding to length X−L is removed, resulting in C**3**. However, if X is less than L, then C**2** is inputted into the padding unit **1702***c*. From C**2**, the padding portion length corresponding to length L−X is inserted/added to C**2**, resulting in C**4**. Here, the padding portion can be inserted to either end or both ends of C**2**.

FIGS. **18** and **19** illustrate cross-correlation characteristics of the code sequence. The illustrations of FIGS. **18** and **19** is based on the value of length X being the smallest prime number greater than the value of the desired length L; however, the illustrations are not limited to the smallest prime number greater than length L but can have a prime number value of length X smaller than the value of length L.

Referring to FIGS. **18** and **19**, the x-axis represents values of circular shift while the y-axis represents un-normalized cross-correlation values. Furthermore, a thinner line represents the value of cross-correlation of the code sequence with circular shift applied thereto after a code sequence portion having the length X−L is removed. A darker/thicker line represents values of code sequence to which circular shift is applied prior to removing the code sequence portion corresponding to the length X−L. More specifically, FIG. **7** illustrates a graph where L is 75 and X is 79 which is the smallest prime number greater than 75. Moreover, FIG. **8** illustrates a graph where L **8** is 225 and X is 227 which is the smallest prime number greater than 225.

In FIGS. **18** and **19**, if the value of circular shift is 0 or put differently, if there is no shift, then high correlation value is indicated only when the auto-correlation value of the code sequence corresponds and in other cases, moderate correlation is maintained. On the contrary, if the code sequence has a section corresponding to length X−L is removed and thereafter applied circular shift, severe fluctuations occur with correlation values, resulting in deteriorated correlation characteristics. As such, if cross-correlation is used to analyze the code sequence, the code sequence according to the embodiments of the present invention shows superior performance and outcome to that of the conventional code sequence.

FIG. **20** is an exemplary diagram illustrating boosting the power of the generated code sequence. As discussed, the code sequence is generated based on length X, and a padding portion, whose length corresponds to length L−X, is attached to the code sequence (e.g., CAZAC sequence). Thereafter, the portion of the code sequence corresponding to length X is used where length L is divided by length X(L/X). The result of the division is the amount of power that can be boosted. Moreover, the amount of power that can be boosted can be applied to the code sequence whose length is length X. When the receiving end receives power boosted code sequence, more effective detection performance can be achieved since interference is reduced.

However, regarding a code sequence generated with a padding portion with cyclic prefix/postfix attached thereto, there is no need to power boost since all of the code sequences corresponding to length L are used for acquiring sequence ID information.

In the receiving end, information related to the generated code sequence and length X used to generate the code sequence is received. From the code sequence, a portion corresponding to length X is processed to acquire the control information. To this end, it is important to first receive synchronization information of the received data. Equation 7 and Equation 8 can be used to acquire synchronization information. Here, Equation 7 relates to auto-correlation, and Equation 8 relates to cross-correlation.

$$R_{M:N}(d) = \sum_{k=0}^{X-1} c(k, M, X) \cdot c^*(\mathrm{mod}(k+d), X); M, X) \quad \text{[Equation 7]}$$

$$R_{M_1:M_2:N}(d) = \sum_{k=0}^{X-1} c(k, M_1, X) \cdot c^*(\mathrm{mod}(k+d), X); M_2, X) \quad \text{[Equation 8]}$$

Equation 7 is used to acquire auto-correlation value(s) from the received code sequence whose sequence ID is M. Further, the acquired auto-correlation value d, which is a value other than 0, is used to achieve synchronization. to acquire the ID information of the received sequence using the smallest prime number corresponding to length X.

As discussed, if the differential sequence of the CAZAC sequence is calculated using Equations 9 or 10, k of the sequence index is generated, and the result therefrom is transformed by the Fourier transform scheme, to show a single peak value. Thereafter, by detecting the peak value, the ID information of the sequence can be acquired.

The discussion of above regarding a code sequence or a code sequence set can be applied to 3rd Generation Partnership Project (3GPP) system or 3GPP2 system as well as a Wibro system or a Wimax system.

It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the spirit or scope of the inventions. Thus, it is intended that the present invention covers the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

What is claimed is:

1. A method for transmitting a code sequence from a transmitting party to a receiving party in a wireless communication system, the method comprising:

acquiring a code sequence having a second length by a cyclic extension of a code sequence having a first length;

performing a circular shift to the code sequence having the second length; and

transmitting the circular shifted code sequence having the second length to the receiving party,

wherein the first length is a largest prime number smaller than the second length, and

wherein the cyclic extension of the code sequence having the first length is performed such that a part of the code sequence having the first length, having a length corresponding to a difference between the first length and the second length, is added to either a start or an end of the code sequence having the first length, and

wherein the circular shift is performed to the code sequence having the second length such that either a rear portion of the code sequence having the second length moves to a start of the code sequence having the second length, or a front portion of the code sequence having the second length moves to an end of the code sequence having the second length.

2. The method according to claim **1**, wherein the part of the code sequence having the first length comprises at least a cyclic prefix or a cyclic postfix.

3. The method according to claim **1**, wherein the cyclic extension is performed such that a cyclic postfix of the code sequence having the first length, having the length corresponding to the difference between the first length and the second length, is added to the end of the code sequence having the first length.

4. The method according to claim **1**, wherein the code sequence having the first length is a Zadoff-Chu (ZC) sequence.

5. The method according to claim **1**, wherein the code sequence having the second length is transmitted as a reference signal sequence.

6. An apparatus for transmitting a code sequence in a wireless communication system, the apparatus comprising:

a code sequence generator for generating a code sequence having a second length by cyclic extension of a code sequence having a first length, and performing a circular shift to the code sequence having the second length; and

a transmitting unit for transmitting the circular shifted code sequence having the second length,

wherein the first length is a largest prime number smaller than the second length,

wherein the cyclic extension of the code sequence having the first length is performed such that a part of the code sequence having the first length, having a length corresponding to a difference between the first length and the second length, is added to either a start or an end of the code sequence having the first length, and

wherein the circular shift is performed to the code sequence having the second length such that either a rear portion of the code sequence having the second length moves to a start of the code sequence having the second length, or a front portion of the code sequence having the second length moves to an end of the code sequence having the second length.

7. The apparatus according to claim **6**, wherein the part of the code sequence having the first length comprises at least a cyclic prefix or a cyclic postfix.

8. The apparatus according to claim **6**, wherein the cyclic extension is performed such that a cyclic postfix of the code sequence having the first length, having the length corresponding to the difference between the first length and the second length, is added to the end of the code sequence having the first length.

9. The apparatus according to claim **6**, wherein the code sequence having the first length is a Zadoff-Chu (ZC) sequence.

10. The apparatus according to claim **6**, wherein the code sequence having the second length is transmitted as a reference signal sequence.

11. A method for transmitting a code sequence in a wireless communication system, the method comprising:

performing a circular shift to a code sequence having a first length to produce a circularly-shifted code sequence having the first length;

performing a cyclic extension of the circularly-shifted code sequence having the first length, to produce a code sequence having a second length; and

transmitting the code sequence having the second length,

wherein the first length is a largest prime number smaller than the second length,

wherein performing the circular shift comprises either moving a rear portion of the code sequence having the first length to a start of the code sequence having the first length, or moving a front portion of the code sequence having the first length to an end of the code sequence having the first length, and

wherein performing the cyclic extension comprises adding a portion of the circularly-shifted code sequence having the first length, having a length corresponding to a difference between the first length and the second length, to either a start or an end of the circularly-shifted code sequence having the first length.

* * * * *

EXHIBIT 2

US007768965B2

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

(10) **Patent No.: US 7,768,965 B2**
(45) **Date of Patent: Aug. 3, 2010**

(54) **METHOD FOR TRANSMITTING AND RECEIVING SIGNALS BASED ON SEGMENTED ACCESS SCHEME AND METHOD FOR ALLOCATING SEQUENCE FOR THE SAME**

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(73) Assignee: **LG Electronics Inc.**, Seoul (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 8 days.

(21) Appl. No.: **12/440,869**

(22) PCT Filed: **Sep. 10, 2007**

(86) PCT No.: **PCT/KR2007/004359**

§ 371 (c)(1),
(2), (4) Date: **Mar. 11, 2009**

(87) PCT Pub. No.: **WO2008/032959**

PCT Pub. Date: **Mar. 20, 2008**

(65) **Prior Publication Data**

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Related U.S. Application Data

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(30) **Foreign Application Priority Data**

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Sep. 27, 2006 (KR) 10-2006-0094103

(51) **Int. Cl.**
H04W 4/00 (2009.01)

(52) **U.S. Cl.** **370/328**; 370/330

(58) **Field of Classification Search** 370/328–339
See application file for complete search history.

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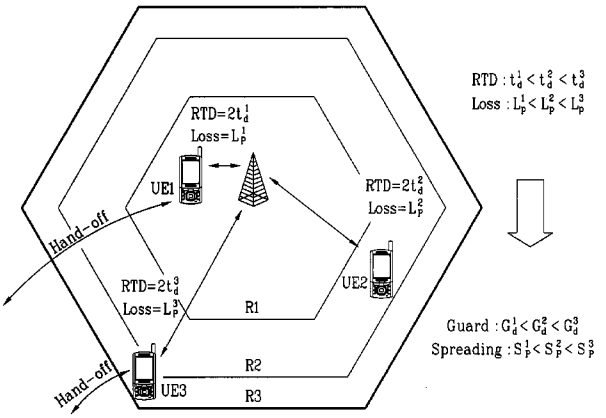
Primary Examiner—Frank Duong
(74) *Attorney, Agent, or Firm*—Birch, Stewart, Kolasch & Birch, LLP

(57) **ABSTRACT**

A segmented access based signal transmitting/receiving method and a sequence allocating method for the same are disclosed. According to one embodiment of the present invention, a method of transmitting a signal of a user equipment in a communication system includes selecting a channel in accordance with at least one selected from the group consisting of a signal attenuation extent of a downlink signal to the αser equipment and a speed of the user equipment from channels differently provided based on at least one selected from the group consisting of the signal attenuation extent of the downlink signal and the speed of the user equipment and transmitting the signal using the selected channel.

11 Claims, 17 Drawing Sheets



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* cited by examiner

FIG. 1

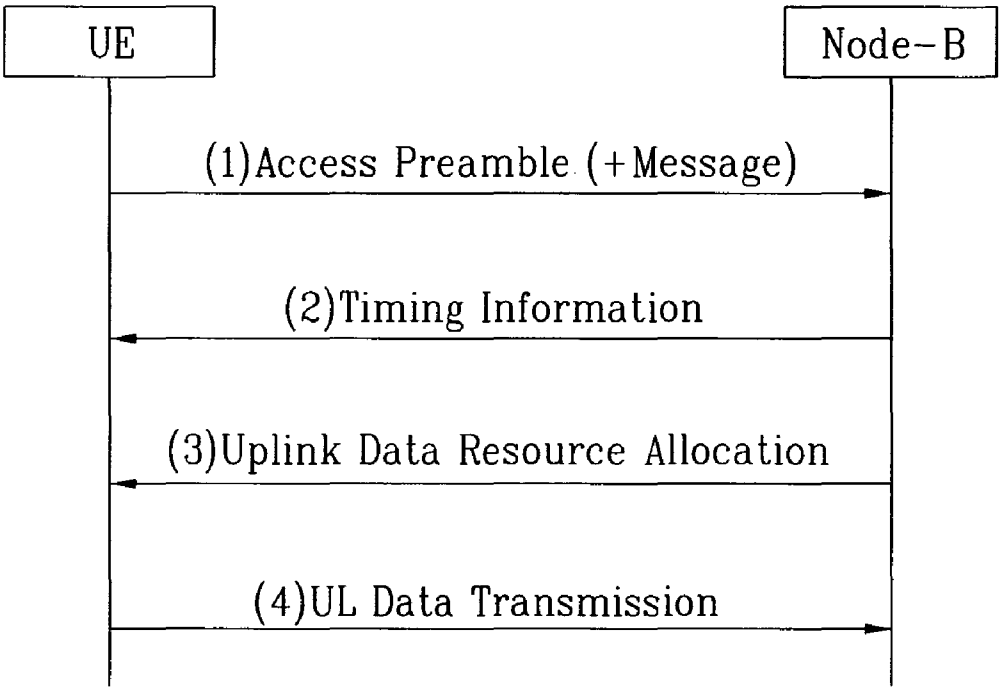

UE
Node-B
(1)Access Preamble (+Message)
(2)Timing Information
(3)Uplink Data Resource Allocation
(4)UL Data Transmission

FIG. 2

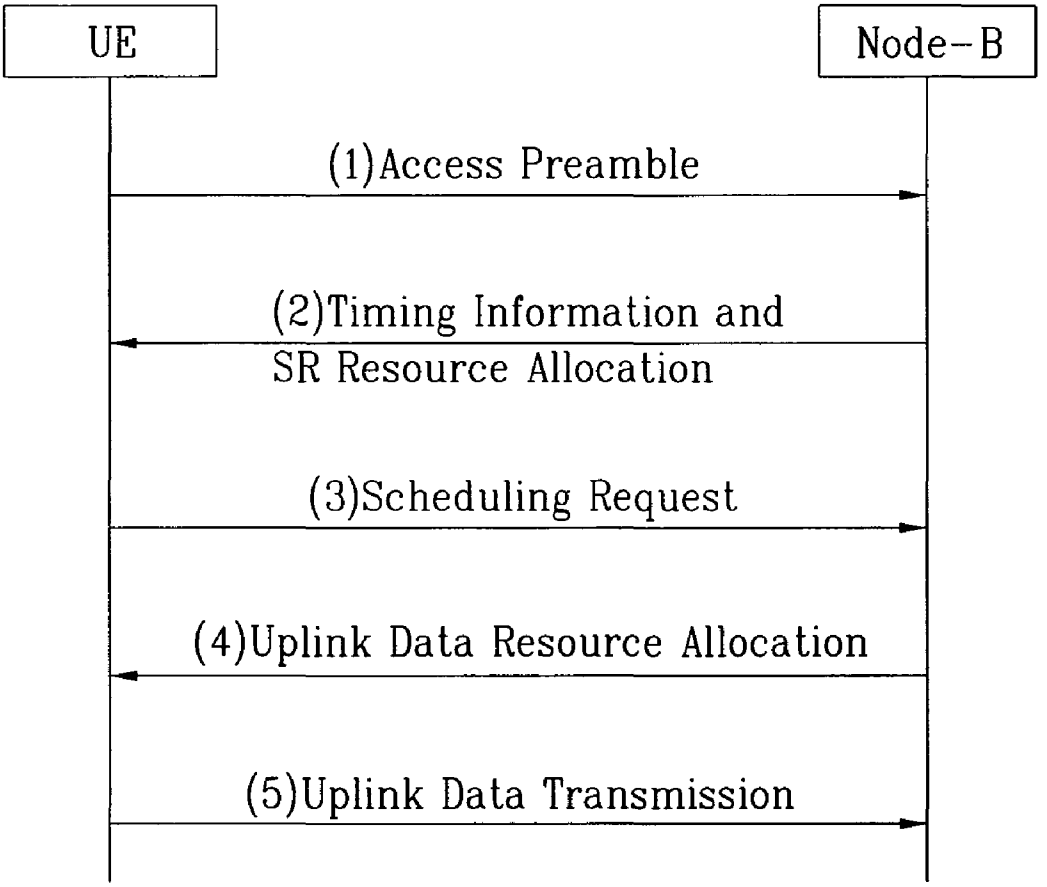

UE
Node-B
(1)Access Preamble
(2)Timing Information and
SR Resource Allocation
(3)Scheduling Request
(4)Uplink Data Resource Allocation
(5)Uplink Data Transmission

FIG. 3

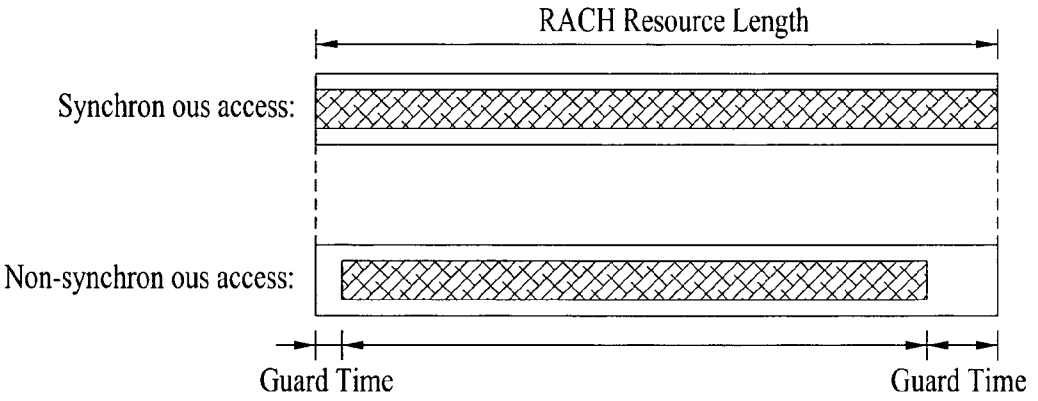

RACH Resource Length
Synchron ous access:
Non-synchron ous access:
Guard Time
Guard Time

FIG. 4

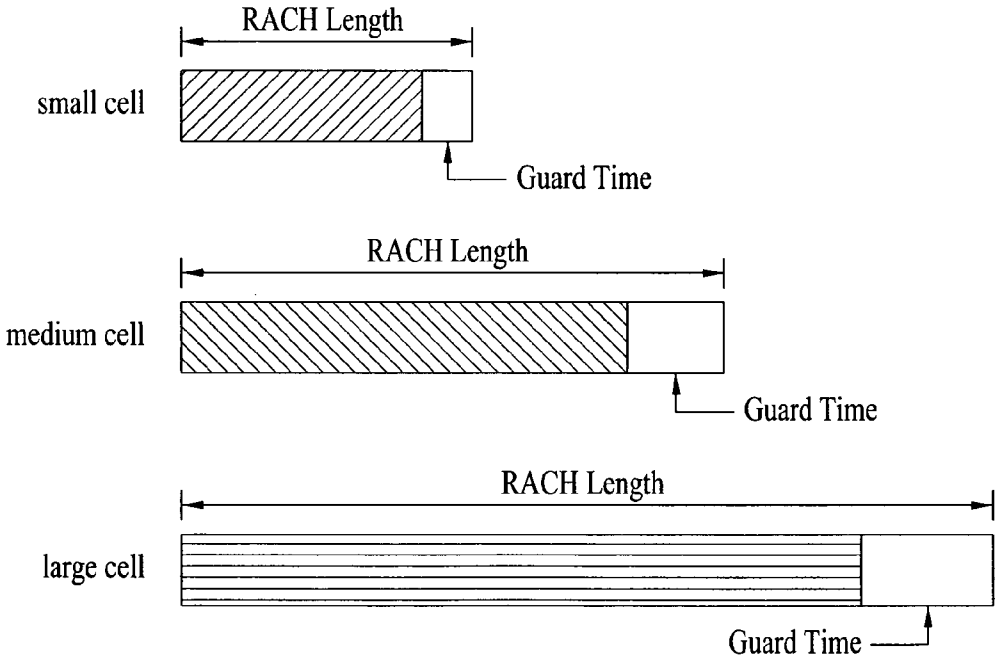

RACH Length
small cell
Guard Time
RACH Length
medium cell
Guard Time
RACH Length
large cell
Guard Time

FIG. 5

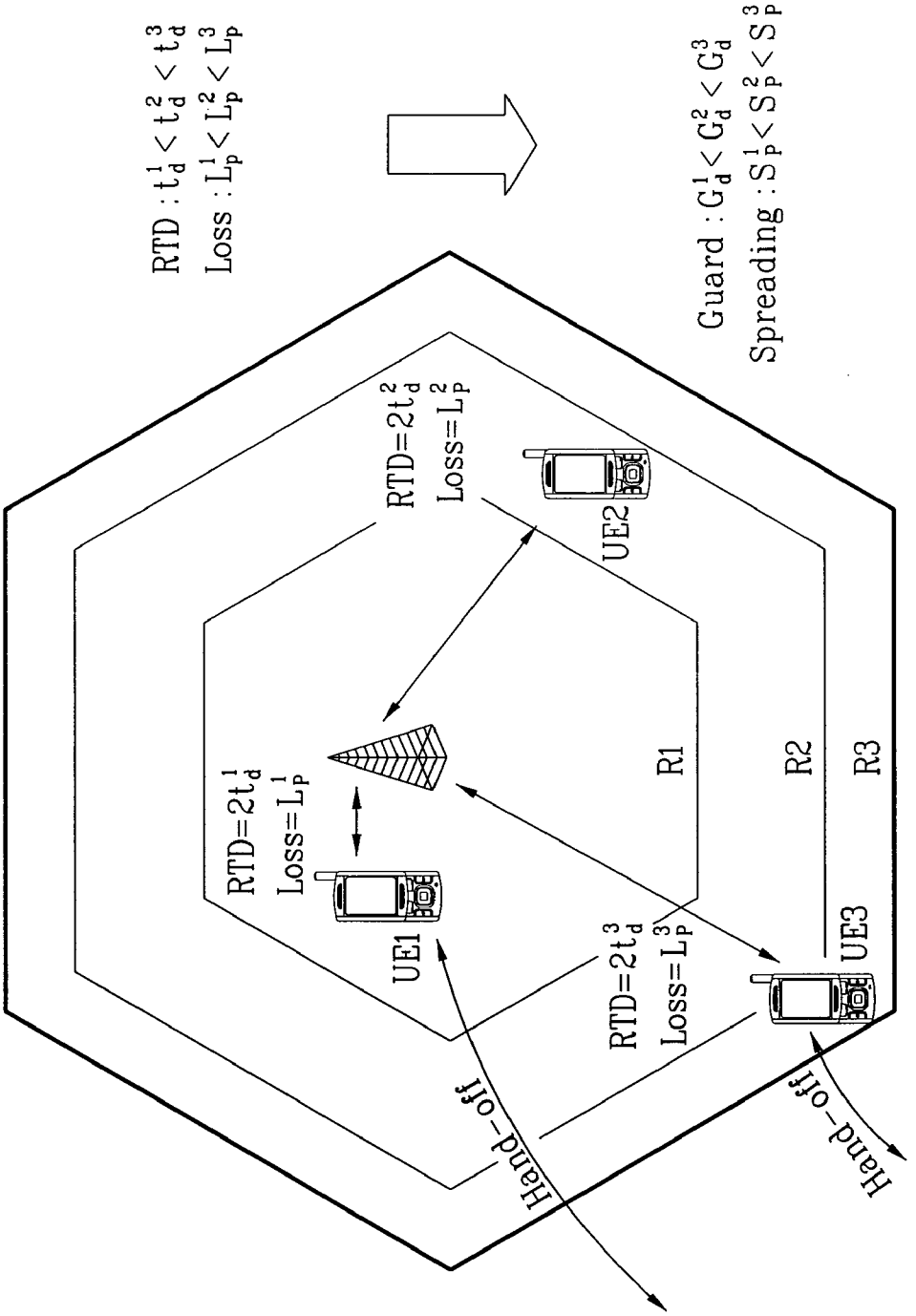
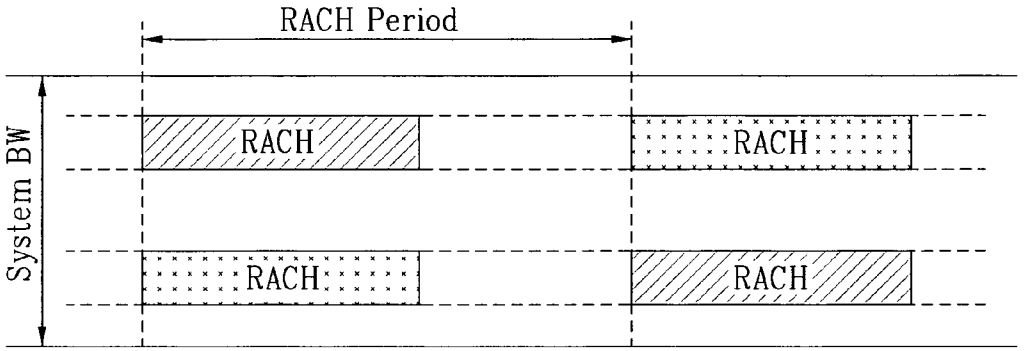

RTD : $t_d^1 < t_d^2 < t_d^3$
Loss : $L_p^1 < L_p^2 < L_p^3$
Guard : $G_d^1 < G_d^2 < G_d^3$
Spreading : $S_P^1 < S_P^2 < S_P^3$
RTD=$2t_d^2$
Loss=L_P^2
UE2
RTD=$2t_d^1$
Loss=L_P^1
UE1
R1
R2
R3
RTD=$2t_d^3$
Loss=L_P^3
UE3
Hand-off
Hand-off

FIG. 6



Multiple RACH slots per RACH period

FIG. 7

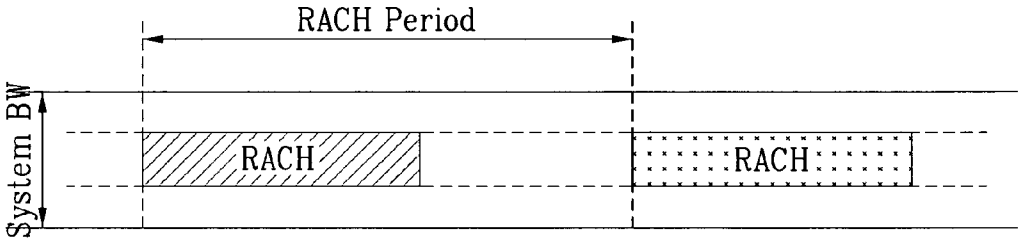


FIG. 8

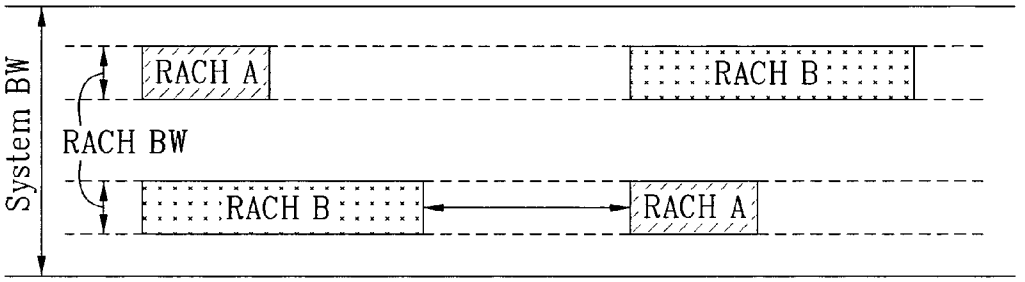

System BW
RACH A
RACH B
RACH BW
RACH B
RACH A

FIG. 9

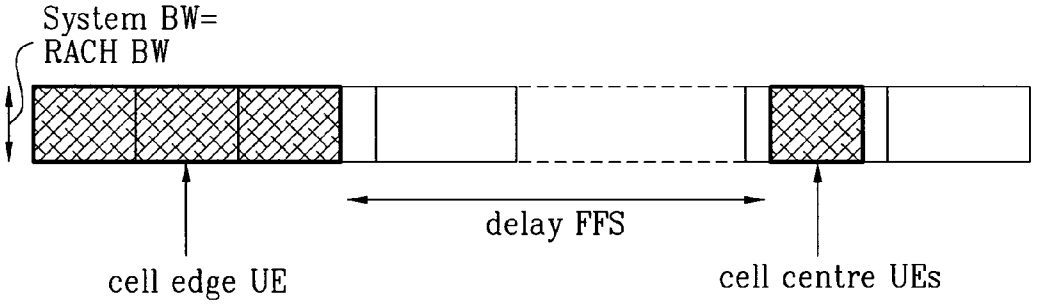

System BW=
RACH BW
delay FFS
cell edge UE
cell centre UEs

FIG. 10

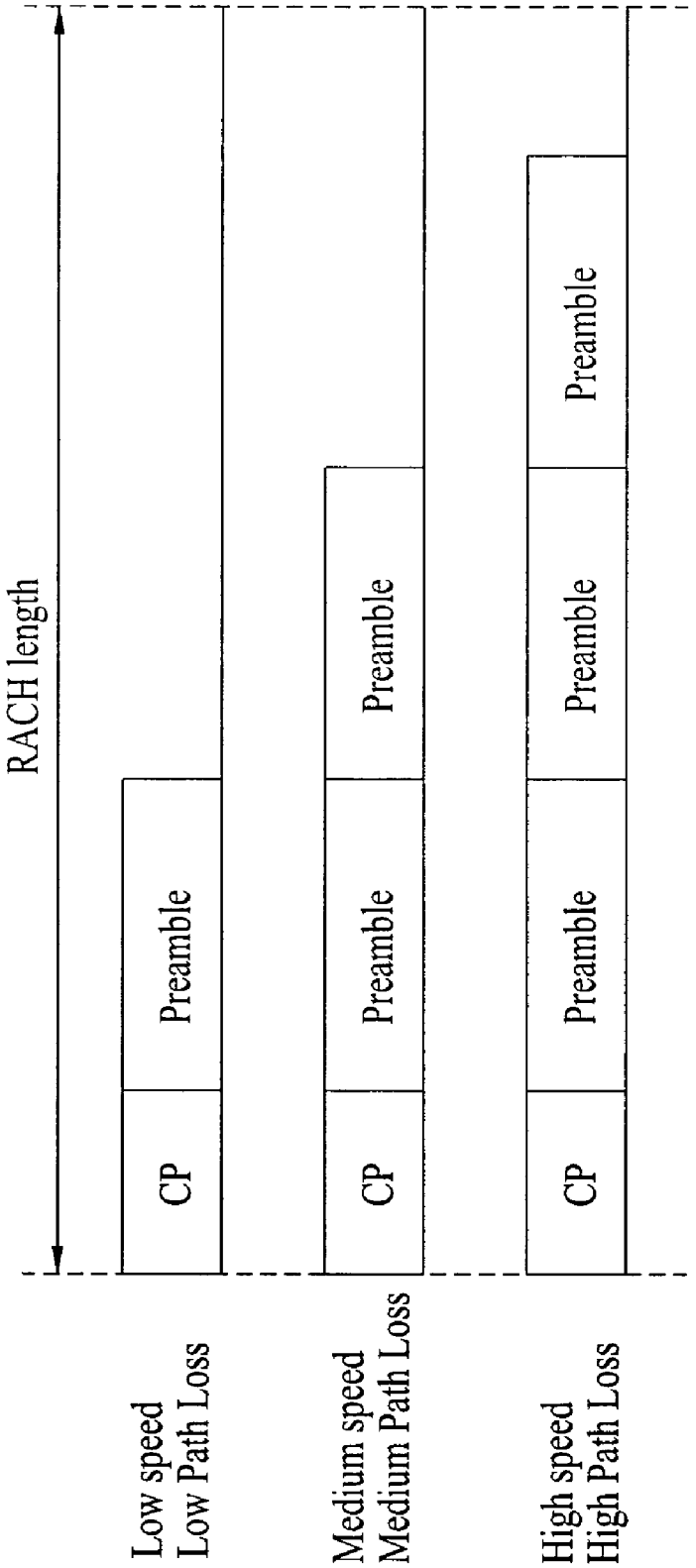

RACH length
CP
Preamble
CP
Preamble
Preamble
CP
Preamble
Preamble
Preamble
Low speed
Low Path Loss
Medium speed
Medium Path Loss
High speed
High Path Loss

FIG. 11

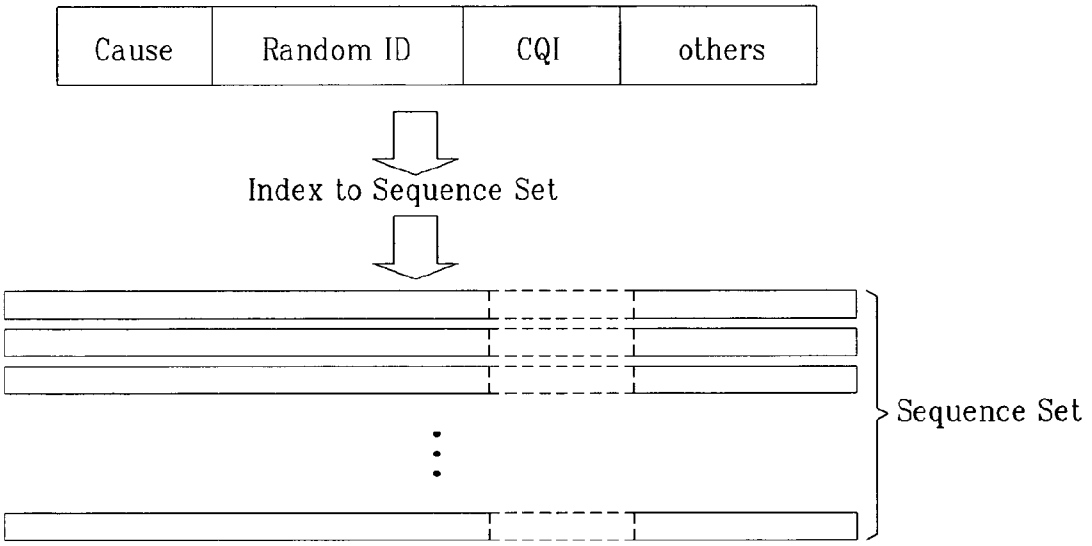

Cause
Random ID
CQI
others
Index to Sequence Set
Sequence Set

FIG. 12

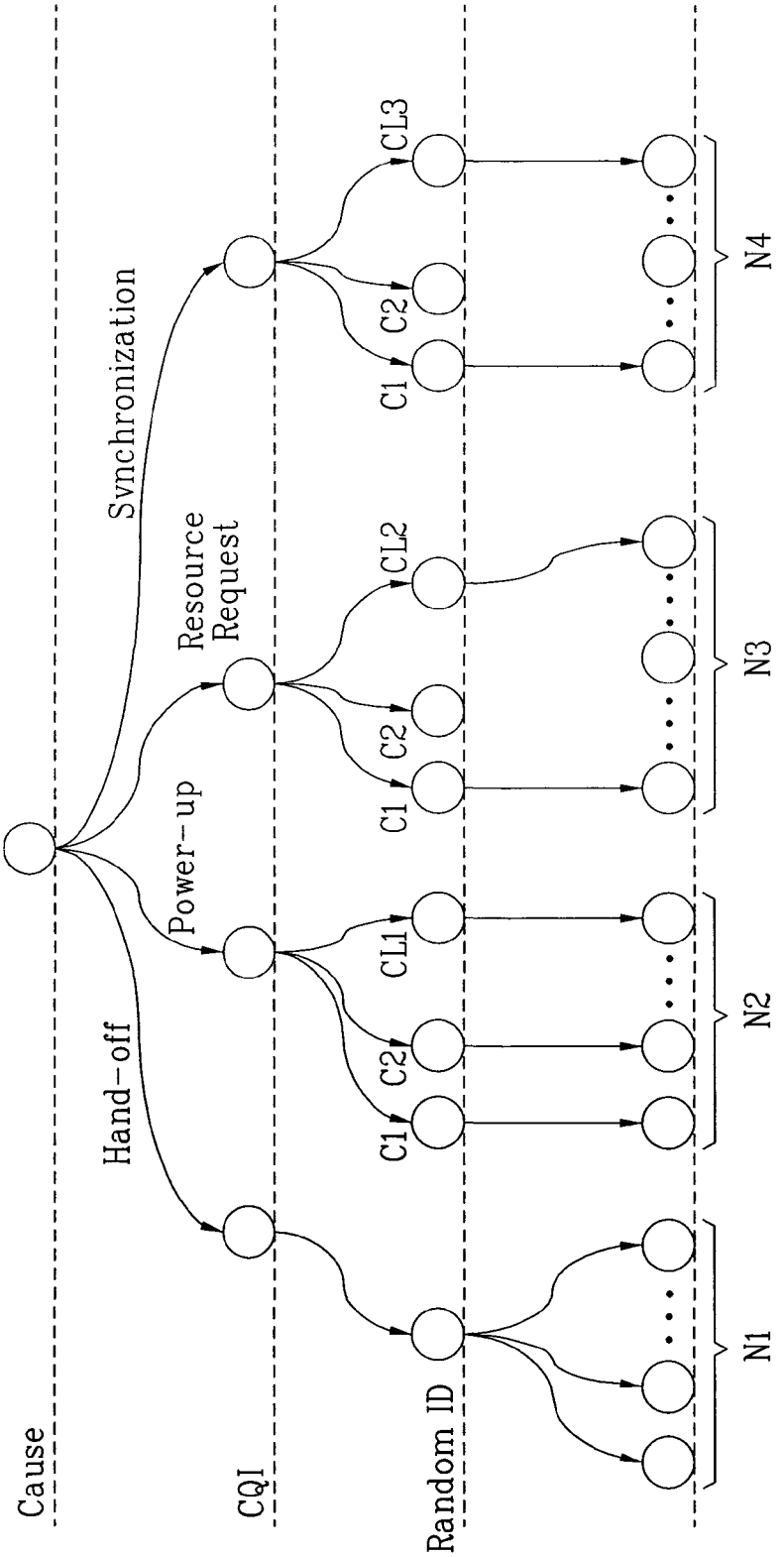

Cause
CQI
Random ID
Hand-off
Power-up
Resource Request
Synchronization
C1
C2
CL1
CL2
CL3
N1
N2
N3
N4

FIG. 13

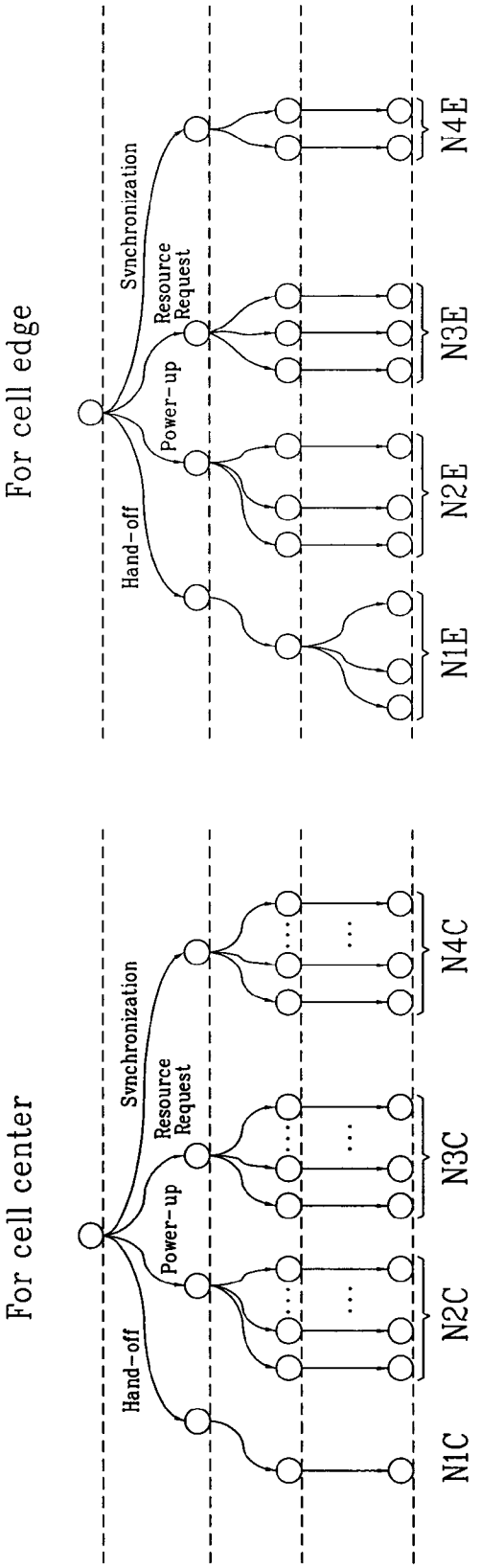

For cell edge
Hand-off
Power-up
Resource Request
Synchronization
N1E
N2E
N3E
N4E
For cell center
Hand-off
Power-up
Resource Request
Synchronization
N1C
N2C
N3C
N4C

FIG. 14

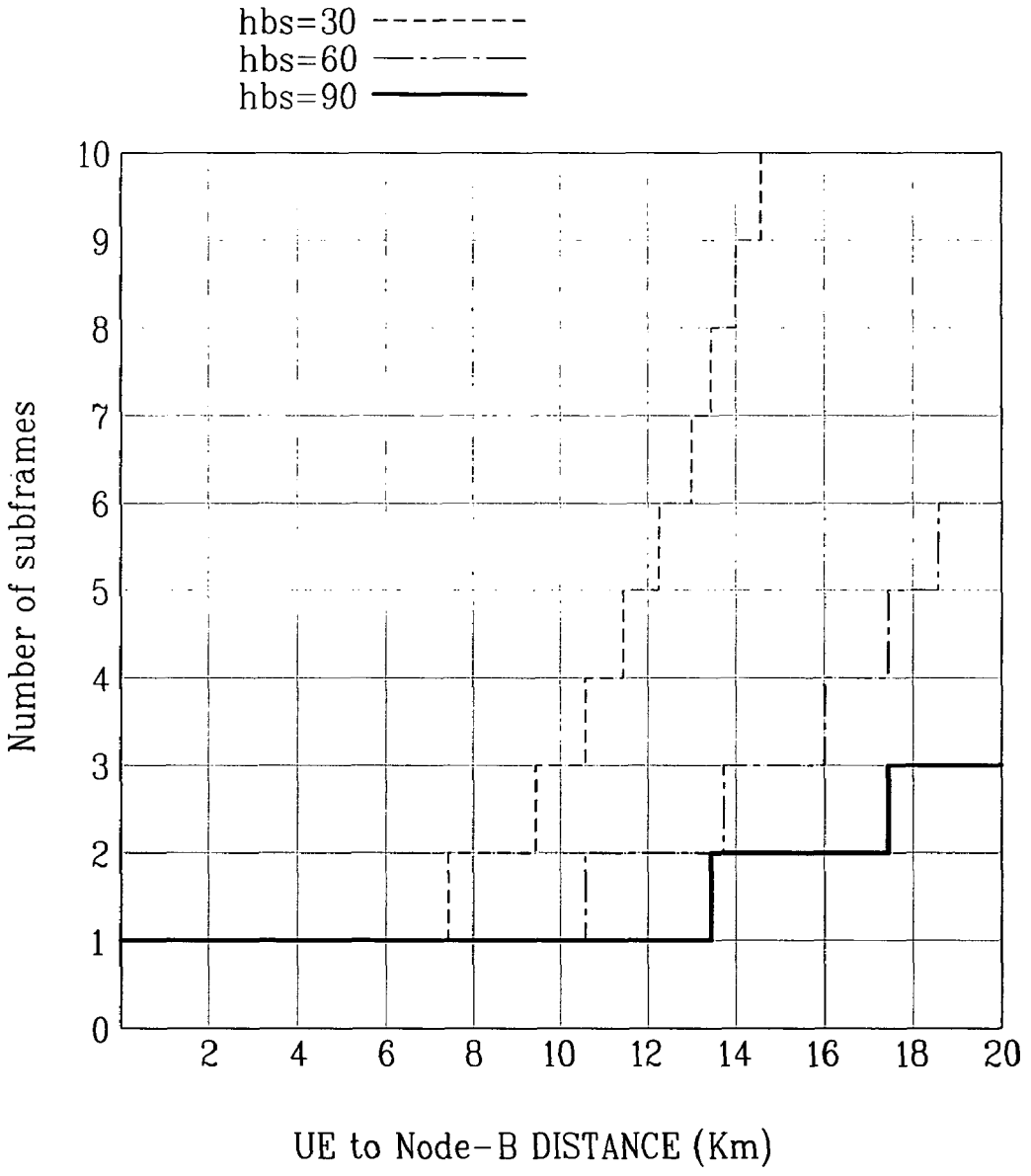

hbs=30
hbs=60
hbs=90
Number of subframes
0
1
2
3
4
5
6
7
8
9
10
2
4
6
8
10
12
14
16
18
20
UE to Node-B DISTANCE (Km)

FIG. 15

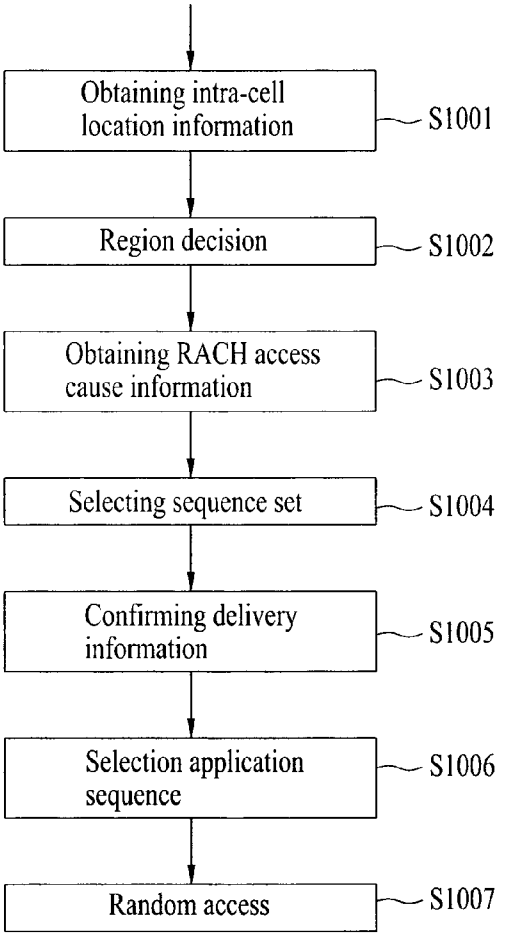

Obtaining intra-cell location information
S1001
Region decision
S1002
Obtaining RACH access cause information
S1003
Selecting sequence set
S1004
Confirming delivery information
S1005
Selection application sequence
S1006
Random access
S1007

FIG. 16

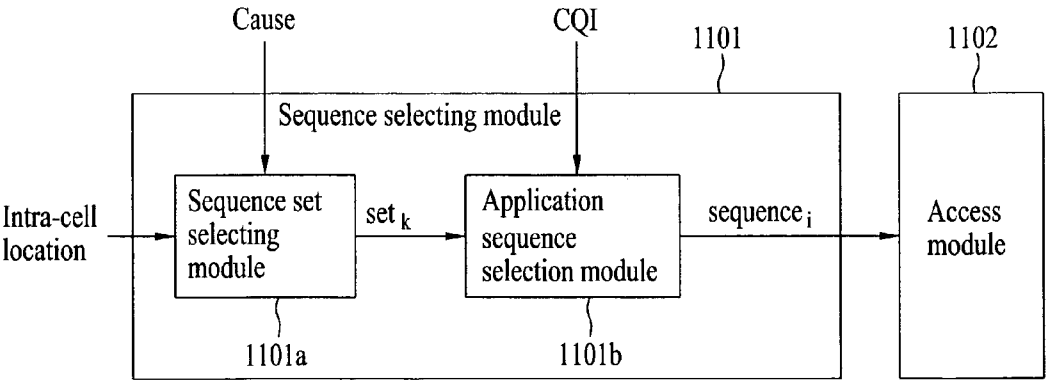

Cause
CQI
1101
1102
Sequence selecting module
Intra-cell location
Sequence set selecting module
set k
Application sequence selection module
sequence i
Access module
1101a
1101b

FIG. 17

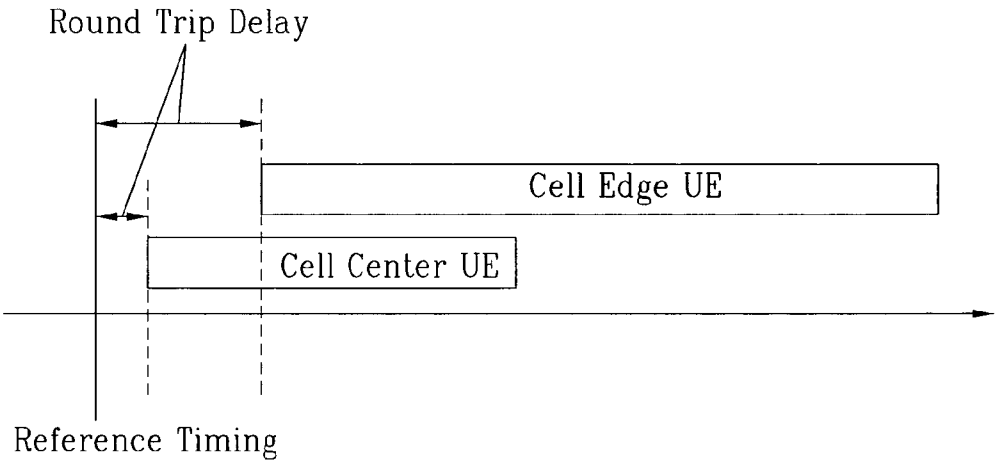

Round Trip Delay
Cell Edge UE
Cell Center UE
Reference Timing

FIG. 18

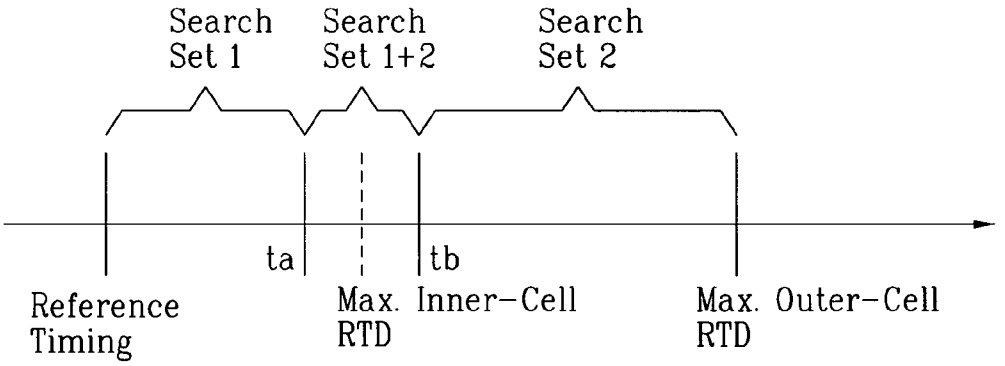

Search Set 1
Search Set 1+2
Search Set 2
ta
tb
Reference Timing
Max. RTD
Inner-Cell
Max. RTD
Outer-Cell

FIG. 19

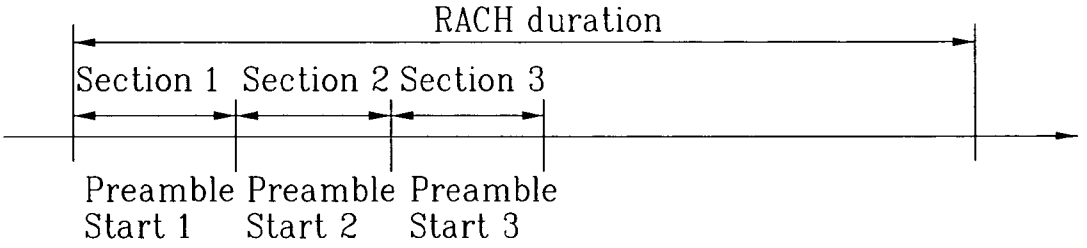

RACH duration
Section 1
Section 2
Section 3
Preamble Start 1
Preamble Start 2
Preamble Start 3

FIG. 20

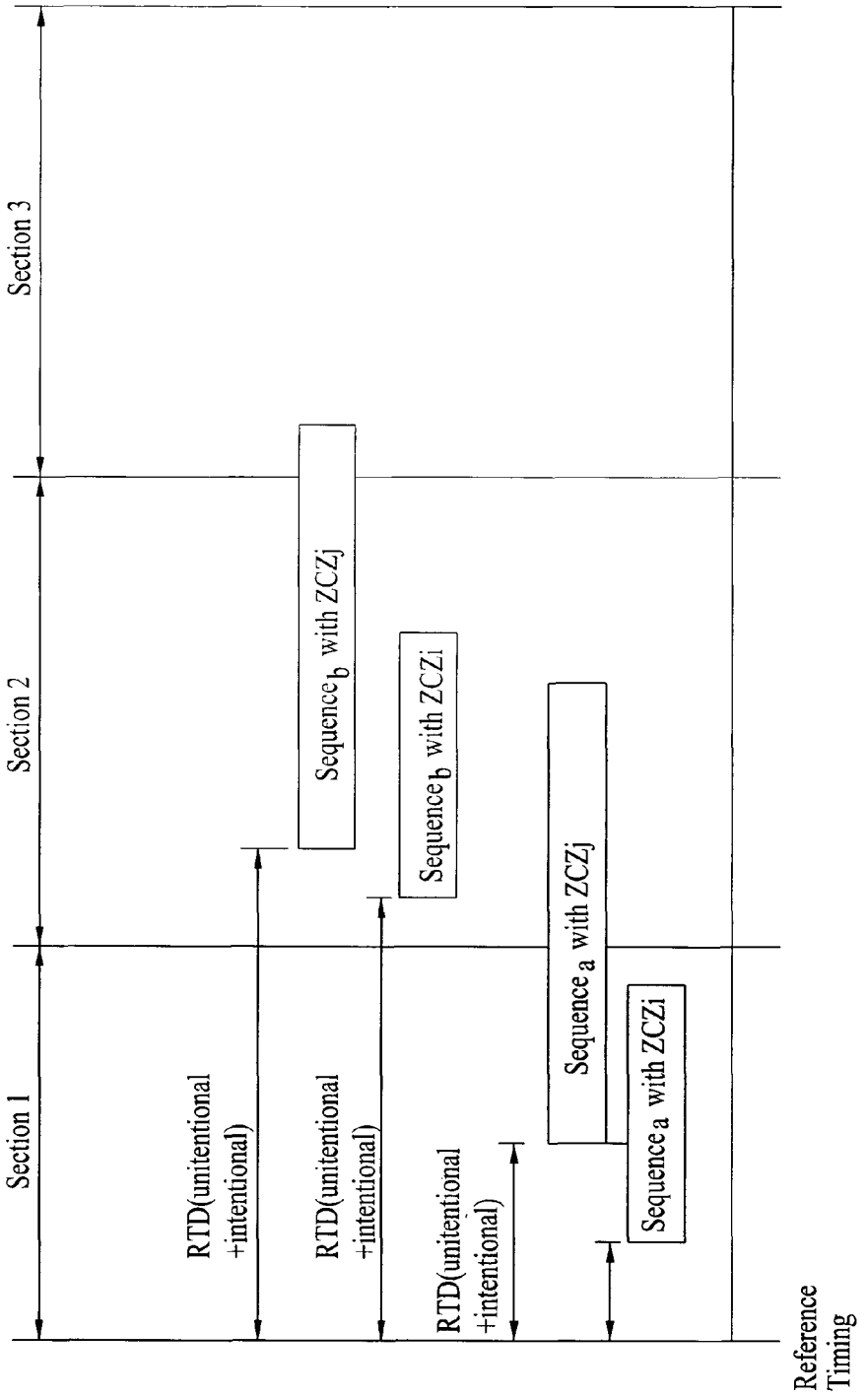

Section 1
Section 2
Section 3
RTD(unitentional +intentional)
RTD(unitentional +intentional)
RTD(unitentional +intentional)
Sequence$_b$ with ZCZj
Sequence$_b$ with ZCZi
Sequence$_a$ with ZCZj
Sequence$_a$ with ZCZi
Reference Timing

FIG. 21

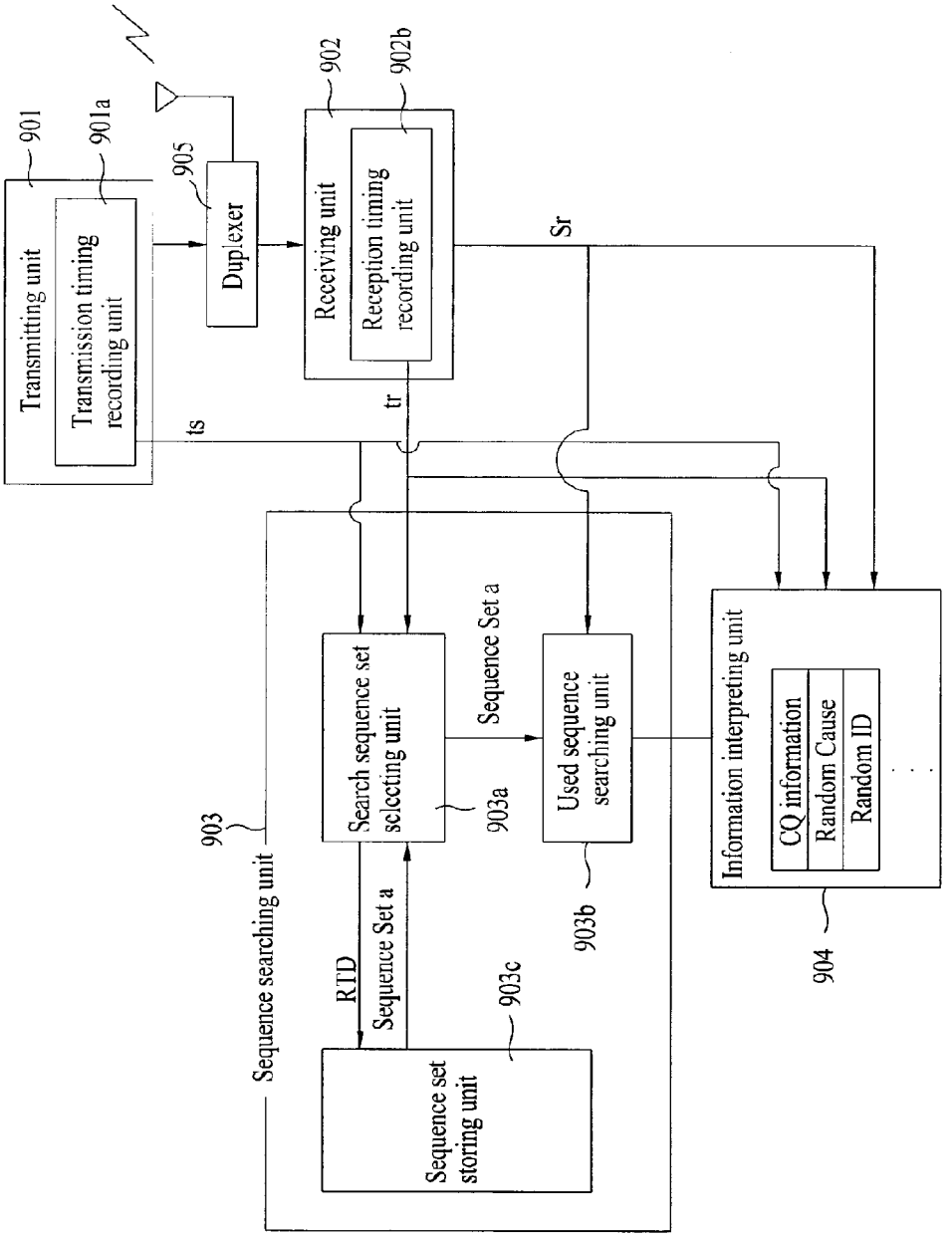
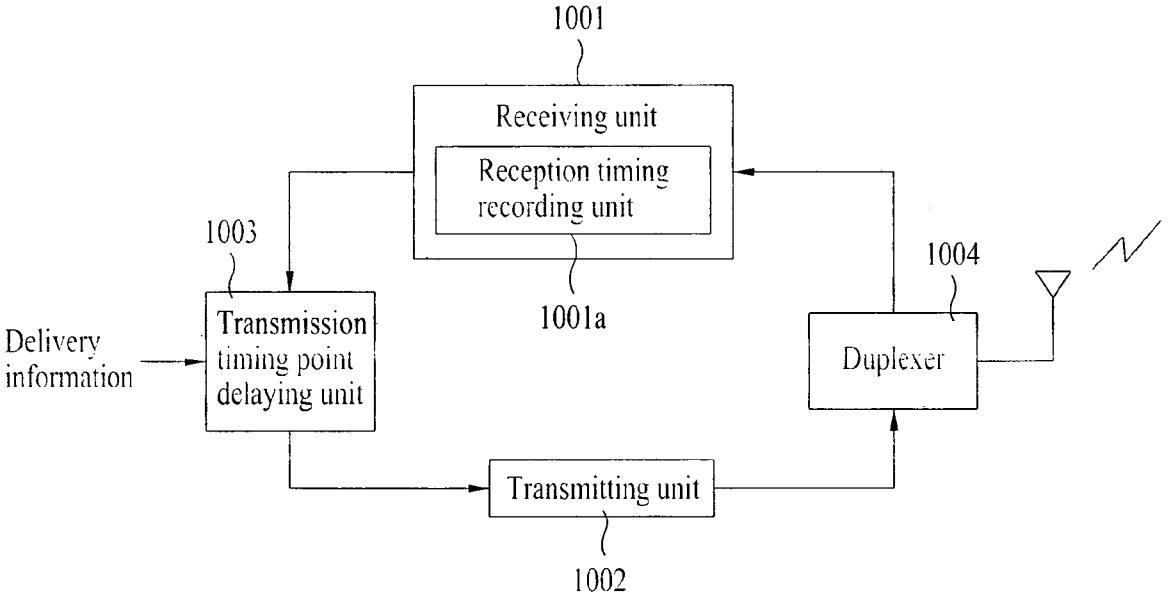

901
901a
Transmitting unit
Transmission timing recording unit
905
Duplexer
902
902b
Receiving unit
Reception timing recording unit
Sr
ts
tr
903
Sequence searching unit
Search sequence set selecting unit
903a
Sequence Set a
Used sequence searching unit
903b
RTD
Sequence Set a
903c
Sequence set storing unit
Information interpreting unit
CQ information
Random Cause
Random ID
904

FIG. 22


1001
Receiving unit
Reception timing recording unit
1001a
1003
Delivery information
Transmission timing point delaying unit
1004
Duplexer
Transmitting unit
1002

METHOD FOR TRANSMITTING AND RECEIVING SIGNALS BASED ON SEGMENTED ACCESS SCHEME AND METHOD FOR ALLOCATING SEQUENCE FOR THE SAME

This application is the National Phase of PCT/KR2007/0004359 filed on Sep. 10, 2007, which claims priority under 35 U.S.C. 119(e) to U.S. Provisional Application No. 60/863,329 filed on Oct. 27, 2006, and under 35 U.S.C. 119(a) to Patent Application Nos. 10-2006-0087290 and 10-2006-0094103 filed in the Republic of Korea on Sep. 11, 2006, and Sep. 27, 2006 respectively, all of which are hereby expressly incorporated by reference into the present application.

TECHNICAL FIELD

The present invention relates to a wireless communication technology, and more particularly, to a method of allocating a sequence set for a random access channel based on a segmented access scheme in a communication system, an apparatus and method for transmitting and receiving signals using the sequence set, and an apparatus and method for searching a delay based sequence.

BACKGROUND ART

Generally, uplink channels for a currently discussed communication system include a random access channel (RACH or a ranging channel) for a user equipment to randomly access a base station, an uplink shared channel (e.g., HS-DPCCH) for carrying a channel quality indicator (CQI) and ACK/NACK information, and the like.

The RACH or ranging channel is a random access channel for a user equipment to perform downlink synchronization with a base station and can be found through bases station information. A location of a corresponding channel and the like can be acquired from the base station information. And, the RACH or ranging channel is a unique channel that can be accessed by a user terminal which is not synchronized with a base station yet.

If a user equipment transmits a signal to a corresponding base station on the RACH or ranging channel, the base station informs the user equipment of modification information on an uplink signal timing for synchronization with the base station and various information for the corresponding user equipment to be connected to the base station.

After a connection between the user equipment and the base station has been completed through the RACH or the ranging channel, communications can be carried out using other channels.

FIG. **1** and FIG. **2** are diagrams for examples of a process generated when a user equipment connects an uplink communication with a base station.

First of all, a user equipment can acquire both uplink and downlink synchronizations with a base station by accessing an RACH or a ranging channel. So, the user equipment is in a state capable of accessing the corresponding base station. FIG. **1** shows a situation that a user equipment is initially connected to a base station after a power of the user equipment has been turned on. FIG. **2** shows that a user equipment having performed initial synchronization with a base station accesses the base station if the synchronization is mismatched or if a request for an uplink resource needs to be made (i.e., if a resource for uplink transmission data is requested).

In a step (**1**) of FIG. **1** or FIG. **2**, a user equipment transmits an access preamble and a message to a base station if necessary. The base station recognizes why the corresponding user equipment accesses an RACH or a ranging channel and then makes an action for a corresponding process.

In case of the initial access shown in FIG. **1** or FIG. **2**, the base station allocates timing information and an uplink data resource to the corresponding user equipment in steps (**2**) and (**3**). So, the user equipment is able to transmit uplink data in a step (**4**).

FIG. **2** shows an example of a case that the user equipment accesses the RACH or the ranging channel in the step (**1**) because of a scheduling request (hereinafter abbreviated SR). In the step (**2**), the base station performs resource allocation for the timing information and the SR to the user equipment. For the SR (step (**3**) of the user equipment, the base station performs uplink data resource allocation [step (**4**)] to enable the user equipment to perform uplink data transmission [step (**5**)]. In case that the SR is transmitted on a random access channel, it means a case that the user equipment having been in an idle/sleep mode for a long time is decided to have a timing mismatched with that of the base station. So, this scheme enables both of the timing information and the resource allocation request to be handled at a time.

In accessing the RACH or the ranging channel, in case of the case shown in FIG. **2** instead of the initial access, a different signal is usable according to whether a signal carried on the RACH or the ranging channel is matched in synchronization with the base station.

FIG. **3** is a diagram for a structure of an RACH or a ranging channel used for a synchronous/asynchronous access.

In case of a synchronized access, a user equipment having performed synchronization with a base station makes an access to a RACH or a ranging channel in a situation that the synchronization is maintained (synchronization can be maintained through control information such as a downlink signal or a CQ pilot transmitted in uplink). And, the base station is facilitated to recognize a signal carried on the RACH or the ranging channel.

Since the synchronization is being maintained, the user equipment, as shown in an upper part of FIG. **3**, is able to use a longer sequence or further transmit additional data.

In case of a non-synchronized access, when a user equipment makes an access to a base station, if synchronization is mismatched due to some cause, a guard time, as shown in a lower part of FIG. **3**, should be set in accessing an RACH or a ranging channel. The guard time is set by considering a maximum roundtrip delay that a user equipment attempting to receive a service within the base station can have.

The RACH or the ranging channel should vary in length according to a cell size of the base station. As the user equipment gets farther from the base station, a round-trip delay gets increased. And, this means that the guard time set for the user equipment in the non-synchronized access gets longer. If the cell size is increased, a path loss between the user equipment and the base station is increased. So, a signal needs to be transmitted by being spread longer, which is shown in FIG. **4**.

FIG. **4** is a diagram to explain a cell size and a channel length.

Referring to FIG. **4**, a length of a channel, and more particularly, a length of an RACH or a ranging channel is set proportional to a cell size at a place where a communication will be actually installed. FIG. **4** shows three kinds of RACHs according to a rule of categorizing cell sizes into a small cell size, a medium cell size, and a large cell size. And, a different sequence is applied to each of the RACHs respectively having three kinds of lengths, which is indicated by a different shaded portion. In particular, how an inside of a cell is segmented can be diversified according to a condition of a cor-

responding system. And, a scheme for extending the length of the RACH or the ranging channel and a sequence applied thereto can be diverse as well.

Meanwhile, a user equipment transmits a signal via an RACH or a ranging channel. This is because the user equipment can obtain a specific service in a manner of transmitting a selected sequence to a base station to match a synchronization of an uplink signal to the corresponding base station. To achieve this object, entire user equipments within an area defined as a cell should have success probability over a predetermined level regardless of a location of the corresponding user equipment. For this, in case that a cell size is small, a variation of an RACH or ranging channel resource is not considerable. So, a quantity occupied by an RACH or a ranging channel in an overall system is very small. For instance, in case that 1 subframe is used as an RACH or a ranging channel in 3GPP LTE system, the system uses 1/20 of overhead as the RACH or the ranging channel. Yet, if 5 subframes need to be used due to an increased cell size, the overhead increases 5 times to considerably affect overall system performance.

As a scheme for reducing the overhead in a large cell, a method of changing a cycle of an RACH or a ranging channel can be taken into consideration. Yet, this method raises a problem that an access latency is elongated when a user equipment access the RACH or the ranging channel. And, it is also disadvantageous that probability of collision occurrence in an RACH or ranging channel slot is raised.

In case that entire user equipments within a large cell use an identically specified sequence, probability of collision in an RACH or ranging channel slot can be raised in proportion to an increasing number of user equipments within the corresponding cell.

Accordingly, the demand for a technology in reducing probability of collision occurrence in the same RACH or ranging channel slot and overhead attributed to an RACH or a ranging channel in a large cell has risen.

However, a detailed scheme for solving the problem has not been proposed.

DISCLOSURE OF THE INVENTION

Technical Object

Although a resource quantity of an RACH or a ranging channel increases according to a cell radius, this is just advantageous to UEs remote from a base station but may be unnecessary for UEs close to the base station.

As mentioned in the foregoing description, a path loss may appear differently for each UE due to a location within a cell and the like or a different requirement may rise for a frequency offset and the like according to a per UE speed.

Hence, by considering conditions for an RACH or a ranging channel for each UE to use an RACH or a ranging channel more effectively in case of a large cell radius, an RACH or ranging channel structure, interpretation of the RACH or the ranging channel, and a sequence applied as the corresponding RACH or ranging channel are designed. For this, the present invention proposes a segmented access scheme.

Accordingly, the present invention is directed to a method of allocating a sequence set for a random access channel based on a segmented access scheme in a communication system, an apparatus and method for transmitting and receiving signals using the sequence set, and an apparatus and method for searching a delay based sequence that substantially obviate one or more of the problems due to limitations and disadvantages of the related art.

An object of the present invention is to reduce probability of collision possible in using an identical sequence by entire user equipments within a cell in a manner of providing a sequence set differently allocated according to a location of a user equipment within a cell.

Another object of the present invention is to provide a method and apparatus for enabling a user equipment to transmit and receive signals using a sequence set.

Another object of the present invention is to provide a method and apparatus for reducing a load imposed on a base station in sequence search and a signal transmitting/receiving method using the same, in which a base station searches for a sequence used for an RACH or a ranging channel in a manner of selecting a sequence set to be searched by considering delay time of a reception signal, search complexity and the like and then deciding/searching which sequence is used as a sequence used for the received RACH or the ranging channel using the selected sequence.

Another object of the present invention is to provide a method and apparatus for reducing sequence dependency of information transfer in an RACH or a ranging channel, in which a UE inserts intentional delay information in a transmission signal as a means for indicating information to be delivered to a base station and in which the base station having received the signal obtains the corresponding information through a delayed extent of a reception signal.

Additional features and advantages of the invention will be set forth in the description which follows, and in part will be apparent from the description, or may be learned by practice of the invention. The objectives and other advantages of the invention will be realized and attained by the structure particularly pointed out in the written description and claims thereof as well as the appended drawings.

Technical Solution

To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described, a signal transmitting method of a user equipment in a communication system according to one embodiment of the present invention is provided. For this, according to one embodiment of the present invention, a method of transmitting a signal of a user equipment in a communication system includes the steps of selecting a channel in accordance with at least one selected from the group consisting of a signal attenuation extent of a downlink signal to the user equipment, a speed of the user equipment and an intra-cell location of a user from channels differently provided based on at least one selected from the group consisting of the signal attenuation extent of the downlink signal and the speed of the user equipment; and transmitting the signal using the selected channel.

To further achieve these and other advantages and in accordance with the purpose of the present invention, according to another embodiment of the present invention, in a method that a specific user equipment transmits a signal via a random access channel, a signal transmitting method includes the steps of selecting at least one or more sequence sets according to an intra-cell location of the specific user equipment from total sequence sets allocated by being differently discriminated from each other according to the intra-cell location of each user equipment, selecting a prescribed sequence from the selected sequence set in accordance with transmission information of the specific user equipment, and then transmitting the selected sequence via the random access channel in accordance with a location of the user equipment (e.g., a

transmission start time is chanted, a modulation scheme of the sequence itself is changed, or modulation applied to the sequence is changed, etc.).

To further achieve these and other advantages and in accordance with the purpose of the present invention, according to a further embodiment of the present invention, in a method of receiving a signal from at least one user equipment via a random access channel, a signal receiving method includes the steps of receiving a signal via the random access channel from the at least one user equipment and obtaining reception timing point information of the received signal and searching for a sequence used for the received signal using a search target sequence set differing in accordance with the reception timing point information by considering a delay time differing in accordance with an intra-cell location of the at least one user equipment.

To further achieve these and other advantages and in accordance with the purpose of the present invention, a sequence allocating method, a signal transmitting apparatus, and a signal receiving apparatus for the above embodiments of the present invention are provided.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

Advantageous Effects

According to one embodiment of the present invention, a separate RACH or ranging channel is generated in accordance with a different condition for an RACH or a ranging channel per a user equipment and then used. Hence, overhead for the RACH or the ranging channel can be reduced.

According to one embodiment of the present invention, a sequence set for allocating a different number of sequences in accordance with a location of a user equipment within a cell is provided. Hence probability in collision, which may be generated in case that all user equipments within the cell use the same sequence, can be lowered.

In case that a user equipment additionally considers a cause why a user equipment attempts to access an RACH or a ranging channel, collision probability in the corresponding RACH or ranging channel can be more efficiently lowered. In particular, more efficient sequence allocation can be achieved in a manner of providing a sequence capable of obtaining a number of sequences proportional to a frequency of accessing an RACH or a ranging channel due to the corresponding cause within a specific cell region.

According to one embodiment of the present invention, when a base station searches for a sequence used for an RACH or a ranging channel, a sequence set to be searched is selected by considering a delay time of a reception signal and it is then searched which sequence is used for the received RACH or ranging channel using the selected sequence set. Hence, load imposed on the base station in sequence search can be reduced.

A UE inserts intentional delay information in a transmission signal as a means for indicating information to be delivered to a base station. The base station having received the signal obtains the corresponding information through a delayed extent of a reception signal. Hence, sequence dependency of information transfer in an RACH or a ranging channel can be lowered.

DESCRIPTION OF DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and together with the description serve to explain the principles of the invention.

In the drawings:

FIG. **1** and FIG. **2** are diagrams for examples of a process generated when a user equipment connects an uplink communication with a base station;

FIG. **3** is a diagram for a structure of an RACH or a ranging channel used for a synchronous/asynchronous access;

FIG. **4** is a diagram to explain a cell size and a channel length;

FIG. **5** is a diagram to explain a condition differently requested in accordance with a location of a UE within a cell;

FIG. **6** and FIG. **7** are diagrams of schemes for allocating an identical RACH or ranging channel to all UEs;

FIG. **8** and FIG. **9** are diagrams of schemes for allocating an RACH or a ranging channel having a different time domain length in correspondence to a different condition for each UE according to one embodiment of the present invention;

FIG. **10** is a diagram to explain a method of delivering UE information in correspondence to a preamble repetition count of an RACH or a ranging channel according to one embodiment of the present invention;

FIG. **11** is a diagram for a structure of a sequence set for generating information in a bitmap format;

FIG. **12** is a diagram of a example for differentiating a number of CQIs and a number of random IDs due to a cause for a user equipment to access an RACH or a ranging channel according to one embodiment of the present invention;

FIG. **13** is a diagram of a example for differentiating a number of CQIs and a number of random IDs in correspondence to a cause for a user equipment to access an RACH or a ranging channel and a location of the user equipment within a cell according to one embodiment of the present invention;

FIG. **14** is a graph for an increasing transition of an RACH or ranging channel length requested in correspondence to an increasing distance between a user equipment and a base station in proportion to an antenna length of the base station;

FIG. **15** is a flowchart to explain a signal transmitting method according to one embodiment of the present invention;

FIG. **16** is a diagram of a signal transmitting device according to one embodiment of the present invention;

FIG. **17** is a diagram for a round-trip delay time of an RACH or ranging channel signal received by a base station;

FIG. **18** is a diagram to explain a method of changing a sequence set searched in correspondence to a delay time of an RACH or ranging channel signal received by a base station according to one embodiment of the present invention;

FIG. **19** is a diagram to explain a method of inserting intentional delay information in a transmission signal by a UE according to one embodiment of the present invention;

FIG. **20** is a diagram to explain a method of interpreting information based on a delay time, which is attributed to a location of a UE having transmitted an RACH or ranging channel signal received by a base station, and intentional delay time according to one embodiment of the present invention;

FIG. **21** is a block diagram of a sequence searching device for searching a sequence used for a received RACH or ranging channel signal and a signal transmitting device of a base station for interpreting received information as soon as the sequence is searched according to one embodiment of the present invention; and

FIG. **22** is a block diagram of a signal transmitting device of a UE for transmitting a signal in a manner of inserting

intentional delay information in an RACH or ranging channel signal according to one embodiment of the present invention.

BEST MODE

Mode for Invention

Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings.

The following detailed description disclosed together with the accompanying drawings intends to present not a unique embodiment of the present invention but an exemplary embodiment. The following details include particular details to provide complete understanding of the present invention. Yet, it is apparent to those skilled in the art that the present invention can be implemented without the particular details. For instance, in the following description, 'terminal' is described as a subject to transmit an uplink signal and 'base station' is described as a receiving subject. Theses terminologies do not put limitation of the present invention. So, 'user equipment' can be used as an uplink transmission subject and 'node B' can be used as a receiving subject, for example.

In some case, a structure or device known to public is omitted to avoid conceptional vagueness of the present invention or depicted as a block diagram centering on core functions of the structure or the device. And, the same reference numbers are designated the same elements in this closure overall.

First of all, a basic requisite for an RACH or a ranging channel is to meet requisites for a roundtrip delay and a path loss regardless of a UE speed, a frequency offset, a cell size, and the like. Assumptions for basic RACH or ranging channel allocation (e.g., working assumption of 3GPP LTE) include a preamble length 0.8 ms, a guard time 100 μs, and a 1 ms RACH or ranging channel capable of covering 15 km. Yet, since a cell size exceeds 15 Km, it may happen a case that an RACH or a ranging channel should cover 30 Km section.

Meanwhile, in designing an RACH or a ranging channel to support such a large cell, predetermined limitation is put on a frequency offset in such a manner that a number of ZCZ sequences available for a sequence design is limited. So, a sequence reuse factor can be reduced. And, it can be observed that a repetitive preamble has performance better than that in case of using a short preamble simply.

Thus, in order to design an RACH or ranging channel structure to support a large cell, various factors should be taken into consideration. In this case, the carious factors include: (1) a number of available sequences to prepare for a reduction of ZCZ sequences due to a cell size increase and a reduction of a corresponding overall sequence reuse factor; (2) a preamble repetition number enough to cope with a frequency offset; (3) RACH or ranging channel overhead that may be generated in case of designing an RACH or a ranging channel to support a large cell, e.g., designing an RACH or a ranging channel across a plurality of TTIs, designing an RACH or a ranging channel across a wide bandwidth, etc.; and (4) a number of TTIs for an RACH or a ranging channel, an antenna length in a base station, and the like.

Each embodiment of the present invention explained in the following description considers the above factors taken into consideration in designing the RACH or ranging channel structure. Particularly, locations of UEs within a cell, a downlink signal state measured by a UE in correspondence to the measured location, and the like are additionally taken into consideration to intensively disclose a scheme for reducing overhead generated from an RACH or ranging channel design to support a large cell.

For this, one embodiment of the present invention proposes an RACH or ranging channel structure and/or a method of providing a sequence applied thereto by considering the aforesaid RACH or ranging channel factors differently requested for each UE within a cell.

Another embodiment of the present invention proposes a method of providing a sequence set for an RACH or a ranging channel differently to meet different requisites regarding why a UE accesses an RACH or a ranging channel and a location of a UE within a cell to reduce collision probability in a random access.

And, a further embodiment of the present invention proposes a method of facilitating a receiving side to detect a sequence carried on an RACH or a ranging channel using a different delay time depending on a location of each UE within a cell.

In order to reduce RACH or ranging channel overhead and decrease collision probability in a corresponding RACH or ranging channel, it should be considered that a different requisite for the RACH or the ranging channel is generated in accordance with a location of a user equipment.

FIG. **5** is a diagram to explain a condition differently requested in accordance with a location of a UE within a cell.

In FIG. **5**, a most outer edge region of a cell supported by a cell is represented as R**3** and a UE lies in the region R**3** is represented as UE**3**. A region in the middle of the cell is represented as R**2** and a UE lies in the region R**2** is represented as UE**2**. A region closest to the base station is represented as a region R**1** and a UE lies in the region R**1** is represented as UE**1**. And, each case is exemplarily depicted in FIG. **5**.

In FIG. **5**, path losses of UE**1**, UE**2** and UE**3** are represented as L_p^1, L_p^2 and L_p^3 and roundtrip delays (RTDs) are represented as $2t_d^1$, $2t_d^2$ and $2t_d^3$, respectively. In this case, $2t_d^1$, $2t_d^2$ and $2t_d^3$ indicate that roundtrip delays are twice greater than delays t_d^1, t_d^2 and t_d^3 taken for unidirectional transmissions, respectively.

Generally, path losses are ordered as $L_p^1<L_p^2<L_p^3$ in correspondence to an order of distance. Likewise, roundtrip delays are ordered as $2t_d^1<2t_d^2<2t_d^3$. So, guard section lengths G_d^1, G_d^2 and G_d^3 necessary according to positions of UE**1**, UE**2** and UE**3** within a cell correspond to $G_d^1<G_d^2<G_d^3$. And, spreading coefficients S_p^1, S_p^2 and S_p^3 of sequences to be applied to a channel also have the relation of $S_p^1<S_p^2<S_p^3$.

Namely, the UE**3** has to access an RACH or a ranging channel with a long RACH or ranging channel and a sequence having a high spreading coefficient in order to have performance equal to that of the UE**1** which accesses an RACH or a ranging channel with a shorter RACH or ranging channel and a low spreading coefficient.

In case of the UE**1**, an RACH or a ranging channel allocated by a base station is used. Yet, if a cell radius is large, a size of the RACH or the ranging channel is designed to fir the condition for supporting a UE at an edge of the cell (e.g., UE**3**).

Hence, it may happen that a UE in the vicinity of the base station, e.g., UE**1** does not actually need such a long RACH or ranging channel.

In particular, if a base station and a user equipment get closer to each other, an RACH or ranging channel having a short length is enough. Moreover, since a length of the RACH or ranging channel is short, a length of a sequence the user equipment should transmit can be decreased. Namely, if a location of a user equipment is known rather than all the user equipments identically use a single long RACH or ranging channel, it is quite correct that an RACH or ranging channel

length and a sequence are suitably selected by obtaining the location to which the user equipment belongs.

In FIG. **5**, unlike user equipments in the region R**3**, a shorter RACH or ranging channel is sufficient for the user equipment in the region R**1** or R**2** within the cell. This is because it is advantageous that a path loss of a signal due to a short distance gets smaller with an RACH or ranging channel having a short distance from a base station. So, if a user equipment belonging to the region R**1** or R**2** accesses an RACH or ranging channel designed for the region R**3** as it is, it is apparent that loss is inevitable.

As mentioned in the foregoing description, the method of reducing the RACH or ranging channel overhead using the RACH or ranging channel having a proper length according to a location of UE in a large cell is well disclosed in Korean Patent Application No. 2006-74764 for 'Signal transmitting and receiving method in communication system, apparatus therefore, and channel structure use for the same' applied for a patent by the present applicant.

In the following description, instead of setting an RACH or a ranging channel to meet the common requisites for entire UEs in a cell, all the schemes for setting requisites for an RACH or a ranging channel to differ in accordance with a location of each UE within a cell is generically named 'segmented access scheme'.

And, as mentioned in the foregoing description, the factors required for a RACH or a ranging channel in accordance with a UE can be designed different in correspondence to a degree of path loss of a downlink signal generated to correspond to the location of the UE within the cell.

Moreover, if a specific UE is a high speed UE, it can be more sensitive to an influence of a frequency offset in an RACH or ranging channel design than a low speed UE. For this, it may be more advantageous that repetition of an RACH or ranging channel preamble or the like is used.

Hence, according to one embodiment of the present invention, a method of providing a different RACH or ranging channel structure by considering factors for an RACH or a ranging channel differently requested per a UE in the RACH or the ranging channel within a cell and/or a sequence applied thereto are provided as an example for the above-mentioned segmented access scheme. And, this is explained as a first embodiment of the present invention in the following description.

According to another embodiment of the present invention, a method of reducing collision probability in an RACH or a ranging channel by differently allocating a sequence in correspondence to a location of a UE or a cause why a UE accesses the RACH or the ranging channel and using the differently allocated sequence in the RACH or the ranging channel is provided as an example for the above-mentioned segmented access scheme. And, this is explained as a second embodiment of the present invention in the following description.

According to a further embodiment of the present invention, to solve a problem that a sequence detection in a receiving side becomes complicated if a sequence configuration is diversified to correspond to a different requisite requested per a UE, a signal receiving method of detecting a sequence used for an RACH or a ranging channel by considering a different delay time in correspondence to a location of each UE is provided. And, this is explained as a third embodiment of the present invention in the following description.

An aspect of adjusting a setup for an RACH or a ranging channel based on a location of a UE within a cell is common to the respective embodiments of the present invention. The first embodiment intensively deals with an aspect of an RACH or a ranging channel and a sequence itself applied to the RACH or the ranging channel. The second embodiment intensively deals with an aspect of transmitting an RACH or a ranging channel. And, the third embodiment intensively deals with an aspect of receiving an RACH or a ranging channel. Yet, schemes according to the embodiments of the present invention can be suitably combined with each other to be used by transmitting and receiving sides.

The first embodiment of the present invention is explained as follows.

FIRST EMBODIMENT

For clarity and facilitation of the following description, a central region is represented as R**1** and a cell edge region is represented as R**2**. Yet, a specific boundary value can be varied to correspond to various conditions. And, a boundary number can be varied to correspond to a condition as well.

FIG. **6** and FIG. **7** are diagrams of schemes for allocating an identical RACH or ranging channel to all UEs.

As mentioned in the foregoing description, if an RACH or a ranging channel is allocated without considering a condition, which is differently demanded in correspondence to a location of a UE within a cell, for the RACH or the ranging channel, a corresponding allocating scheme is shown in FIG. **6** or FIG. **7**.

In this case, a base station simply allocates an RACH or a ranging channel to each UE for each RACH or ranging channel section without considering an RACH or ranging channel condition per a UE. So, signaling overhead is small. Yet, since the corresponding RACH or ranging channel has an RACH or ranging channel structure to support a poorest UE within a cell, overhead can be large for an RACH or ranging channel structure to support a large cell overall.

Hence, according to one embodiment of the present invention, a scheme for providing an RACH or ranging channel structure to meet an RACH or ranging channel requisite for each UE and selecting the corresponding structure in correspondence to a location of the corresponding UE within a cell, a CQ decision or the like is proposed. This is explained as follows.

FIG. **8** and FIG. **9** are diagrams of schemes for allocating an RACH or a ranging channel having a different time domain length in correspondence to a different requisite for each UE according to one embodiment of the present invention.

First of all, an RACH or a ranging channel is provided by a base station to enable a UE failing to be connected to or synchronized with the base station to access the corresponding base station and then notified to the corresponding UE. So, the RACH or the ranging channel enables a random UE to access the base station. Yet, since a corresponding length is increased in a large cell, the base station is unable to frequently generate and provide an RACH or a ranging channel to utilize a resource for a data area. To prevent this, channels differing in length are opened in generating the RACH or the ranging channel and UEs located in different regions are accessible to the channels differing in length.

In particular, in actually allocating RACHs or ranging channels, as shown in FIG. **9**, a short RACH or ranging channel (e.g., RACH A) and a long RACH or ranging channel (e.g., RACH B) are utilized for UEs located in R**1** (or UEs having a corresponding CQ value measured: same in the following description) (long RACH or ranging channel can meet the RACH or ranging channel requisite for UEs located in R**1**). And, UEs located in R**2** are allowed to use a long RACH or ranging channel (e.g., RACH B) only.

By performing the allocation shown in FIG. **8**, collision probability between UEs can be reduced. And, it is also advantageous in that access latency is not varied in accessing an RACH or a ranging channel by a transmitting terminal. Nonetheless, it can be observed that a quantity of a resource allocated to the RACH or the ranging channel by the base station is reduced smaller than an overhead generated from allocating the entire resource long.

In this case, the RACH A and the RACH B are represented as RACHs or ranging channels allocated with different probabilities by the base station, respectively. And, these probabilities are set to minimize a whole collision probability in accordance with the R**1** and R**2** sizes or UE distribution.

If a bandwidth of an RACH or a ranging channel is equal to that of a system or if it is impossible to allocate at least two RACHs or ranging channels to a frequency domain at a time, a long RACH and a short RACH, as shown in FIG. **9**, alternately appears according to the given frequency with cycles adjusted by the base station in the above-explained allocation scheme.

The scheme of allocating an identical RACH or ranging channel regardless of a requisite for each UE in FIG. **6** and FIG. **7** and the scheme of allocating a different RACH or ranging channel by considering a requisite for each UE in FIG. **8** and FIG. **9** are compared to each other in aspect of overhead as follows.

TABLE 1

			UL System BW (MHz)					
			1.25	2.5	5	10	15	20
RACH Slots per Assignment (Ns)			<=1	<=2	<=4	<=8	<=12	<=16
RACH	P	10	0.100	0.050	0.025	0.013	0.008	0.006
Overhead	Ns	1						
Case 1	N	1						
RACH	P	10	0.200	0.100	0.050	0.025	0.017	0.013
Overhead	Ns	1						
Case 2	N	2						
RACH	P	10	0.300	0.150	0.075	0.038	0.025	0.019
Overhead	Ns	1						
Case 3	N	3						
RACH	P	10	0.150	0.075	0.038	0.019	0.013	0.009
Overhead	Ns	1						
Case 2 -	N	2						
Segmented	SR	0.50						
	Reduction (%)		25.000	25.000	25.000	25.000	25.000	25.000
RACH	P	10	0.200	0.100	0.050	0.025	0.017	0.013
Overhead	Ns	1						
Case 3 -	N	3						
Segmented	SR	0.50						
	Reduction (%)		33.333	33.333	33.333	33.333	33.333	33.333

In Table 1, 'p' indicates an RACH or ranging channel period by a unit of ms. 'Ns' indicates a number of RACH or ranging channel slots per an RACH or ranging channel periods, 'N' indicates an RACH or ranging channel length by a unit of ms, and 'SR' indicates a rate of an RACH or ranging channel slot having a length of 1TTI.

Comparing 'Case 2' and 'Case 2-Segmented' in Table 1 to each other, it can be observed that one case of applying a scheme for providing and assigning a different RACH or ranging channel structure in accordance with an RACH or ranging channel requisite per a UE according to one embodiment of the present invention (i.e., Case 2-Segmented) obtains an overhead reduced 25% smaller than that of the other case (i.e., Case 2).

Comparing 'Case 3' to 'Case 3-Segmented' to each other, it can be observed that one case according to one embodiment of the present invention (i.e., Case 3-Segmented) obtains an overhead reduced about 33.3% smaller than that of the other case (i.e., Case 3).

As mentioned in the foregoing description, a scheme for enabling UEs in each region within a cell to have different widths on a frequency domain can be provided as well as a scheme for providing UEs in each region within a cell to have different lengths on a time domain.

In the description of the above-explained embodiment of the present invention, a UE, which is located in each region within a cell according to the embodiment for providing a requisite for an RACH or ranging channel based on a location of the UE within the cell, can be applied to correspond to a UE having a CQ value and speed corresponding to each case according to an embodiment for providing an RACH or ranging channel requisite in accordance with a downlink signal attenuation degree (e.g., CQ information) measured by the UE, a speed of the corresponding UE, and the like.

Meanwhile, as a number of available ZCZ sequences in accordance with an increase of a roundtrip time in a large cell is decreased, there rises a problem that a sequence reuse is reduced overall. And, as mentioned in the foregoing description, a preamble needs to be repeated for a UE having a high path loss and a high speed in a large cell.

Hence, another embodiment of the present invention proposes a scheme for increasing a quantity of information that can be delivered using a limited sequence in a manner of using preamble repetition as information of UE, e.g., CQ information.

FIG. **10** is a diagram to explain a method of delivering UE information in correspondence to a preamble repetition count of an RACH or a ranging channel according to one embodiment of the present invention.

First of all, a first RACH or ranging channel structure in an upper end of FIG. **10** represents that a UE having a low speed and a low path loss delivers its CQ information using a single preamble. A second RACH or ranging channel structure represents that a UE having a medium speed and a medium path loss delivers its CQ information by repeating a preamble twice. And, a last RACH or ranging channel structure having a high speed and a high path loss delivers its CQ information by repeating a preamble three times. Thus, the different req-

uisite for each UE may correspond to a condition in accordance with a location of the corresponding UE within a cell.

Referring to FIG. **10**, it is able to deliver more information using a limited sequence in a manner of delivering UE information in accordance with a preamble repetition count.

As mentioned in the above description, a segmented access scheme for configuring an RACH or a ranging channel by considering a different RACH or ranging channel requisite per a UE according to a first embodiment of the present invention has been intensively explained.

A second embodiment of the present invention is explained as follows.

SECOND EMBODIMENT

Despite UEs within a same cell explained in the description of FIG. **5**, a different condition for an RACH or a ranging channel can be demanded in accordance with a location of each UE within a cell.

Meanwhile, a different condition demanded for an RACH or a ranging channel in accordance with a location of UE includes not only the aforesaid RACH or ranging channel length but also a cause for a UE to access an RACH or a ranging channel. Due to this cause, a frequency in accessing the RACH or the ranging channel may differ.

For instance, a UE (e.g., UE**3**) located on a cell edge, as shown in FIG. **5**, may have a more frequency number in accessing an RACH or a ranging channel due to handoff into a neighbor cell than a UE (e.g., UE**1**) located in a cell center.

On the other hand, the UE**1** located at the cell center has to substantially move into a cell edge from the cell center in advance prior to moving into the neighbor cell. So, it is very less probable that direct handoff may happen in the region R**1**.

Hence, a second embodiment of the present invention proposes a method of reducing collision probability in an RACH or a ranging channel in a manner of varying a number of sequences to be used for the RACH or the ranging channel in accordance with where a UE exists within a cell.

Generally, in a real system, a method of notifying a cause why a UE accesses a base station, a downlink CQI, a resource request, and the like using a sequence allocated to an RACH or a ranging channel is needed.

In this case, the reason why a user equipment uses an RACH or a ranging channel is because a great deal of weight is placed on handoff and because newly powered-on user equipments or user equipments waking from idle mode use signals suitable for their situations, respectively.

The downlink CQI is needed for a user equipment to select a good channel when a base station detects a signal carried on an RACH or a ranging channel and then allocates a corresponding resource to the user equipment having accessed the RACH or the ranging channel.

And, the resource request indicates a requirement for a user equipment to transmit data traffic in uplink.

If a number of sequences allocated to an RACH or a ranging channel is N for example, the N sequences should represent a combination of the above-explained informations that should be transmitted to a base station via the RACH or the ranging channel.

Theses informations can be easily represented by a method of rendering each of the informations into a bit sequence and selecting one from a set of N sequences using the bit sequence as an index.

FIG. **11** is a diagram for a structure of a sequence set for generating information in a bitmap format.

FIG. **11** shows types of information delivered to a base station via an RACH or a ranging channel include a cause for accessing an RACH or a ranging channel, a random ID, a CQI, and the like. A bitmap format shown in FIG. **11** to have an identical bit number for each information is applied in common to entire UEs within a corresponding cell. Yet, a corresponding sequence is selected from suitable sequences each of which indicates corresponding information via a bit number assigned to each information. Namely, in FIG. **11**, the entire UEs within the cell use a same sequence set.

The above scheme is convenient for implementation but may be disadvantageous as a method for reducing collision in an RACH or a ranging channel. This is because a cause for a user equipment to access an RACH or a ranging channel and a frequency number for accessing the RACH or the ranging channel with each cause may totally differ from each other and because it may be inefficient for the entire user equipments to use the sequence selected from the sequence set having the bitmap structure regardless of the frequency number.

For instance, a type of a user equipment accessing an RACH or a ranging channel most frequently corresponds to a handoff user equipment. And, a user equipment having a power turned on, a user equipment making a request for a resource, a user equipment performing timing synchronization, and the like follow the handoff user equipment in order. Os, if more protection is carried out on the most frequently occurring case, it is able to reduce probability of collision occurrence between user equipments in the same RACH or ranging channel.

More preferably, a sequence set suitable for each case is allocated to keep collision probability below a prescribed level by inquiring into a distribution of causes for accessing the RACH or the ranging channel.

Thus, according to one embodiment of the present invention proposes a method of reducing collision probability in an RACH or a ranging channel by providing a sequence set including a sequence number differing in accordance with a cause for a user equipment to access the RACH or the ranging channel as well as a current location of a user equipment within a cell.

FIG. **12** is a diagram of a example for differentiating a number of CQIs and a number of random IDs due to a cause for a user equipment to access an RACH or a ranging channel according to one embodiment of the present invention.

FIG. **12** shows a case that a user equipment accesses an RACH or a ranging channel due to a cause of handoff. Resource allocation request (Resource Request), or synchronization. And, FIG. **12** shows that each of the causes can be represented as a single number of cases (yet, unlike the drawing of FIG. **12**, it is apparent to those skilled in the art that each of the causes can be represented as more number of cases in accordance with a number of available sequences and a number of RACH or ranging channel access causes.).

Moreover, FIG. **12** shows a single CQI is allocated to each of the causes since information report for a downlink channel status is relatively unnecessary in case of handoff for example, and also show that CL**1**, CL**2** and CL**3** CQIs are allocated to the cases of the power-on, the resource request and the synchronization, respectively.

Meanwhile, in case of the handoff occurring by the most frequency number among the shown causes, numerous random IDs are allocated to accommodate more user equipments to access an RACH or a ranging channel. In case of other causes, a less number of random IDs are allocated.

Thus, by providing a sequence set, in which numbers N**1**, N**2**, N**3** and N**4** of sequences indicating corresponding infor-

mation in accordance with the cause for a user equipment to access an RACH or a ranging channel are specified, the following effect can be brought.

Once the number of sequences, as shown in FIG. **12**, is assigned according to each cause for accessing an RACH or a ranging channel, it is decided as one since a variation of CQI is small in case of the handoff frequently used by a user equipment, as mentioned in the foregoing description for example. Instead, more random IDs are assigned. Hence, it is able to reduce collision probability by lowering probability in having the same sequence selected despite accesses made by several user equipments. In particular, in case of using sequences amounting to a different number of cases according to a cause for a user equipment to access an RACH or a ranging channel, collision probability in the RACH or the ranging channel can be lowered.

This scheme can be applied together with the aforesaid segmented access scheme. A user equipment located at a cell center in a relatively large cell and a user equipment located at a cell edge explicitly differ from each other in the cause for accessing an RACH or a ranging channel.

For instance, since a user equipment located at a cell center has no reason to perform handoff, a sequence may not be allocated for that use at all. Yet, it may be more preferable that a minimum handoff sequence is allocated for compatibility.

Meanwhile, in case that a power is turned on, the resource request or the like is more frequently generated within a cell than the handoff. So, sequences reduced for allocation to the handoff can be additionally allocated for these causes.

On the contrary, in case of a user equipment located at a cell edge, it is highly probable that handoff into a neighbor cell may be frequently used. So, an RACH or ranging channel ratio using handoff is very high. So, it is preferable that a number sequences corresponding to handoff is increased at the cell edge.

Namely, if a cell is discriminated by a distance from a base station, frequency of an RACH or ranging channel access cause for each user equipment in a corresponding region varies. So, it is able to allocate a sequence using this factor.

FIG. **13** is a diagram of a example for differentiating a number of CQIs and a number of random IDs in correspondence to a cause for a user equipment to access an RACH or a ranging channel and a location of the user equipment within a cell according to one embodiment of the present invention.

For instance, a number of sequences available for representing each information in FIG. **13** can be provided as follows.

1) Case of Handoff: NIC in sequence for user equipment at cell center<<NIE in sequence for user equipment at cell edge

2) Case of Power-on: N**2**C in sequence for user equipment at cell center>N**2**E in sequence for user equipment at cell edge

3) Case of Resource Request: N**3**C in sequence for user equipment at cell center>N**3**E in sequence for user equipment at cell edge

4) Case of Synchronization: N**4**C in sequence for user equipment at cell center>N**4**E in sequence for user equipment at cell edge

Namely, in the above-explained example, 8 kinds of sequence sets can be provided according to a location of a user equipment within a cell and a cause for a user equipment to access an RACH or a ranging channel (e.g., a set of N**1**C sequence to represent a case of handoff of a cell center user equipment, a set of N**1**E sequences representing handoff of a cell edge user equipment, etc.).

Thus, in a method of providing a sequence set for an RACH or a ranging channel according to one embodiment of the present invention, information on a cause for accessing an RACH or a ranging channel, random ID, CQI and the like is decided as a type of information to be represented via a corresponding sequence. And, a sequence set is provided in a manner that an allocation degree of a sequence number according to each of the information is differently specified according to a location of a user equipment within a cell in the course of deciding allocation information on the sequence number according to each corresponding information.

Of course, a sequence number is allocated by considering a cause for a user equipment to access an RACH or a ranging channel as well as a location of the user equipment within a cell, as mentioned in the foregoing description. Hence, it is more efficient to lower collision probability in an RACH or a ranging channel.

In the above-explained embodiment, a location of a user equipment within a cell may mean a distance from a base station itself. Preferably, preset information, which indicates that a user equipment belongs to which region within a cell, is represented within reference to the distance from the base station.

For instance, if a user equipment is remote from a base station over a predetermined distance, the user equipment decides that it is located at a cell edge. If a user equipment is remote from a base station below a predetermined distance, the user equipment decides that it is located at a cell center. Thus, a distance, which becomes a reference to discriminate a region within a cell, may be equal to or greater than 1. An extent of each reference distance can be decided by depending on various factors including an antenna height of a base station, a transmission power, and the like, which brings signal attenuation, roundtrip delay time, and the like.

FIG. **14** is a graph for an increasing transition of an RACH or ranging channel length requested in correspondence to an increasing distance between a user equipment and a base station in proportion to an antenna length of the base station.

In FIG. **14**, a horizontal axis indicates a distance between a UE from a node B (or a base station) by a unit of km and a vertical axis indicates a number of subframes occupied by an RACH or a ranging channel according to the distance. In FIG. **14**, it is assumed that the subframe has a length of 0.5 ms as currently provided by 3GPP LTE.

Referring to FIG. **14**, in case that an antenna length of a base station (height of base station: hbs) is 90 m, compared to a case that the hbs is 60 m or 30 m, an increment of the number of the subframes necessary for the distance increasing from the base station is small. Yet, in case that the hbs is 30 m, the number of the necessary subframes is rapidly incremented according to the distance.

Hence, according to one embodiment of the present invention, the distance from the base station, which is used to discriminate a region within a cell is decided by considering the antenna height of the base station.

For instance, in case that the inner cell region discrimination is carried out by dividing a cell into three regions R**1**, R**2** and R**3**, as shown in FIG. **5**, distances (e.g., D**1** and D**2**) corresponding to references for this discrimination in case of the hbs 90 m can be set greater than those in case of the hbs 30 m. And, various factors including a transmission power and the like as well as the aforesaid antenna height of the base station (hbs) can be taken into consideration for the region discrimination.

In the example shown in FIG. **13**, the region discrimination according to a location of a user equipment within a cell is carried out into two regions. And, causes for a user equipment to access an RACH or a ranging channel include four kinds of handoff, power-on, resource request and synchronization for

example. So, eight kinds of sequence sets are provided. Yet, the sequence set provision is just exemplary. And, it is apparent to those skilled in the art that sequences can be allocated and provided with arbitrary combinations of the causes if collision probability is reduced by providing sequences differing from each other according to a cause for a user equipment to access an RACH or a ranging channel and a location of a user equipment within a cell.

In the above-explained embodiment of the present invention, it is assumed that all the UEs know path loss and roundtrip delay values in accordance with a distance from the base station to some extent. Yet, a UE may have difficulty in deciding the distance from the base station by itself.

If so, rather than providing a different RACH or ranging channel in accordance with the distance between the base station and the UE, it is able to apply a method of selecting a suitable RACH or ranging channel requisite in accordance of measurement performed by the UE itself in a manner of providing an RACH or a ranging channel differing in an arbitrary means for enabling the UE to judge a requisite requested in accordance with a location of the UE within the cell, i.e., an attenuation extent of a downlink signal (e.g., downlink CQ information to each UE, etc.).

Moreover, a UE speed and the like, as explained for the first embodiment, as well as the downlink signal attenuation extent can be taken into consideration as the RACH or ranging channel requisite differently requested by each UE.

Hence, one preferred embodiment of the present invention proposes a method of considering a speed of UE in addition in judging the different requisite for the RACH or the ranging channel per UE. In particular, a corresponding UE obtains information about its location within a cell in accordance with a downlink signal attenuation extent, selects an RACH or ranging channel structure and/or sequence suitable for the information about its location within the cell and/or its speed, and then transmits a signal using the selected structure and/or sequence.

Explained in the following is a method of transmitting a signal in a manner that a user equipment accesses an RACH or a ranging channel using a combination of sequences or a sequence set differently provided in accordance with a location of the user equipment within a cell and the like.

FIG. **15** is a flowchart to explain a signal transmitting method according to one embodiment of the present invention.

In a signal transmitting method of a user equipment according to one embodiment of the present invention, a user equipment selects a sequence set in accordance with its location within a cell and then accesses an RACH or a ranging channel by selecting a sequence from the selected sequence set. For this, information indicating a prescribed location of the corresponding user equipment within the cell needs to be obtained by a step S**1001** shown in FIG. **15**. The information on the location within the cell can be acquired from attenuation of a downlink signal from a base station. And, a acquisition of the information on the location within the cell is disclosed in detail in the aforesaid Korean Patent Application No. 2006-74764.

The aforesaid Korean Patent Application No. 2006-74764 teaches that a user equipment is able to measure a distance from a base station via an extent of attenuation of a downlink signal from the base station. Yet, if the measurement is not available, the user equipment is able to acquire location information in a manner of transmitting an initiation access signal on the assumption of a distance that is farthest from the base station and then receiving a signal from the base station in response to the initiation access signal. Yet, location information of a user equipment within a cell can be obtained in advance prior to accessing a corresponding RACH or a ranging channel. And, it is unnecessary to go though the step S**1001** each time for a signal transmission of the user equipment via an RACH or a ranging channel.

In case that the information indicating the location of the user equipment within the cell is acquired, the user equipment is able to decide a region to which the user equipment itself belongs in a step S**1002** using the acquired information. Such a region decision can be carried out in a manner of deciding to be located at a cell edge if the user equipment is spaced apart from the base station over a specific distance or at a cell center if the user equipment is spaced apart from the base station within a specific distance. Yet, the cell can be divided into three regions instead of two. If so, regions are discriminated from each other according to two kinds of specific distances from the base station. As mentioned in the foregoing description, this region discrimination can be decided according to various factors including an antenna length of a base station, a transmission power, and the like.

Once the location information of the user equipment within the cell is obtained and the corresponding region decision is completed, such a step as a step S**1003** can be carried out to obtain information on a cause for accessing an RACH or a ranging channel.

To a sequence set for an RACH or a ranging channel according to one embodiment of the present invention, a different sequence number is allocated in accordance with a location of the user equipment within the cell only. Instead, it may be more preferable that a different sequence number, as shown in FIG. **13**, is allocated in accordance with RACH or ranging channel access cause information as well as the location information.

After the location information within the cell and the ranging channel access cause information have been obtained, the user equipment is able to select a corresponding sequence set in a step S**1004**. For instance, in the example shown in FIG. **13**, if the user equipment is decided to be located at the cell edge because the location of the user equipment is beyond the prescribed distance and if a cause for the user equipment to access the RACH or the ranging channel is handoff, a sequence set having N**1**E sequences allocated thereto is selected.

After the sequence set has been selected, the user equipment checks additional information to deliver to the base station in a step S**1005**. For instance, in case of transmitting CQI information indicating a downlink channel quality, a sequence suitable for indicating a corresponding CQI is selected from the sequence set.

Having selected a sequence having a randomly selected random ID from the corresponding sequence set in a step S**1006**, the user equipment accesses an RAH or a ranging channel through the selected sequence (step S**1007**).

In the above description, a signal transmitting method of a user equipment via an RACH or a ranging channel according to one embodiment of the present invention has been explained. And, it is apparent to those skilled in the art that an RACH or a ranging channel can be accessed by a scheme different from the sequence set selecting step and the step of selecting the suitable sequence from the corresponding sequence set if the RACH or the ranging channel is accessed using a sequence differently allocated in accordance with a location of a user equipment within a cell and a cause for the user equipment to access the RACH or the ranging channel. So, no limitation is put on the above embodiment.

For clarity and convenience of explanation, a terminology 'sequence set' is used to describe each set having a different

number of sequences allocated thereto in accordance with a location of a user equipment within a cell in the following description.

FIG. **16** is a diagram of a signal transmitting device according to one embodiment of the present invention.

Referring to FIG. **16**, a signal transmitting device according to one embodiment of the present invention includes a sequence selecting module **1101** and an access module **1102**.

The sequence selecting module **1101** selects a sequence in accordance with information to be delivered to a base station. And, the sequence selecting module **1101** can include a sequence set selecting module **1101***a* and an application sequence selecting module **1101***b* in accordance with its function.

The sequence set selecting module **1101***a* obtains a location of a user equipment within a cell and then selects a corresponding sequence set set_k through intra-cell inclusive region information decided according to the obtained location. Optionally, a mentioned in the foregoing description, if a sequence set is selected by considering a case for a user equipment to access an RACH or a ranging channel as well the intra-cell location information, it is able to more efficiently reduce collocation probability in the RACH or the ranging channel.

The selected sequence set set_k is inputted to the application sequence selecting module **1101***b*. The application sequence selecting module **110***b* then selects a suitable sequence $sequence_i$ by considering other informations including CQI to be delivered to a base station via the RACH or the ranging channel.

In case that a sequence to be applied to the RACH or the ranging channel is selected, the access module **1102** accesses the RACH or the ranging channel through the sequence $sequence_i$. Through this, the signal transmitting device according to one embodiment of the present invention can reduce the collision probability in the RACH or the ranging channel.

Thus, according to a second embodiment of the present invention, collision probability in an RACH or a ranging channel can be reduced in a manner of allocating a sequence set differently based on an intra-cell location of each UE and preferably a cause for a user equipment to access an RACH or a ranging channel and then using the allocated sequence set.

Meanwhile, explained in the following description is a signal receiving method using a different delay time in accordance with an intra-cell location of a UE (i.e., the segmented access scheme in a broad meaning), which is to facilitate a receiving side to perform a sequence detection in an RACH or a ranging channel if factors for a sequence get complicated, according to a third embodiment of the present invention.

THIRD EMBODIMENT

To meet the different factor in accordance with an intra-cell location of a UE, as mentioned in the foregoing description of FIG. **5**, if a different sequence is used in accordance with the intra-cell location of the UE, more burden is imposed on a base station that searches for a sequence used for an RACH or a ranging channel.

In case that all information delivered to a base station is carried by a sequence applied to an RACH or a ranging channel, sequence types used for the RACH or the ranging channel are more diversified. Yet, this may be accompanied with a reduction of a number of available sequences.

Hence, a third embodiment of the present invention intends to provide a method of representing information to be delivered to a base station using another scheme except a sequence type and reducing a burden imposed on a base station in searching for a sequence used for an RACH or a ranging channel.

A third embodiment of the present invention intends to propose an efficient sequence searching method and an efficient signal receiving method by paying attention to a fact that a signal carried on an RACH or a ranging channel is delivered with delay information differing in accordance with a location of a UE among the conditions differently requested in accordance with an intra-cell location of the UE in the description of FIG. **5**.

In particular, a signal is transmitted at a timing point distant by a roundtrip delay corresponding to a location of a UE from a reference timing corresponding to a downlink signal transmitting timing point. So, if a cell size is increased, a section having a signal spread therein is elongated. Such delay information facilitates a sequence detection performed by a receiving end and provides a UE with an additional RACH or ranging channel access opportunity.

In a related art, a delay time for a signal detected within an RACH or a ranging channel is used as information for a timing detection for a UE only. Yet, there exists a scheme for enabling the information to carry more additional information. Namely, if a signal delay is interpreted in a different way, it is advantageous to obtain better features.

This is considered in all aspects with reference to FIG. **17** as follows.

FIG. **17** is a diagram for a roundtrip delay time of an RACH or ranging channel signal received by a base station.

Referring to FIG. **17**, if a timing point of transmitting a downlink signal from a base station is set to a reference timing point, an RACH or ranging channel signal transmitted by a cell center UE in response to the downlink signal from the base station has a short roundtrip delay time, whereas an RACH or ranging channel signal transmitted by a cell edge UE in response to the downlink signal from the base station has a relatively long roundtrip delay time. So, a signal in a receiving end seems to be discriminated by a delay time in each of the cell edge UE and the cell center UE. Thus, a roundtrip delay difference in accordance with a region to which a prescribed location of a UE belongs among a plurality of regions within a cell is generally increased to correspond to an increasing cell size.

Hence, one embodiment of the present invention proposes a method of reducing a search time in a manner of differently setting a sequence set (a set variation of a reference set (e.g., PN, CAZAC, etc.), a cyclic shift set variation, a cyclic shift interval variation, etc.) that should be searched with the delay time by the receiving end in detecting an RACH or ranging channel signal. In this case, the delay time means a roundtrip delay time until a base station receives an RACH or ranging channel signal from a corresponding UE in response to a downlink signal from the base station if a downlink transmission timing point of the base station is set to a reference timing point. And, the delay time increases in proportion to a distance between the UE and the base station.

As taught by the aforesaid patent application and the first and second embodiments of the present invention, if a sequence to be used in accordance with a region to which an intra-cell location of a UE belongs is set, it is possible to perform a search by taking a sequence set, which is assigned to be used for a corresponding region with reference to an arriving timing point of an RACH or ranging channel signal, as shown in FIG. **17**, and more particularly, to a start timing point of a sequence used for an RACH or a ranging channel as a search target sequence only. This scheme is explained with reference to FIG. **18** for example as follows.

FIG. **18** is a diagram to explain a method of changing a sequence set searched in correspondence to a delay time of an RACH or ranging channel signal received by a base station according to one embodiment of the present invention.

FIG. **18** shows a sequence searching scheme according to one embodiment of the present invention by taking a case of discriminating a cell into two regions, a cell center and a cell edge as an example.

If a delay time is smaller than a prescribed threshold a at a reference time position, it is the delay time a transmission signal of a cell center UE can have only. It is unnecessary to search for a sequence used by a cell edge UE.

If a delay time is greater than another prescribed threshold tb, a transmission signal of a cell center UE is unable to have the delay time. So, sequences used by cell edge UEs are searched only.

In FIG. **18**, assuming that a sequence used by the cell center UE is named a sequence set **1** and a sequence used by the cell edge UE is named a sequence set **2**, if the delay time is equal to smaller than ta, the sequence set **1** is searched as a search target sequence set. If the delay time is equal to or greater than tb, the sequence set **2** is searched as a search target sequence set.

Yet, if a UE approaches a boundary between the cell center and the cell edge, unless the UE is able to accurately recognize its location, a location of the UE may be irregularly determined between the cell center and the cell edge. So, sequences of both regions will be mixed and used. So, if a delay time of a received signal is in the vicinity of a maximum roundtrip delay time of a UE within a cell, i.e., in the region except a region (region below ta) a signal of an intra-cell UE can have only and a region (region above tb) a signal of a cell edge UE can have only ($ta \leqq RTD \leqq tb$), it is preferable that the entire sequence sets are searched. Yet, since a number of sequences searched for each delay time can be reduced overall, the base station is able to considerably reduce complexity of calculations.

As mentioned in the above description, using the sequence search method shown in FIG. **18**, there is another advantage as well as the complexity of calculations is reduced. For instance, there is no problem in using different zero correlation zones for sequences used in the cell center and the cell edge, respectively.

Generally, a representative sequence used for an RACH or a ranging channel is a CAZAC sequence. And, a number of available CAZAC sequences amounts to a multiplication of a number of mother sequences according to ID of CAZAC sequence and a number of ZCZ transformable by applying a cyclic shift to the CAZAC sequence. Preferably, ZCZ has an interval enough for a receiving end to discriminate the ACA even if a cyclic shift is applied within CAZAC sequence. Since vagueness of a cyclic shift applied to a sequence by a receiving end can be generated due to delay spreading and the like, a sequence having a short ZCZ length is preferably applied in case of a cell center UE having small, delay spreading and the like. In case of a cell edge UE, it is preferable that a sequence having a long ZCZ length is used.

Based on this, a transmission signal of a cell center UE and a transmission signal of a cell edge UE, as shown in FIG. **18**, are discriminated from each other in accordance with a delay time of a received RACH or ranging channel signal and each corresponding sequence set is searched only.

So, even if ZCZ uses a different sequence, vagueness of discrimination is reduced.

In particular, if a mother sequence used for a search target sequence set **2** and a mother sequence used for a search target sequence set **1** are set different from each other, a base station performs a detection with a received delay time even if the mother sequences have ZCZs differing from each other in interval. So, it is more preferable that vagueness is not generated in detecting ZCZs having different intervals from different mother sequences, respectively.

The above-explained scheme corresponds to a physical delay phenomenon generated in accordance with a distance between a UE and a base station.

Yet, another embodiment of the present invention proposes a scheme for attaching an intentional delay time thereto. In this case, the intentional delay means a scheme for inserting an additional delay to discriminate a signal transmitting timing point from a physical delay time in accordance with information to be transmitted to a base station. Such a scheme is explained with reference to FIG. **19** as follows.

FIG. **19** is a diagram to explain a method of inserting intentional delay information in a transmission signal by a UE according to one embodiment of the present invention.

In case that a physical delay time in a given cell size is (roundtrip delay time+delay spreading), FIG. **19** proposes a scheme that an intentional delay time corresponding to a size of each section (Section **1**, Section **2**, . . .) divided on a time axis in FIG. **19** defines an additional region, as shown in FIG. **19**, using a size of the aforesaid delay time as a basic unit. And, it is not mandatory to limit a unit of an intentional delay to a size of a physical delay time. Actually, it can be greater or smaller than the physical delay time. Yet, it may be preferable that a time section for an intentional delay is set to a unit of a physical delay of a whole region UE within a cell in that a base station as a receiving end does not confuse a physical delay time of an RACH or ranging channel signal transmitted by a UE in each region with a quantity of an intentional time delay for delivering corresponding information.

In case that an intentional delay, as shown in FIG. **19**, is inserted, a transmission start area of each preamble becomes an RACH or ranging channel preamble transmission position provided in advance to coincide with information defined in the corresponding position.

Namely, in case that each time section shown in FIG. **19** is interpreted as CQ information, a UE calculates downlink CQ information and then transmits an RACH or a ranging channel signal at a corresponding preamble transmission start position. If so, an additional sequence is unnecessary to transmit CQI. So, overall sequence reuse increases. Information transmittable with reference to a delayed position includes CQ information, RACH or ranging channel access cause information, random ID information, or the like.

Meanwhile, in case that each section (Section **1**, Section **2**, . . .) divided on a time axis uses a sequence of a same mother index, it may happen that different ZCZ sequences having the same mother sequence transmitted from different sections are not discriminated from each other due to a delay.

Hence, according to one embodiment of the present invention, since an RACH or ranging channel preamble transmitted from a start position of each section in delivering an RACH or ranging channel signal should be a discriminative sequence, it is able use a ZCZ sequence set of which different mother sequences are used by the sections, respectively.

According to one embodiment of the present invention, the sequence searching method shown in FIG. **18** is executable as soon as information is delivered by the scheme shown in FIG. **19**.

FIG. **20** is a diagram to explain a method of interpreting information based on a delay time, which is attributed to a location of a UE having transmitted an RACH or ranging

channel signal received by a base station, and intentional delay time according to one embodiment of the present invention.

FIG. **20** shows a case that a time section for an intentional delay is set equal to or greater than a maximum roundtrip delay time, which is physically possible, to discriminate a physical delay time.

In particular, an RACH or ranging channel signal from a UE in a region located at a cell edge selecting a transmission timing point as a section **1** according to information to be delivered is set to arrive at a base station faster than an RACH or ranging channel signal of a UE in a region at a cell center selecting a transmission timing point as a section **2**. In case that a time section for an intentional delay is set to a first time section and a time section according to a physical delay time is set to a second time section, it is assumed that the first time section is wider than the second time section and that a section according to all the second time sections is included each section on a time axis having the first time section.

Hence, it is able to prevent a location of a UE having transmitted a corresponding RACH or ranging channel signal from being confused due to an intentional delay according to information to be delivered.

A base station is able to select a search target sequence set according to a delay time of a received signal in each section shown in FIG. **20**. For instance, search is carried out in a manner of setting a sequence set having ZCZ_i of a mother sequence called a sequence a until a prescribed time in a section **1** shown in FIG. **20** and then using a sequence set having ZCZ_j of the same mother sequence as a search target sequence after the corresponding time.

Hence, as a number of search target sequences is decremented, calculation complexity in the base station can be reduced.

Meanwhile, the UE selects a section for transmitting an RACH or ranging channel signal with an intentional delay according to information to be delivered to the base station and then transmits the signal. The base station then interprets the delivered information according to which section corresponds to a start timing point of the sequence used for the received RACH or ranging channel signal.

In this case, if each section uses a different mother sequence, it is preferable to reduce vagueness of discrimination. And, FIG. **20** shows that a sequence b as a different mother sequence is used for the section **2** unlike the section **1**. Of course, if a search target sequence set is selected within the section **2** using a physical delay time, it is able to facilitate the base station to perform a sequence search.

To carry out the above-explained sequence searching and signal transmitting/receiving methods, the following device configuration is preferably used. A sequence searching device and a signal transmitting device are explained as follows.

FIG. **21** is a block diagram of a sequence searching device for searching a sequence used for a received RACH or ranging channel signal and a signal transmitting device of a base station for interpreting received information as soon as the sequence is searched according to one embodiment of the present invention.

Referring to FIG. **21**, a signal transmitting device according to one embodiment of the present invention includes a transmitting unit **901**, a receiving unit **902**, and a sequence searching unit **903**.

The sequence searching unit **903** shown in FIG. **21** is cable of playing a role as an independent sequence searching device. And, the sequence searching unit **903** can include a search sequence set selecting unit **903***a*, a used sequence searching unit **903***b*, and a sequence set storing unit **903***c*.

A signal transmitting device according to another embodiment of the present invention can further include an information interpreting unit **904** as well as the above-explained elements.

The above device configuration is included in a base station. And, the base station can include a transmitting unit **901** and a duplexer **905** enabling an antenna to be shared by the transmitting unit **901** and the receiving unit **902**.

Details of the above elements are explained in the following description.

According to one embodiment of the present invention, the base station is able to transmit a downlink signal via the transmitting unit **901**. And, the transmitting unit **901** can include a transmission timing point recording unit **901***a* recording a timing point ts of transmitting the downlink signal.

Such a transmission signal is transmitted in downlink via the duplexer **905**. If a UE transmits an RACH or ranging channel signal in response to the transmission signal, the base station receives the RACH or the ranging channel signal via the duplexer **905** using the receiving unit **902**.

And, the receiving unit **902** can have a reception timing point recording unit **902***b* recording a timing point tr of receiving the RACH or the ranging channel signal like the transmitting unit **901**.

Informations ts and tr for the timing points of the transmission and reception timing point recording units **901***a* and **902***a* are inputted to the search sequence set selecting unit **903***a*.

The search sequence selecting unit **903***a* calculates a roundtrip delay time RTD via a delay time corresponding to a difference between the transmission timing point ts and the reception timing point tr and then selects a search target sequence set (sequence set_a) from stored sequence sets stored in the sequence set storing unit **903***c* through the calculated roundtrip delay time RTD. Information on the selected search target sequence set (sequence set_a) is then delivered to the used sequence searching unit **903***b*.

The used sequence searching unit **903***b* searches that a sequence used for the RACH or ranging channel signal received by the receiving unit **902** belongs to which sequence of the search target sequence set (sequence set_a). This search can be executed by a correlation operation between the RACH or ranging channel signal and each of search target sequences or decided by another arbitrary operation.

Thus, in case that the used sequence searching unit **903***b* checks which sequence is used for the received RACH or ranging channel signal, synchronization is estimated using the corresponding sequence. If there exists information inserted in the corresponding sequence, it can be obtained.

According to another embodiment of the present invention, an information interpreting unit **904** can be included to interpret information delivered to the base station through an extent of a delay confirmed through the timing point information of the transmitting unit **901** and the receiving unit **902**, and more particularly, through an extent of the intentional delay explained with reference to FIG. **19** and FIG. **20**.

The information interpreting unit **904** is able to receive transmission timing point information ts from the reception timing point recording unit **901***a* of the transmitting unit and reception timing point information tr from the reception timing point recording unit **902***a* of the receiving unit **902**.

Through this, the information interpreting unit **904** is able to calculate a roundtrip delay time of a received signal. In the present embodiment, the roundtrip delay time includes an intentional delay time for information delivery as well as a

physical delay attributed to an intra-cell location of the UE having transmitted the corresponding signal.

Information obtained by the information interpreting unit **904** through the roundtrip delay time information includes CQ information, random access cause information, random ID information, and the like, as shown in FIG. **21**. And, every random information deliverable to the base station via an uplink signal can be included in the corresponding information.

Configurational features of a signal transmitting device of a UE according to one embodiment of the present invention are explained as follows.

FIG. **22** is a block diagram of a signal transmitting device of a UE for transmitting a signal in a manner of inserting intentional delay information in an RACH or ranging channel signal according to one embodiment of the present invention.

Referring to FIG. **22**, a signal transmitting device according to one embodiment of the present invention includes a receiving unit **1001**, a transmitting unit **1002**, and a transmission timing point delaying unit **1003**.

The signal transmitting device is preferably included in a UE and can include a duplexer **1004** for enabling an antenna to be shared by both of the receiving and transmitting units **1001** and **1002**. The respective elements are explained in more detail as follows.

First of all, the receiving unit **1001** receives a downlink signal transmitted by a base station and then records a corresponding reception timing point. Such a reception timing point recording, as shown in FIG. **22**, can be performed by a separate reception timing point recording unit **1001***a*.

The UE having received the downlink signal is able to transmit a necessary RACH or ranging channel signal if a random access to the base station is needed. And, such an RACH or ranging channel signal can be transmitted via the transmitting unit **1002**.

Yet, according to one embodiment of the present invention, a transmission timing point delaying unit **1003** can be further included to intentionally delay a transmission timing point according to information to be delivered to the base station in a downlink signal reception and an RACH or ranging channel signal transmission in response thereto. Through this, the base station receiving an RACH or ranging channel signal transmitted via the transmitting unit **1002** is able to obtain corresponding information according to an extent of an intentional delay.

Of course, as mentioned in the foregoing description with reference to FIG. **19** and FIG. **20**, a time intentionally delayed by the transmission timing point delaying unit **1002** is equal to greater than a quantity resulting from adding a physical delay according to an intra-cell location of a UE, i.e., a roundtrip delay time and a delay spreading together, which is preferable for the base station to discriminate a sequence.

The aspect in adjusting a setup for an RACH or a ranging channel based on intra-call location of UE is common to the first to third embodiments of the present invention.

The first embodiment of the present invention intensively deals with an RACH or ranging channel configuration itself according to RACH or ranging channel requisites differing from each other per UE.

The second embodiment of the present invention intensively deals with the aspect in transmitting an RACH or ranging channel.

And, the third embodiment of the present invention intensively deals with the aspect in receiving an RACH or ranging channel.

Moreover, the schemes according to the respective embodiments of the present invention can be appropriately combined together to be used by both of the transmitting and receiving sides.

For instance, in case that an RACH or a ranging channel is accessed using a sequence set differently allocated according to an intra-cell location of a UE and/or a cause for a UE to access the RACH or the ranging channel, a transmission timing point of the RACH or the ranging channel for an additional information transmission can be adjusted by the third embodiment to be transmitted.

And, a sequence set differently allocated according to an intra-cell location of each UE and/or a cause for a UE to access the RACH or the ranging channel according to the second embodiment can be a sequence set to be applied to an RACH or a ranging channel configured to meet a different RACH or ranging channel requisite per UE according to the first embodiment. Namely, if a sequence set is established according to the second embodiment, a peed of UE and the like can be additionally taken into consideration by considering such a condition as a frequency offset and the like according to the first embodiment.

Moreover, when a receiving side searches sequences by considering a delay time of an RACH or a ranging channel according to the third embodiment, a sequence set considered in accordance with each delay time can be a sequence set differently allocated in accordance with an intra-cell location of a UE and/or a cause for a UE to access an RACH or a ranging channel according to the second embodiment. This can be transmitted via an RACH or ranging channel structure established according to the first embodiment.

While the present invention has been described and illustrated herein with reference to the preferred embodiments thereof, it will be apparent to those skilled in the art that various modifications and variations can be made therein without departing from the spirit and scope of the invention. Thus, it is intended that the present invention covers the modifications and variations of this invention that come within the scope of the appended claims and their equivalents.

INDUSTRIAL APPLICABILITY

Accordingly, a signal transmitting/receiving method and apparatus and a sequence allocating method for the same according to the respective embodiments of the present invention are applicable to 3GPP LTE system.

Yet, a basic configuration of a scheme of allocating a sequence by considering different requisites in accordance with an intra-cell location of a UE and then detecting a corresponding sequence is applicable to every random mobile communication system to which a different requisite is requested in accordance with an intra-cell location of a UE, a terminal, a mobile device or the like as well as to the 3GPP LTE system.

What is claimed is:

1. A method for a specific user equipment (UE) to transmit a signal via a random access channel, the method comprising:

selecting one random access preamble sequence set from among predetermined random access preamble sequence sets considering at least one of a size of information to be transmitted by the specific UE and a degree of a path loss;

randomly selecting a specific sequence within the selected random access preamble sequence set; and

transmitting the selected sequence via the random access channel.

2. The method of claim **1**, wherein the specific sequence is a CAZAC (Constant Amplitude Zero Auto Correlation) sequence.

3. The method of claim **1**, wherein the path loss is determined as a path loss of a downlink signal.

4. The method of claim **1**, wherein the degree of the path loss is determined in accordance with a intra-cell location of the specific user equipment.

5. The method of claim **1**, wherein the predetermined random access preamble sequence sets are pre-allocated by being additionally discriminated in accordance with a cause for each user equipment to access the random access channel.

6. The method of claim **5**,

wherein the information to be transmitted by the specific user equipment comprises at least one of information on the cause to access the random access channel, a random ID, and a channel quality indicator (CQI).

7. The method of claim **5**, wherein the cause to access the random access channel comprises a handoff, a power-on, a resource request, and a synchronization acquisition.

8. An apparatus for transmitting a signal, the apparatus comprising:

a sequence selecting module acquiring information about predetermined two or more random access preamble sequence sets, selecting one random access preamble sequence set from among the predetermined random access preamble sequence sets considering at least one of a size of information to be transmitted by the apparatus and a degree of a path loss, and randomly selecting a specific sequence within the selected random access sequence set; and

an access module accessing a random access channel using the specific sequence selected by the sequence selecting module.

9. The apparatus of claim **8**, wherein the specific sequence is a CAZAC (Constant Amplitude Zero Auto Correlation) sequence.

10. The apparatus of claim **8**, wherein the degree of the path loss is determined in accordance with an intra-cell location of the apparatus.

11. The apparatus of claim **8**, wherein the predetermined random access preamble sequence sets are pre-allocated by being additionally discriminated in accordance with a cause for each user equipment to access the random access channel.

* * * * *

EXHIBIT 3

US007809373B2

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

(10) **Patent No.: US 7,809,373 B2**
(45) **Date of Patent: Oct. 5, 2010**

(54) **METHOD OF TRANSMITTING AND RECEIVING RADIO ACCESS INFORMATION IN A WIRELESS MOBILE COMMUNICATIONS SYSTEM**

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(73) Assignee: **LG Electronics Inc.**, Seoul (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 324 days.

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Related U.S. Application Data

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
H04W 36/00 (2009.01)

(52) **U.S. Cl.** **455/436**; 370/338; 370/349; 455/552

(58) **Field of Classification Search** 455/552, 455/450, 452, 458, 435, 436, 509; 370/338, 370/349, 329, 328, 466, 469, 335
See application file for complete search history.

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Assistant Examiner—Mahendra Patel
(74) *Attorney, Agent, or Firm*—Lee, Hong, Degerman, Kang & Waimey

(57) **ABSTRACT**

In a wireless mobile communications system, a method of transmitting and receiving radio access information that allows a faster and an efficient way of establishing a radio connection between a terminal and a target base station while performing a handover for the terminal to a cell of the target base station. The network transmits in advance, the radio access information and the like, to the terminal so that the terminal can be connected with the target cell in a faster manner which minimizes the total time for the handover process.

26 Claims, 7 Drawing Sheets

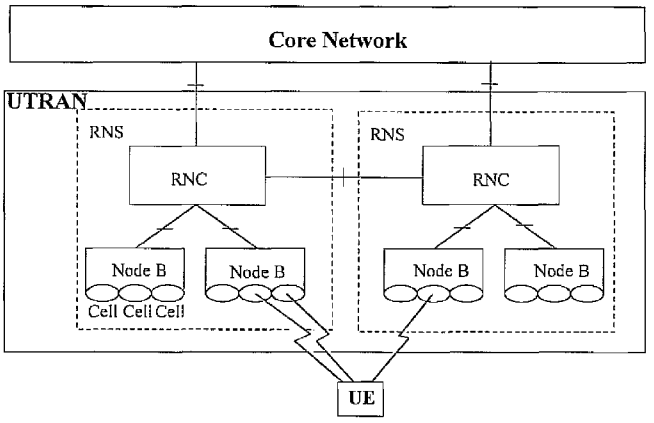

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Fig 1

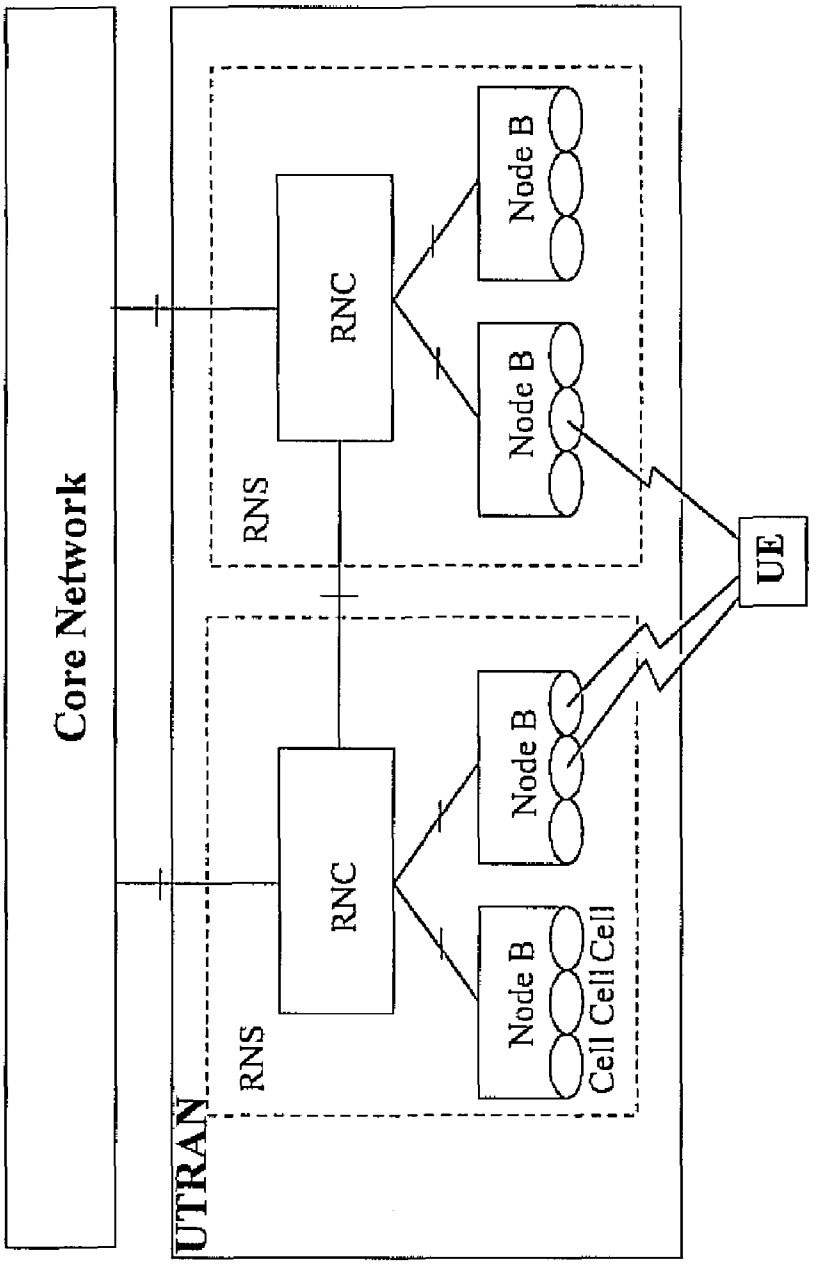

Core Network
UTRAN
RNS
RNC
Node B
Node B
RNS
RNC
Node B
Node B
Cell Cell Cell
UE

Fig 2

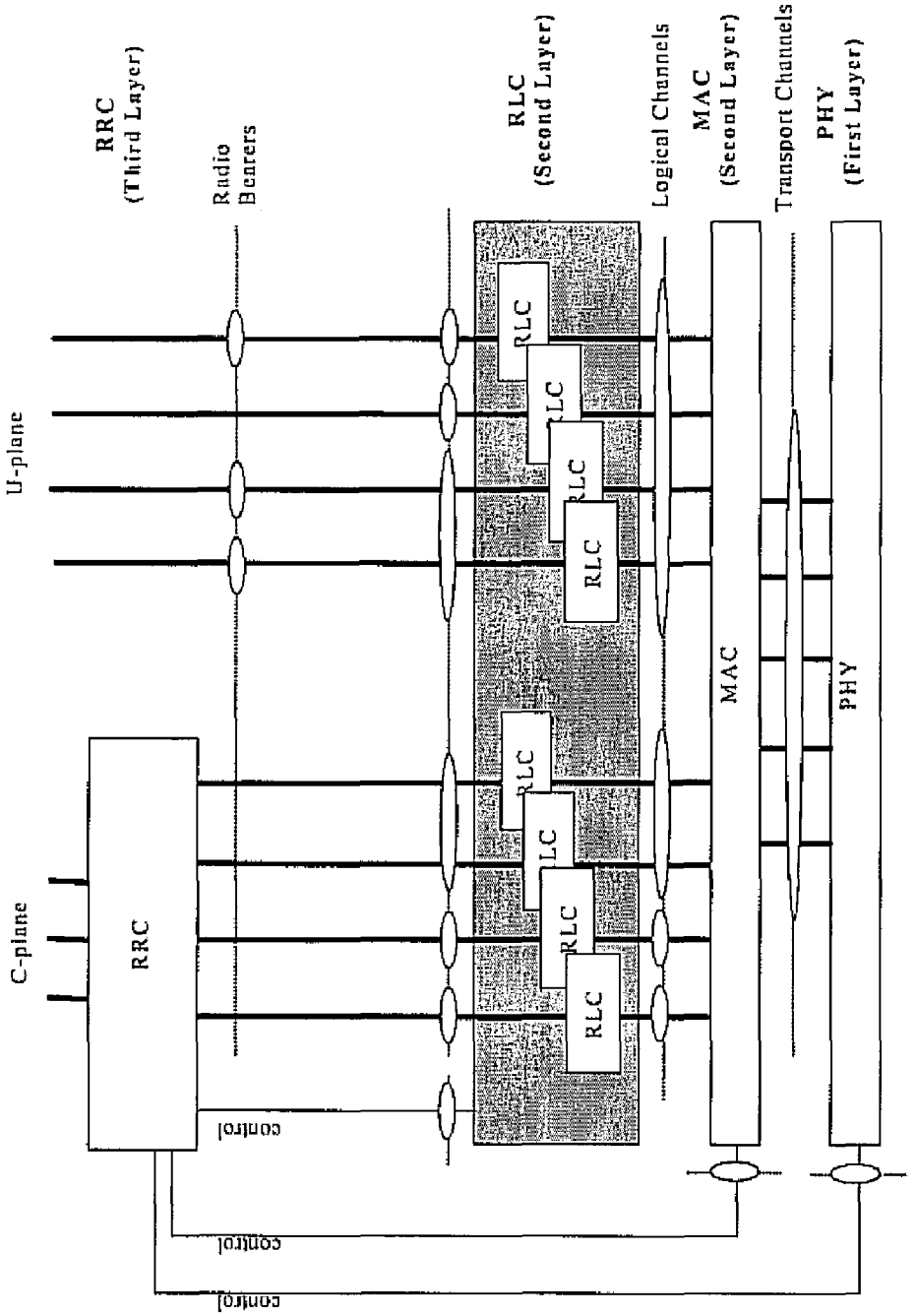

RRC
(Third Layer)
Radio
Bearers
RLC
(Second Layer)
Logical Channels
MAC
(Second Layer)
Transport Channels
PHY
(First Layer)
U-plane
C-plane
RRC
RLC
RLC
RLC
RLC
RLC
RLC
RLC
RLC
MAC
PHY
control
control
control

Fig 3

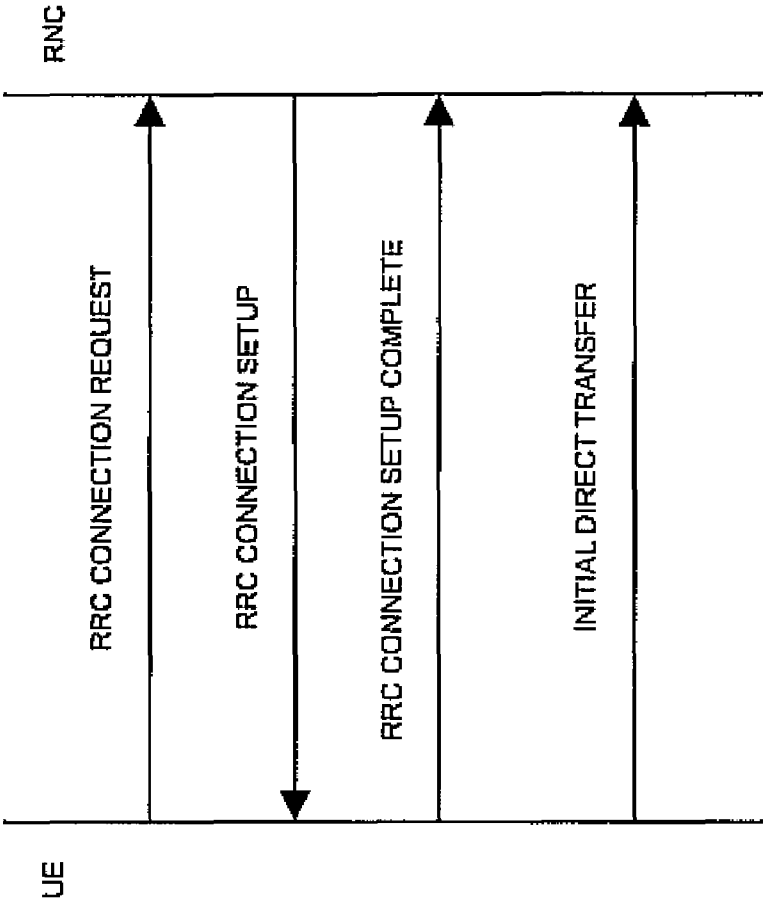

RNC
RRC CONNECTION REQUEST
RRC CONNECTION SETUP
RRC CONNECTION SETUP COMPLETE
INITIAL DIRECT TRANSFER
UE

Fig 5

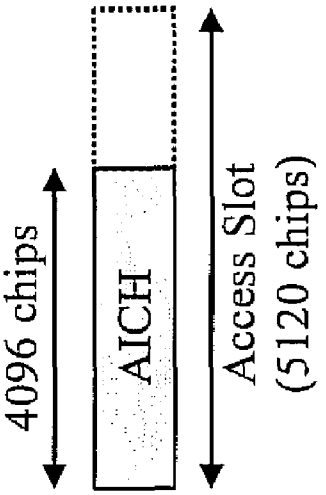

4096 chips
AICH
Access Slot
(5120 chips)

Fig 4

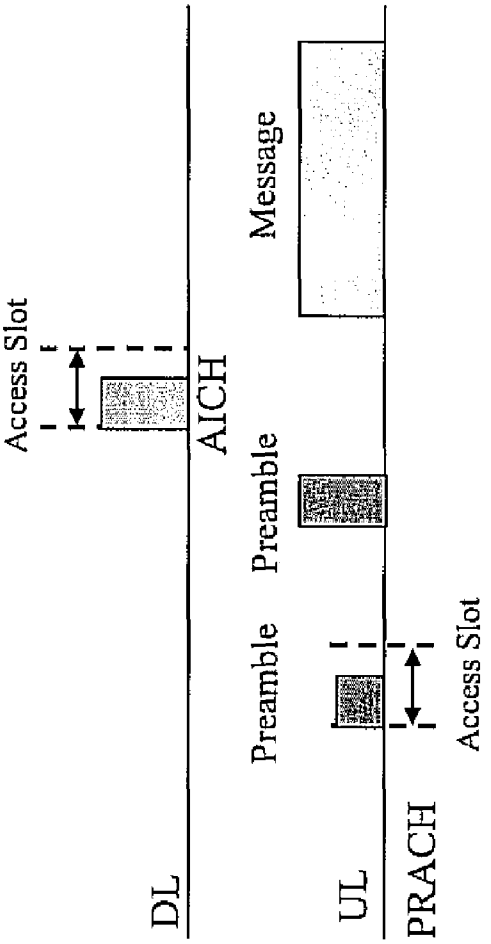

Access Slot
AICH
Message
Preamble
Preamble
Access Slot
DL
UL
PRACH

Fig 6

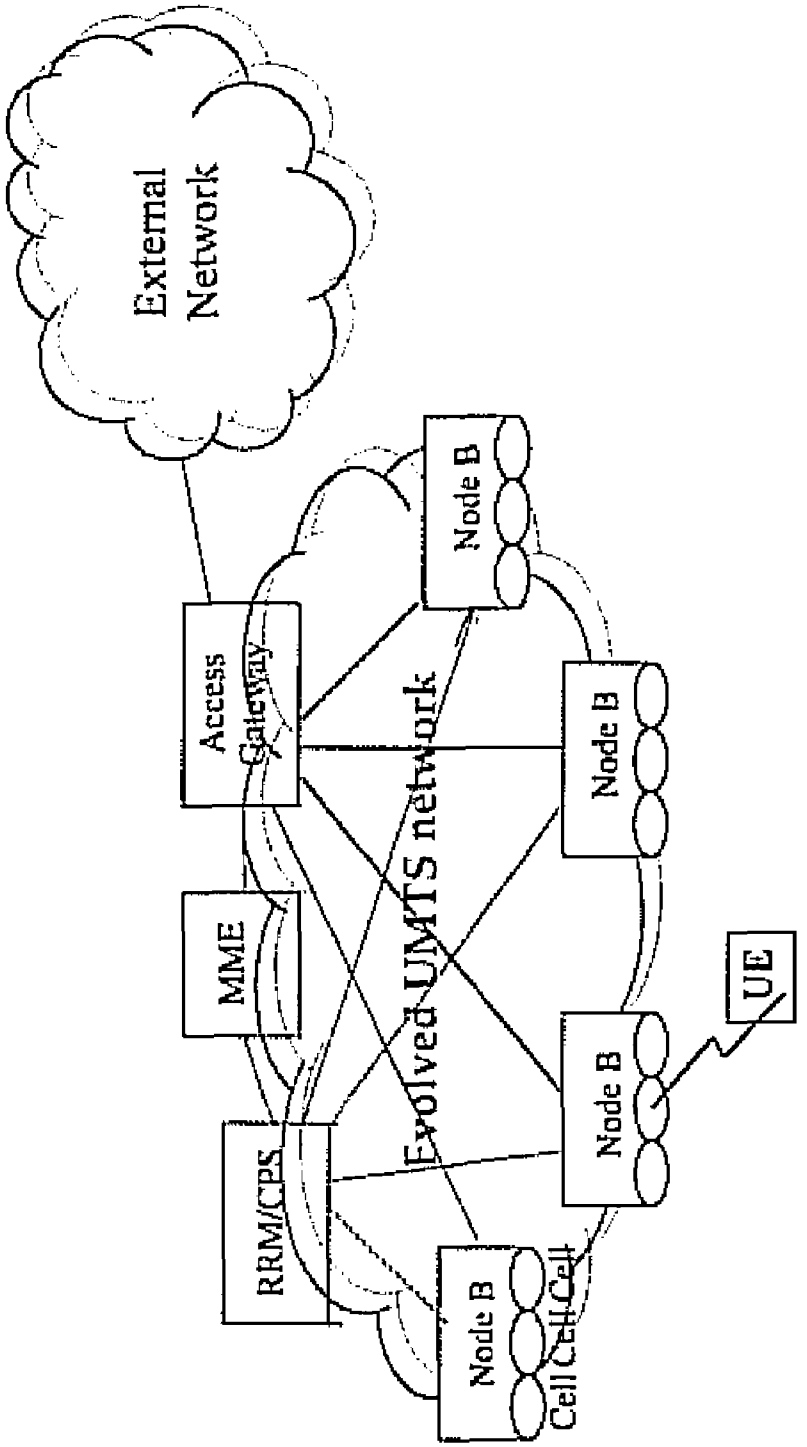

External Network
Access Gateway
MME
RRM/CPS
Evolved UMTS network
Node B
Node B
Node B
Node B
Cell Cell Cell
UE

Fig 8

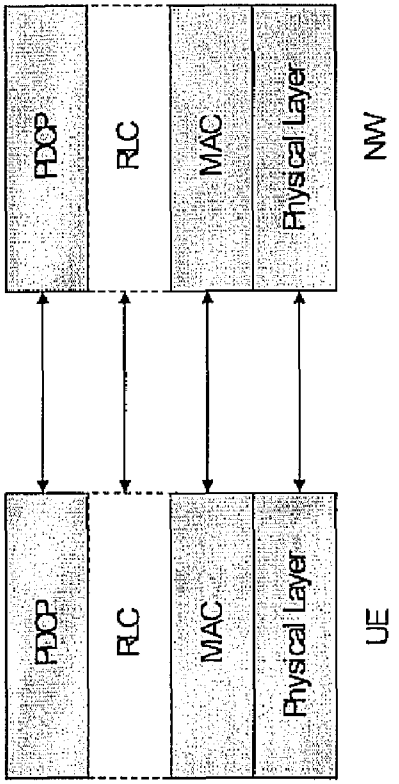

PDCP
RLC
MAC
Physical Layer
UE
PDCP
RLC
MAC
Physical Layer
NW

Fig 7

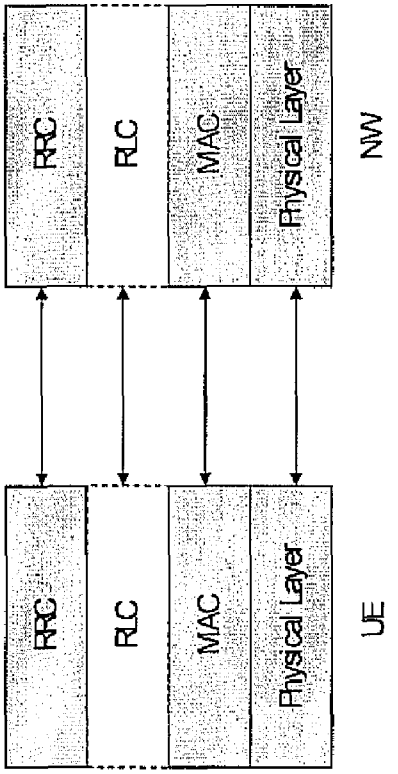
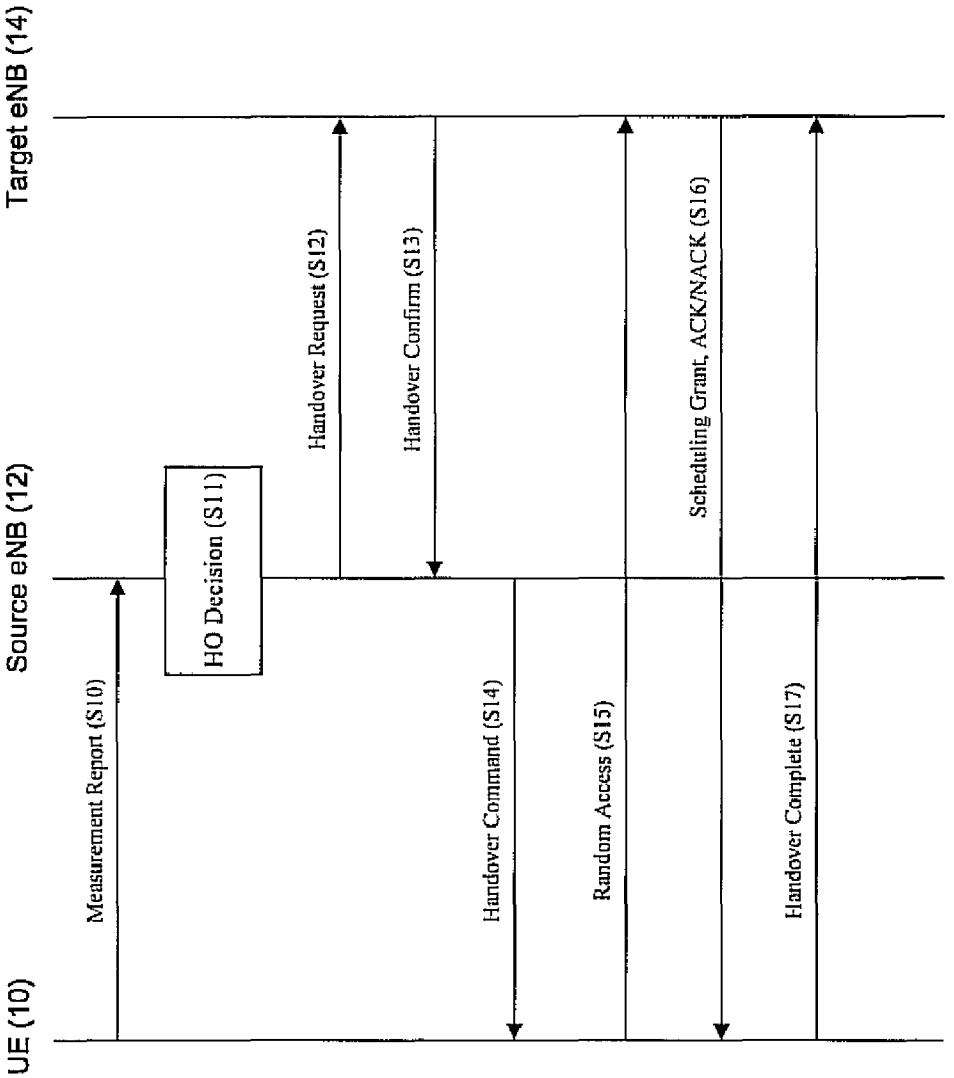

RRC
RLC
MAC
Physical Layer
UE
RRC
RLC
MAC
Physical Layer
NW

Fig 9


UE (10)
Source eNB (12)
Target eNB (14)
Measurement Report (S10)
HO Decision (S11)
Handover Request (S12)
Handover Confirm (S13)
Handover Command (S14)
Random Access (S15)
Scheduling Grant, ACK/NACK (S16)
Handover Complete (S17)

METHOD OF TRANSMITTING AND RECEIVING RADIO ACCESS INFORMATION IN A WIRELESS MOBILE COMMUNICATIONS SYSTEM

CROSS REFERENCE TO RELATED APPLICATION

Pursuant to 35 U.S.C. §119, this application claims the benefit of earlier filing date and right of priority to U.S. Provisional Application No. 60/732,080, filed Oct. 31, 2005, and Korean Patent Application No. 10-2006-0063135, filed Jul. 5, 2006, the contents of which are hereby incorporated by reference herein in their entirety.

FIELD OF THE INVENTION

The present invention relates to wireless (radio) mobile communications systems, and in particular, relates to a method of transmitting and receiving radio connection information that allows a terminal to access a target base station (i.e., target eNB) in a faster and more efficient manner while performing a handover for the terminal to a cell of the target base station.

BACKGROUND ART

The universal mobile telecommunications system (UMTS) is a third-generation mobile communications system evolving from the global system for mobile communications system (GSM), which is the European standard. The UMTS is aimed at providing enhanced mobile communications services based on the GSM core network and wideband code-division multiple-access (W-CDMA) technologies.

FIG. **1** shows an exemplary diagram illustrating an Universal Mobile Telecommunication System (UMTS) network of a conventional mobile communication system. The UMTS is comprised of, largely, a user equipment (UE) or terminal, a UMTS Terrestrial Radio Access Network (UTRAN), and a core network (CN). The UTRAN comprises at least one Radio Network Sub-system (RNS), and each RNS is comprised of one Radio Network Controller (RNC) and at least one base station (Node B) which is controlled by the RNC. For each Node B, there is at least one cell.

FIG. **2** is an exemplary diagram illustrating a structure of a Radio Interface Protocol (RIP) between a UE and the UTRAN. Here, the UE is associated with a 3rd Generation Partnership Project (3GPP) wireless access network standard. The structure of the RIP is comprised of a physical layer, a data link layer, and a network layer on the horizontal layers. On the vertical plane, the structure of the RIP is comprised of a user plane, which is used for transmitting data, and a control plane, which is used for transmitting control signals. The protocol layers of FIG. **2** can be categorized as L1 (first layer), L2 (second layer), and L3 (third layer) based on an Open System Interconnection (OSI) model. Each layer will be described in more detail as follows. The first layer (L1), namely, the physical layer, provides an upper layer with an information transfer service using a physical channel. The physical layer is connected to an upper layer called a medium access control (MAC) layer through a transport channel. Data is transferred between the MAC layer and the physical layer through the transport channel. Data is also transferred between different physical layers, i.e. between physical layers of a transmitting side and a receiving side, through the physical channel.

The MAC layer of the second layer (L2) provides an upper layer called a radio link control (RLC) layer with a service through a logical channel. The RLC layer of the second layer supports reliable data transfer and performs segmentation and concatenation of a service data unit (SDU) received from an upper layer.

A radio resource control (RRC) layer at a lower portion of the L3 layer is defined in the control plane and controls logical channels, transport channels, and physical channels for configuration, re-configuration and release of radio bearers (RBs). A RB is a service provided by the second layer for data transfer between the terminal and the UTRAN. The configuration of the RBs includes defining characteristics of protocol layers and channels required to provide a specific service, and configuring respective specific parameters and operation methods.

A RRC connection and a signaling connection will be described in more detail as follows.

In order to perform communications, a terminal needs to have a RRC connection with the UTRAN and a signaling connection with the Core Network (CN). The terminal transmits and/or receives a terminal's control information with the UTRAN or the CN via the RRC connection and the signaling connection.

FIG. **3** shows an exemplary diagram for explaining how a RRC connection is established.

In FIG. **3**, to establish the RRC connection, the terminal transmits a RRC Connection Request Message to the RNC, and then the RNC transmits a RRC Connection Setup Message to the terminal in response to the RRC Connection Request Message. After receiving the RRC Connection Setup Message by the terminal, the terminal transmits a RRC Connection Setup Complete Message to the RNC. If the above steps are successfully completed, the terminal establishes the RRC connection with the RNC. After the RRC connection is established, the terminal transmits an Initial Direct Transfer (IDT) message to the RNC for initializing a process of the signaling connection.

A Random Access Channel of a WCDMA will be described in more detail as follows.

The Random Access Channel (RACH) is used to transfer a short length data on an uplink, and some of the RRC message (i.e., RRC Connection Request Message, Cell Update Message, URA Update Message) is transmitted via the RACH. The RACH is mapped to a Common Control Channel (CCCH), a Dedicated Control Channel (DCCH) and a Dedicated Traffic Channel (DTCH), and then the RACH is mapped to a Physical Random Access Channel.

FIG. **4** shows how the physical random access channel (PRACH) power ramping and message transmission may be performed.

Referring to FIG. **4**, the PRACH, which is an uplink physical channel, is divided into a preamble part and a message part. The preamble part is used to properly control a transmission power for a message transmission (i.e., a power ramping function] and is used to avoid a collision between multiple terminals. The message part is used to transmit a MAC PDU that was transferred from the MAC to the Physical channel.

When the MAC of the terminal instructs a PRACH transmission to the physical layer of the terminal, the physical layer of the terminal first selects one access slot and one (preamble) signature, and transmits the preamble on the PRACH to an uplink. Here, the preamble is transmitted within a particular the length of access slot duration (e.g., 1.33

ms). One signature is selected among the 16 different signatures within a first certain length of the access slot, and it is transmitted.

If the preamble is transmitted from the terminal, a base station transmits a response signal via an Acquisition indicator channel (AICH) which is a downlink physical channel. The AICH, in response to the preamble, transmits a signature that was selected within the first certain length of the access slot. Here, the base station transmits an ACK response or a NACK response to the terminal by means of the transmitted signature from the AICH.

If the ACK response is received, the terminal transmits a 10 ms or 20 ms length of the message part using an OVSF code that correspond with the transmitted signature. If the NACK response is received, the MAC of the terminal instructs the PRACH transmission again to the physical layer of the terminal after a certain time period. Also, if no AICH is received with respect to the transmitted preamble, the terminal transmits a new preamble with a higher power compared to that used for the previous preamble after a predetermined access slot.

FIG. **5** illustrates an exemplary structure of an Acquisition Indicator Channel (AICH).

As shown in FIG. **5**, the AICH, which is a downlink physical channel, transmits 16 symbol signatures (Si, i=0, . . . 15) for the access slot having a length of 5120 chips. The terminal may select any arbitrary signature (Si) from **S0** signature to **S15** signature, and then transmits the selected signature during the first 4096 chips length. The remaining 1024 chips length is set as a transmission power off period during which no symbol is transmitted. Also, as similar to FIG. **51** the preamble part of the uplink PRACH transmits 16 symbol signatures (Si, i=0, . . . , 15) during the first 4096 chips length.

An Evolved Universal Mobil Telecommunication System (E-UMTS) will be described in more detail as follows.

FIG. **6** shows an exemplary structure of an Evolved Universal Mobile Telecommunications System (E-UMTS). The E-UMTS system is a system that has evolved from the UMTS system, and its standardization work is currently being performed by the 3GPP standards organization.

The E-UMTS network generally comprises at least one mobile terminal (i.e., user equipment: UE), base stations (i.e., Node Bs), a control plane server (CPS) that performs radio (wireless) control functions, a radio resource management (RRM) entity that performs radio resource management functions, a mobility management entity (MME) that performs mobility management functions for a mobile terminal, and an access gateway (AG) that is located at an end of the E-UMTS network and connects with one or more external networks. Here, it can be understood that the particular names of the various network entities are not limited to those mentioned above.

The various layers of the radio interface protocol between the mobile terminal and the network may be divided into L1 (Layer 1), L2 (Layer 2), and L3 (Layer 3) based upon the lower three layers of the Open System Interconnection (OSI) standard model that is known the field of communication systems. Among these layers, a physical layer that is part of Layer 1 provides an information transfer service using a physical channel, while a Radio Resource Control (RRC) layer located in Layer 3 performs the function of controlling radio resources between the mobile terminal and the network. To do so, the RRC layer exchanges RRC messages between the mobile terminal and the network. The functions of the RRC layer may be distributed among and performed within the Node B, the CPS/RRM and/or the MME.

FIG. **7** shows an exemplary architecture of the radio interface protocol between the mobile terminal and the UTRAN (UMTS Terrestrial Radio Access Network). The radio interface protocol of FIG. **7** is horizontally comprised of a physical layer, a data link layer, and a network layer, and vertically comprised of a user plane for transmitting user data and a control plane for transferring control signaling. The radio interface protocol layer of FIG. **2** may be divided into L1 (Layer 1), L2 (Layer 2), and L3 (Layer 3) based upon the lower three layers of the Open System Interconnection (OSI) standards model that is known the field of communication systems.

Particular layers of the radio protocol control plane of FIG. **7** and of the radio protocol user plane of FIG. **8** will be described below. The physical layer (i.e., Layer 1) uses a physical channel to provide an information transfer service to a higher layer. The physical layer is connected with a medium access control (MAC) layer located thereabove via a transport channel, and data is transferred between the physical layer and the MAC layer via the transport channel. Also, between respectively different physical layers, namely, between the respective physical layers of the transmitting side (transmitter) and the receiving side (receiver), data is transferred via a physical channel.

The MAC layer of Layer 2 provides services to a radio link control (RLC) layer (which is a higher layer) via a logical channel. The RLC layer of Layer 2 supports the transmission of data with reliability. It should be noted that the RLC layer in FIG. **7** is depicted in dotted lines, because if the RLC functions are implemented in and performed by the MAC layer, the RLC layer itself may not need to exist. The PDCP layer of Layer 2 performs a header compression function that reduces unnecessary control information such that data being transmitted by employing Internet protocol (IP) packets, such as IPv4 or IPv6, can be efficiently sent over a radio (wireless) interface that has a relatively small bandwidth.

The radio resource control (RRC) layer located at the lowermost portion of Layer 3 is only defined in the control plane, and handles the control of logical channels, transport channels, and physical channels with respect to the configuration, re-configuration and release of radio bearers (RB). Here, the RB refers to a service that is provided by Layer 2 for data transfer between the mobile terminal and the UTRAN.

As for channels used in downlink transmission for transmitting data from the network to the mobile terminal, there is a broadcast channel (BCH) used for transmitting system information, and a shared channel (SCH) used for transmitting user traffic or control messages. Also, as a downlink transport channel, there is a downlink Shared Control Channel (SCCH) that transmits necessary control information for the terminal to receive the downlink SCH. The downlink SCCH transmission includes information regarding a data variation, a data channel coding technique, and a data size where the data is transmitted to the downlink SCH.

As for channels used in uplink transmission for transmitting data from the mobile terminal to the network, there is a random access channel (RACH) used for transmitting an initial control message, and a shared channel (SCH) used for transmitting user traffic or control messages. Also, in an uplink transport channel, there is an uplink Shared Control Channel (SCCH) that transmits necessary control information for the terminal to receive the uplink SCH. The uplink SCCH transmission includes information regarding a data variation, a data channel coding technique, and a data size where the data is transmitted to the uplink SCH.

In the related art, when the mobile terminal moves from a source cell to a target cell, the mobile terminal uses a RACH

to transmit a cell update message to the target cell. Namely, in order to transmit the cell update message, the terminal uses the RACH for an uplink time synchronization with the target cell and for an uplink resource allocation. However, due to a collision possibility of the RACH, the message transmission my be delayed, and a handover processing time is increased because of the possibility of RACH collision.

SUMMARY

The present invention has been developed in order to solve the above described problems of the related art. As a result, the present invention provides a method of transmitting and receiving control radio connection information that allows a faster and an efficient way of accessing a terminal to a target base station while performing a handover for the terminal to a cell of the target base station.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows an exemplary diagram illustrating an Universal Mobile Telecommunication System (UMTS) network of a conventional mobile communication system.

FIG. **2** shows an exemplary diagram illustrating a structure of a Radio Interface Protocol (RIP) between a UE and the UTRAN.

FIG. **3** shows an exemplary diagram for explaining how a RRC connection is established.

FIG. **4** shows how the physical random access channel (PRACH) power ramping and message transmission may be performed.

FIG. **5** illustrates an exemplary structure of an Acquisition Indicator Channel (AICH).

FIG. **6** shows an overview of an E-UMTS network architecture.

FIGS. **7** and **8** show an exemplary structure (architecture) of a radio interface protocol between a mobile terminal and a UTRAN according to the 3GPP radio access network standard.

FIG. **9** shows an exemplary diagram for transmitting and receiving radio connection information according to an exemplary embodiment of the present invention.

DESCRIPTION

One aspect of the present invention is the recognition by the present inventors regarding the problems and drawbacks of the related art described above and explained in more detail hereafter. Based upon such recognition, the features of the present invention have been developed.

In the related art, when the mobile terminal moves from a source cell to a target cell, the mobile terminal uses a RACH to transmit a cell update message to the target cell. However, because of a possibility for a RACH collision (i.e. the same signature is being selected from multiple terminals that use of the RACH), the processing time for the handover process may be delayed.

In contrast, the features of the present invention provide that the terminal receives necessary information from a source cell in advance (i.e., before the terminal transmits a RACH setup request to a network) in order to utilize the RACH in a later step. As a result, the terminal can connect with the target cell with minimal delays.

It should be noted that the features of the present invention may be related to issues regarding the long-term evolution (LTE) of the 3GPP standard. As such, the 3GPP standard and its related sections or portions thereof, as well as various developing enhancements thereof pertain to the present invention. For example, in present invention, a source enhanced Node B (eNB) may manage the source cell described above and a target enhanced Node B (eNB) may manage the target cell.

FIG. **9** shows an exemplary diagram for transmitting and receiving radio connection information according to an exemplary embodiment of the present invention.

As illustrated in FIG. **9**, the UE (or terminal) (**10**) may transmit a measurement report to the source eNB (**12**) by measuring a condition of a downlink physical channel for other cells periodically or upon the occurrence of event (i.e., user command, setting information, etc) (S**10**). As the measurement report is transmitted to the source eNB with a result for the measured condition of the downlink physical channel for other cells, the eNB may determine which cell, that the UE will be moved to, has a better channel condition compared to the current cell.

Using the measurement report which contains information about the condition of the downlink physical channel for other cells, the source eNB (**12**) may determine whether to perform a handover for the UE (**10**) from a current cell to the other cell, or whether to keep the UE in current cell (S**11**).

If the UE (**10**) needs to perform handover from the source eNB to an other particular cell, the source eNB (**12**) may transmit a handover request message to the target eNB (**14**) in order to request a handover for the UE to the target eNB. (S**12**) Here, the handover request message may include a UE identification (ID) and/or a buffer state of the UE.

If the target eNB (**14**) allows the handover to be performed for the UE upon receiving the handover request from the source eNB (**12**); the target eNB (**14**) may transmit a handover confirm message to the source eNB (**12**) (S**13**). The handover confirm message may include information that may be necessary in the course of connecting the UE (**10**) to the target cell. Namely, the necessary information may include information used in the RACH which is used for performing a radio access procedure from the UE to the target eNB. For example, when the RACH is being used while the UE accesses to the target eNB, the UE may utilize a preamble which is selected from signatures contained in the UE. System information transmitted from the eNB may include signatures related information. So, the UE may transmit the preamble to the eNB after selecting one of the signatures. However, in some cases, one or more UEs could select a same signature because there are a limited number of signatures. Therefore, if two or more UEs transmit the preamble of the same signature to the eNB at the same time, the eNB can not possibly determine which UE transmitted such preamble. To avoid this from happening, the UE should not transmit a preamble that is selected from the signatures used in the RACH during the handover; but rather, the UE may transmit a preamble of a previously defined signature through the handover confirm message from the target eNB. Here, the target eNB may acknowledge the mapping relationship between an UE's ID and the signature, where the UE's ID is transmitted from the Handover Request Message. Therefore, when the UE transmits the preamble to the target eNB for establishing a radio connection to the target cell, the target eNB may determine an ID of the UE using the preamble. Also, the Handover Confirm message may include a transmission characteristic of the preamble that is transmitted from the UE (**10**) to the target eNB (**14**). The transmission characteristic may relate to frequency and time used in transmitting the preamble information.

If the source eNB (**12**) receives the Handover confirm message of the UE from the target eNB (**14**), the source eNB

(**12**) may transmit a Handover Command message to the UE (**10**). (S**14**) The Handover Command message may include necessary information which comes from the target eNB, for establishing the radio connection to the target eNB. Also, the Handover Command message may include information of the signature and the preamble which is to be used in the access procedure to the target eNB.

The UE (**10**), which received the handover command message from the source eNB (**12**), may utilize the RACH for establishing the radio connection between the UE and the target eNB. (S**15**) Here, the preamble transmission of the UE is based upon information in the handover command message received from the source eNB (**12**). Also, if the information includes system information of the target eNB (**14**), the UE (**10**) may perform a radio accessing procedure without reading broadcast system information from the target eNB (**14**). For example, when the UE performs to establish the radio connection with a new cell, the UE usually reads system information of the corresponding eNB after time synchronization of the downlink. Since the system information includes information related to a radio access request message from the UE to an uplink, the radio accessing is performed after reading the system information. However, according to the present invention, the UE (**10**) may perform the radio access procedure without reading the system information in the target cell, as the system information of the target eNB is previously transmitted to the source eNB in advance and the system information was included in the handover command message.

The target eNB (**14**) may receive the preamble of the UE. Since the target eNB (**14**) already allocates a signature used in the preamble to the UE in the use of handover, the UE can be identified by the preamble. The target eNB (**14**) may allocate the uplink radio resource to the UE (**10**) for the UE to access the target eNB and to transmit the handover complete message to the target eNB. (S**16**) Also, the allocated radio resources information may be transmitted to the UE (**10**) via a downlink SCH. Alternatively, the allocated radio resources information may be transmitted via a downlink SCCH. Further, the allocated radio resources may be transmitted within an ACK/NACK signaling.

The UE (**10**) may transmit the handover complete message to the target eNB (**14**) based on a scheduling grant of the target eNB. (S**17**) If the scheduling grant includes information of allocated radio resources upon an allocation request of the uplink radio resources of the UE, the scheduling grant may be transmitted with the ACK/NACK signaling of the preamble transmitted from the UE (**10**). In this case, the Handover complete message from the UE may include a buffer state of the UE or its related information. If the allocated uplink radio resources, which is transmitted from the target eNB (**14**) to the UE (**10**), is sufficient, the handover complete message may be transmitted with additional traffic data when there is additional uplink traffic data.

It can be said that the present invention provides a method of transmitting access information in a mobile communications system, the method comprising: deciding to perform a handover for a terminal to a cell of a target base station; transmitting, to the target base station, a handover request for performing a handover from a source base station to the target base station; receiving access information from the target base station that received the handover request, wherein the access information is then transmitted to the terminal to access the target base station; receiving a measurement report from the terminal; determining whether to perform a handover based upon the received measurement report; and transmitting a handover command that contains the access information to the terminal upon receiving the response by the source base station, wherein the measurement report includes a downlink physical channel condition for multiple cells including the cell of the target base station, the handover request includes at least one of terminal identification (ID) information and/or buffer state information of the terminal, the access information is random access information, the access information is for a random access channel (RACH), the access information includes at least one of signature information and/or preamble information, the signature information is determined by the target base station based upon terminal identification information, the preamble information includes frequency information and time information, and the handover command includes access information which contains at least one of signature information and/or preamble information to allow the terminal to access the target base station.

Also, the present invention may provide a method of transmitting access information in a mobile communications system, the method comprising: receiving, from a source base station, a handover request for performing a handover from the source base station to a target base station; transmitting access information to the source base station upon receiving the handover request, wherein the access information is used to allow a terminal to access the target base station; allocating a radio resource for an uplink and transmitting radio resource allocation information to the terminal; receiving, from the terminal, preamble information of the terminal; and receiving a handover complete message from the terminal, wherein the radio resource allocation information is transmitted to the terminal through at least one of a downlink shared channel (SCH) and a downlink shared control channel (SCCH), an ACK/NACK signal includes the allocated resource information, the preamble information is used to identify the terminal, the handover complete message includes at least one of buffer state information of the terminal and uplink traffic data, and the handover complete message includes uplink traffic data if the radio resource allocation for the uplink is sufficient to transmit the uplink traffic data.

It can be said that the present invention provides a method of receiving access information in mobile communications system, the method comprising: receiving access information from a source base station after a handover is accepted by a target base station; performing a random access procedure with the target base station using the received access information; transmitting a measurement report to the source base station by measuring a condition of a downlink physical channel for other cells, the measuring performed periodically or upon an occurrence of an event; transmitting the preamble information to the target base station for performing a radio access procedure with the target cell; receiving, from a network, radio resource information through a downlink shared channel (SCCH); receiving, from a network, radio resource information within an ACK/NACK signaling; and transmitting a handover complete message to the target base station, wherein the measurement report is used to determine whether to perform a handover from a current cell to an other cell, the access information is random access information for a random access channel (RACH) which includes preamble information within signature information, the access information includes a transmission characteristic of the preamble information, the transmission characteristic relates to frequency and time used in transmitting the preamble information, the access information includes system information transmitted from the target base station, and the handover complete message includes at least one of buffer state information of the terminal and uplink traffic data.

The present invention also may provide a mobile terminal for establishing a radio connection to a target base station in a mobile communications system, the mobile terminal comprising: a radio protocol adapted to receive access information from a source base station after a handover is accepted by the target base station and to perform a random access procedure with the target base station using the received access information, wherein the source base station is a source enhanced Node B (source eNB) and the target base station is a target enhanced Node B (target eNB) respectively in an Evolved Universal Mobile Telecommunication System (E-UMTS).

Although the present invention is described in the context of mobile communications, the present invention may also be used in any wireless communication systems using mobile devices, such as PDAs and laptop computers equipped with wireless communication capabilities (i.e. interface). Moreover, the use of certain terms to describe the present invention should not limit the scope of the present invention to a certain type of wireless communication system. the present invention is also applicable to other wireless communication systems using different air interfaces and/or physical layers, for example, TDMA, CDMA, FDMA, WCDMA, OFDM, EV-DO, Mobile Wi-Max, Wi-Bro, etc.

The preferred embodiments may be implemented as a method, apparatus or article of manufacture using standard programming and/or engineering techniques to produce software, firmware, hardware, or any combination thereof. The term "article of manufacture" as used herein refers to code or logic implemented in hardware logic (e.g., an integrated circuit chip, Field Programmable Gate Array (FPGA), Application Specific Integrated Circuit (ASIC), etc.) or a computer readable medium (e.g., magnetic storage medium (e.g., hard disk drives, floppy disks, tape, etc.), optical storage (CD-ROMs, optical disks, etc.), volatile and non-volatile memory devices (e.g., EEPROMs, ROMs, PROMs, RAMs, DRAMs, SRAMs, firmware, programmable logic, etc).

Code in the computer readable medium is accessed and executed by a processor. The code in which preferred embodiments are implemented may further be accessible through a transmission media or from a file server over a network. In such cases, the article of manufacture in which the code is implemented may comprise a transmission media, such as a network transmission line, wireless transmission media, signals propagating through space, radio waves, infrared signals, etc. Of course, those skilled in the art will recognize that many modifications may be made to this configuration without departing from the scope of the present invention, and that the article of manufacture may comprise any information bearing medium known in the art.

This specification describes various illustrative embodiments of the present invention. The scope of the claims is intended to cover various modifications and equivalent arrangements of the illustrative embodiments disclosed in the specification. Therefore, the following claims should be accorded the reasonably broadest interpretation to cover modifications, equivalent structures, and features that are consistent with the spirit and scope of the invention disclosed herein.

The invention claimed is:

1. A method of transmitting access information in a mobile communications system, the method comprising:

deciding to perform a handover for a terminal to a cell of a target base station;

transmitting, from a source base station to the target base station, a handover request for performing a handover of the terminal from the source base station to the target base station;

receiving, at the source base station, access information from the target base station that received the handover request, wherein the receiving of the access information occurs after the transmitting of the handover request; and

transmitting, from the source base station to the terminal, the access information being configured to permit the terminal to access the target base station;

wherein the access information includes preamble information for a random access procedure,

wherein the preamble information is a dedicated preamble used only for a specific terminal, and

wherein the dedicated preamble is determined by the target base station.

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

receiving a measurement report from the terminal.

3. The method of claim **2**, wherein the measurement report includes a downlink physical channel condition for multiple cells including the cell of the target base station.

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

determining whether to perform a handover based upon the received measurement report.

5. The method of claim **1**, wherein the access information is for a random access channel (RACH).

6. The method of claim **1**, wherein the preamble information includes frequency information and time information.

7. The method of claim **1**, further comprising: transmitting a handover command that contains the access information to the terminal upon receiving the access information by the source base station.

8. A method of transmitting access information in a mobile communications system, the method comprising:

receiving, at a target base station from a source base station, a handover request for performing a handover of a terminal from the source base station to the target base station; and

transmitting, from the target base station to the source base station, access information upon receiving the handover request, wherein the access information is used to allow the terminal to access the target base station,

wherein the access information includes preamble information for a random access procedure,

wherein the preamble information is a dedicated preamble used only for a specific terminal, and

wherein the dedicated preamble is determined by the target base station.

9. The method of claim **8**, further comprising: allocating a radio resource for an uplink and transmitting radio resource allocation information to the terminal.

10. The method of claim **9**, wherein the radio resource allocation information transmits to the terminal through at least one of a downlink shared channel (SCH) and a downlink shared control channel (SCCH).

11. The method of claim **10**, wherein an ACK/NACK signal includes the allocated resource information.

12. The method of claim **8**, wherein the preamble information is used to identify the terminal.

13. The method of claim **8**, further comprising:

receiving a handover complete message from the terminal.

14. The method of claim **13**, wherein the handover complete message includes uplink traffic data if the radio resource allocation for the uplink is sufficient to transmit the uplink traffic data.

15. A method of receiving access information in a mobile communications system, the method comprising:

receiving access information from a source base station after a handover request is accepted by a target base station,

wherein the access information includes preamble information for a random access procedure,

wherein the preamble information is a dedicated preamble used only for a specific terminal, and

wherein the dedicated preamble is determined by the target base station; and

performing the random access procedure with the target base station using the received access information, such that the access information is configured to permit the terminal to access the target base station.

16. The method of claim **15**, further comprising:

transmitting a measurement report to the source base station by measuring a condition of a downlink physical channel for other cells, the measuring performed periodically or upon an occurrence of an event.

17. The method of claim **16**, wherein the measurement report is used to determine whether to perform a handover from a current cell to one of the other cells.

18. The method of claim **15**, further comprising:

transmitting the preamble information to the target base station for performing a radio access procedure with the target cell.

19. The method of claim **15**, wherein the access information includes a transmission characteristic of the preamble information, and the transmission characteristic relates to frequency and time used in transmitting the preamble information.

20. The method of claim **15**, wherein the access information includes system information transmitted from the target base station.

21. The method of claim **15**, further comprising:

receiving, from a network, radio resource information through a downlink shared channel (SCCH).

22. The method of claim **15**, further comprising:

receiving, from a network, radio resource information within an ACK/NACK signaling.

23. The method of claim **15**, further comprising:

transmitting a handover complete message to the target base station.

24. A mobile terminal for establishing a radio connection to a target base station in a mobile communications system, the mobile terminal comprising:

a radio protocol adapted to receive access information from a source base station after a handover request is accepted by the target base station and to perform a random access procedure with the target base station using the received access information, such that the access information is configured to permit the terminal to access the target base station,

wherein the access information includes preamble information for the random access procedure,

wherein the preamble information is a dedicated preamble used only for a specific terminal, and

wherein the dedicated preamble is determined by the target base station.

25. The terminal of claim **24**, wherein the source base station is a source enhanced Node B (source eNB) and the target base station is a target enhanced Node B (target eNB) respectively in an Evolved Universal Mobile Telecommunication System (E-UMTS).

26. The method of claim **1**, wherein the access information permits the terminal to access the target base station via a random access channel (RACH).

* * * * *

EXHIBIT 4

US007881236B2

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

(10) **Patent No.: US 7,881,236 B2**
(45) **Date of Patent: Feb. 1, 2011**

(54) **DATA TRANSMISSION METHOD AND USER EQUIPMENT FOR THE SAME**

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(73) Assignee: **LG Electronics Inc.**, Seoul (KR)

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

(21) Appl. No.: **12/538,514**

(22) Filed: **Aug. 10, 2009**

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
H04L 12/56 (2006.01)
H04J 1/16 (2006.01)

(52) **U.S. Cl.** **370/278**; 370/329; 370/412

(58) **Field of Classification Search** 370/329, 370/412, 278

See application file for complete search history.

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Primary Examiner—John Pezzlo
(74) *Attorney, Agent, or Firm*—Birch, Stewart, Kolasch & Birch, LLP

(57) **ABSTRACT**

A mobile communication technology, and, more particularly, a method for efficiently transmitting data stored in a message **3** (Msg**3**) buffer and a user equipment for the same is disclosed. The method of transmitting data by a user equipment in uplink includes receiving an uplink (UP) Grant signal from a base station on a specific message, determining whether there is data stored in a message **3** (Msg**3**) buffer when receiving the UL Grant signal on the specific message, determining whether the specific message is a random access response message, and transmitting the data stored in the Msg**3** buffer to the base station using the UL Grant signal received on the specific message, if there is data stored in the Msg**3** buffer when receiving the UL Grant signal on the specific message and the specific message is the random access response message.

13 Claims, 10 Drawing Sheets

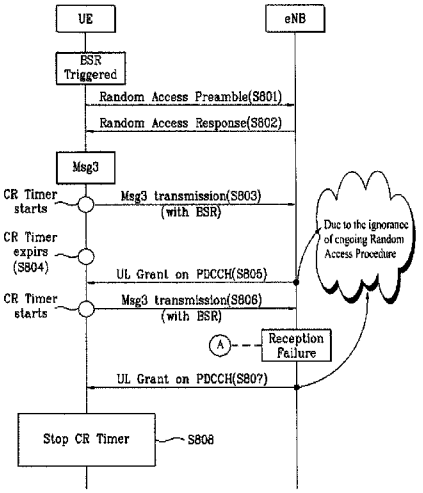

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FIG. 1

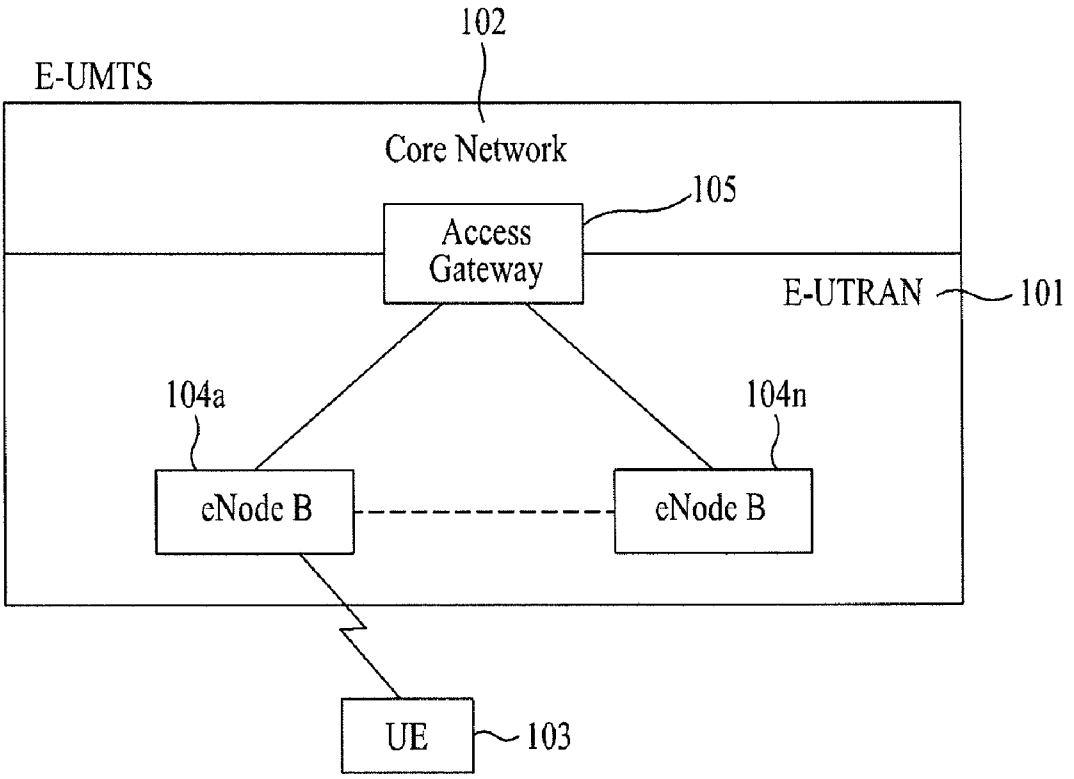

102
E-UMTS
Core Network
105
Access Gateway
E-UTRAN
101
104a
104n
eNode B
eNode B
UE
103

FIG. 2

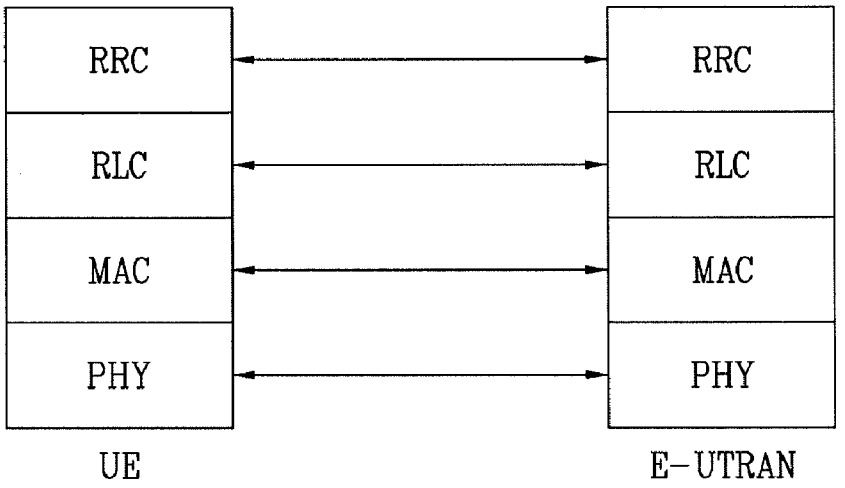

RRC
RLC
MAC
PHY
UE
RRC
RLC
MAC
PHY
E-UTRAN

FIG. 3

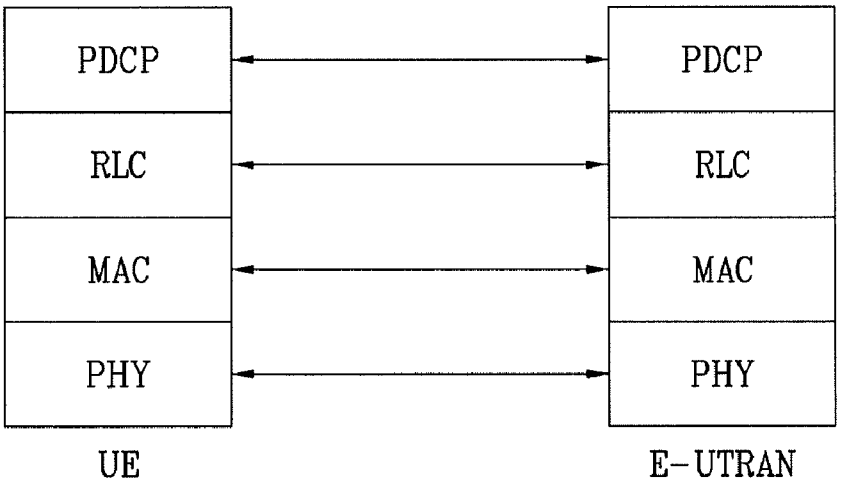

PDCP
RLC
MAC
PHY
UE
PDCP
RLC
MAC
PHY
E-UTRAN

FIG. 4

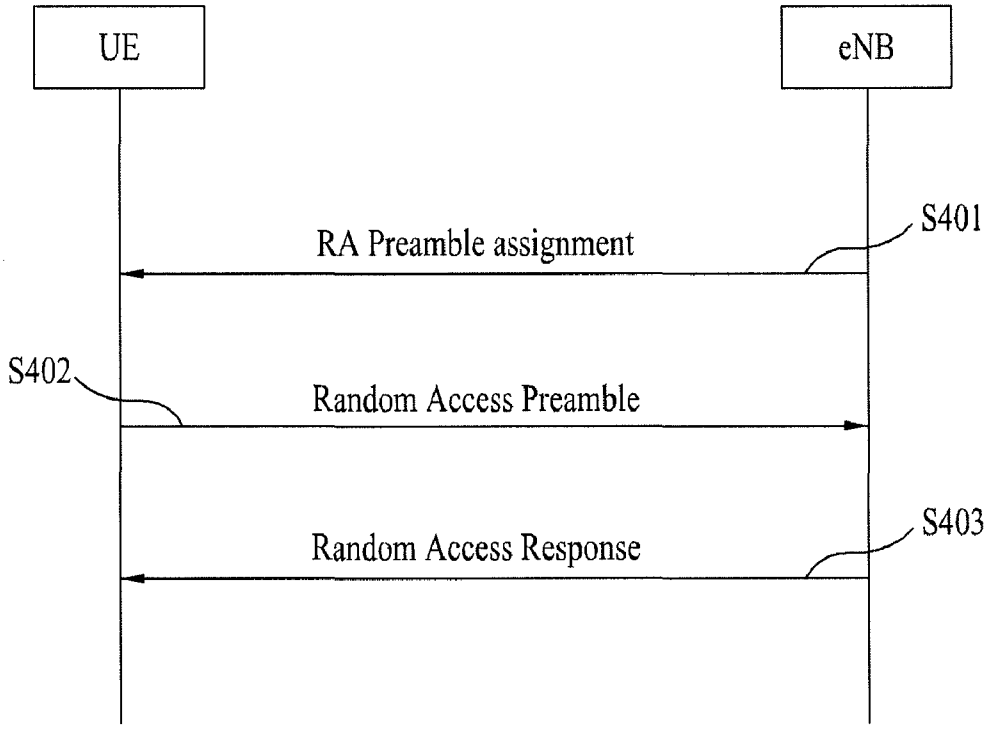

UE
eNB
S401
RA Preamble assignment
S402
Random Access Preamble
S403
Random Access Response

FIG. 5

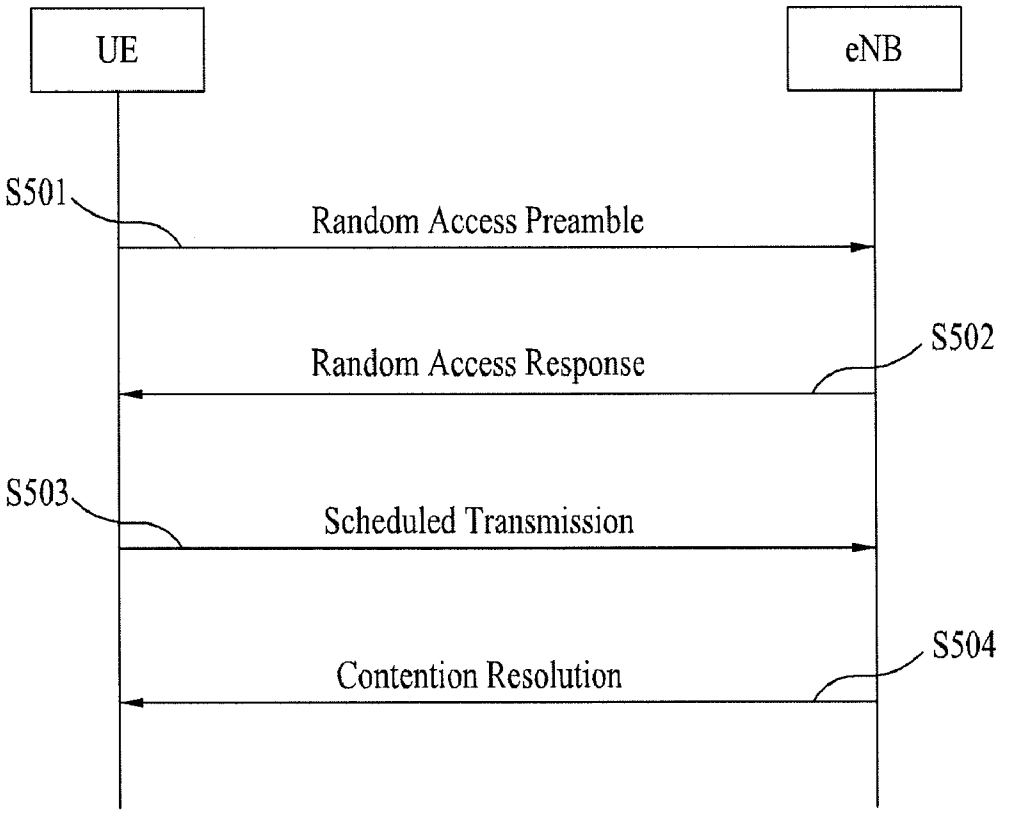

UE
eNB
S501
Random Access Preamble
S502
Random Access Response
S503
Scheduled Transmission
S504
Contention Resolution

FIG. 6

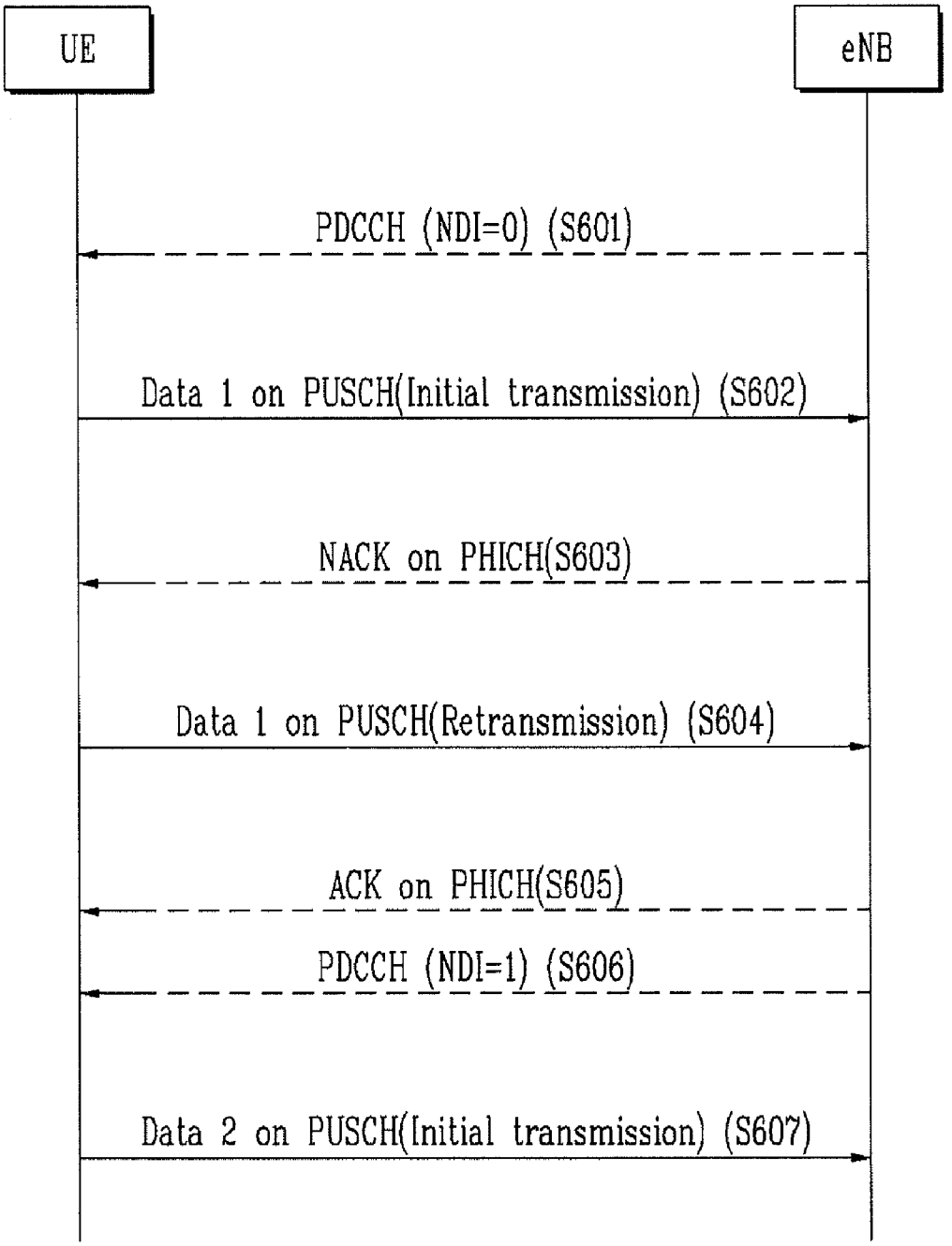

UE
eNB
PDCCH (NDI=0) (S601)
Data 1 on PUSCH(Initial transmission) (S602)
NACK on PHICH(S603)
Data 1 on PUSCH(Retransmission) (S604)
ACK on PHICH(S605)
PDCCH (NDI=1) (S606)
Data 2 on PUSCH(Initial transmission) (S607)

FIG. 7

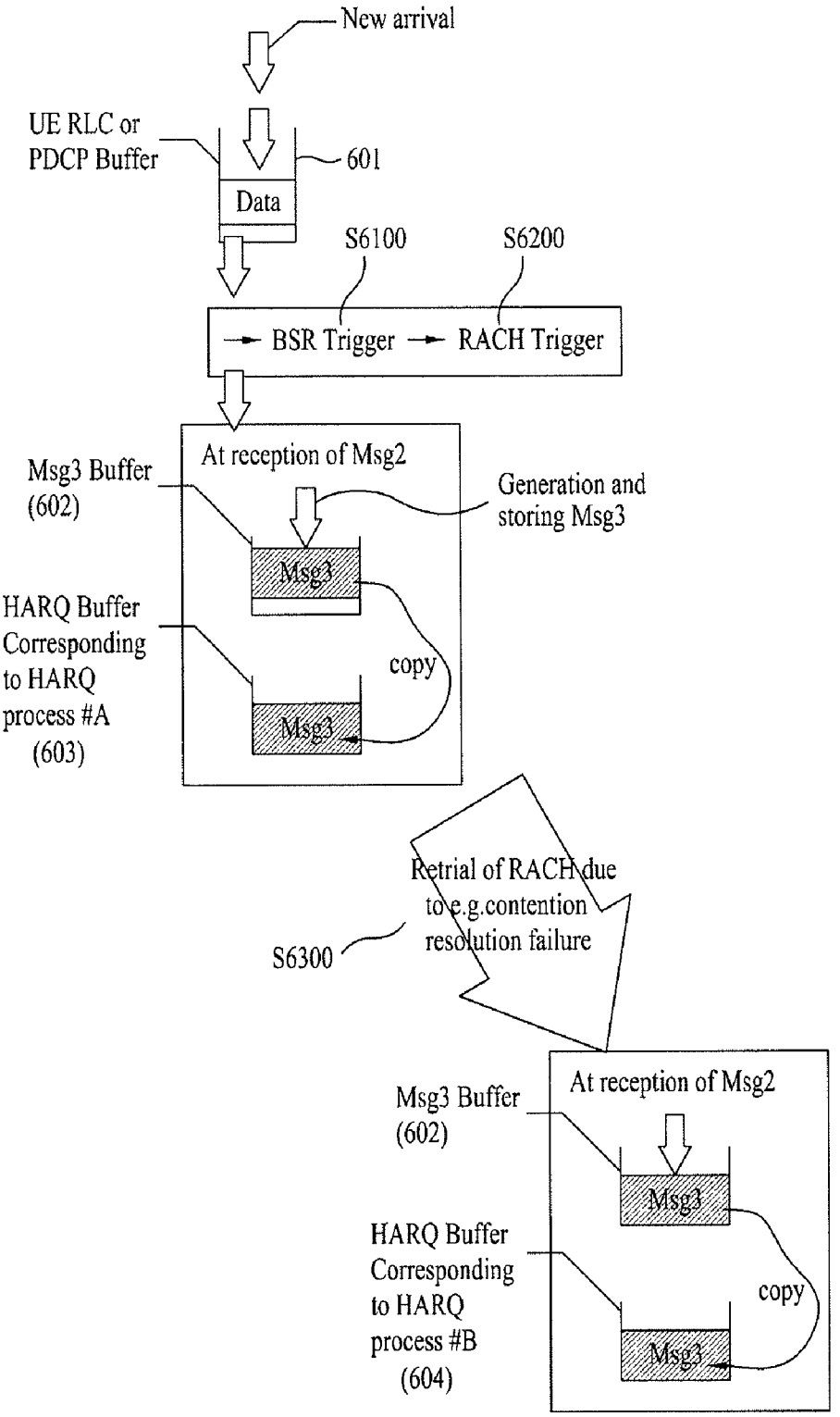

New arrival
UE RLC or PDCP Buffer
601
Data
S6100
S6200
BSR Trigger
RACH Trigger
At reception of Msg2
Msg3 Buffer (602)
Generation and storing Msg3
Msg3
HARQ Buffer Corresponding to HARQ process #A (603)
copy
Msg3
Retrial of RACH due to e.g.contention resolution failure
S6300
At reception of Msg2
Msg3 Buffer (602)
Msg3
HARQ Buffer Corresponding to HARQ process #B (604)
copy
Msg3

FIG. 8

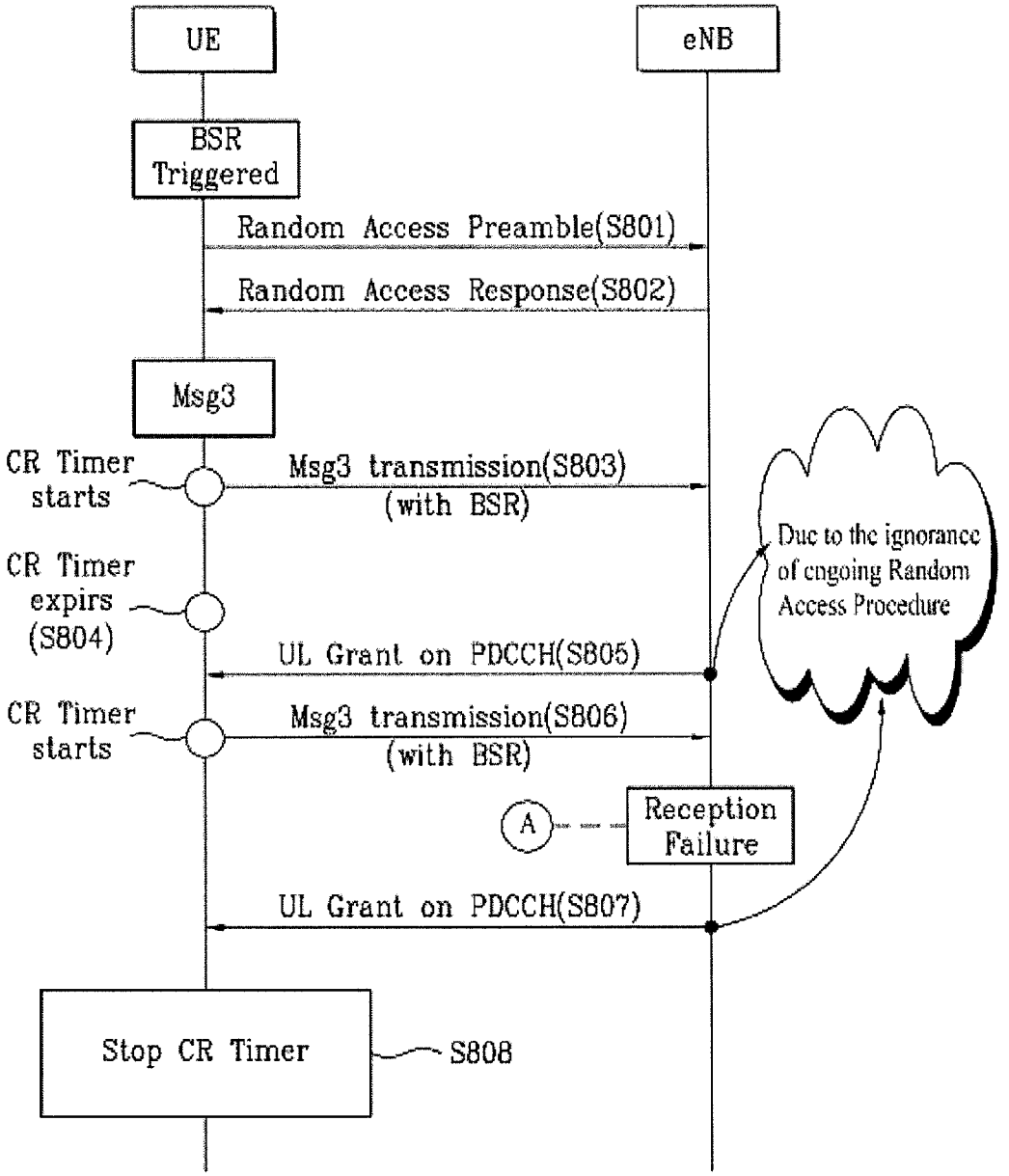

UE
eNB
BSR Triggered
Random Access Preamble(S801)
Random Access Response(S802)
Msg3
CR Timer starts
Msg3 transmission(S803) (with BSR)
CR Timer expirs (S804)
UL Grant on PDCCH(S805)
CR Timer starts
Msg3 transmission(S806) (with BSR)
A
Reception Failure
UL Grant on PDCCH(S807)
Due to the ignorance of ongoing Random Access Procedure
Stop CR Timer
S808

FIG. 9

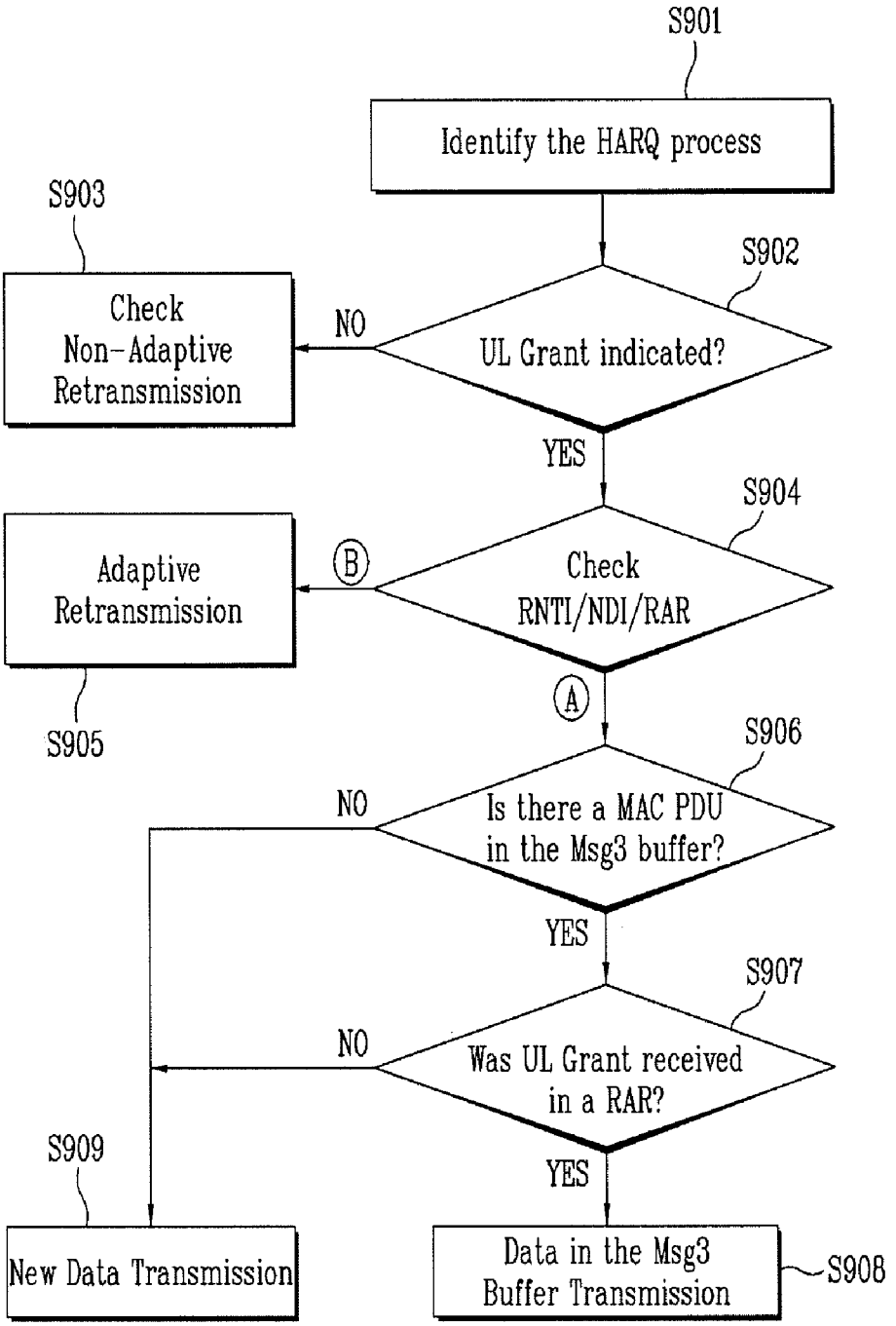

S901
Identify the HARQ process
S902
UL Grant indicated?
NO
S903
Check Non-Adaptive Retransmission
YES
S904
Check RNTI/NDI/RAR
B
Adaptive Retransmission
S905
A
S906
Is there a MAC PDU in the Msg3 buffer?
NO
YES
S907
Was UL Grant received in a RAR?
NO
YES
S909
New Data Transmission
Data in the Msg3 Buffer Transmission
S908

FIG. 10

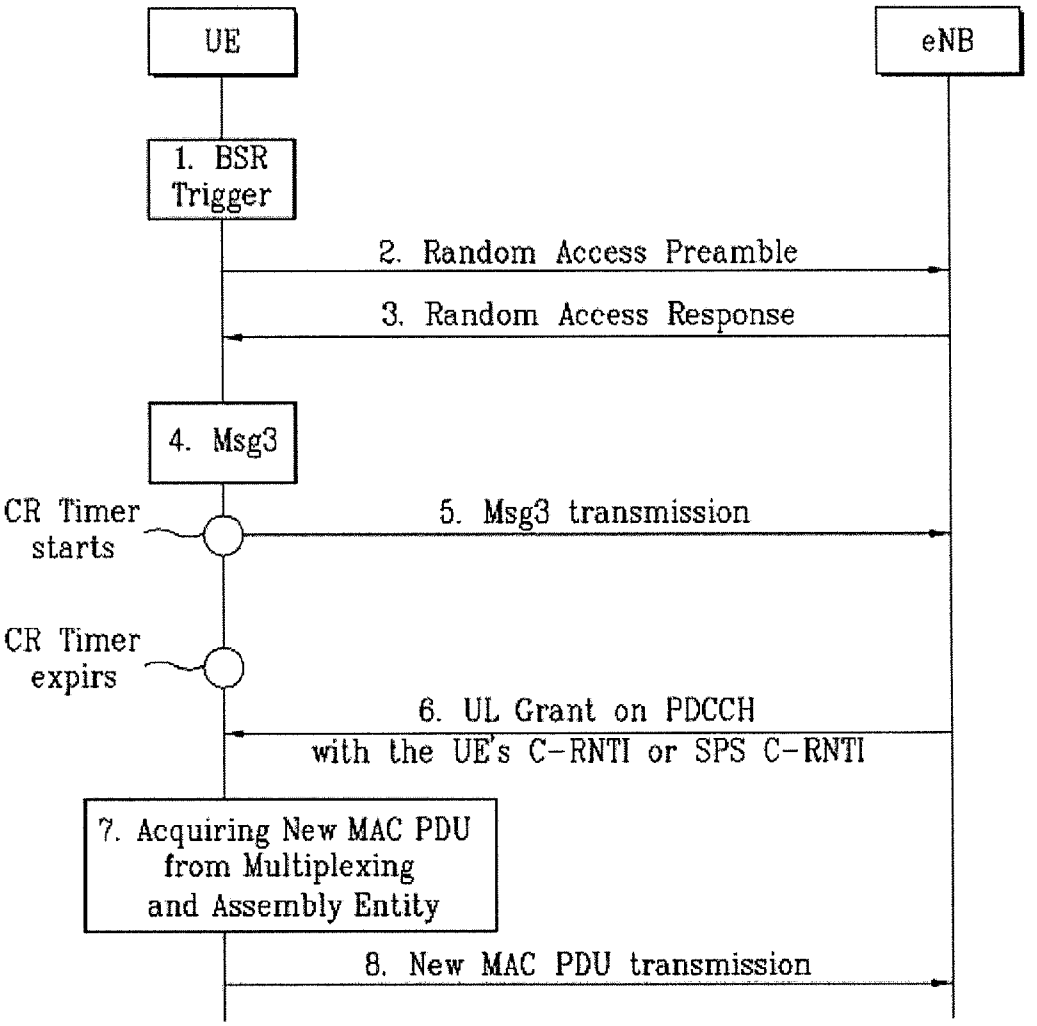
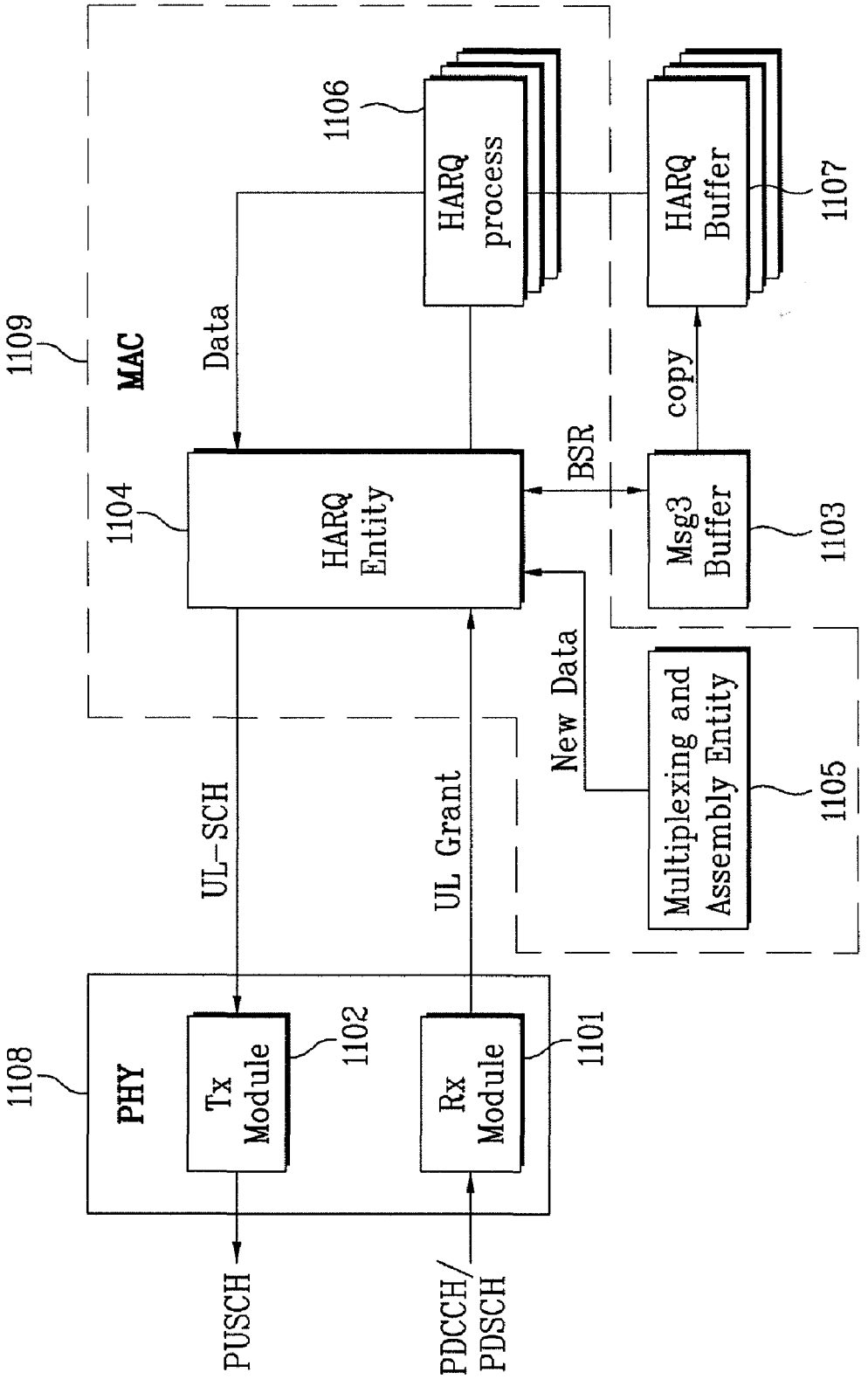

UE
eNB
1. BSR Trigger
2. Random Access Preamble
3. Random Access Response
4. Msg3
CR Timer starts
5. Msg3 transmission
CR Timer expirs
6. UL Grant on PDCCH with the UE's C-RNTI or SPS C-RNTI
7. Acquiring New MAC PDU from Multiplexing and Assembly Entity
8. New MAC PDU transmission

FIG. 11


1109
MAC
1104
HARQ Entity
Data
1106
HARQ process
HARQ Buffer
1107
copy
BSR
Msg3 Buffer
1103
New Data
Multiplexing and Assembly Entity
1105
UL-SCH
UL Grant
1108
PHY
Tx Module
1102
Rx Module
1101
PUSCH
PDCCH/ PDSCH

DATA TRANSMISSION METHOD AND USER EQUIPMENT FOR THE SAME

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Application No. 61/087,988, filed on Aug. 11, 2008, which is hereby incorporated by reference as if fully set forth herein.

This application claims the benefit of Korean Patent Application No. 10-2009-0057128, filed on Jun. 25, 2009, which is hereby incorporated by reference as if fully set forth herein.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a mobile communication technology, and more particularly, to a method for efficiently transmitting data stored in a message **3** (Msg**3**) buffer and a user equipment for the same.

2. Discussion of the Related Art

As an example of a mobile communication system to which the present invention is applicable, a 3rd Generation Partnership Project Long Term Evolution (3GPP LTE) communication system will be schematically described.

FIG. **1** is a schematic view showing the network architecture of an Evolved Universal Mobile Telecommunication System (E-UMTS) as an example of a mobile communication system.

The E-UMTS is evolved from the existing UMTS and has been currently standardized in the 3GPP. Generally, the E-UMTS may be called an LTE system.

An E-UMTS network may be largely divided into an Evolved UMTS Terrestrial Radio Access Network (E-UTRAN) **101** and a Core Network (CN) **102**. The E-UTRAN **101** may include a User Equipment (UE) **103**, a base station (hereinafter, referred to as an "eNode B" or "eNB") **104**, and an Access Gateway (AG) **105** positioned at the end of the network and connected to an external network. The AG **105** may be divided into a portion for processing user traffic and a portion for processing control traffic. At this time, an AG for processing new user traffic and an AG for processing control traffic may communicate with each other using a new interface.

One or more cells may exist in one eNode B. A plurality of eNode Bs may be connected by an interface for transmitting the user traffic or control traffic. The CN **102** may include the AG **105** and a node for registering a user of the UE **103**. An interface for distinguishing between the E-UTRAN **101** and the CN **102** may be used.

Layers of radio interface protocol between the UE and the network may be classified into a first layer L1, a second layer L2 and a third layer L3 based on three lower layers of an Open System Interconnection (OSI) reference model that is widely known in the field of communication systems. A physical layer belonging to the first layer provides an information transfer service using a physical channel. A Radio Resource Control (RRC) layer belonging to the third layer serves to control radio resources between the UE and the network. The UE and the network exchange an RRC message via the RRC layer. The RRC layer may be distributed and located at network nodes of the eNode B **104** and the AG **105**. Alternatively, the RRC layer may be located at only the eNode B **104** or the AG **105**.

FIGS. **2** and **3** show the structures of radio interface protocols between the UE and the UTRAN based on a 3GPP radio access network standard.

The radio interface protocols of FIGS. **2** and **3** are horizontally formed of a physical layer, a data link layer and a network layer. The radio interface protocols are vertically formed of a user plane for transmitting data information and a control plane for transmitting control signals. In detail, FIG. **2** shows the layers of a radio protocol control plane and FIG. **3** shows the layers of a radio protocol user plane. The protocol layers of FIGS. **2** and **3** may be divided into a first layer (L1), a second layer (L2) and a third layer (L3) based on three lower layers of an OSI reference model that is widely known in the field of communication systems.

Hereinafter, the layers of the control plane of the radio protocol of FIG. **2** and the user plane of the radio protocol of FIG. **3** will be described.

A physical (PHY) layer of the first layer provides an information transfer service to an upper layer using a physical channel. The PHY layer is connected to an upper layer, such as a Medium Access Control (MAC) layer, via a transport channel. Data is transferred between the MAC layer and the PHY layer via the transport channel. At this time, the transport channel is largely divided into a dedicated transport channel and a common transport channel, depending on whether or not a channel is shared. Data is also transferred between different PHY layers, such as a physical layer of a transmitting side and a physical layer of a receiving side, via a physical channel using radio resources.

Various layers exist in the second layer. First, the MAC layer serves to map various logical channels to various transport channels and serves to multiplex several logical channels into one transport channel. The MAC layer is connected to a Radio Link Control (RLC) layer, which is an upper layer, by the logical channel. The logical channel may be largely divided into a control channel for transmitting information about the control plane and a traffic channel for transmitting information about the user plane according to the kinds of information transmitted.

The RLC layer of the second layer serves to segment and concatenate data received from an upper layer so as to adjust data size such that a lower layer transmits data in a radio section. In addition, the RLC provides three modes, namely, a Transparent Mode (TM), an Unacknowledged Mode (UM) and an Acknowledged Mode (AM) in order to guarantee various Quality of Services (QoSs) requested by Radio Bearers (RBs). In particular, the AM RLC performs a retransmission function using an Automatic Repeat and Request (ARQ) function for reliable data transmission.

A Packet Data Convergence Protocol (PDCP) layer of the second layer performs a header compression function to reduce the size of an Internet Protocol (IP) packet header that includes unnecessary control information and has a relatively large size, for effective transmission in a radio section having a relatively small bandwidth when transmitting an IP packet such as an IPv4 packet or an IPv6 packet. Therefore, only necessary information in a header portion of data is transmitted so as to improve transmission efficiency of the radio section. In the LTE system, the PDCP layer also performs a security function, which includes ciphering for preventing data from being intercepted by a third party and integrity protection for preventing data from being handled by a third party.

A Radio Resource Control (RRC) located at a highest portion of the third layer is defined only in the control plane. The RRC layer handles logical channels, transport channels and physical channels for the configuration, re-configuration and release of RBs. Here, the RBs refer to logical paths provided by the first and second layers of the radio protocol, for data transfer between the UE and the UTRAN, and the

configuration of the RBs refers to a process of defining the characteristics of the radio protocol layer and channel necessary for providing a specific service, and setting detailed parameters and operation methods. Each of the RBs is divided into a signaling RB and a data RB. The SRB is used as a path for transmitting an RRC message in the control plane (C-plane), and the DRB is used as a path for transmitting user data in the user plane (U-plane).

Downlink transport channels for transmitting data from a network to a UE may include a Broadcast Channel (BCH) for transmitting system information and a downlink Shared Channel (SCH) for transmitting user traffic or a control message. The traffic or the control message of a downlink multicast or broadcast service may be transmitted via the downlink SCH or via a separate Downlink Multicast Channel (MCH). Uplink transport channels for transmitting data from a UE to a network may include a Random Access Channel (RACH) for transmitting an initial control message and an uplink SCH for transmitting user traffic or a control message.

Downlink physical channels for transmitting information transferred via the downlink transport channels in a radio section between a network and a UE may include a Physical Broadcast Channel (PBCH) for transmitting information about a BCH, a Physical Multicast Channel (PMCH) for transmitting information about an MCH, a Physical Downlink Shared Channel (PDSCH) for transmitting information about a PCH and a downlink SCH, and a Physical Downlink Control Channel (PDCCH) (also referred to as a DL L1/L2 control channel) for transmitting control information provided by the first layer and the second layer, such as downlink (DL) or uplink (UL) scheduling grant information. Uplink physical channels for transmitting information transferred via the uplink transport channels in a radio section between a network and a UE may include a Physical Uplink Shared Channel (PUSCH) for transmitting information about an uplink SCH, a Physical Random Access Channel (PRACH) for transmitting information about an RACH, and a Physical Uplink Control Channel (PUCCH) for transmitting control information provided by the first layer and the second layer, such as a HARQ ACK or NACK, a Scheduling Request (SR), a Channel Quality Indicator (CQI) report.

Hereinafter, a random access procedure provided by an LTE system will be schematically described based on the above description.

First, a UE performs the random access procedure in the following cases.

- when the UE performs initial access because there is no RRC Connection with an eNode B,
- when the UE initially accesses a target cell in a handover procedure,
- when the random access procedure is requested by a command of an eNode B,
- when there is uplink data transmission in a situation where uplink time synchronization is not aligned or where a specific radio resource used for requesting radio resources is not allocated, and
- when a recovery procedure is performed in case of radio link failure or handover failure.

In the LTE system, there are provided two procedures in selecting a random access preamble: one is a contention based random access procedure in which the UE randomly selects one preamble within a specific group for use, and another is a non-contention based random access procedure in which the UE uses a random access preamble allocated only to a specific UE by the eNode B. The non-contention based random access procedure may be used only in the handover procedure or when it is requested by the command of the base station, as described above.

A random access procedure of a UE with a specific eNode B may largely include (1) a step of, at the UE, transmitting a random access preamble to the eNode B (hereinafter, referred to as a "message **1**" transmitting step if such use will not lead to confusion), (2) a step of receiving a random access response from the eNode B in correspondence with the transmitted random access preamble (hereinafter, referred to as a "message **2**" receiving step if such use will not lead to confusion), (3) a step of transmitting an uplink message using the information received by the random access response message (hereinafter, referred to as a "message **3**" transmitting step if such use will not lead to confusion), and (4) a step of receiving a message corresponding to the uplink message from the eNode B (hereinafter, referred to as a "message **4**" receiving step if such use will not lead to confusion).

In the random access procedure, the UE stores data to be transmitted via the message **3** in a message **3** (Msg**3**) buffer and transmits the data stored in the msg**3** buffer in correspondence with the reception of an Uplink (UL) Grant signal. The UL Grant signal indicates information about uplink radio resources which may be used when the UE transmits a signal to the eNode B, and is received on a random access response message received on a PDCCH or a PUSCH in the LTE system. According to the current LTE system standard, it is defined that, if the UL Grant signal is received in a state in which data is stored in the Msg**3** buffer, the data stored in the Msg**3** buffer is transmitted regardless of the reception mode of the UL Grant signal. As described above, if the data stored in the Msg**3** buffer is transmitted in correspondence with the reception of all UL Grant signals, problems may occur. Accordingly, there is a need for research to solve such problems.

SUMMARY OF THE INVENTION

Accordingly, the present invention is directed to a data transmission method and a user equipment for the same that substantially obviate one or more problems due to limitations and disadvantages of the related art.

An object of the present invention is to provide a data transmission method and a user equipment for the same, which is capable of solving a problem which may occur when data stored in a message **3** (Msg**3**) buffer is transmitted according to a reception mode of an Uplink (UL) Grant signal.

Additional advantages, objects, and features of the invention will be set forth in part in the description which follows and in part will become apparent to those having ordinary skill in the art upon examination of the following or may be learned from practice of the invention. The objectives and other advantages of the invention may be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

To achieve these objects and other advantages and in accordance with the purpose of the invention, as embodied and broadly described herein, a method of transmitting data by a user equipment through an uplink includes receiving an uplink grant (UL Grant) signal from a base station on a specific message, determining whether there is data stored in a message **3** (Msg**3**) buffer when receiving the UL Grant signal on the specific message, determining whether the specific message is a random access response message, and transmitting the data stored in the Msg**3** buffer to the base station using the UL Grant signal received on the specific

message, if there is data stored in the Msg3 buffer when receiving the UL Grant signal on the specific message and the specific message is the random access response message.

If there is no data stored in the Msg3 buffer when receiving the UL Grant signal on the specific message or the specific message is not the random access response message, new data may be transmitted to the base station in correspondence with the UL Grant signal received on the specific message.

The UL Grant signal received on the specific message may be a UL Grant signal received on a Physical Downlink Control Channel (PDCCH). In this case, the user equipment may transmit new data in correspondence with the UL Grant signal received on the PDCCH.

The UL Grant signal received on the specific message may be a UL Grant signal received on a random access response message received on Physical Downlink Shared Channel (PDSCH). In this case, if there is data stored in the Msg3 buffer when receiving the UL Grant signal on the random access response message, the user equipment may transmit the data stored in the buffer in the Msg3 buffer using the UL Grant signal received on the random access response message.

The data stored in the Msg3 buffer may be a Medium Access Control Protocol Data Unit (MAC PDU) including a user equipment identifier, and the data stored in the Msg3 buffer further include information about a buffer status report (BSR) if the user equipment starts the random access procedure for the BSR.

In another aspect of the present invention, a user equipment includes a reception module receiving an uplink grant (UL Grant) signal from a base station on a specific message, a transmission module transmitting data to the base station using the UL Grant signal received on the specific message, a message 3 (Msg3) buffer storing UL data to be transmitted in a random access procedure, and a Hybrid Automatic Repeat Request (HARQ) entity determining whether there is data stored in the Msg3 buffer when the reception module receives the UL Grant signal and the specific message is a random access response message, acquiring the data stored in the Msg3 buffer if there is data stored in the Msg3 buffer when the reception module receives the UL Grant signal and the specific message is the random access response message, and controlling the transmission module to transmit the data stored in the Msg3 buffer to the base station using the UL Grant signal received by the reception module on the specific message.

The user equipment may further include a multiplexing and assembly entity used for transmission of new data. In this case, the HARQ entity may acquire the new data to be transmitted from the multiplexing and assembly entity if there is no data stored in the Msg3 buffer when the reception module receives the UL Grant signal on the specific message or the received message is not the random access response message, and control the transmission module to transmit the new data acquired from the multiplexing and assembly entity using the UL Grant signal received by the reception module on the specific message.

The user equipment may further include one or more HARQ processes, and HARQ buffers respectively corresponding to the one or more HARQ processes. In this case, the HARQ entity may transfer the data acquired from the multiplexing and assembly entity or the Msg3 buffer to a specific HARQ process of the one or more HARQ processes and control the specific HARQ process to transmit the data acquired from the multiplexing and assembly entity or the Msg3 buffer through the transmission module.

When the specific HARQ process transmits the data stored in the Msg3 buffer through the transmission module, the data stored in the Msg3 buffer may be controlled to be copied into a specific HARQ buffer corresponding to the specific HARQ process, and the data copied into the specific HARQ buffer may be controlled to be transmitted through the transmission module.

The UL Grant signal received by the reception module on the specific message may be a UL Grant signal received on a Physical Downlink Control Channel (PDCCH). In this case, the HARQ entity may control new data to be transmitted in correspondence with the received UL Grant signal received on the PDCCH.

The UL Grant signal received by the reception module on the specific message may be a UL Grant signal received on a random access response message received on Physical Downlink Shared Channel (PDSCH), and the HARQ entity may control the data stored in the Msg3 buffer to be transmitted using the UL Grant signal received on the random access response message if there is data stored in the Msg3 buffer when the reception module receives the UL Grant signal on the random access response message.

According to the above-described embodiments of the present invention, it is possible to transmit data stored in a Msg3 buffer according to a reception mode of a UL Grant signal, without confusion.

It is to be understood that both the foregoing general description and the following detailed description of the present invention are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this application, illustrate embodiment(s) of the invention and together with the description serve to explain the principle of the invention. In the drawings:

FIG. 1 is a schematic view showing the network architecture of an Evolved Universal Mobile Telecommunication System (E-UMTS) as an example of a mobile communication system;

FIGS. 2 and 3 are views showing the structures of radio interface protocols between a user equipment (UE) and a UMTS Terrestrial Radio Access Network (UTRAN) based on a 3rd Generation Partnership Project (3GPP) radio access network standard;

FIG. 4 is a view illustrating an operating procedure of a UE and a base station (eNode B) in a non-contention based random access procedure;

FIG. 5 is a view illustrating an operating procedure of a UE and an eNode B in a contention based random access procedure;

FIG. 6 is a view illustrating an uplink Hybrid Automatic Repeat Request (HARQ) scheme;

FIG. 7 is a view illustrating a method of transmitting a message 3 in a random access procedure when uplink radio resources are requested;

FIG. 8 is a view illustrating a problem which may occur when data stored in a message 3 buffer is transmitted by an Uplink (UL) Grant signal received on a message other than a random access response message;

FIG. 9 is a flowchart illustrating a method of transmitting uplink data by a UE according to a preferred embodiment of the present invention;

FIG. **10** is a view illustrating a method of transmitting uplink data when a Buffer status Report (BSR) is triggered in a UE, according to an embodiment of the present invention; and

FIG. **11** is a schematic view showing the configuration of a UE according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Hereinafter, the preferred embodiments of the present invention will be described with reference to the accompanying drawings. It is to be understood that the detailed description which will be disclosed along with the accompanying drawings is intended to describe the exemplary embodiments of the present invention, and is not intended to describe a unique embodiment which the present invention can be carried out. Hereinafter, the detailed description includes detailed matters to provide full understanding of the present invention. However, it will be apparent to those skilled in the art that the present invention can be carried out without the detailed matters. For example, the following description will be made on the assumption that a mobile communication system is a 3rd Generation Partnership Project Long Term Evolution (3GPP LTE) system, but the present invention is applicable to other mobile communication systems excluding the 3GPP LTE system.

In some instances, well-known structures and devices are omitted in order to avoid obscuring the concepts of the present invention and the important functions of the structures and devices are shown in block diagram form. The same reference numbers will be used throughout the drawings to refer to the same or like parts.

In the following description, it is assumed that a terminal includes a mobile or fixed user end device such as a user equipment (UE) and a mobile station (MS), and a base station includes a node of a network end communicating with a terminal, such as a Node-B, an eNode B, and a base station.

As described above, in the following description, a problem which may occur when data stored in a message **3** (Msg**3**) buffer is transmitted according to a reception mode of an Uplink (UL) Grant signal will be described in detail and a method of solving the problem will be described. Transmission and reception of a signal using a random access procedure and a Hybrid Automatic Repeat Request (HARQ) scheme will be described in detail.

FIG. **4** is a view illustrating an operating procedure of a terminal (UE) and a base station (eNode B) in a non-contention based random access procedure.

(1) Random Access Preamble Assignment

As described above, a non-contention based random access procedure may be performed (1) in a handover procedure and (2) when the random access procedure is requested by a command of an eNode B. Even in these cases, a contention based random access procedure may be performed.

First, it is important that a specific random access preamble without the possibility of collision is received from the eNode B, for the non-contention based random access procedure. Methods of receiving the random access preamble may include a method using a handover command and a method using a Physical Downlink Control Channel (PDCCH) command. The UE receives an assigned random access preamble (S**401**).

(2) Message **1** Transmission

The UE transmits the preamble to the eNode B after receiving the assigned random access preamble from the eNode B as described above (S**402**).

(3) Message **2** Transmission

The UE attempts to receive a random access response within a random access response reception window indicated by the eNode B through a handover command or system information after transmitting the random access preamble in step S**402** (S**403**). More specifically, the random access response information may be transmitted in the form of a Medium Access Control (MAC) Packet Data Unit (PDU), and the MAC PDU may be transferred via a Physical Downlink Shared Channel (PDSCH). In addition, the UE preferably monitors the PDCCH in order to enable to the UE to properly receive the information transferred via the PDSCH. That is, the PDCCH may preferably include information about a UE that should receive the PDSCH, frequency and time information of radio resources of the PDSCH, a transfer format of the PDSCH, and the like. Here, if the PDCCH has been successfully received, the UE may appropriately receive the random access response transmitted on the PDSCH according to information of the PDCCH. The random access response may include a random access preamble identifier (e.g. Random Access-Radio Network Temporary Identifier (RA-RNTI)), an UL Grant indicating uplink radio resources, a temporary C-RNTI, a Time Advance Command (TAC), and the like.

As described above, the reason why the random access response includes the random access preamble identifier is because a single random access response may include random access response information of at least one UE and thus it is reported to which UE the UL Grant, the Temporary C-RNTI and the TAC are valid. In this step, it is assumed that the UE selects a random access preamble identifier matched to the random access preamble selected by the UE in step S**402**.

In the non-contention based random access procedure, it is determined that the random access procedure is normally performed, by receiving the random access response information, and the random access procedure may be finished.

FIG. **5** is a view illustrating an operating procedure of a UE and an eNode B in a contention based random access procedure.

(1) Message **1** Transmission

First, the UE may randomly select a single random access preamble from a set of random access preambles indicated through system information or a handover command, and select and transmit a Physical Random Access Channel (PRACH) capable of transmitting the random access preamble (S**501**).

(2) Message **2** Reception

A method of receiving random access response information is similar to the above-described non-contention based random access procedure. That is, the UE attempts to receive its own random access response within a random access response reception window indicated by the eNode B through the system information or the handover command, after the random access preamble is transmitted in step S**501**, and receives a Physical Downlink Shared Channel (PDSCH) using random access identifier information corresponding thereto (S**502**). Accordingly, the UE may receive a UL Grant, a Temporary C-RNTI, a TAC and the like.

(3) Message **3** Transmission

If the UE has received the random access response valid for the UE, the UE may process all of the information included in the random access response. That is, the UE applies the TAC, and stores the temporary C-RNTI. In addition, data which will be transmitted in correspondence with the reception of the valid random access response may be stored in a Msg**3**

buffer. A process of storing the data in the Msg**3** buffer and transmitting the data will be described later with reference to FIG. **7**.

The UE uses the received UL Grant so as to transmit the data (that is, the message **3**) to the eNode B (S**503**). The message **3** should include a UE identifier. In the contention based random access procedure, the eNode B may not determine which UEs are performing the random access procedure, but later the UEs should be identified for contention resolution.

Here, two different schemes for including the UE identifier may be provided. A first scheme is to transmit the UE's cell identifier through an uplink transmission signal corresponding to the UL Grant if the UE has already received a valid cell identifier allocated by a corresponding cell prior to the random access procedure. Conversely, the second scheme is to transmit the UE's unique identifier (e.g., S-TMSI or random ID) if the UE has not received a valid cell identifier prior to the random access procedure. In general, the unique identifier is longer than the cell identifier. If the UE has transmitted data corresponding to the UL Grant, the UE starts a contention resolution (CR) timer.

(4) Message **4** Reception

After transmitting the data with its identifier through the UL Grant included in the random access response, the UE waits for an indication (instruction) from the eNode B for contention resolution. That is, the UE attempts to receive the PDCCH so as to receive a specific message (S**504**). Here, there are two schemes to receive the PDCCH. As described above, the UE attempts to receive the PDCCH using its own cell identifier if the message **3** transmitted in correspondence with the UL Grant is transmitted using the UE's cell identifier, and the UE attempts to receive the PDCCH using the temporary C-RNTI included in the random access response if the identifier is its unique identifier. Thereafter, in the former scheme, if the PDCCH is received through its own cell identifier before the contention resolution timer is expired, the UE determines that the random access procedure has been normally performed and completes the random access procedure. In the latter scheme, if the PDCCH is received through the temporary C-RNTI before the contention resolution timer has expired, the UE checks data transferred by the PDSCH indicated by the PDCCH. If the unique identifier of the UE is included in the data, the UE determines that the random access procedure has been normally performed and completes the random access procedure.

Hereinafter, the LTE system, by way of example, a uplink Hybrid Automatic Repeat Request (HARQ) scheme of a MAC layer will be described, concentrating on the transmission of uplink data.

FIG. **6** is a view illustrating an HARQ scheme.

A UE may receive UL Grant information or UL scheduling information from an eNode B on a PDCCH (step S**601**), in order to transmit data to the eNode B by the HARQ scheme. In general, the UL scheduling information may include a UE identifier (e.g., a C-RNTI or a Semi-Persistent Scheduling C-RNTI), resource block assignment, transmission parameters (modulation, coding scheme and redundancy version), and a New Data Indicator (NDI). In the LTE system, the UE has eight HARQ processes and the HARQ processes are synchronously performed with Transmission Time Intervals (TTIs). That is, specific HARQ processes may be sequentially assigned according to points in time when data is received, in a manner of using the first HARQ process at TTI **9** and using the second HARQ process at TTI **10** after a first HARQ process is used at TTI **1**, a second HARQ process is used at TTI **2**, . . . , and an eighth HARQ process is used at TTI **8**.

In addition, since the HARQ processes are synchronously assigned as described above, a HARQ process connected to a TTI in which a PDCCH for initial transmission of specific data is received is used for the transmission of the data. For example, if it is assumed that the UE has received a PDCCH including UL scheduling information at an Nth TTI, the UE transmits data at an $(N+4)^{th}$ TTI. In other words, a Kth HARQ process assigned at the $(N+4)^{th}$ TTI is used for the transmission of the data. That is, the UE may transmit the data to the eNode B on a PUSCH according to the UL scheduling information after checking the UL scheduling information transmitted to the UE by monitoring the PDCCH at every TTI (step S**602**).

When the data has been received, the eNode B stores the data in a soft buffer and attempts to decode the data. The eNode B transmits an ACK signal if the decoding of the data succeeds and transmits an NACK signal if the decoding of the data fails. An example in which the decoding of the data fails and the eNode B transmits the NACK signal on a Physical HARQ Indicator Channel (PHICH) is shown in FIG. **6** (step S**603**).

When the ACK signal has been received from the eNode B, the UE determines that the transmission of the data to the eNode B succeeds and transmits next data. However, when the UE receives the NACK signal as shown in FIG. **6**, the UE may determine that the transmission of the data to the eNode B has failed and retransmit the same data by the same scheme or a new scheme (step S**604**).

The HARQ retransmission of the UE may be performed by a non-adaptive scheme. That is, the initial transmission of specific data may be performed when the PDCCH including the UL scheduling information should be received, but the retransmission may be performed even when the PDCCH is not received. In the non-adaptive HARQ retransmission, the data is retransmitted using the same UL scheduling information as the initial transmission at a TTI at which a next HARQ process is assigned, without receiving the PDCCH.

The HARQ retransmission of the UE may be performed by an adaptive scheme. In this case, transmission parameters for retransmission are received on the PDCCH, but the UL scheduling information included in the PDCCH may be different from that of the initial transmission according to channel statuses. For example, if the channel status is better than that of the initial transmission, transmission may be performed at a high bit rate. In contrast, if the channel status is worse than that of the initial transmission, transmission may be performed at a lower bit rate than that of the initial transmission.

If the UE receives the UL scheduling information on the PDCCH, it is determined whether data which should be transmitted at this time is data which is initially transmitted or previous data which is retransmitted, by an NDI field included in the PDCCH. The NDI field is toggled in the order of 0, 1, 0, 1, . . . whenever new data is transmitted as described above, and the NDI field of the retransmission has the same value as that of the initial transmission. Accordingly, the UE may compare the NDI field with the previously transmitted value so as to determine whether or not the data is retransmitted.

The UE counts the number of times of transmission (CURRENT_TX_NB) whenever data is transmitted by the HARQ scheme, and deletes the data stored in the HARQ buffer when CURRENT_TX_NB has reached a maximum transmission number set in an RRC layer.

When the retransmitted data is received, the eNode B attempts to combine the received data and the data stored in the soft buffer due to the failure of the decoding by various schemes and decodes the combined data. The eNode B transmits an ACK signal to the UE if the decoding succeeds and transmits an NACK signal to the UE if the decoding fails. The eNode B repeats a process of transmitting the NACK signal and receiving the retransmitted data until the decoding of the data succeeds. In the example of FIG. **6**, the eNode B attempts to combine the data retransmitted in step S**604** and the data which is previously received and stored and decodes the combined data. The eNode B transmits the ACK signal to the UE on the PHICH if the decoding of the received data succeeds (step S**605**). The UE may transmit the UL scheduling information for the transmission of next data to the UE on the PDCCH, and may transmit the NDI toggled to 1 in order to report that the UL scheduling information is not used for the adaptive retransmission, but is used for the transmission of new data (step S**606**). The UE may transmit new data to the eNode B on the PUSCH corresponding to the received UL scheduling information (step S**607**).

The random access procedure may be triggered in the above-described cases as described above. Hereinafter, the case where the UE requests UL radio resources will be described.

FIG. **7** is a view illustrating a method of transmitting a message **3** in a random access procedure when UL radio resources are requested.

When new data is generated in a transfer buffer **601** of the UE, for example, an RLC buffer and a PDCP buffer, the UE should generally inform the eNode B of information about the generation of the data. More accurately, when data having priority higher than that of data stored in the transfer buffer of the UE is generated, the UE informs the eNode B that the data is generated.

This indicates that the UE requests radio resources to the eNode B in order to transmit the generated data. The eNode B may assign proper radio resources to the UE according to the above information. The information about the generation of the data is called a buffer status report (hereinafter, referred to as "BSR"). Hereinafter, as described above, the request for the transmission of the BSR is represented by triggering of the BSR transmission (S**6100**). If the BSR transmission is triggered, the UE should transmit the BSR to the eNode B. However, if the radio resources for transmitting the BSR are not present, the UE may trigger a random access procedure and attempt to request radio resources (S**6200**).

As described above, if the random access procedure for requesting the radio resources to the eNode B is triggered, the UE may transmit a random access preamble to the eNode B and receive a random access response message corresponding thereto as described with reference to FIGS. **4** and **5**. In addition, a message **3** (that is, a MAC PDU) including a UE identifier and a BSR may be generated and stored in a Msg**3** buffer **602**, in a MAC layer of the UE through a UL Grant signal included in the random access response message. The message **3** stored in the Msg**3** buffer **602** may be copied and stored in a HARQ process buffer **603** indicated by the UL Grant information. FIG. **7** shows, by way of example, the case where the HARQ process A is used for the transmission of the message **3**. Thus, the message **3** is copied to the HARQ buffer **603** corresponding to the HARQ process A. The message **3** stored in the HARQ buffer **603** may be transmitted to the eNode B on a PUSCH.

Meanwhile, if the UE should perform retrial of the random access procedure due to contention resolution failure, the UE may transmit the random access preamble to the eNode B again and receive a random access response (S**6300**). However, in the retried random access procedure, the UE uses the message **3** stored in the Msg**3** buffer **602** again, without generating a new message **3**. That is, the UE may copy and store the MAC PDU corresponding to the message **3** stored in the Msg**3** buffer **602** in a HARQ buffer **604**, and transmit the MAC PDU, according to the UL Grant signal included in the random access response received in the retried random access procedure. FIG. **7** shows the case where the reattempted random access procedure is performed by a HARQ process B. The data stored in the Msg**3** buffer **602** may be copied into the HARQ buffer B and transmitted.

As described above, if the random access response is received while the random access procedure is performed, the UE stores the message **3** stored in the Msg**3** buffer in the HARQ buffer and transmits the message **3**. As described above, in the current the LTE system standard for the HARQ process, it is defined that the transmission of the data stored in the Msg**3** buffer is triggered by the reception of any UL Grant signal. Accordingly, the CR timer may be erroneously driven such that an erroneous contention resolution process is performed. Due to the erroneous contention resolution procedure, the above-described BSR may not be normally transmitted and the UE may come to deadlock. This problem will be described in detail with reference to FIG. **8**.

FIG. **8** is a view illustrating a problem which may occur when data stored in a Msg**3** buffer is transmitted by an Uplink (UL) Grant signal received on a message other than a random access response message.

As described with reference to FIG. **7**, the UE may trigger the BSR when high priority data is generated, transmit the random access preamble in order to transmit the BSR to the eNode B (S**801**), and receive the random access response corresponding thereto (S**802**).

Thereafter, the UE may transmit a message **3** including the BSR via UL Grant information included in the random access response message received in step S**802** (S**803**). If the message **3** is transmitted, the CR timer is operated as described with reference to FIG. **5**.

If the random access procedure is completed before the CR timer expires, the UE determines that the random access procedure has not been successfully completed (S**804**). In this case, the UE may try to restart the random access procedure from the transmission of the random access preamble.

At this time, since the eNode B does not yet know that the UE is performing the random access procedure, the eNode B may transmit a UL Grant signal independent of the random access procedure on a masked PDCCH (S**805**). In this case, according to the current LTE system standard, the UE transmits the message **3** stored in the Msg**3** buffer according to the UL Grant signal received on the PDCCH in step S**805** (S**806**). In addition, when the message **3** is transmitted, the CR timer is restarted. That is, even when the UE does not perform the transmission of the random access preamble and the reception of the random access response message, the CR timer is restarted in step S**806**.

Although the CR timer is started as the UE transmits the message **3** in step S**806**, the eNode B may not know that the UE is performing the random access procedure because the reception of the random access preamble and the transmission of the random access response message are not performed. If another UL Grant signal is received on the PDCCH including the UE identifier (S**807**), the UE determines that the ongoing random access procedure is successfully completed. Accordingly, the UE may stop the ongoing CR time (S**808**).

If the message **3** transmitted to the eNode B in step S**806** is not successfully received by the eNode B (A), the UE no

longer transmits the message **3** including the BSR. Accordingly, if additional data is not generated, the UE may not transmit the data generated in the transfer buffer to the eNode B.

The above-described problem will be described as follows.

According to the current LTE system standard, if the UL Grant signal is received in a state in which the data is stored in the Msg**3** buffer, the UE transmits the data stored in the Msg**3** buffer to the eNode B. At this time, the UL Grant signal may be transmitted by the eNode B, not for the transmission of the data stored in the Msg**3** buffer, but for the transmission of other data. Accordingly, the CR timer may be erroneously started.

In addition, if the eNode B does not know that the CR timer is erroneously started in the UE and transmits the UL Grant signal for the transmission of other data as described with reference to FIG. **8**, information (e.g., BSR) to be transmitted through the message **3** may be lost.

In addition, the UE may not receive a message **4** for completing a proper contention resolution procedure even with respect to the ongoing random access procedure.

In a preferred embodiment of the invention for solving the above-described problem, the data stored in the Msg**3** buffer is restrictively transmitted only in the case where the UL Grant signal received from the eNode B is received on the random access response message, but not in all cases where the UL Grant signal is received from the eNode B. If the UL Grant signal is received on the masked PDCCH not by the random access response message but by the UE identifier (C-RNTI or a Semi Persistent Scheduling Radio Network Temporary Identifier (SPS-RNTI)) in a state in which the data is stored in the Msg**3** buffer, a method of acquiring and transmitting new data (MAC PDU) to the eNode B instead of the data stored in the Msg**3** buffer is suggested.

FIG. **9** is a flowchart illustrating a method of transmitting UL data by a UE according to a preferred embodiment of the present invention. In more detail, FIG. **9** shows the operation of a HARQ entity of the UE according to an embodiment of the present invention at every TTI.

First, the HARQ entity of the UE may identify a HARQ process associated with a TTI (S**901**). If the HARQ process associated with the TTI is identified, the HARQ entity of the UE may determine whether or not a UL Grant signal received from the eNode B indicated at the TTI (S**902**). The UE may determine whether or not a HARQ buffer corresponding to the HARQ process is empty if there is no information about the received UL Grant signal at the TTI, and perform non-adaptive retransmission as described with reference to FIG. **6** if there is data in the HARQ buffer (S**903**).

Meanwhile, if there is a UL Grant signal received from the eNode B at the TTI, it may be determined (1) whether the UL Grant signal is not received on the PDCCH indicated by the temporary C-RNTI and the NDI is toggled from the value during transmission prior to the HARQ process, (2) whether there is previous NDI and this transmission is initial transmission of the HARQ process, (3) whether the UL Grant signal is received on the PDCCH indicated by the C-RNTI and the HARQ buffer of the HARQ process is empty, or (4) whether the UL Grant signal is received on the random access response message (S**904**). If any one of the conditions (1) to (4) is satisfied in step S**904** (A), the method progresses to step S**906**. In contrast, if any one of the conditions (1) to (4) is not satisfied in step S**904** (B), the method progresses to step S**905** of performing adaptive retransmission using the UL Grant signal (S**905**).

Meanwhile, the UE determines whether there is data in the Msg**3** buffer in step S**906** (S**906**). In addition, even when there is data in the Msg**3** buffer, the UE determines whether the received UL Grant signal is received on the random access response message (S**907**). That is, the UE according to the present embodiment transmits the data stored in the Msg**3** buffer only when there is data in the Msg**3** buffer when receiving the UL Grant signal and the UL Grant signal is received on the random access response message (S**908**). If there is no data in the Msg**3** buffer when receiving the UL Grant signal or the UL Grant is not received on the random access response message, the UE determines that the eNode B makes a request not for the transmission of the data stored in the Msg**3** buffer but for transmission of new data, and performs new data transmission (S**909**). In more detail, the HARQ entity of the UE may be controlled such that a MAC PDU including new data from a multiplexing and assembly entity is acquired and is transmitted through the HARQ process.

Hereinafter, an example applied to a process of transmitting a BSR by the UE which operates by the embodiment described with reference to FIG. **9** as shown in FIG. **8** will be described.

FIG. **10** is a view illustrating a method of transmitting UL data when a BSR is triggered in a UE, according to an embodiment of the present invention.

As described above, new data may be generated in the RLC and PDCP buffers of the UE. It is assumed that the generated new data has higher priority than that of the data already stored in the RLC and PDCP buffers. The UE may trigger the BSR transmission in order to inform an eNode B of information about the generation of the data (step **1**).

The UE should transmit the BSR according to BSR transmission trigger, but, in a special case, there may be no radio resource for transmitting the BSR. In this case, the UE may trigger a random access procedure for transmitting the BSR. It is assumed that the random access procedure triggered in the present embodiment is the contention based random access procedure described with reference to FIG. **5**.

The UE may transmit a random access preamble to the eNode B according to the triggering of the random access procedure (step **2**).

The eNode B may receive the random access preamble transmitted by the UE and transmit a random access response message to the UE (step **3**). The UE may receive the random access response message.

The UE may generate a message **3** including the BSR and a UE identifier according to a UL Grant signal included in the random access response message received in step **3** and store the message **3** in a Msg**3** buffer (step **4**).

The UE may select a HARQ process according to the UL Grant information included in the random access response message received in step **3** and copy and store the message **3** stored in the Msg**3** buffer in the buffer corresponding to the selected HARQ process. Thereafter, the data stored in the HARQ buffer may be transmitted to the eNode B according to the UL HARQ procedure described with reference to FIG. **6** (step **5**). The UE starts (or restarts) the CR timer by the transmission of the message **3**.

When the CR timer expires, the UE may perform retrial of the random access procedure. That is, a random access preamble and a PRACH resource may be prepared to be selected and transmitted to the eNode B. However, in a state in which the CR timer is not operated, the UE may receive the UL Grant signal from the eNode B on a PDCCH masked by a UE identifier (step **6**).

When the UL Grant signal has been received on the PDCCH in step **6**, the UE generates new data different from the data stored in the Msg**3** buffer according to the UL Grant

information received in step **6** as a new MAC PDU, unlike the procedure of the embodiment of FIG. **8** for transmitting the message **3** stored in the Msg**3** buffer according to the UL Grant information received in step **6** (step **7**). In more detail, if the UE receives the UL Grant signal in step **6** but does not receive the UL Grant signal on the random access response message, a MAC PDU for transmitting not the data stored in the Msg**3** buffer but new data from a multiplexing and assembly entity may be acquired and transmitted using a HARQ process corresponding thereto.

After the new MAC PDU is generated, the UE according to the present embodiment may select a HARQ process according to the UL Grant signal received in step **6**, store the MAC PDU newly generated in step **7** in the buffer corresponding to the HARQ process, and transmit the MAC PDU to the eNode B according to the UL HARQ procedure (step **8**).

Thereafter, the UE may perform a random access procedure including the transmission of the random access preamble and the reception of the random access response and transmit the BSR stored in the Msg**3** buffer to the eNode B.

According to the above-described embodiment, it is possible to prevent the eNode B from erroneously operating the CR timer due to the UL Grant signal transmitted not for transmission of the data stored in the Msg**3** buffer but for transmission of new data. Accordingly, the problem that the message **3** is lost may be solved. In addition, the random access procedure of the UE with the eNode B may be normally performed.

Unlike the above-described embodiment, as another embodiment of the present invention, a method of performing a process while ignoring the UL Grant signal if the UL Grant signal is received from the eNode B on the PDCCH masked by the UE identifier during the random access procedure of the UE may be implemented. In this case, the UE may transfer the message **3** to the eNode B by the normal random access procedure, and the eNode B may retransmit the UL Grant signal for the transmission of new data after the random access procedure of the UE is completed.

Hereinafter, the configuration of the UE for implementing the above-described embodiment of the present invention will be described.

FIG. **11** is a schematic view showing the configuration of a UE according to an embodiment of the present invention.

As shown in FIG. **11**, the UE according to the present embodiment may include a reception (Rx) module **1101** for receiving a UL Grant signal from an eNode B on a specific message, a transmission (TX) module **1102** for transmitting data to the eNode B using the received UL Grant signal, a Msg**3** buffer **1103** for storing UL data transmitted in a random access procedure, and a HARQ entity **1104** for controlling the transmission of UL data of the UE.

In particular, the HARQ entity **1104** of the UE according to the present embodiment performs a function of determining whether there is data stored in the Msg**3** buffer **1103** when the Rx module **1101** receives the UL Grant signal and a function of determining whether the Rx module **1101** receives the UL Grant signal on a random access response message. If there is data stored in the Msg**3** buffer **1103** when the Rx module **1101** receives the UL Grant signal and the RX module **1101** receives the UL Grant signal on the random access response message, the data stored in the Msg**3** buffer **1103** is controlled to be acquired and transmitted to the eNode B. If there is no data stored in the Msg**3** buffer **1103** when the Rx module **1101** receives the UL Grant signal and the RX module **1101** receives the UL Grant signal not on the random access response message but on the PDCCH, the data stored in the Msg**3** buffer **1103** is not transmitted but new data is acquired from the multiplexing and assembly entity in the form of a MAC PDU and is transmitted to the eNode B.

In addition, in order to perform the UL HARQ procedure, the UE according to the present embodiment may include one or more HARQ processes **1106** and HARQ buffers **1107** corresponding to the HARQ processes **1106**. In the current LTE system, eight independent HARQ processes are defined for use, but the present invention is not limited thereto.

Meanwhile, the HARQ entity **1104** according to the present embodiment may transfer the data acquired from the multiplexing and assembly entity **1105** or the msg**3** buffer **1103** to a specific HARQ process **1106** using the above-described configuration, and control the specific HARQ process **1106** to transmit the data acquired from the multiplexing and assembly entity **1105** or the Msg**3** buffer **1103** through the Tx module **1102**. As described above, if the specific HARQ process **1106** transmits the data stored in the Msg**3** buffer **1103** through the Tx module **1102** as described above, the data stored in the Msg**3** buffer **1103** may be copied into the specific HARQ buffer **1107** corresponding to the specific HARQ process **1106** and the data copied into the specific HARQ buffer **1107** may be transmitted through the Tx module **1102**.

At this time, the data stored in the Msg**3** buffer **1103** is a MAC PDU including a UE identifier and may further include information such as a BSR according to the purpose of the random access procedure.

In the configuration of the UE shown in FIG. **11**, the Tx module **1102** and the Rx module **1101** may be configured as a physical layer processing module **1108**, and the HARQ entity **1104**, the multiplexing and assembly entity **1105** and one or more HARQ processes **1106** may be configured as a MAC layer module **1109**. However, the invention is not limited thereto. In addition, the Msg**3** buffer **1103** and the HARQ buffers **1107** corresponding to the HARQ processes **1106** may be implemented using any storage medium.

Although the signal transmission or reception technology and the UE for the same are applied to a 3GPP LTE system, they are applicable to various mobile communication systems having a similar procedure, in addition to the 3GPP LTE system.

It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the spirit or scope of the invention. Thus, it is intended that the present invention covers the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

What is claimed is:

1. A method of transmitting data by a user equipment through an uplink, the method comprising:

receiving an uplink grant (UL Grant) signal from a base station on a specific message;

determining whether there is data stored in a message **3** (Msg**3**) buffer when receiving the UL Grant signal on the specific message;

determining whether the specific message is a random access response message;

transmitting the data stored in the Msg**3** buffer to the base station using the UL Grant signal received on the specific message, if there is data stored in the Msg**3** buffer when receiving the UL Grant signal on the specific message and the specific message is the random access response message; and

transmitting new data to the base station in correspondence with the UL Grant signal received on the specific message, if there is no data stored in the Msg**3** buffer when

receiving the UL Grant signal on the specific message or the specific message is not the random access response message.

2. The method according to claim **1**, wherein the transmitting the new data to the base station includes:

acquiring a Medium Access Control Protocol Data Unit (MAC PDU) from a multiplexing and assembly entity; and

transmitting the MAC PDU to the base station.

3. The method according to claim **1**, wherein the UL Grant signal received on the specific message is a UL Grant signal received on a Physical Downlink Control Channel (PDCCH), and

wherein the user equipment transmits new data in correspondence with the UL Grant signal received on the PDCCH.

4. The method according to claim **1**, wherein the data stored in the Msg**3** buffer is a Medium Access Control Protocol Data Unit (MAC PDU) including a user equipment identifier.

5. The method according to claim **4**, wherein the data stored in the Msg**3** buffer further includes information about a buffer status report (BSR) if the user equipment starts a random access procedure for the BSR.

6. The method of claim **1**, wherein the UL Grant signal received on the specific message is either a UL Grant signal received on a Physical Downlink Control Channel (PDCCH) or a UL Grant signal received on the random access response message.

7. A user equipment, comprising:

a reception module adapted to receive an uplink grant (UL Grant) signal from a base station on a specific message;

a transmission module adapted to transmit data to the base station using the UL Grant signal received on the specific message;

a message **3** (Msg**3**) buffer adapted to store UL data to be transmitted in a random access procedure;

a Hybrid Automatic Repeat Request (HARQ) entity adapted to determine whether there is data stored in the Msg**3** buffer when the reception module receives the UL Grant signal and the specific message is a random access response message, acquiring the data stored in the Msg**3** buffer if there is data stored in the Msg**3** buffer when the reception module receives the UL Grant signal and the specific message is the random access response message, and controlling the transmission module to transmit the data stored in the Msg**3** buffer to the base station using the UL Grant signal received by the reception module on the specific message; and

a multiplexing and assembly entity used for transmission of new data,

wherein the HARQ entity acquires the new data to be transmitted from the multiplexing and assembly entity if there is no data stored in the Msg**3** buffer when the reception module receives the UL Grant signal on the specific message or the received message is not the random access response message, and controls the transmission module to transmit the new data acquired from the multiplexing and assembly entity using the UL Grant signal received by the reception module on the specific message.

8. The user equipment according to claim **7**, further comprising:

one or more HARQ processes; and

HARQ buffers respectively corresponding to the one or more HARQ processes,

wherein the HARQ entity transfers the data acquired from the multiplexing and assembly entity or the Msg**3** buffer to a specific HARQ process of the one or more HARQ processes and controls the specific HARQ process to transmit the data acquired from the multiplexing and assembly entity or the Msg**3** buffer through the transmission module.

9. The user equipment according to claim **8**, wherein, when the specific HARQ process transmits the data stored in the Msg**3** buffer through the transmission module, the data stored in the Msg**3** buffer is controlled to be copied into a specific HARQ buffer corresponding to the specific HARQ process, and the data copied into the specific HARQ buffer is controlled to be transmitted through the transmission module.

10. The user equipment according to claim **7**, wherein the UL Grant signal received by the reception module on the specific message is a UL Grant signal received on a Physical Downlink Control Channel (PDCCH), and

wherein the HARQ entity controls new data to be transmitted in correspondence with the received UL Grant signal received on the PDCCH.

11. The user equipment according to claim **7**, wherein the UL Grant signal received by the reception module on the specific message is a UL Grant signal received on a random access response message received on Physical Downlink Shared Channel (PDSCH), and

wherein the HARQ entity controls the data stored in the Msg**3** buffer to be transmitted using the UL Grant signal received on the random access response message if there is data stored in the Msg**3** buffer when the reception module receives the UL Grant signal on the random access response message.

12. The user equipment according to claim **7**, wherein the data stored in the Msg**3** buffer is a Medium Access Control Protocol Data Unit (MAC PDU) including a user equipment identifier.

13. The user equipment of claim **7**, wherein the UL Grant signal received on the specific message is either a UL Grant signal received on a Physical Downlink Control Channel (PDCCH) or a UL Grant signal received on the random access response message.

* * * * *

EXHIBIT 5

US008218481B2

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

(10) **Patent No.: US 8,218,481 B2**
(45) **Date of Patent: Jul. 10, 2012**

(54) **METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM**

(75) Inventors: **Yeong Hyeon Kwon**, Gyeonggi-do (KR); **Seung Hee Han**, Gyeonggi-do (KR); **Hyun Hwa Park**, Gyeonggi-do (KR); **Dong Cheol Kim**, Gyeonggi-do (KR); **Hyun Woo Lee**, Gyeonggi-do (KR); **Min Seok Noh**, Gyeonggi-do (KR)

(73) Assignee: **LG Electronics Inc.**, Seoul (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 135 days.

(21) Appl. No.: **12/303,947**

(22) PCT Filed: **Jun. 8, 2007**

(86) PCT No.: **PCT/KR2007/002784**

§ 371 (c)(1),
(2), (4) Date: **Jul. 7, 2010**

(87) PCT Pub. No.: **WO2007/142492**

PCT Pub. Date: **Dec. 13, 2007**

(65) **Prior Publication Data**

US 2010/0296436 A1 Nov. 25, 2010

(30) **Foreign Application Priority Data**

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Jun. 26, 2006 (KR) 10-2006-0057488

(51) **Int. Cl.**
H04L 12/50 (2006.01)

(52) **U.S. Cl.** **370/328**; 370/329; 370/330

(58) **Field of Classification Search** 370/328
See application file for complete search history.

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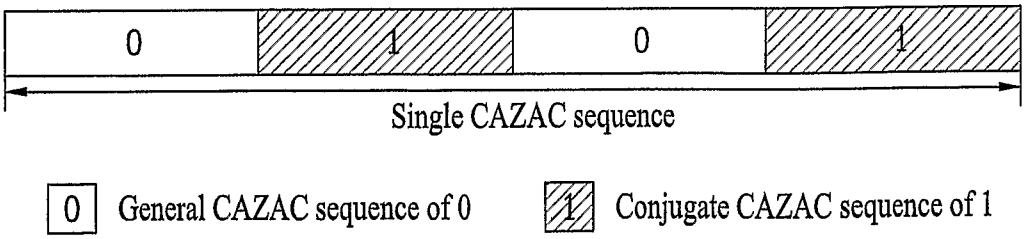
Primary Examiner — Jeffrey Pwu
Assistant Examiner — Shripal Khajuria
(74) *Attorney, Agent, or Firm* — Lee, Hong, Degerman, Kang & Waimey

(57) **ABSTRACT**

Disclosed is a data transmission method in a mobile communication system. The data transmission method through a code sequence in a mobile communication system includes grouping input data streams into a plurality of blocks consisting of at least one bit so as to map each block to a corresponding signature sequence, multiplying a signature sequence stream, to which the plurality of blocks are mapped, by a specific code sequence, and transmitting the signature sequence stream multiplied by the specific code sequence to a receiver.

16 Claims, 22 Drawing Sheets



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JP	2004512728		4/2004
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JP	2005260337		9/2005
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WO	01/11909	A1	2/2001
WO	2005/011128		2/2005
WO	2005/055527		6/2005
WO	2006/015108		2/2006

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* cited by examiner

FIG. 1

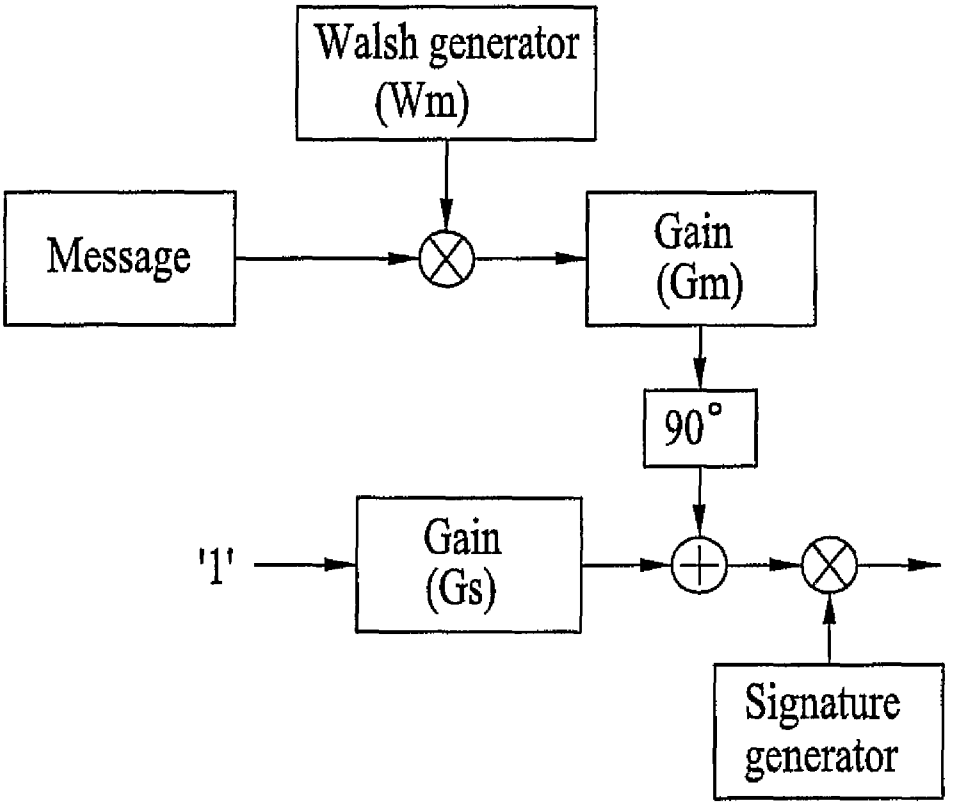

Walsh generator
(Wm)
Message
Gain
(Gm)
90°
'1'
Gain
(Gs)
Signature
generator

FIG. 2

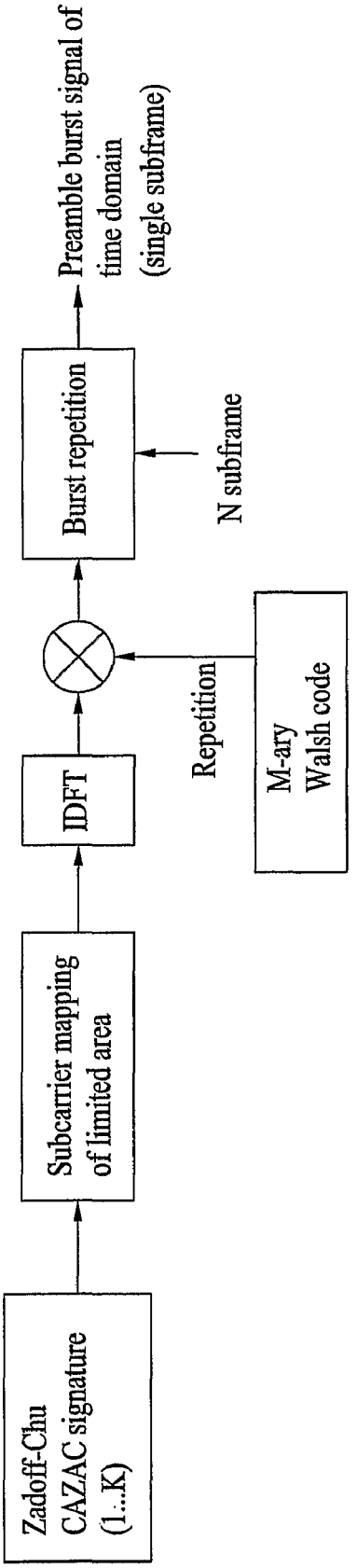

Zadoff-Chu
CAZAC signature
(1...K)
Subcarrier mapping
of limited area
IDFT
Repetition
M-ary
Walsh code
Burst repetition
N subframe
Preamble burst signal of
time domain
(single subframe)

FIG. 3A

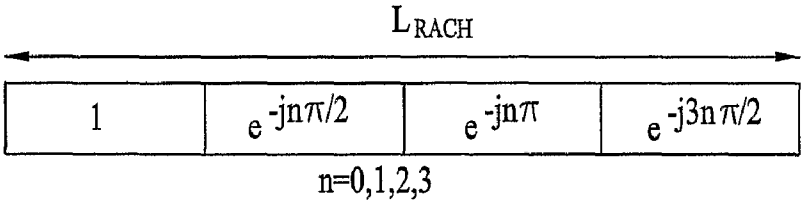


FIG. 3B

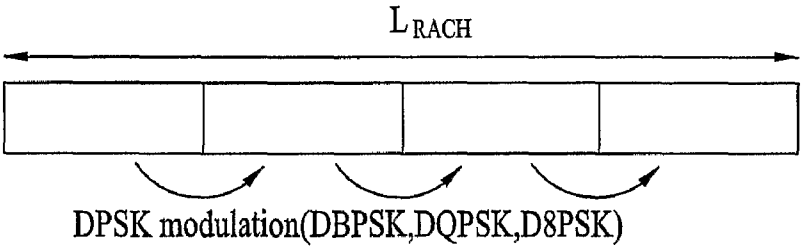


FIG. 4A

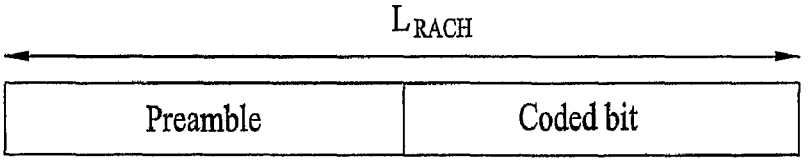


FIG. 4B

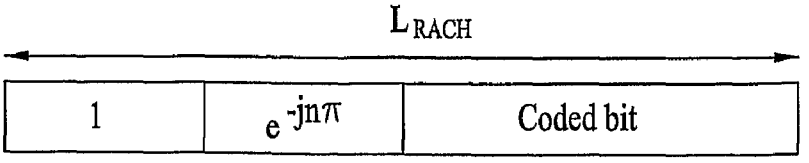


FIG. 5

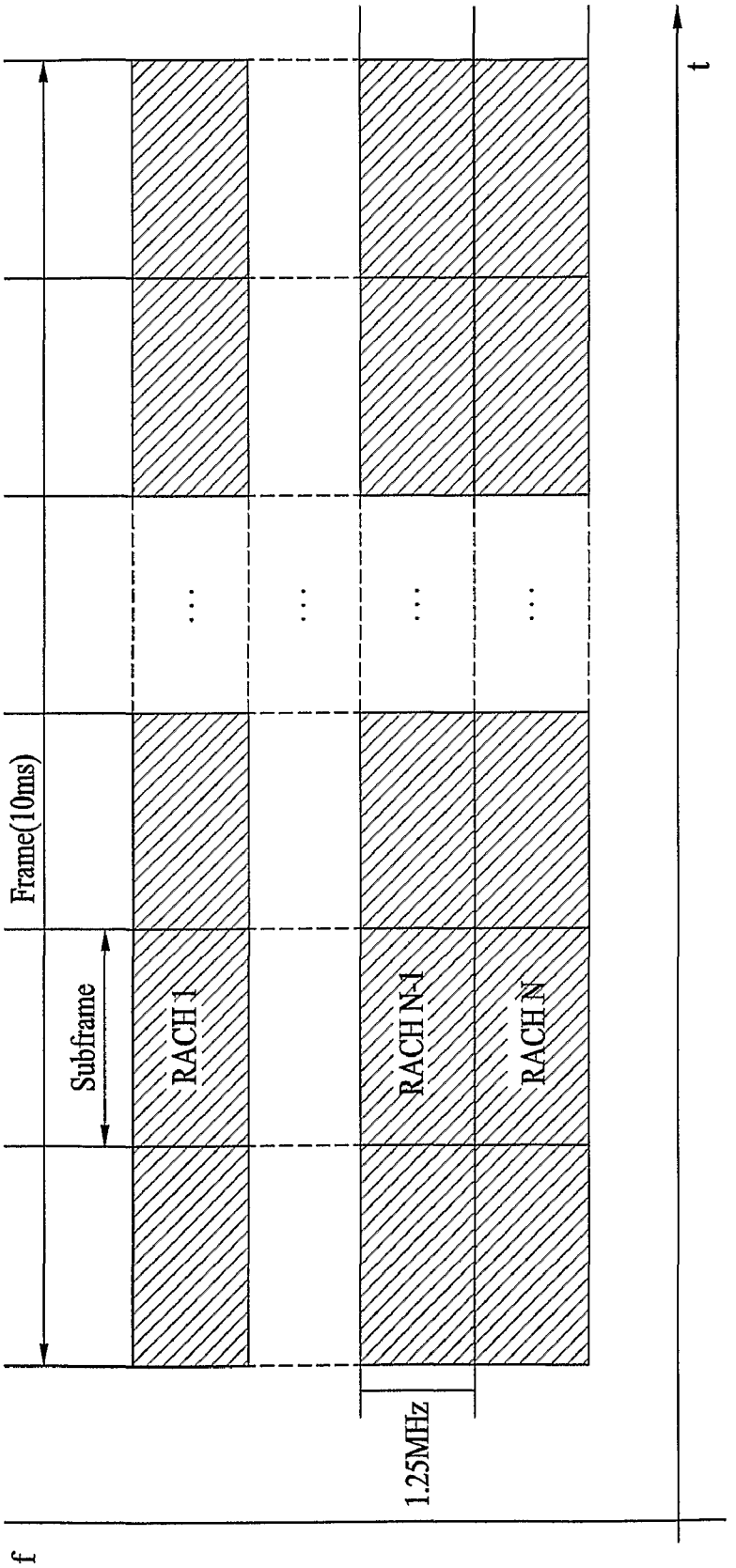


FIG. 6A

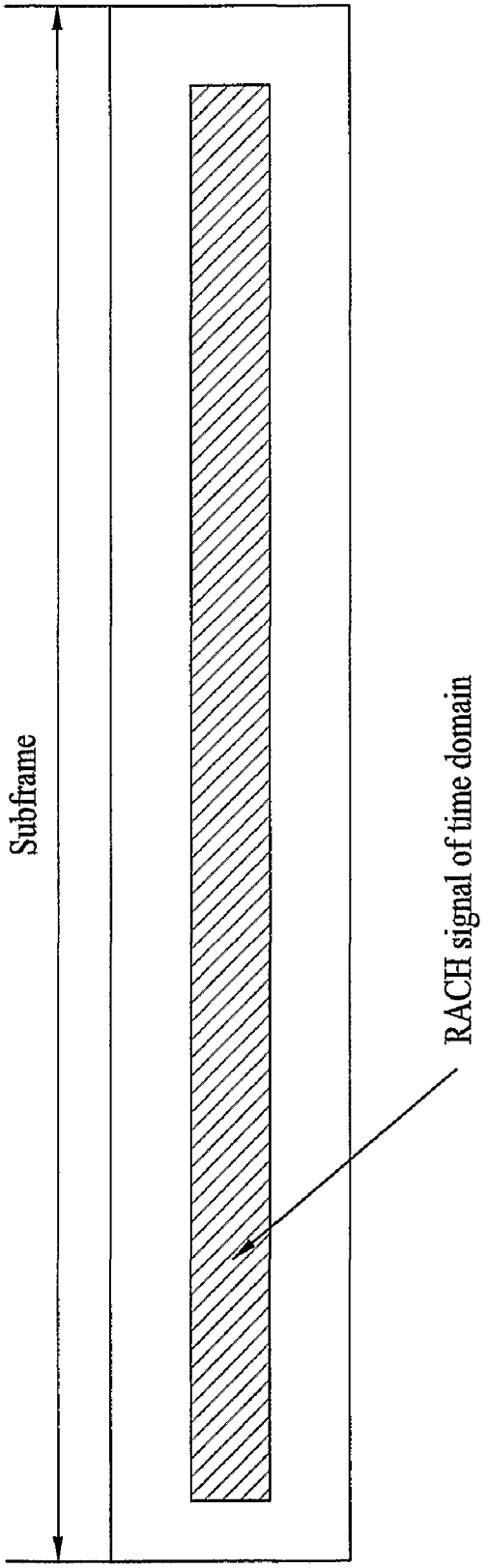


FIG. 6B

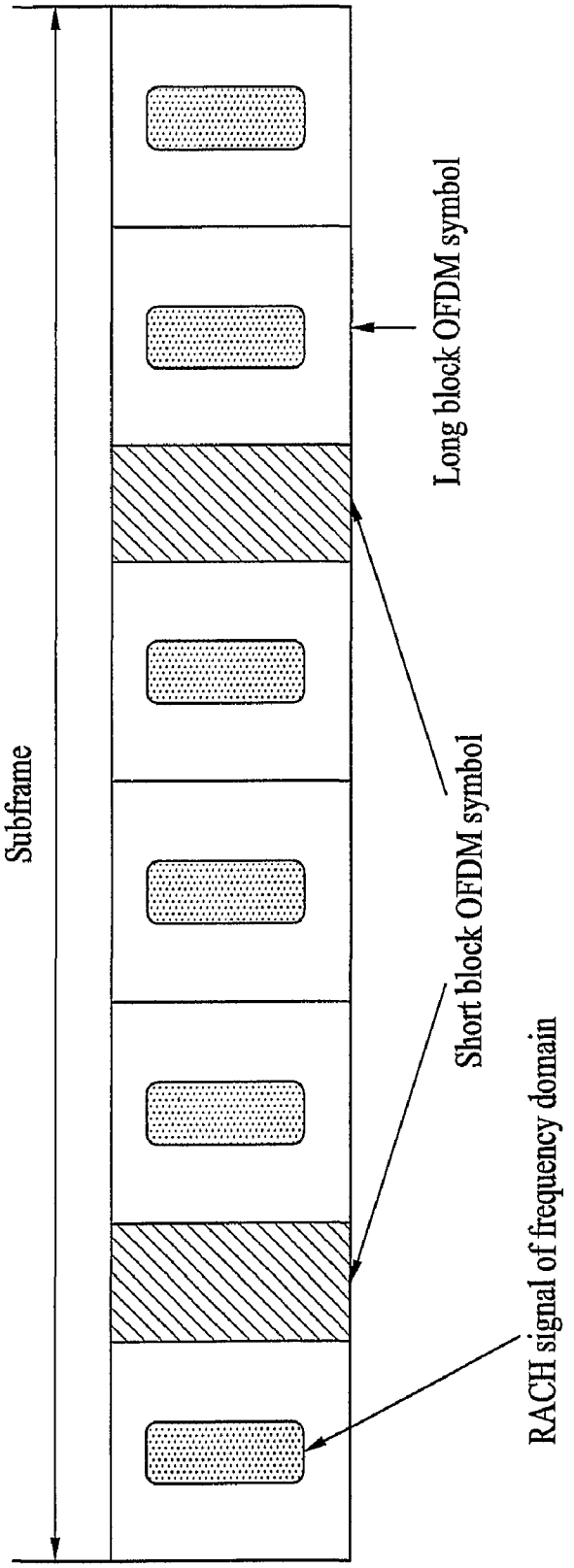

Subframe
Long block OFDM symbol
Short block OFDM symbol
RACH signal of frequency domain

FIG. 7

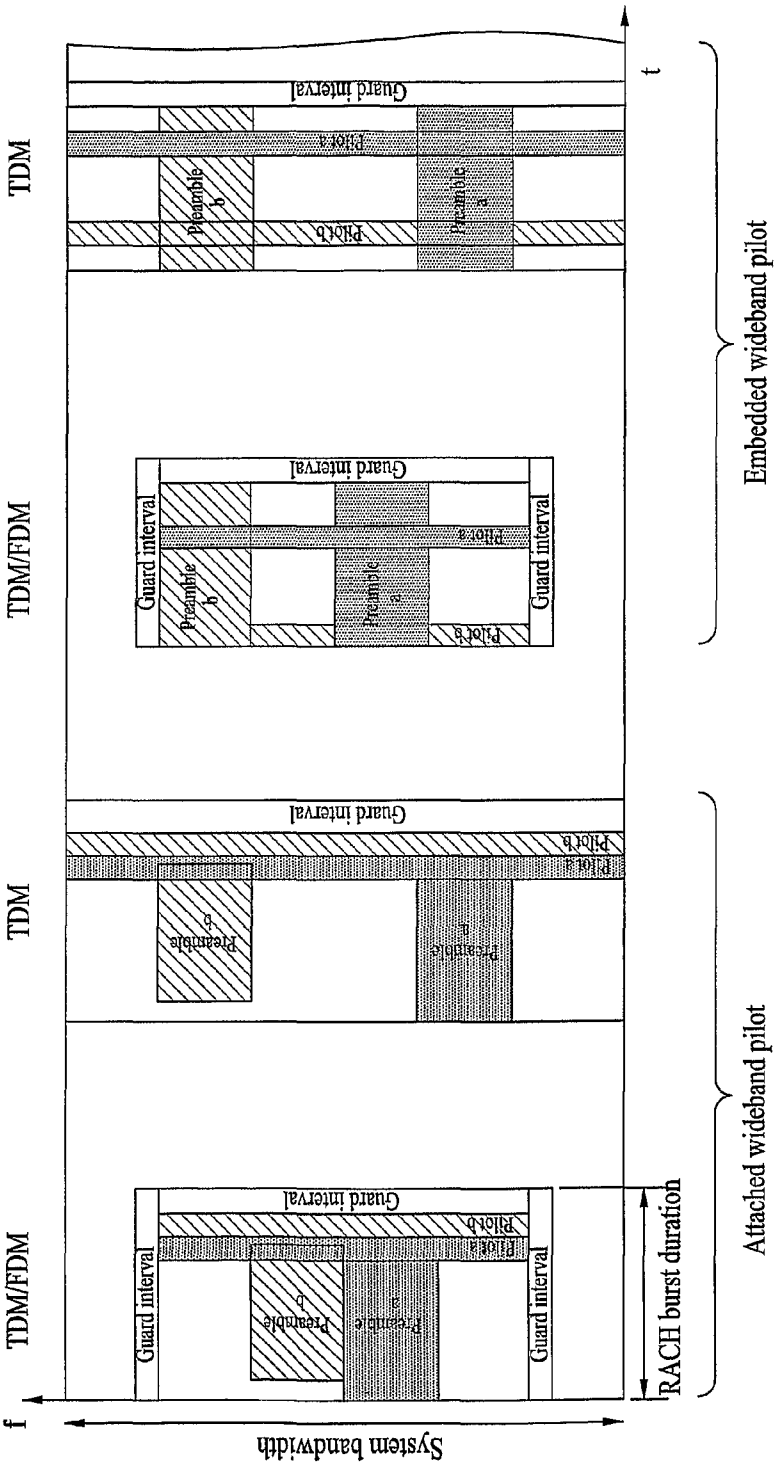

TDM/FDM
TDM
TDM/FDM
TDM
f
System bandwidth
Guard interval
Preamble b
Preamble a
Pilot a
Pilot b
RACH burst duration
Attached wideband pilot
Embedded wideband pilot
t

FIG. 8A

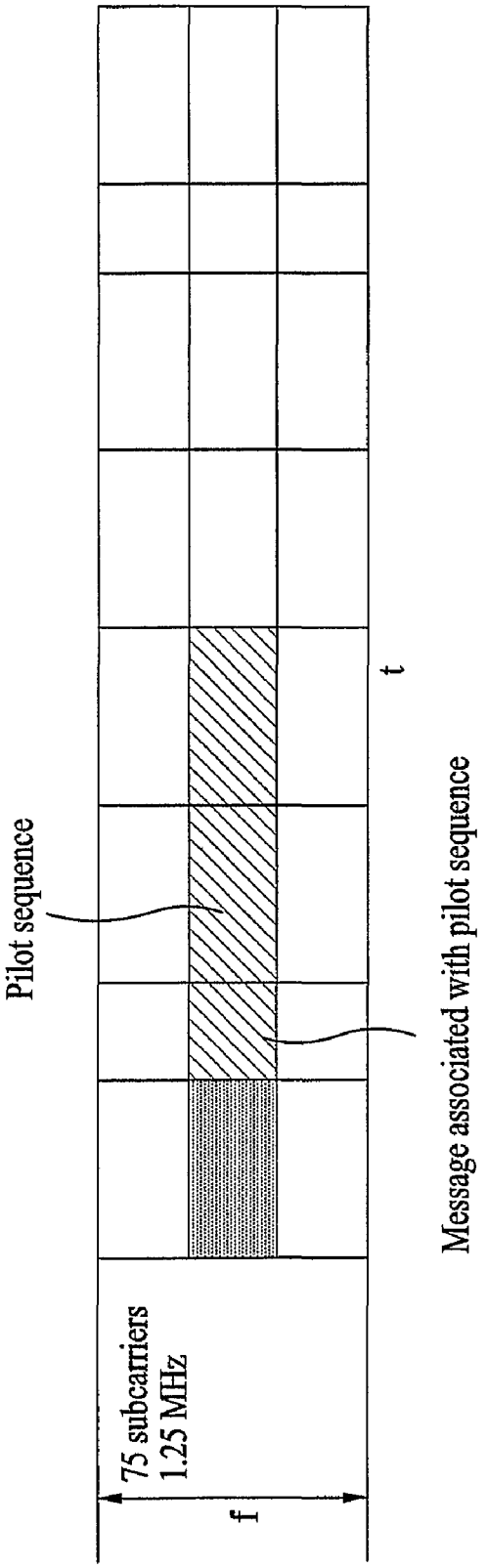

Pilot sequence
Message associated with pilot sequence
t
75 subcarriers
1.25 MHz
f

FIG. 8B

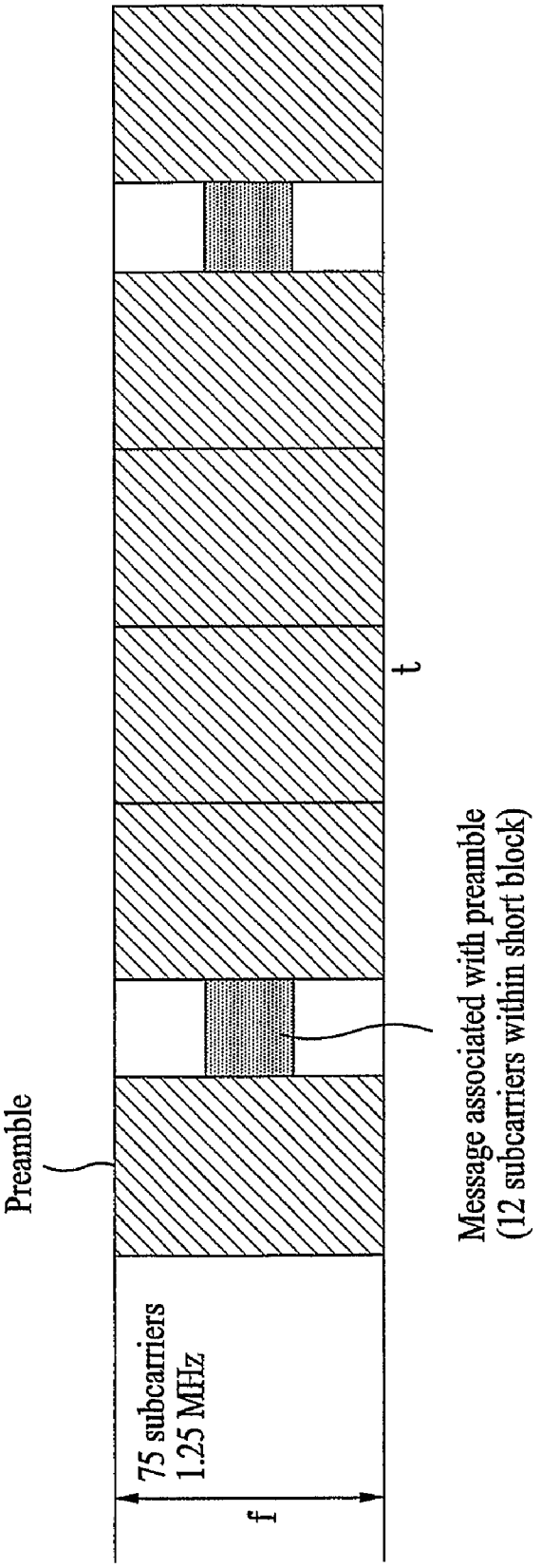

Preamble
75 subcarriers
1.25 MHz
f
t
Message associated with preamble
(12 subcarriers within short block)

FIG. 9

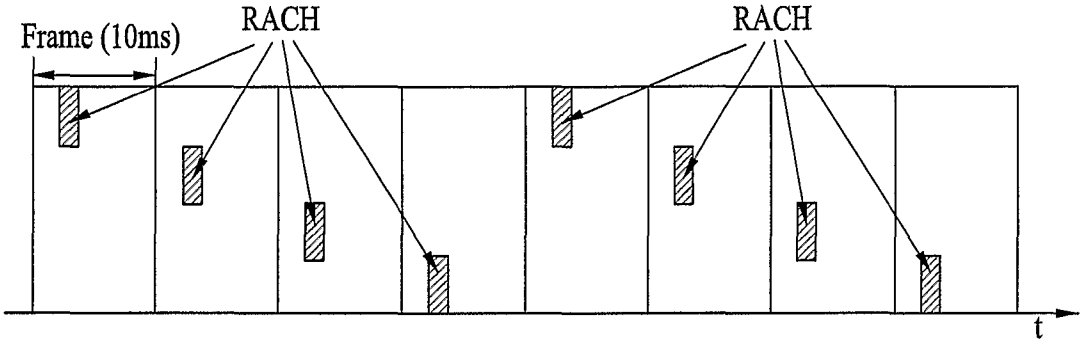


FIG. 10

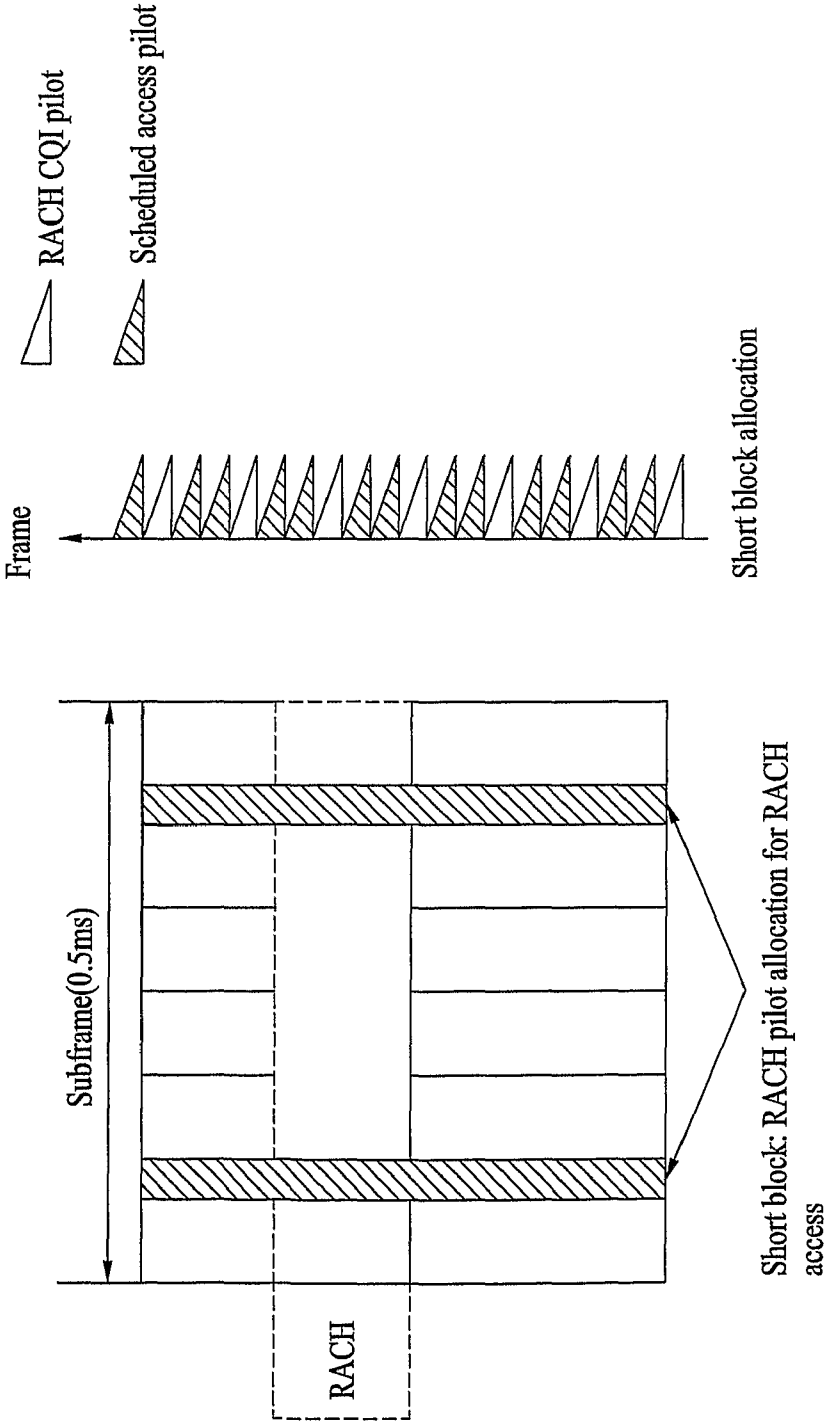

RACH CQI pilot
Scheduled access pilot
Frame
Short block allocation
Subframe(0.5ms)
RACH
Short block: RACH pilot allocation for RACH access

FIG. 11

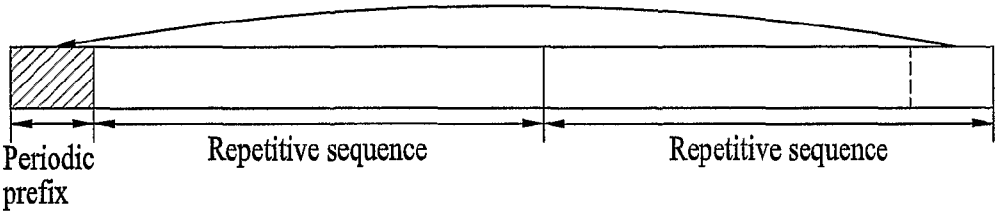

Periodic prefix
Repetitive sequence
Repetitive sequence

FIG. 12

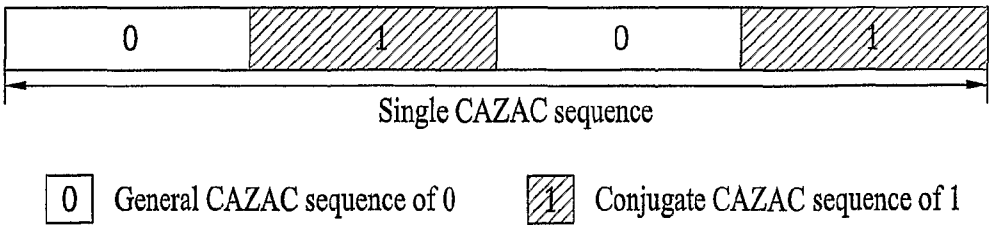

0
1
0
1
Single CAZAC sequence
0 General CAZAC sequence of 0
1 Conjugate CAZAC sequence of 1

FIG. 13

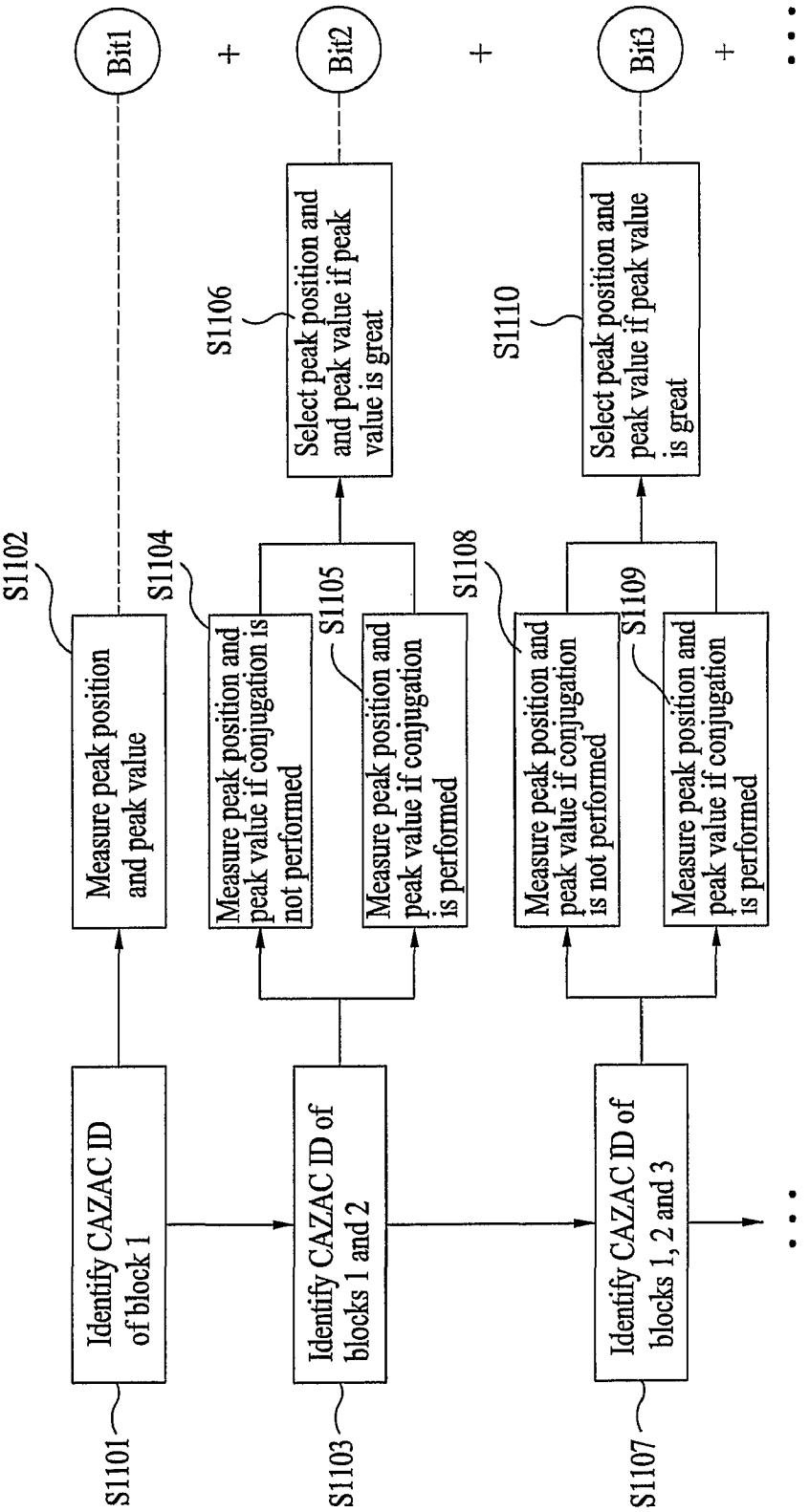

S1101
Identify CAZAC ID of block 1
S1102
Measure peak position and peak value
Bit1
+
S1103
Identify CAZAC ID of blocks 1 and 2
S1104
Measure peak position and peak value if conjugation is not performed
S1105
Measure peak position and peak value if conjugation is performed
S1106
Select peak position and and peak value if peak value is great
Bit2
+
S1107
Identify CAZAC ID of blocks 1, 2 and 3
S1108
Measure peak position and peak value if conjugation is not performed
S1109
Measure peak position and peak value if conjugation is performed
S1110
Select peak position and peak value if peak value is great
Bit3
+
...

FIG. 14

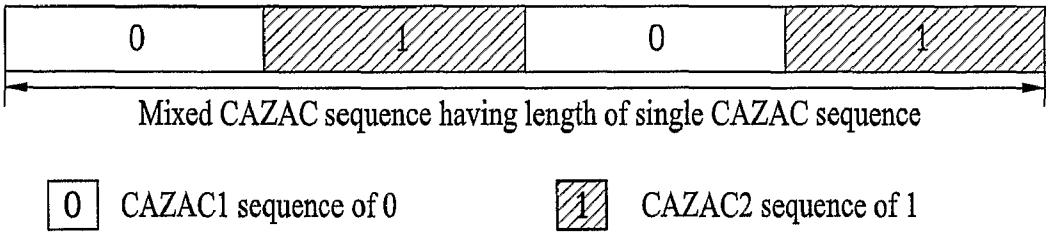

0
1
0
1
Mixed CAZAC sequence having length of single CAZAC sequence
0
CAZAC1 sequence of 0
1
CAZAC2 sequence of 1

FIG. 15

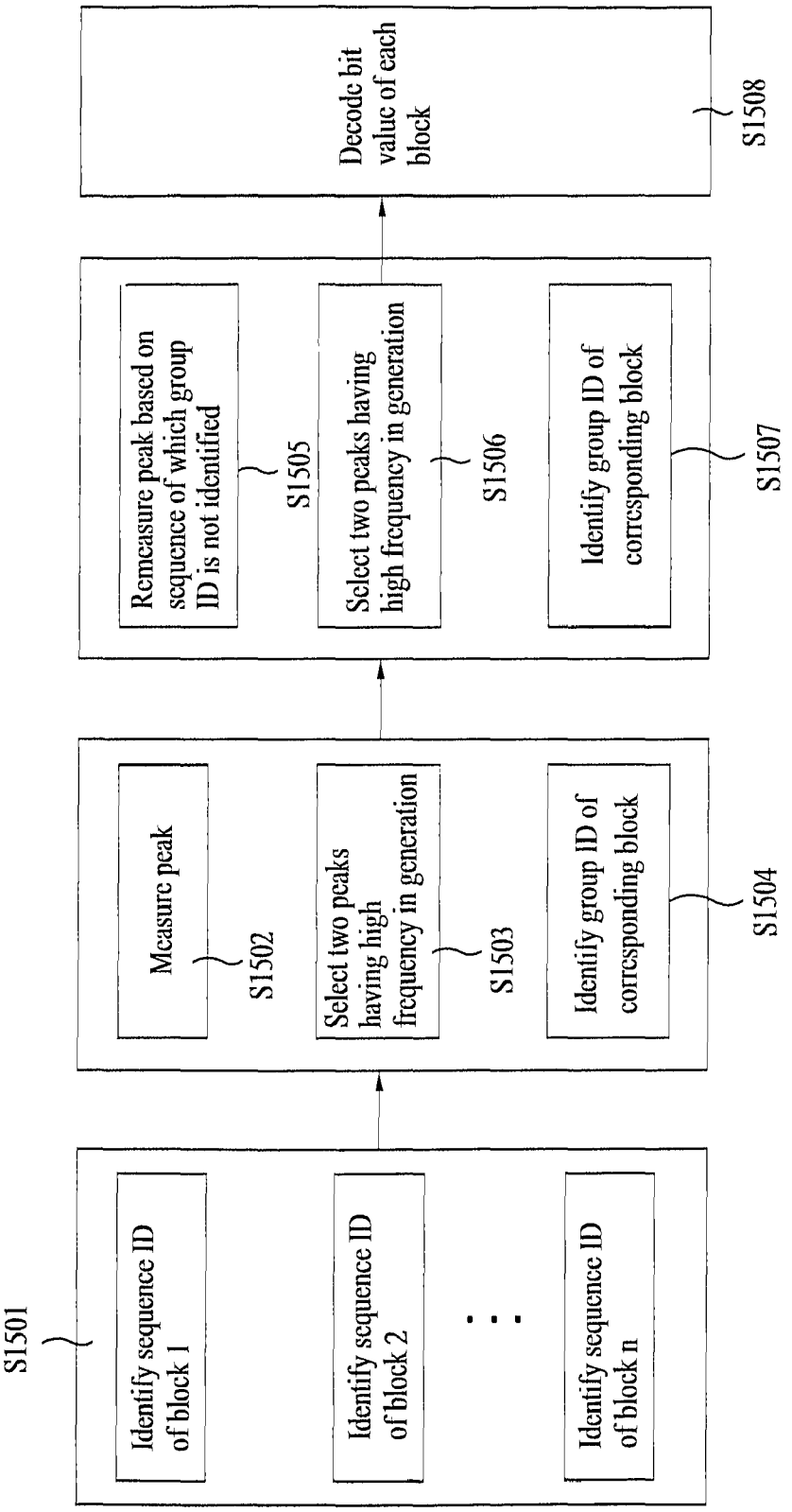

S1501
Identify sequence ID of block 1
Identify sequence ID of block 2
Identify sequence ID of block n
S1502
Measure peak
S1503
Select two peaks having high frequency in generation
S1504
Identify group ID of corresponding block
S1505
Remeasure peak based on sequence of which group ID is not identified
S1506
Select two peaks having high frequency in generation
S1507
Identify group ID of corresponding block
S1508
Decode bit value of each block

FIG. 16

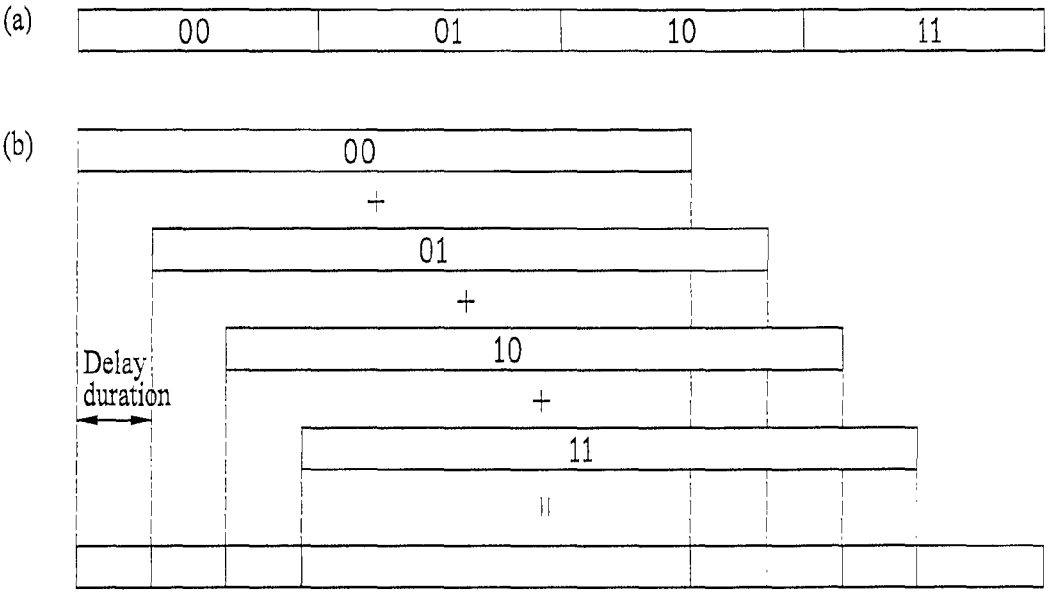


FIG. 17

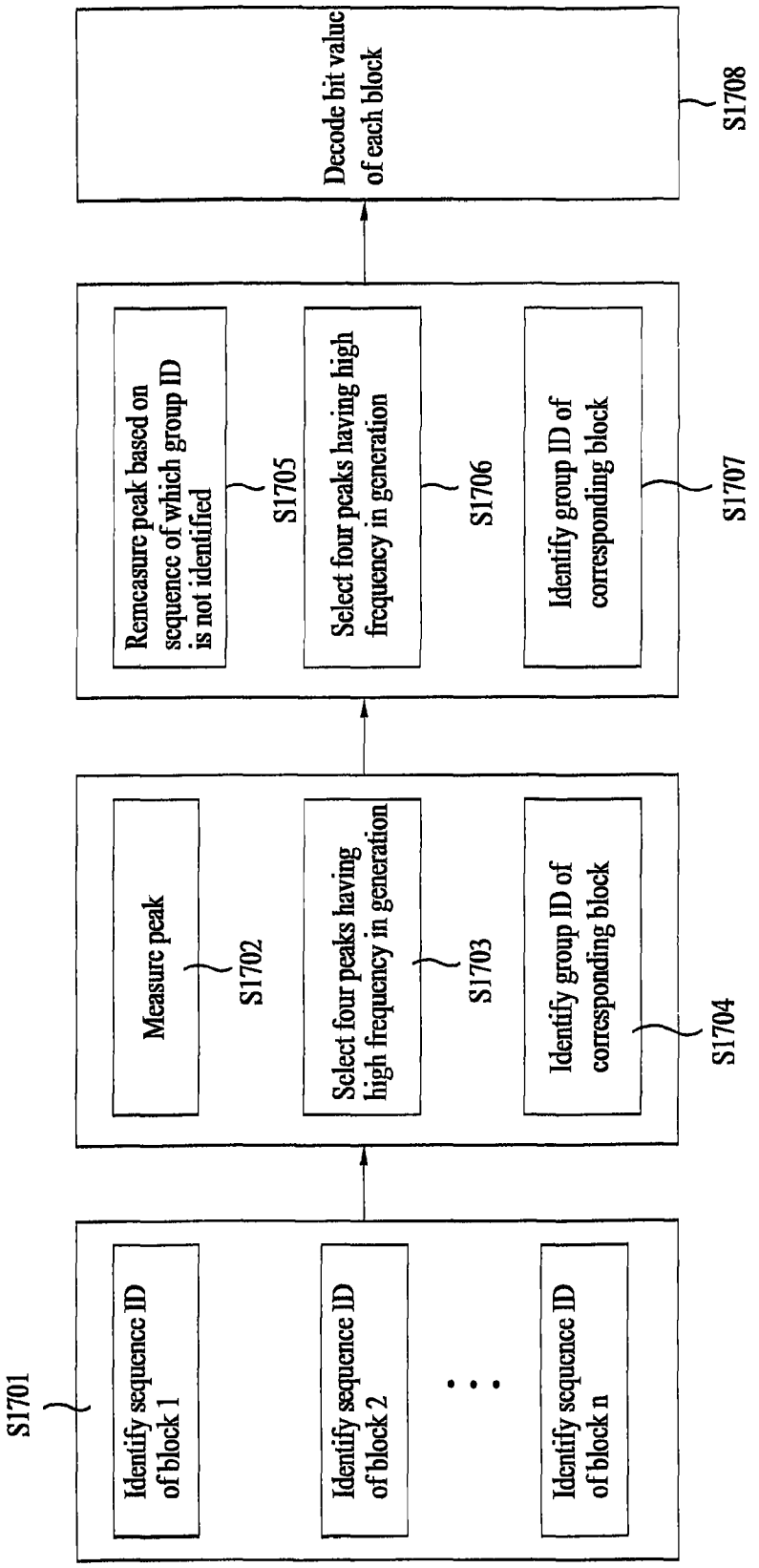

S1701
Identify sequence ID of block 1
Identify sequence ID of block 2
Identify sequence ID of block n
Measure peak
S1702
Select four peaks having high frequency in generation
S1703
Identify group ID of corresponding block
S1704
Remeasure peak based on sequence of which group ID is not identified
S1705
Select four peaks having high frequency in generation
S1706
Identify group ID of corresponding block
S1707
Decode bit value of each block
S1708

FIG. 18

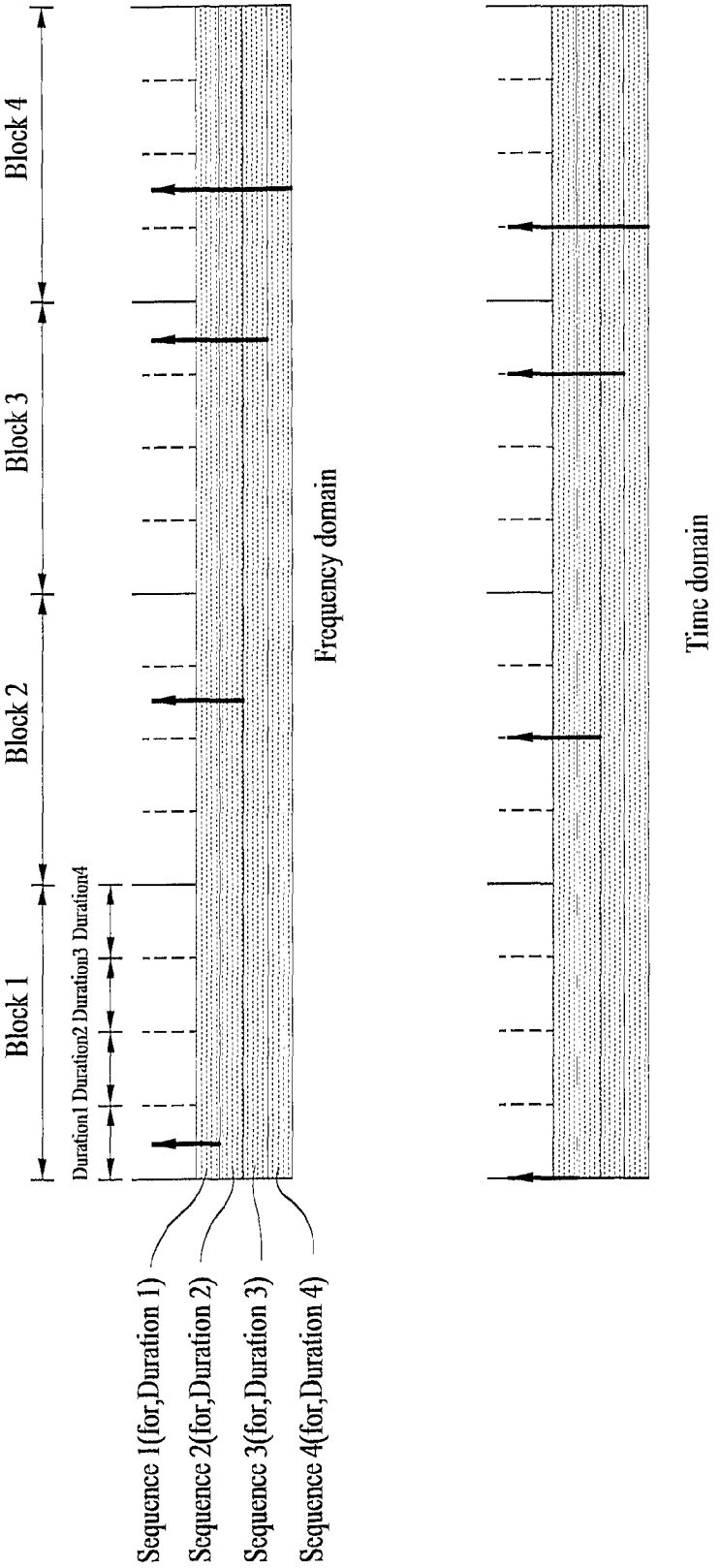

Block 1
Block 2
Block 3
Block 4
Duration1 Duration2 Duration3 Duration4
Sequence 1(for,Duration 1)
Sequence 2(for,Duration 2)
Sequence 3(for,Duration 3)
Sequence 4(for,Duration 4)
Frequency domain
Time domain

FIG. 19

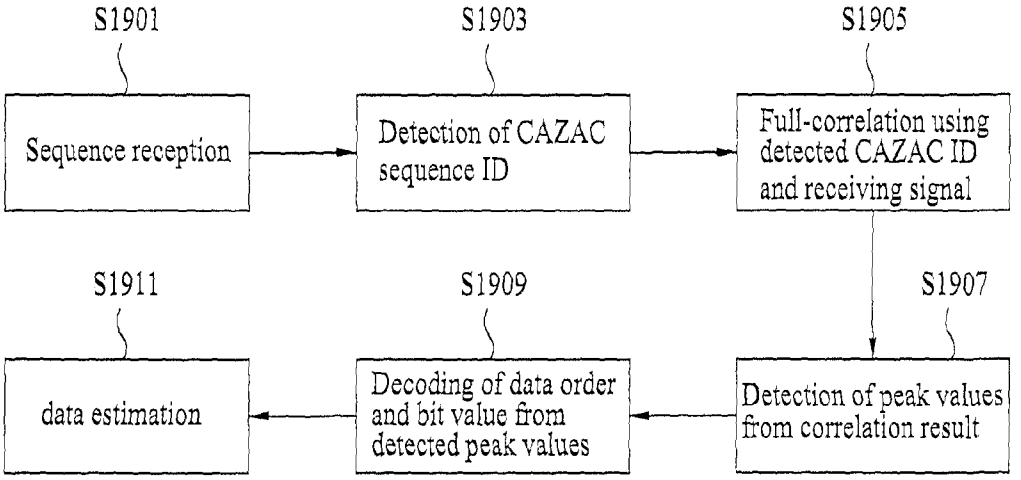

S1901
Sequence reception
S1903
Detection of CAZAC sequence ID
S1905
Full-correlation using detected CAZAC ID and receiving signal
S1907
Detection of peak values from correlation result
S1909
Decoding of data order and bit value from detected peak values
S1911
data estimation

FIG. 20A

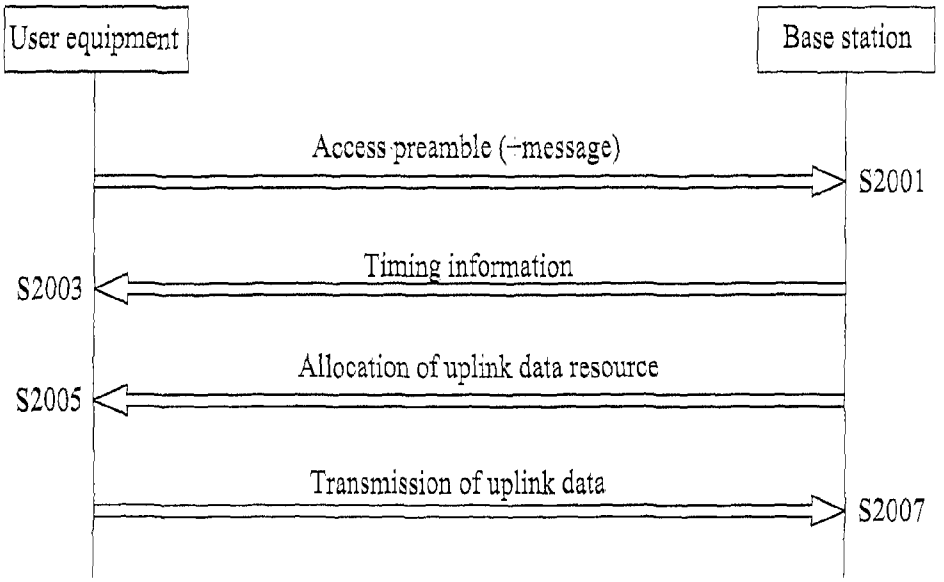


FIG. 20B

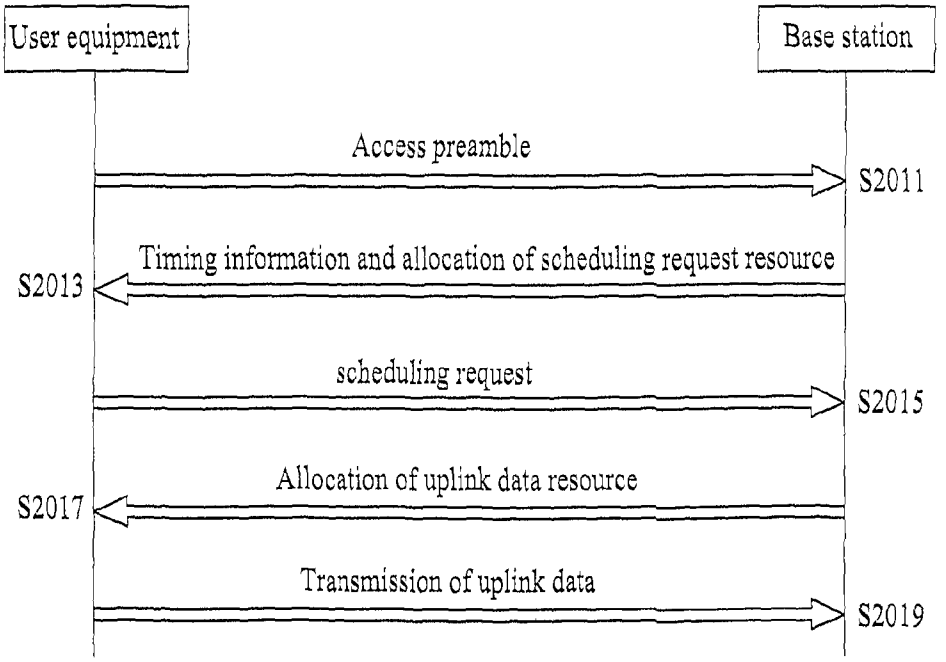


FIG. 21

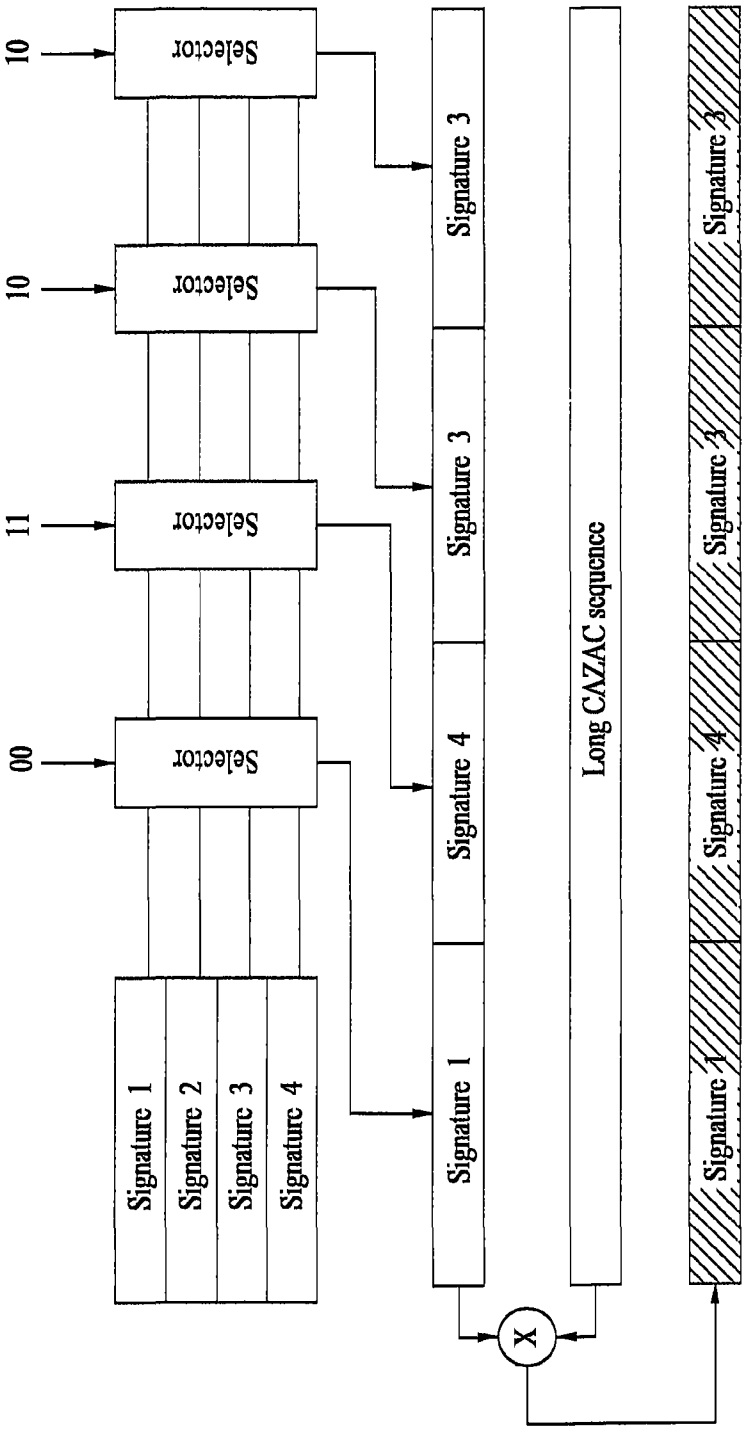
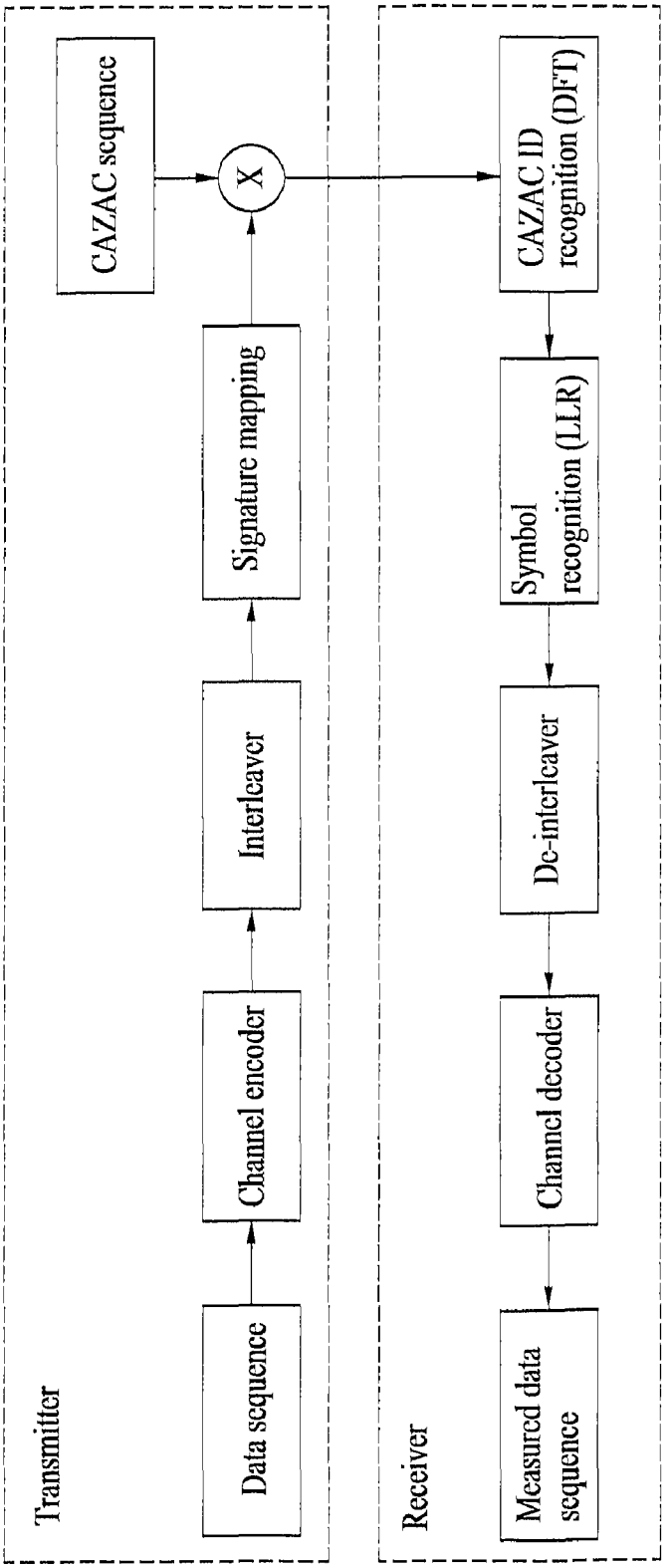

00
11
10
10
Selector
Selector
Selector
Selector
Signature 1
Signature 2
Signature 3
Signature 4
Signature 1
Signature 4
Signature 3
Signature 3
Long CAZAC sequence
X
Signature 1
Signature 4
Signature 3
Signature 3

FIG. 22


Transmitter
Data sequence
Channel encoder
Interleaver
Signature mapping
CAZAC sequence
X
Receiver
Measured data sequence
Channel decoder
De-interleaver
Symbol recognition (LLR)
CAZAC ID recognition (DFT)

METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is the National Stage filing under 35 U.S.C. §371 of International Application No. PCT/KR07/02784, filed on Jun. 8, 2007, which claims the benefit of earlier filing date and right of priority to Korean Application Nos. 10-2006-0052167, filed on Jun. 9, 2006, and 10-2006-0057488, filed on Jun. 26, 2006.

TECHNICAL FIELD

The present invention relates to a mobile communication system, and more particularly, to a method of expanding a code sequence, a structure of a random access channel and a method of transmitting data in a mobile communication system.

BACKGROUND ART

A user equipment uses a random access channel (RACH) to access a network in a state that the user equipment is not uplink synchronized with a base station. A signal having repetitive characteristic in a time domain is used in the random access channel, so that a receiver easily searches a start position of a transmission signal. In general, the repetitive characteristic is realized by repetitive transmission of a preamble.

A representative example of a sequence for realizing the preamble includes a CAZAC (Constant Amplitude Zero Auto Correlation) sequence. The CAZAC sequence is expressed by a Dirac-Delta function in case of auto-correlation and has a constant value in case of cross-correlation. In this respect, it has been estimated that the CAZAC sequence has excellent transmission characteristics. However, the CAZAC sequence has limitation in that maximum N−1 number of sequences can be used for a sequence having a length of N. For this reason, a method for increasing available bits of the sequence while maintaining the excellent transmission characteristics is required.

Meanwhile, there are provided various methods for transmitting data from a random access channel by using the CAZAC sequence. Of them, the first method is to directly interpret CAZAC sequence ID to message information. Assuming that data to be transmitted is a preamble, if a sufficient number of sequences that can be used as the preamble are provided, message passing can be performed with only CAZAC sequence ID without additional manipulation. However, since a method of transmitting additional information should be considered in an actual synchronized RACH, problems occur in that there is difficulty in realizing a sufficient number of CAZAC sequence sets, and the cost required for search of a receiver increases.

The second method is to simultaneously transmit CAZAC sequence and Walsh sequence by using a code division multiplexing (CDM) mode. In this case, CAZAC sequence ID is used as user equipment identification information, and the Walsh sequence transmitted in the CDM mode is interpreted as message information. FIG. **1** is a block schematic view illustrating a transmitter for realizing the second method. However, the second method has limitation in that even though the Walsh sequence is added to the CAZAC sequence, bits of message that can additionally be obtained are only $\log_2 N$ bits when the Walsh sequence has a length of N.

The third method is to transmit CAZAC sequence and Walsh sequence in such a way to mix the Walsh sequence with the CAZAC sequence. In this case, CAZAC sequence ID is used as user equipment identification information, and the Walsh sequence is interpreted as message information. FIG. **2** is a block diagram illustrating a data processing procedure at a transmitter for realizing the third method. However, according to the third method, since the Walsh sequence acts as noise in detection of the CAZAC sequence to cause difficulty in detecting sequence ID, there is limitation in that repetitive sequences should be transmitted to prevent the Walsh sequence from acting as noise in detection of the CAZAC sequence.

The fourth method is to either give orthogonality between blocks constituting a corresponding sequence by multiplying an exponential term by a CAZAC sequence or directly apply data modulation such as DPSK, DQPSK, D8PSK, etc. In this case, CAZAC sequence ID is used as user equipment identification information, and the modulated sequence is demodulated and then used as message information. FIG. **3**A illustrates data modulation according to the former method of the fourth method, and FIG. **3**B illustrates data modulation according to the latter method of the fourth.

Furthermore, the fifth method is to transmit CAZAC sequence by attaching a message part to the CAZAC sequence. FIG. **4**A illustrates the case where a message (coded bit) is attached to the CAZAC sequence used as a preamble, and FIG. **4**B illustrates the case where a message (coded bit) is attached to a sequence consisting of a predetermined number of blocks to which orthogonality is given.

However, the fourth method and the fifth method have a problem in that they are susceptible to change of channel condition.

DISCLOSURE OF THE INVENTION

Accordingly, the present invention has been suggested to substantially obviate one or more problems due to limitations and disadvantages of the related art, and an object of the present invention is to provide a method of transmitting and receiving message between a user equipment and a base station by using a long sequence to maximize time/frequency diversity and alleviating performance attenuation due to channel.

Another object of the present invention is to provide a method of transmitting data through a code sequence in a mobile communication system, in which the quantity of data can be increased and the transmitted data becomes robust to noise or channel change.

Still another object of the present invention is to provide a method of suggesting a structure of an efficient random access channel in a multi-carrier system.

Further still another object of the present invention is to provide a method of minimizing access time of a user equipment to a random access channel in a mobile communication system.

To achieve these objects and other advantages and in accordance with the purpose of the invention, as embodied and broadly described herein, a data transmission method through a random access channel in a mobile communication system comprises generating a new code by multiplying a code sequence by an exponential sequence, and transmitting the new code sequence to a receiving side.

In another aspect of the present invention, a data transmission method by using a code sequence in a mobile communication system comprises conjugating at least one element included in at least one block of a code sequence divided by at

least two blocks to indicate predetermined information, and transmitting the code sequence, in which the at least one block is conjugated, to a receiving side.

In still another aspect of the present invention, a data transmission method by using a code sequence in a mobile communication system generating a second code sequence indicating predetermined information by combining at least two first code sequences mapped with at least one information bit, respectively, and transmitting the second code sequence to a receiving side.

In further still another aspect of the present invention, a code sequence transmission method in a mobile communication system comprises generating a combination code sequence by combining a base code sequence to at least one code sequence obtained by circular shift of the base code sequence, and transmitting the combination code sequence to a receiving side.

In further still another aspect of the present invention, a code sequence transmission method in a mobile communication system generating a repetitive code sequence by repeatedly concatenating a first code sequence at least one or more times, generating a cyclic prefix (CP) by copying a certain part of a rear end of the repetitive code sequence and concatenating the copied part to a front end of the repetitive code sequence, and transmitting the repetitive code sequence, in which the CP is generated, to a receiving side.

In further still another aspect of the present invention, a method of allocating a random access channel (RACH) in a multi-carrier system comprises allocating a random access channel to each of at least two consecutive frames in a way that frequency bands of the random access channels allocated to the at least two consecutive frames are not overlapped with each other, and transmitting allocation information of the random access channels allocated to the at least two consecutive frames to at least one user equipment.

In further still another aspect of the present invention, a data transmission method through a code sequence in a mobile communication system mapping each of a plurality of blocks having at least one bit of a input data stream, respectively to a corresponding signature sequence, multiplying a signature sequence stream, to which the plurality of blocks are mapped, by a specific code sequence, and transmitting the signature sequence stream multiplied by the specific code sequence to a receiving side.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates an example of a data transmission method through a random access channel in an OFDMA system according to the related art;

FIG. **2** illustrates another example of a data transmission method through a random access channel in an OFDMA system according to the related art;

FIG. **3**A and FIG. **3**B illustrate still another example of a data transmission method through a random access channel in an OFDMA system according to the related art;

FIG. **4**A and FIG. **4**B illustrate further still another example of a data transmission method through a random access channel in an OFDMA system according to the related art;

FIG. **5** illustrates an example of a structure of a random access channel used in an OFDMA system;

FIG. **6**A and FIG. **6**B illustrate examples of sending an RACH signal in a time domain or a frequency domain based on a structure of a random access channel of FIG. **5**;

FIG. **7** illustrates another example of a structure of a random access channel used in an OFDMA system;

FIG. **8**A and FIG. **8**B illustrate still another example of a structure of a random access channel used in an OFDMA system;

FIG. **9** illustrates a structure of a random access channel according to one embodiment of the present invention;

FIG. **10** illustrates a structure of a random access channel of a sub-frame to which RACH pilot is allocated;

FIG. **11** illustrates a repetitive structure of a preamble according to one embodiment of the present invention;

FIG. **12** is a structural view of unit data to illustrate one embodiment of the present invention, which transmits data by using a code sequence expanded through conjugation;

FIG. **13** is a flow chart illustrating a procedure of receiving and decoding data transmitted in a code sequence expanded through conjugation in accordance with one embodiment of the present invention;

FIG. **14** is a structural view of unit data to illustrate one embodiment of the present invention, which transmits data by using a code sequence expanded through grouping;

FIG. **15** is a flow chart illustrating a procedure of receiving and decoding data transmitted in a code sequence expanded through grouping;

FIG. **16** is a structural view of unit data to illustrate one embodiment of the present invention, which transmits data by using a code sequence expanded through grouping and delay processing;

FIG. **17** is a flow chart illustrating a procedure of receiving and decoding data transmitted in a code sequence expanded through grouping and delay processing;

FIG. **18** is a structural view of unit data to illustrate one embodiment of the present invention, which transmits data by using a code sequence expanded through PPM modulation;

FIG. **19** is a flow chart illustrating a procedure of receiving and decoding data transmitted in a code sequence expanded through PPM modulation;

FIG. **20**A and FIG. **20**B are flow charts illustrating a procedure of performing synchronization in a random access channel in accordance with a data transmission method of the present invention;

FIG. **21** illustrates a method of transmitting data to a receiver through a signaling channel in accordance with one embodiment of the present invention; and

FIG. **22** illustrates an example of a receiver and a transmitter for transmitting a preamble and data through RACH, SCH or other channel in accordance with one embodiment of the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

Hereinafter, structures, operations, and other features of the present invention will be understood readily by the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings.

A random access channel (RACH) is used to allow a user equipment to access a network in a state that the user equipment is not uplink synchronized with a base station. A random access mode can be classified into an initial ranging access mode and a periodic ranging access mode depending on an access mode to network. According to the initial ranging access mode, the user equipment acquires downlink synchronization and first accesses a base station. According to the periodic ranging access mode, the user equipment connected with a network accesses the network if necessary. The initial ranging access mode is used to allow the user equipment to synchronize with the network while accessing the network and receive its required ID from the network. The periodic

ranging access mode is used to initiate a protocol to receive data from the base station or when a packet to be transmitted exists.

In particular, the periodic ranging access mode can be classified into two types in the 3GPP LTE (long term evolution) system, i.e., a synchronized access mode and a non-synchronized access mode. The synchronized access mode is used if an uplink signal is within a synchronization limit when the user equipment accesses the RACH. The non-synchronized access mode is used if the uplink signal is beyond the synchronization limit. The non-synchronized access mode is used when the user first accesses the base station or synchronization update is not performed after synchronization is performed. At this time, the synchronized access mode is the same as the periodic ranging access mode, and is used when the user equipment accesses the RACH for the purpose of notifying the base station of the change status of the user equipment and requesting resource allocation.

On the other hand, the synchronized access mode alleviates limitation of a guard time in the RACH by assuming that the user equipment does not depart from uplink synchronization with the base station. For this reason, much more time-frequency resources can be used. For example, a considerable amount of messages (more than 24 bits) may be added to a preamble sequence for random access in the synchronized access mode so that both the preamble sequence and the messages may be transmitted together.

A structure of the RACH, which performs a unique function of the RACH while satisfying the aforementioned synchronized and non-synchronized access modes will now be described.

FIG. **5** is a diagram illustrating an example of a structure of a random access channel (RACH) used in an OFDMA system. As shown in FIG. **5**, it is noted that the RACH is divided into N number of sub-frames on a time axis and M number of frequency bands on a frequency axis depending on a radius of a cell. Frequency in generation of the RACH is determined depending on QoS (Quality of Service) requirements in a medium access control (MAC) layer. In general, the RACH is generated per certain period (several tens of milliseconds (ms) to several hundreds of ms). In this case, frequency diversity effect and time diversity effect are provided in generating several RACHs and at the same time collision between user equipments which access through the RACH is reduced. The length of the sub-frame can be 0.5 ms, 1 ms, etc.

In the RACH structure as shown in FIG. **5**, a random sub-frame will be referred to as a time-frequency resource (TFR) which is a basic unit of data transmission. FIG. **6**A is a diagram illustrating a type of sending a random access signal to the TFR in a time domain, and FIG. **6**B illustrates a type of sending a RACH signal in a frequency domain.

As shown in FIG. **6**A, if a random access signal is generated in a time domain, the original sub-frame structure is disregarded and the signal is aligned through only the TFR. By contrast, as shown in FIG. **6**B, in case of the synchronized random access mode, the sub-frame structure is maintained in the frequency domain and at the same time a random access signal to be transmitted to sub-carriers of each OFDM symbol is generated. Accordingly, orthogonality can be maintained between respective blocks constituting TFR, and channel estimation can easily be performed.

FIG. **7** is a diagram illustrating another example of a structure of RACH used in an OFDMA system. As shown in FIG. **7**, it is noted that a preamble 'b' and a pilot 'a' are partially overlapped in a TDM/FDM mode and a TDM mode of RACH burst duration of an attached wideband pilot. It is also noted that a pilot 'a' and a pilot 'b' are simultaneously overlapped with a preamble 'a' and the preamble 'b' in the TDM/FDM mode and the TDM mode of an embedded wideband pilot. In other words, it is designed that a preamble and a pilot are together transmitted through the RACH, so that message decoding is easily performed through channel estimation if message is added to the RACH. Alternatively, a wideband pilot is used so that channel quality information (CQI) of a total of RACH bands can be acquired in addition to a preamble band of the RACH.

FIG. **8**A and FIG. **8**B are diagrams illustrating another examples of a structure of the RACH used in the OFDMA system,

As shown in FIG. **8**A, a preamble is transmitted for a predetermined time period through a frequency band, and a short block duration is provided at a certain period so that a pilot for decoding a preamble is transmitted to a corresponding short block. At this time, the pilot transmission is performed through a part of a total of frequency bands (transmission through **25** sub-carriers corresponding to a middle band of a total of 75 sub-carriers), so that the pilot can be transmitted to a specific user equipment under a multi-access environment.

Furthermore, as shown in FIG. **8**B, a message to be transmitted and a pilot for decoding the message are multiplexed and continue to be transmitted through some frequency bands (for example, 25 middle sub-carrier bands of a total of 75 sub-carrier bands) selected from a total of frequency bands. Accordingly, respective user equipments which perform multi-access can be identified by allocating some frequency bands at different frequencies.

FIG. **9** is a diagram illustrating a structure of RACH according to one embodiment of the present invention.

Generally, frequency in generation of the RACH is determined depending on QoS requirements in a MAC layer. The RACH is generated at a variable period (several ms to several hundreds of ms) depending on requirements of a cell. The RACH can be generated in a time domain or a frequency domain as described above with reference to FIG. **6**A and FIG. **6**B. In the embodiment of FIG. **9**, the structure of the RACH corresponds to the case where a random access signal is generated in the frequency domain.

Referring to FIG. **9**, in this embodiment, to overcome a drawback of a long interval required for retry when the user equipment fails to access the RACH, a corresponding RACH resource is dispersed in each frame within one period if frequency in generation of the RACH and the quantity of overhead are determined. The number of frames included in one period can freely be determined as occasion demands. At this time, it is preferable that the RACH is divisionally arranged so as to be uniformly distributed for each frequency band with respect to a plurality of frames constituting one period. However, position on the time axis may be changed without change of position on the frequency axis and vice versa depending on specific requirements (synchronized action or decrease of inter-cell interference) of a cell or if a system band is small. Also, arrangement of any one of frequency and time may be changed to obtain the minimum interval between the RACHs arranged in each frame.

In the embodiment of FIG. **9**, the network should notify the user equipment of position information of the allocated RACH resource. In other words, the network can notify each user equipment of frequency and time information occupied by the RACH resource allocated for each frame included in one period, and each user equipment can try random access through the allocated RACH resource by using the position information from the network. The position information of the RACH resource of each frame can be expressed by sub-

carrier offset, the number of sub-carriers, timing offset, and the number of symbols. However, if the RACH information on each frame is expressed by the above four parameters, it may be undesirable in that the quantity of the information can be increased. Accordingly, a method of decreasing the quantity of the information for expressing the position information of the RACH allocated on each frame is required. The position information of the RACH can be transmitted through a broadcast channel (BCH) or other downlink control channel.

As one method, a method using a hopping pattern may be considered. The hopping pattern means a pattern consisting of information indicating frequency domains of the RACH resource allocated to each frame within one period. In other words, in the embodiment of FIG. **9**, since the RACH resource is divisionally arranged so as to be uniformly distributed for each frequency band with respect to a plurality of frames constituting one period, an indicator which indicates a frequency band that can be allocated to each frame as the RACH resource is previously determined, and the frequency band of the RACH resource allocated to each frame within one period can be notified through a pattern of the indicator which indicates a corresponding frequency band.

For example, if four frames are used as one period in a system which uses a total of bands of 10 MHz, the position of the RACH includes sub-bands having an interval of 2.5 MHz as one RACH frequency band (band smaller than 1.25 MHz or 2.5 MHz). At this time, a total of bands consist of four sub-bands, wherein the respective sub-bands are designated by indicators, which indicate each sub-band, as 1, 2, 3 and 4 in due order from a high frequency band to a low frequency band. In this way, the frequency band position information of the RACH resource allocated to all frames within one period can be expressed by patterns configured by the above indicators, for example 2, 3, 1, 4. The hopping pattern may be configured differently or equally depending on each frame. Time information of the RACH resource allocated to each frame within one period can generally be expressed by timing offset and the number of symbols. At this time, at least any one of the timing offset and the number of symbols may be fixed to decrease the quantity of the information. For example, if it is previously scheduled that the timing offset and the number of symbols for the RACH resource of each frame are fixed, the network only needs to transmit the hopping pattern to notify the user equipment of the position information of the RACH resource of all frames within one period.

If each sub-band is narrow or considering influence of interference between user equipments, hopping patterns for all frames may be set equally. In this case, the network only needs to notify the user equipment of a frame period.

Hereinafter, the procedure of transmitting uplink data from the user equipment to the base station by using the structure of the RACH as shown in the embodiment of FIG. **9** will be described. In this case, data transmission is performed through the RACH among reverse common channels consisting of a plurality of frames.

First of all, the user equipment tries to access the dispersed RACH included in the current frame to transfer its information to the base station. If the user equipment successfully accesses the RACH, the user equipment transmits preamble data through the corresponding RACH. However, if the user equipment fails to access the RACH, the user equipment tries to access the RACH divisionally arranged in the frame of the next order. At this time, the RACH included in the frame of the next order is preferably arranged in a frequency band different from that of the RACH of the previous frame if the frequency band is not sufficiently wide or there are no specific requirements (inter-cell interference or limitation in action range of user equipment). Also, the above access procedure continues to be performed in the frame of the next order until the user equipment successfully accesses the RACH.

Meanwhile, in case of the synchronized RACH, the sub-frame of each frame preferably includes a short block to which a pilot for the user equipment which has accessed the corresponding RACH is allocated. At least one RACH pilot and access pilot may be allocated to the short block at a predetermined pattern. In other words, the user equipment which has accessed the RACH should know channel information to receive a channel from the base station. The channel information may be set in RACH pilot within an uplink short block. The base station allocates a proper channel to the user equipment through the corresponding RACH pilot. Meanwhile, if the user equipment which accesses the RACH notifies the base station of information of channel quality as to whether the user equipment is preferably allocated with which channel through the RACH pilot, a favorable channel can be allocated to the user equipment during scheduling, whereby communication of good quality can be maintained.

Accordingly, the RACH pilot that can be used for the user equipment which accesses the RACH is separately allocated to the sub-frame which includes RACH. Thus, the user equipment which accesses the RACH sends a preamble to the base station through the corresponding RACH and also sends a pilot for transmission of channel quality information to the designated RACH pilot. The RACH pilot is a sequence designated depending on a preamble, and it is preferable that the user equipments, which use different preamble sequences, use different RACH pilot sequences if possible or select RACH pilot of different sub-carriers or partially overlapped sub-carriers.

FIG. **10** is a diagram illustrating a structure of a random access channel of a sub-frame to which the RACH pilot is allocated. It is noted that each sub-frame includes at least one short block to which at least one RACH pilot and access pilot are allocated at a predetermined pattern. In this case, the RACH pilot exists in the frequency band of the allocated RACH and other system bands. In this embodiment, it has been described that two short blocks exist per one frame and the RACH pilot is transmitted to the short blocks. However, the present invention is not limited to such embodiment, and various modifications can be made within the apparent range by those skilled in the art.

As described above, it has been described that preamble, synchronization timing information including pilot information, uplink resource allocation information and message such as uplink data can be transmitted through the RACH of various structures. It will be apparent that the data transmission method according to the embodiments of the present invention can be used in the RACH and other channels.

Meanwhile, the preamble and the message may separately be transmitted through the RACH. Alternatively, the message may be transmitted by being implicitly included in the preamble. One embodiment of the present invention relates to a method of transmitting a preamble through the latter transmission manner. In one embodiment of the present invention, a code sequence more expanded than that of the related art can be used for effective transmission of the preamble. Hereinafter, a method of improving CAZAC sequence according to one embodiment of the present invention for effective transmission of the preamble will be described.

Since the receiver should search a start position of a transmission signal in the random access channel, it is generally designed that a transmission signal has a specific pattern in a time domain. To this end, the preamble is transmitted repeat-

edly or a certain interval is maintained between sub-carriers in a frequency domain to obtain repetitive characteristics in the time domain, thereby identifying time synchronization.

In the former case, the preamble represents a reference signal used for the purpose of initial synchronization setting, cell detection, frequency offset, and channel estimation. In a cellular mobile communication system, a sequence having good cross-correlation characteristic is preferably used for repetitive transmission of the preamble. To this end, binary hardamard code or poly-phase CAZAC sequence may be used. Particularly, the CAZAC sequence has been estimated that it has excellent transmission characteristics as it is expressed by a Dirac-Delta function in case of auto-correlation and has a constant value in case of cross-correlation.

The CAZAC sequence can be classified into GCL sequence (Equation 1) and Zadoff-Chu sequence (Equation 2) as follows.

$$c(k;N,M)=\exp\left(-\frac{j\pi Mk(k+1)}{N}\right)\text{ for odd }N \qquad \text{[Equation 1]}$$

$$c(k;N,M)=\exp\left(-\frac{j\pi Mk^2}{N}\right)\text{ for even }N$$

$$c(k;N,M)=\exp\left(\frac{j\pi Mk(k+1)}{N}\right)\text{ for odd }N \qquad \text{[Equation 2]}$$

$$c(k;N,M)=\exp\left(\frac{j\pi Mk^2}{N}\right)\text{ for even }N$$

In the above Equations, it is noted that if the CAZAC sequence has a length of N, actually available sequences are limited to N−1 number of sequences. Accordingly, it is necessary to increase the number of CAZAC sequences to efficiently use them in an actual system.

For example, a method of expanding the number of available sequences by 1 is suggested by providing an improved CAZAC sequence p(k) in such a way to multiply a CAZAC sequence c(k) by a predetermined modulation sequence m(k). In other words, assuming that Zadoff-Chu sequence is used as the CAZAC sequence, the CAZAC sequence c(k), the modulation sequence m(k) and the improved CAZAC sequence p(k) can be defined by the following Equations 3, 4, and 5, respectively.

$$\textit{CAZAC}\text{ sequence: }c(k;N,M)=\exp\left(\frac{j\pi Mk(k+1)}{N}\right) \qquad \text{[Equation 3]}$$

$$\text{Modulation sequence: }m(k)=\exp\left(\frac{j2\pi\delta}{N}k\right) \qquad \text{[Equation 4]}$$

Improved *CAZAC* sequence (or improved preamble): [Equation 5]

$$p(k)=c(k)*m(k)=\exp\left(\frac{j\pi M}{N}k(k+1)+\frac{j2\pi\delta}{N}k\right)$$

The improved CAZAC sequence p(k) maintains auto-correlation and cross-correlation characteristics of the CAZAC sequence. The following Equation 6 illustrates auto-correlation characteristic of p(k), and it is noted from the Equation 6 that the final result is a Dirac-delta function. In particular, if the modulation sequence m(k) is a sequence having a certain phase, it is characterized in that the modulation sequence m(k) always maintains the auto-correlation characteristic.

$$\begin{aligned}ad(d)&=\sum_k\exp\left(\frac{j\pi M}{N}(k+d)(k+d+1)+\frac{j2\pi\delta}{N}(k+d)\right)\\&\quad\exp\left(-\frac{j\pi M}{N}k(k+1)-\frac{j2\pi\delta}{N}k\right)\\&=\sum_k\exp\left(\frac{j2\pi M}{N}(2dk+d(d+1))+\frac{j2\pi\delta}{N}d\right)\\&=\exp\left(\frac{j2\pi\delta}{N}d\right)\sum_k\exp\left(\frac{j\pi M}{N}(2dk+d(d+1))\right)\\&=\begin{cases}1 & d=0\\0 & d\neq 0\end{cases}\end{aligned} \qquad \text{[Equation 6]}$$

Furthermore, the following Equation 7 illustrates cross-correlation characteristic of p(k).

$$\begin{aligned}cc(d)&=\sum_k\exp\left(\frac{j\pi(M+x)}{N}(k+d)(k+d+1)+\frac{j2\pi\delta}{N}(k+d)\right)\\&\quad\exp\left(-\frac{j\pi M}{N}k(k+1)-\frac{j2\pi\delta}{N}k\right)\\&=\sum_k\exp\left(\frac{j\pi x}{N}(k+d)(k+d+1)\right)\\&\quad\exp\left(\frac{j\pi M}{N}(k+d)(k+d+1)+\frac{j2\pi\delta}{N}(k+d)\right)\\&\quad\exp\left(-\frac{j\pi M}{N}k(k+1)-\frac{j2\pi\delta}{N}k\right)\\&=\sum_k\exp\left(\frac{j\pi x}{N}(k+d)(k+d+1)\right)\\&\quad\exp\left(\frac{j\pi M}{N}(2dk+d(d+1))+\frac{j2\pi\delta}{N}d\right)\\&=\exp\left(\frac{j\pi M}{N}d(d+1)\right)\sum_k\exp\left(\frac{j\pi x}{N}(k+d)(k+d+1)\right)\\&\quad\exp\left(\frac{j2\pi dM}{N}k\right)\end{aligned} \qquad \text{[Equation 7]}$$

In this case, although Equation 7 seems to be similar to Equation 6, it is noted that in view of summation term, auto-correlation is expressed by sum of exponential but cross-correlation is expressed by the product of two sequences. The first term is another CAZAC sequence of which seed value is x, and the second term is a simple exponential function. The sum of the product of two sequences is equal to obtaining a coefficient of the exponential function, and its value is equal to a value obtained by converting the CAZAC sequence of which seed value is x into a frequency domain and extracting a value from the frequency position of exponential.

Since the CAZAC sequence has auto-correlation of Dirac-delta characteristic, if it undergoes Fourier transform, it maintains auto-correlation characteristic of Dirac-delta of a constant amplitude even in the transformed area. For this reason, if values of specific positions are extracted from the frequency domain, their sizes are 1 and equal to each other but their phases are different from each other. Accordingly, if this result is added to the Equation 7 to obtain cross-correlation, the obtained cross-correlation can briefly be expressed by the following Equation 8.

$$cc(d)=\exp\left(\frac{j\pi M}{N}d(d+1)+\frac{j2\pi\delta}{N}d\right) \qquad \text{[Equation 8]}$$

-continued

$$\sum_k \exp\left(\frac{j\pi x}{N}(k+d)(k+d+1)\right)$$

$$\exp\left(\frac{j2\pi dM}{N}k\right)$$

$$= \exp\left(\frac{j\pi M}{N}d(d+1) + \frac{j2\pi\delta}{N}d\right)C(dM/N;x)$$

It is noted from the Equation 8 that since C(dM/N;x) always has a size of 1 and an exponential term also has a size of 1, the cross-correlation is always fixed at 1.

After all, characteristics of the related art CAZAC sequence can be maintained by the Equation 5 and at the same time the number of codes can be increased. This means that the result in the area where the exponential terms are multiplied is equal to applying circular shift to the Fourier transformed area, and multiplying exponential sequences in the time domain is equal to performing circular shift in the frequency domain.

In other words, it is noted that if correlation between two sequences p(k;M,N,d**1**) and p(k;M,N,d**2**) of which seed values are equal to each other is obtained, impulse occurs in a point where a delay value d in cross-correlation reaches d**1**-d**2**. Although design of the improved sequence as above has the same result as that of circular shift of the CAZAC sequence, this embodiment of the present invention is advantageous in that the result can be obtained by a simple procedure such as multiplying two exponential sequences without Fourier inverse transform after Fourier transform and circular shift.

Hereinafter, a method of improving data transmission reliability of a preamble by performing predetermined data processing for the related art code sequence and a method of expanding a length of a code sequence when data are simultaneously transmitted will be described. If the CAZAC sequence is used as the code sequence, the CAZAC sequence expanded by the above method is preferably used. However, the CAZAC sequence is not necessarily limited to the CAZAC sequence expanded by the above method, and the related art CAZAC sequence may be used.

First of all, a structure of transmission data, i.e., preamble, which is commonly applied to the embodiments of the present invention, will be described.

In a 3GPP LTE (Long Term Evolution) system, a transmitter can repeatedly transmit the same sequence two times or more so as to allow a receiver to easily detect transmission data or improve additional detection performance (i.e., increase of spreading gain). Accordingly, since the receiver only needs to detect repetitive patterns regardless of the type of the received sequence, it can simply identify time position of a user equipment which accesses the RACH and improve detection performance.

FIG. **11** is a diagram illustrating a structure of a preamble according to one embodiment of the present invention. In an orthogonal frequency divisional transmission system, a cyclic prefix (CP) is used, in which the last part of OFDM symbol is copied and then prefixed to the OFDM symbol to compensate a multi-path loss in signal transmission. Accordingly, if the OFDM symbol consists of two repetitive preambles, a part of the preamble of the later order is copied in the first part by CP to enable compensation of the multi-path loss for the corresponding preamble. Also, the CP is advantageous in that it is easy to identify user equipments which access different RACHs in case of CAZAC having good periodic correlation.

Since inter-symbol interference does not occur even though a single sequence is transmitted by prefixing CP thereto instead of repetitive transmission of sequence, a predetermined receiving algorithm can be realized in the frequency domain without any problem. However, if the receiver realizes a receiving algorithm in the time domain with neither repetitive transmission nor CP, the receiver should detect all kinds of code sequences to identify user equipments which access the RACH. In this respect, the preamble is preferably realized by a structure of a repetitive pattern. At this time, whether to realize a repetition pattern can be determined depending on a data rate supported by the system or the number of repetitive times can be determined if a repetitive pattern is realized. For example, to support a minimum data rate supported by the system, RACH preamble can repeatedly be transmitted one or more times depending on the length of the sequence.

First to fourth embodiments which will be described later relate to a data processing method of a sequence constituting the structure of the preamble. In these embodiments, data transmitted to the receiver could be the structure of the preamble of FIG. **11** or a partially omitted structure (having neither repetitive transmission nor CP). Although it is assumed that the CAZAC sequence is used as the code sequence for data transmission, the code sequence is not necessarily limited to the CAZAC sequence. Every sequence having excellent transmission characteristic, such as Hadarmad code and gold code, can be used as the code sequence.

<First Embodiment>

To transmit data, a landmark that can be identified is generally required for a transmission signal constituting data. In this embodiment, conjugation is used as the landmark. Since a phase variation width between a conjugated transmission signal and other transmission signal is very great, interference between transmission signals decreases, whereby reliability of data transmission can be improved in spite of influence of channel.

FIG. **12** illustrates a method of transmitting data through conjugation according to one embodiment of the present invention. In the embodiment of FIG. **12**, one CAZAC sequence is divided into four blocks, and '0 ' or '1 ' indicates whether to perform conjugate for each block. For example, it may be promised that a block which is not conjugated is expressed by '0 ', and a block which is conjugated is expressed by '1.' In this way, one CAZAC sequence can express information of 4 bits. In other words, if one CAZAC sequence is divided into N number of blocks, information of N bits can be expressed.

At this time, in a single CAZAC sequence of a long length corresponding to a length of transmission data, a part of the single CAZAC sequence, which corresponds to a specific block having a value of 1, may be conjugated. Also, in a plurality of CAZAC sequences of a short length corresponding to each block length of transmission data, a CAZAC sequence corresponding to a specific block having a value of 1 may be conjugated.

FIG. **13** is a diagram illustrating an example of a method of receiving and decoding the sequence transmitted through conjugation from the transmitter in accordance with one embodiment of the present invention.

It is preferable that the transmitter always allocates a value of 0 to the first block of the transmission data so that the first block is used as a reference later. Accordingly, the receiver identifies sequence ID for the received first block (S**1101**), and then measures a peak by using only the corresponding block (S**1102**). Next, the receiver identifies sequence IDs for the first and second blocks (S**1103**), and then measures a peak

by using the first and second blocks together. At this time, since it is unclear whether the sequence of the second block is in the conjugated status, the receiver respectively measures a peak corresponding to the case where the corresponding block is conjugated (S**1104**) and a peak corresponding to the case where the corresponding block is not conjugated (S**1105**), and then selects greater one of the two peaks (S**1106**). Subsequently, the receiver identifies sequence IDs for the first to third blocks (S**1107**), and then measures a peak by using the first to third blocks together. In this case, since it is unclear whether the sequence of the third block is in the conjugated status, the receiver respectively measures a peak corresponding to the case where the corresponding block is conjugated (S**1108**) and a peak corresponding to the case where the corresponding block is not conjugated (S**1109**), and then selects greater one of the two peaks (S**1110**). In this way, decoding is performed for the first block to the last block so that the original data is finally decoded.

<Second Embodiment>

FIG. **14** is a diagram illustrating a method of transmitting data using a sequence according to another preferred embodiment of the present invention. Although data transmission is performed by change of the sequence in the first embodiment, in this embodiment, a type of a sequence for expressing one block is divided into a sequence (first sequence) for a block value of '0 ' and a sequence (second sequence) for a block value of '1,' and the first and second sequence are grouped. In this case, since the receiver detects only sequence ID (ID of the first sequence or ID of the second sequence) for each block, the receiver is less affected by noise or channel.

All sequences are expressed by one group "$\{c_0(k;M_i), c_1(k;M_j)\}$" by grouping two sub-sequences (first sequence and second sequence) (i and j are integers different from each other). In this case, $c_0(k;M_i)$ is the first sequence for the block value of 0 (or bit value), and $c_1(k;M_j)$ is the second sequence for the block value of 1. At this time, a CAZAC sequence of a long length corresponding to a length of transmission data may be used as each sub-sequence constituting each group. Alternatively, a CAZAC sequence of a short length corresponding to each block length of transmission data may be used as each sub-sequence constituting each group.

Meanwhile, the receiver identifies sequence ID of each block, and identifies a type of the sequence (first sequence or second sequence) for each block from a sequence ID set consisting of the identified sequence IDs. At this time, the type of the sequence for each block can be expressed by group ID. In other words, in this embodiment, since it is assumed that code values of each block can be expressed by 0 and 1, two types of the sequence for each block or two types of group ID are obtained. The code values of each block can be restored through group ID. This decoding procedure will be described in detail with reference to FIG. **15**.

The receiver identifies sequence ID of each block constituting a corresponding sequence if the sequence is received (S**1501**), and measures a peak for a sequence ID set consisting of the identified sequence IDs (S**1502**). In this case, two peaks having high frequency in generation are selected (S**1503**) so that sequences which generate the corresponding peaks are identified as the first sequence and the second sequence constituting the group. At this time, if the first sequence and the second sequence are expressed by predetermined group IDs, respectively, first group ID indicating a code value of 0 and second group ID indicating a code value of 1 can be identified. After all, group ID of each block can be identified through the step S**1503** (S**1504**), and thus the code value of each block can be identified (S**1508**).

If sequence IDs that can not identify group ID exist due to error occurring during the decoding procedure, peaks are searched for a set of corresponding sequence IDs (S**1505**), and among the peaks, two powerful peaks are detected (S**1506**) so that group IDs are again identified from the detected powerful peaks (S**1507**). Subsequently, code values of the corresponding blocks can be identified from the identified group IDs (S**1508**).

<Third Embodiment>

FIG. **16** is a diagram illustrating a method of transmitting data using a sequence according to another preferred embodiment of the present invention.

If the second embodiment is more expanded, a total number of data bits that can be transmitted through one group can be increased. For example, if two sequences are defined as one group like the second embodiment, data of 1 bit per block can be transmitted. If four sequences are defined as one group, data of 2 bits per block can be transmitted. If eight sequences are defined as one group, data of 3 bits per block can be transmitted. However, since a plurality of sequences are grouped and defined as one set, a problem occurs in that if the length of each sequence is short, the number of groups that can be selected is decreased in proportion to the short length of each sequence.

Accordingly, it is necessary to expand the length of the sequence to increase the number of groups that can be selected. To this end, in this embodiment, the length of the sequence for each block is expanded while respective sequences are multi-overlapped as shown in FIG. **16**B and independence is maintained owing to transmission delay between the overlapped sequences.

Referring to FIG. **16**(*a*), a data value of 2 bits is given to each block. Accordingly, a sequence group for each block consists of four different CAZAC sequences. Since each CAZAC sequence constituting the sequence group should identify four values, a group size should be increased correspondingly. However, in this case, a problem occurs in that the number of groups that can be used by each base station is decreased. Accordingly, as shown in FIG. **16**, the length of each CAZAC sequence is expanded as much as need be while a predetermined delay is given to each CAZAC sequence during data transmission, whereby independence is maintained between the respective CAZAC sequences.

Meanwhile, the receiver identifies ID of a corresponding block based on the order of each CAZAC sequence represented in the time/frequency domain, and its method of decoding a code value from corresponding block ID is almost identical with that of the second embodiment. Hereinafter, a data decoding procedure of the receiver will be described in detail with reference to FIG. **17**.

The receiver identifies sequence ID of each block constituting a corresponding sequence if the sequence is received (S**1701**), and measures a peak for a sequence ID set consisting of the identified sequence IDs (S**1702**). In this embodiment, since one block expresses two bits, first, second, third and four sequences which express 00, 01, 10, 11 form one group. Accordingly, the receiver should select 4 peaks having high frequency in generation as a result of measurement (S**1703**). In this case, the selected peaks are respectively mapped to the first, second, third and fourth sequences in accordance with the order represented in the time/frequency domain. Also, if the first sequence to the fourth sequence are expressed by predetermined group IDs, respectively, first group ID indicating a code value of 00, second group ID indicating a code value of 01, third group ID indicating a code value of 10, and fourth group ID indicating a code value of 11 can be identified. After all, group ID of each block can be identified

through the step S**1703** (S**1704**), and thus the code value of each block can be identified (S**1708**).

If sequence IDs that can not identify group ID exist due to error occurring during the decoding procedure, peaks are again searched for a set of corresponding sequence IDs (S**1705**), and among the peaks, four powerful peaks are detected (S**1706**) so that group IDs are again identified from the detected powerful peaks (S**1707**). Subsequently, code values of the corresponding blocks can be identified from the identified group IDs (S**1708**).

<Fourth Embodiment>

FIG. **18** is a diagram illustrating a method of transmitting data using a sequence according to another preferred embodiment of the present invention.

In the case that the second embodiment and the third embodiment are more expanded, the signal position is changed through pulse position modulation (PPM) so that the length of the sequence can be expanded logically. The PPM originally transmits data with relative pulse delay but PPM based on start position of the sequence is used in this embodiment.

If bits of data to be transmitted are determined, the base station selects a sequence to be used for transmission of corresponding data and determines a length of a block for applying PPM to a corresponding sequence and a length of a duration constituting each block. A sequence corresponding to each block is separately required when a preamble is generated. However, in this embodiment, since circular shift equivalent to a specific duration within a specific block constituting a corresponding sequence is applied for the same sequence, the respective sequences are originally the same as one another but are identified from one another by circular shift.

For example, assuming that one sequence length is divided into four blocks (block **1** to block **4**) and each block is expressed by 2 bits, each block is again divided into four durations (duration **1** to duration **4**) to express values of "00, 01, 10, 11." At this time, four durations included in one block are used as start identification positions of circular shift for a sequence corresponding to a corresponding block. If a preamble to be transmitted has a total length of **256**, block **1** can have a circular shift value of 0~63, block **2** 64~127, block **3** 128~195, and block **4** 196~255. If a specific sequence to be used for transmission of the preamble is determined and "00" is transmitted through block **1**, sequence **1** undergoes circular shift so that a start position is arranged in duration **1** (0~15) of block **1**. If "10" is transmitted to block **2**, sequence **2** undergoes circular shift so that a start position is arranged in duration **3** (96~111) of block **2**. In this way, circular shift is applied for the other blocks and then the respective sequences (sequence **1** to sequence **4**) are grouped into one to generate one preamble. In this case, the number of blocks can be generated from 1 to every random number. Also, a minimum unit of circular shift can be limited to more than a certain value considering channel or timing error.

Meanwhile, the receiver identifies respective sub sequences (sequence **1** to sequence **4**) constituting corresponding sequences by data processing the transmitted sequences, and searches a start position of each of the identified sequences to perform data decoding. This will be described in detail with reference to FIG. **19**.

If a sequence is received in the receiver (S**1901**), the receiver detects ID of the corresponding sequence (S**1903**) and performs full correlation through predetermined data processing for a total of received signals (received sequence) by using the detected result (S**1905**). At this time, a full search algorithm or a differential search algorithm can be used for detection of the sequence ID.

Since the received signal is transmitted from the transmitter by gathering a plurality of sequences, the signal which has undergone the correlation includes a plurality of peaks. In this embodiment, four peaks are detected, and the receiver determines whether each of the detected peaks corresponds to which one of block **1** to block **4** and also corresponds to which duration of a corresponding block (S**1909**) to decode bit order and bit value of the original data (S**1911**).

The method of effectively transmitting the preamble sequence and message through the RACH has been described as above. Finally, a procedure of transmitting a preamble from a user equipment (UE) to a base station (Node-B) and performing synchronization between both the user equipment and the base station will be described based on two embodiments. FIG. **20**A and FIG. **20**B illustrate the two embodiments.

In the embodiment of FIG. **20**A, synchronization is performed in such a manner the user equipment accesses the base station only once. In other words, if the user equipment transmits a preamble and a messing including information required for synchronization to the base station (S**2001**), the base station transmits timing information to the user equipment (S**2003**) and at the same time allocates a resource for transmission of uplink data (S**2005**). The user equipment transmits the uplink data to the base station through the allocated resource (S**2007**).

In the embodiment of FIG. **20**B, for synchronization, the user equipment accesses the base station twice. In other words, if the user equipment transmits a preamble to the base station (S**2011**), the base station transmits timing information to the user equipment and at the same time allocates a resource for a request of scheduling (S**2013**). The user equipment transmits a message for a request of scheduling to the base station through the allocated resource (S**2015**). Then, the base station allocates a resource for transmission of uplink data to the user equipment (S**2017**). In this way, the user equipment transmits to the uplink data to the base station through the secondly allocated resource (S**2019**).

FIG. **21** is a diagram illustrating a method of transmitting data to a receiver through a signaling channel in accordance with one embodiment of the present invention.

Since the receiver should search a start position of a transmission signal in actually realizing the random access channel, it is generally designed that the random access channel has a specific pattern in the time domain. To this end, a preamble sequence may be used so that the random access signal originally has a repetitive pattern. Alternatively, a certain interval may be maintained between sub-carriers in the frequency domain to obtain repetitive characteristics in the time domain. Accordingly, the access modes of FIG. **6**A and FIG. **6**B are characterized in that the start position of the transmission signal should easily be searched in the time domain. To this end, the CAZAC sequence is used. The CAZAC sequence can be classified into GCL sequence (Equation 1) and Zadoff-Chu sequence (Equation 2). Meanwhile, a specific sequence of a long length is preferably used to transmit unique information of the user equipment or the base station through RACH (Random Access Channel) or SCH (Synchronization Channel). This is because that the receiver easily detects corresponding ID and more various kinds of sequences can be used to provide convenience for system design.

However, if message is transmitted with corresponding ID at a sequence of a long length, since the quantity of the

message is increased by $\log_2$ function, there is limitation in message passing with ID only when the sequence exceeds a certain length. Accordingly, in this embodiment, the sequence is divided by several short blocks, and a short signature sequence corresponding to data to be transmitted to each block of the sequence is used instead of specific manipulation such as conjugation or negation.

Referring to FIG. **21**, the sequence is divided into a predetermined number of blocks, and a short signature sequence corresponding to data to be transmitted is applied for each of the divided blocks. A long CAZAC sequence is multiplied by combination of the blocks for which the short signature sequence is applied, whereby a final data sequence to be transmitted to the receiver is completed.

In this case, assuming that the short signature sequence consists of four signatures, the following signature sets can be used. Also, if there is difference between respective data constituting the signature sets, any other signature set may be used without specific limitation.

1) Modulation values: {1+j, 1−j, −1−j, −1+j}

2) Exponential sequence: $\{[\exp(jw_0n)], [\exp(jw_1n)], [\exp(jw_an)], [\exp(jw_3n]\}$, where n=0 . . . Ns, and Ns is a length of each block

3) Walsh Hadamard sequence: {[1111], [1-11-1], [11-1-1], [1-1-11]}, where, if the length Ns of each block is longer than 4, each sequence is repeated to adjust the length.

Examples of the long CAZAC sequence that can be used in the embodiment of FIG. **21** include, but not limited to, one GCL CAZAC sequence, Zadoff-Chu CAZAC sequence, and a sequence generated by concatenation of two or more short GCL or Zadoff-Chu CAZAC sequences having the same length or different lengths.

The aforementioned manner of applying a short signature sequence for data transmission and reception to the long CAZAC sequence is advantageous in that it is less affected by channel than the related art modulation method of transmission data and performance is little decreased even though the number of bits constituting one signature is increased.

FIG. **22** illustrates an example of a receiver and a transmitter for transmitting a preamble and data through RACH, SCH or other channel by using the aforementioned manner.

Since the number of bits can be increased in accordance with increase of signatures, channel coding can be applied for the transmitter. If channel coding is performed, time/frequency diversity can be obtained through an interleaver. Also, bit to signature mapping can be performed to minimize a bit error rate. In this case, Gray mapping can be used. The sequence which has undergone this procedure is mixed with CAZAC and then transmitted.

The receiver detects CAZAC ID, and calculates a log-likelihood ratio (LLR) for each of bits. Then, the receiver decodes transmission data through a channel decoder. Considering complexity according to sequence search of the receiver configured as shown in FIG. **22**, the transmitter preferably uses an exponential sequence as a signature sequence. In this case, the receiver can simply search CAZAC ID through phase difference Fourier Transform. Afterwards, the receiver can again simply calculate LLR from the signature through Fourier Transform.

According to the present invention, the structure on the frequency axis/time axis of the RACH can be identified more definitely. Also, since the RACH resource is divisionally distributed for each frame, even though the user equipment fails to access a specific RACH, the user equipment can directly access RACH of the next frame, whereby access to the base station is improved. Moreover, the user equipment can easily access the RACH even in case of a traffic area of which QoS condition is strict.

Furthermore, according to the present invention, since information is transmitted and received between the user equipment and the base station by using the code sequence, time/frequency diversity can be maximized, and performance attenuation due to influence of channel can be alleviated through the signature manner.

According to the present invention, since the total length of the corresponding sequence can be used with maintaining the advantage of the code sequence according to the related art, data transmission can be performed more efficiently. Also, since the code sequence undergoes predetermined data processing, the quantity of information to be transmitted can be increased and the transmitted data becomes robust to noise or channel.

It will be apparent to those skilled in the art that the present invention can be embodied in other specific forms without departing from the spirit and essential characteristics of the invention. Thus, the above embodiments are to be considered in all respects as illustrative and not restrictive. The scope of the invention should be determined by reasonable interpretation of the appended claims and all change which comes within the equivalent scope of the invention are included in the scope of the invention.

Industrial Applicability

The present invention is applicable to a wireless communication system such as a mobile communication system or a wireless Internet system.

The invention claimed is:

1. A method of transmitting a preamble sequence in a mobile communication system, the method comprising:

repeating a specific sequence, having a length (L), N times to generate a consecutive sequence having a length (N*L);

generating said preamble sequence by concatenating a single cyclic prefix (CP) to a front end of said consecutive sequence; and

transmitting, on a random access channel, said preamble sequence to a receiving side.

2. The method of claim **1**, further comprising generating said specific sequence from a Constant Amplitude Zero Auto Correlation (CAZAC) sequence.

3. The method of claim **2**, further comprising applying a cyclic shift to said specific sequence generated from said CAZAC sequence.

4. The method of claim **3**, wherein a value of said applied cyclic shift is determined as an integer multiple of a predetermined circular shift unit.

5. The method of claim **3**, wherein a value of said applied cyclic shift is used as additional information.

6. The method of claim **3**, wherein applying said cyclic shift comprises multiplying said specific sequence by an exponential sequence.

7. The method of claim **1**, further comprising generating said specific sequence by combining at least two code sequences mapped with at least one information bit.

8. A transmitter for transmitting a preamble sequence in a mobile communication system, the transmitter comprising:

a preamble generation unit configured to generate said preamble sequence by repeating a specific sequence, having a length (L), N times to generate a consecutive sequence having a length (N*L) and concatenating a single cyclic prefix (CP) to a front end of said consecutive sequence;

a transmission unit configured to transmit, on a random access channel, said preamble sequence to a receiving side.

9. The transmitter of claim **8**, wherein said preamble generation unit is further configured to generate said specific sequence from a Constant Amplitude Zero Auto Correlation (CAZAC) sequence.

10. The transmitter of claim **9**, wherein said preamble generation unit is further configured to apply a cyclic shift to said specific sequence generated from said CAZAC sequence.

11. The transmitter of claim **10**, wherein a value of said applied cyclic shift is determined as an integer multiple of a predetermined circular shift unit.

12. The transmitter of claim **10**, wherein a value of said applied cyclic shift is used as additional information.

13. The transmitter of claim **10**, wherein said preamble generation unit is further configured to apply said cyclic shift by multiplying said specific sequence by an exponential sequence.

14. The transmitter of claim **8**, wherein said preamble generation unit is further configured to generate said specific sequence by combining at least two code sequences mapped with at least one information bit.

15. The method of claim **1**, wherein:

said consecutive sequence comprises at least a first sequence, a second sequence, and an N-th sequence; and

said CP is identical to a rear part of said N-th sequence.

16. The transmitter of claim **8**, wherein:

said consecutive sequence comprises at least a first sequence, a second sequence, and an N-th sequence; and

said CP is identical to a rear part of said N-th sequence.

* * * * *

EXHIBIT 6

iPhone
User Guide

For iOS 8.3 Software

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iPhone at a glance

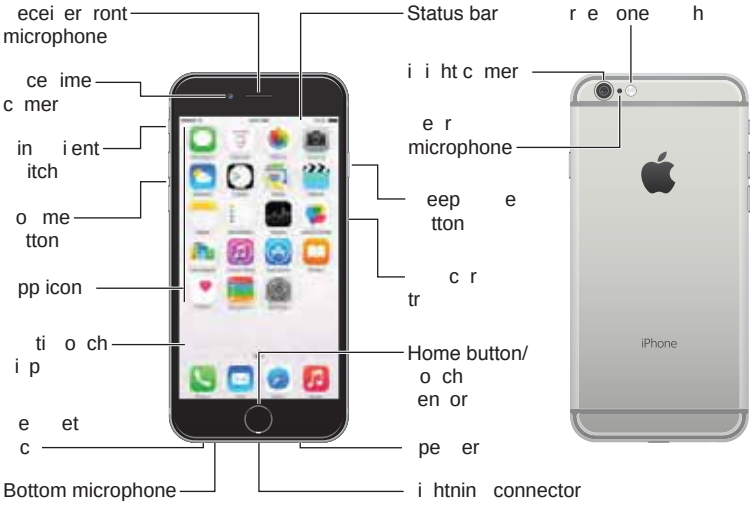
1

iPhone overview

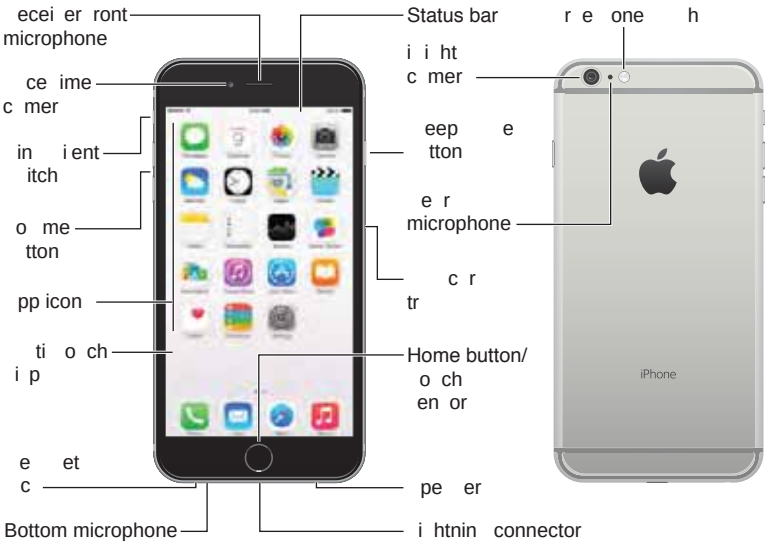
This guide describes iOS 8.3 for:

- iPhone 6
- iPhone 6 Plus
- iPhone 5s
- iPhone 5c
- iPhone 5
- iPhone 4s

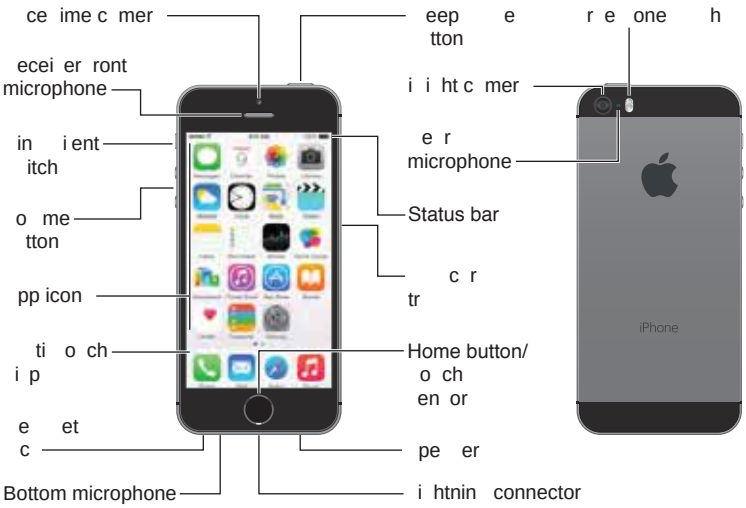
iPhone 6



iPhone 6 Plus



iPhone 5s



Your iPhone features and apps may vary depending on the model of iPhone you have, and on your location, language, and carrier. To find out which features are supported in your area, see www.apple.com/ios/feature-availability/.

Note: Apps and services that send or receive data over a cellular network may incur additional fees. Contact your carrier for information about your iPhone service plan and fees.

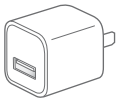
Accessories

The following accessories are included with iPhone:

Apple headset. Use the Apple EarPods with Remote and Mic (iPhone 5 or later) or the Apple Earphones with Remote and Mic (iPhone 4s) to listen to music and videos, and make phone calls. See Use an Apple headset on page 41.

Connecting cable. Use the Lightning to USB Cable (iPhone 5 or later) or the 30-pin to USB Cable (iPhone 4s) to connect iPhone to your computer to sync and charge.

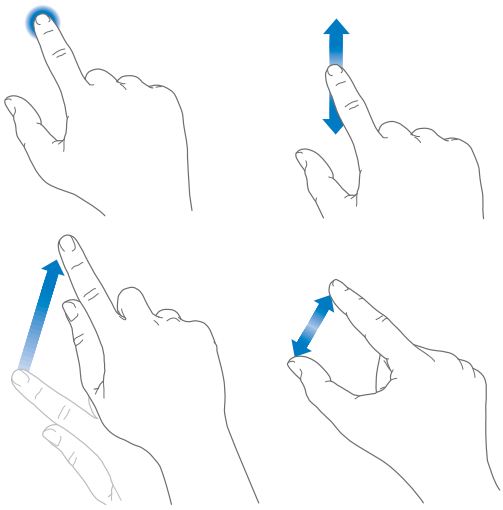
Apple USB power adapter. Use with the Lightning to USB Cable or the 30-pin to USB Cable to charge the iPhone battery.



SIM eject tool. Use to eject the SIM card tray. (Not included in all areas.)

Multi-Touch screen

A few simple gestures—tap, drag, swipe, and pinch—are all you need to use iPhone and its apps.



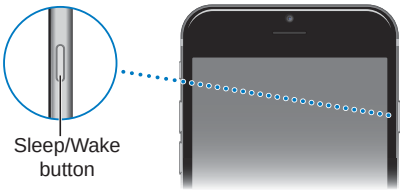
Buttons

Most of the buttons you use with iPhone are virtual ones on the touchscreen. A few physical buttons control basic functions, such as turning iPhone on or adjusting the volume.

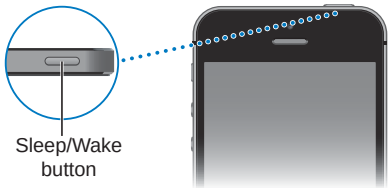
Sleep/Wake button

When you're not using iPhone, press the Sleep/Wake button to lock iPhone. Locking iPhone puts the display to sleep, saves the battery, and prevents anything from happening if you touch the screen. You can still get phone calls, FaceTime calls, text messages, alarms, and notifications. You can also listen to music and adjust the volume.

On iPhone 6 and iPhone 6 Plus, the Sleep/Wake button is on the right side:



On earlier iPhone models, the Sleep/Wake button is on the top edge:



iPhone locks automatically if you don't touch the screen for a minute or so. To adjust the timing, go to Settings > General > Auto-Lock.

Turn iPhone on. Press and hold the Sleep/Wake button until the Apple logo appears.

Unlock iPhone. Press either the Sleep/Wake or Home button, then drag the slider.

Turn iPhone off. Press and hold the Sleep/Wake button until the slider appears, then drag the slider.

For additional security, you can require a passcode to unlock iPhone. Go to Settings > Touch ID & Passcode (iPhone models with Touch ID) or Settings > Passcode (other models). See Use a passcode with data protection on page 44.

Home button

The Home button takes you to the Home screen and provides other convenient shortcuts. On the Home screen, tap any app to open it.

See apps you've opened. Double-click the Home button when iPhone is unlocked. See Start at home on page 23.

Use Siri or Voice Control. Press and hold the Home button. See Chapter 4, Siri, on page 48 and Voice Control on page 33.

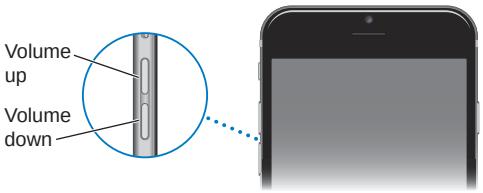
On iPhone models with Touch ID, you can use the sensor in the Home button to read your fingerprint, instead of using your passcode or Apple ID password to unlock iPhone or make purchases in the iTunes Store, App Store, and iBooks Store. See Touch ID on page 44. If you have iPhone 6 or iPhone 6 Plus, you can also use the Touch ID sensor for authentication when using Apple Pay to make a purchase in a store or from within an app. See Touch ID on page 44 and Apple Pay on page 130.

You can also use the Home button to turn accessibility features on or off. See Accessibility Shortcut on page 149.

Volume controls

When you're on the phone or listening to songs, movies, or other media, the buttons on the side of iPhone adjust the audio volume. Otherwise, the buttons control the volume for the ringer, alerts, and other sound effects.

WARNING: For important information about avoiding hearing loss, see Important safety information on page 181.



Lock the ringer and alert volumes. Go to Settings > Sounds, then turn off Change with Buttons. To limit the volume for music and videos, go to Settings > Music > Volume Limit.

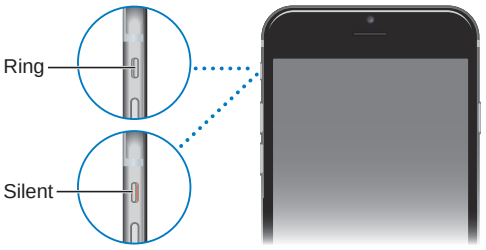
Note: In some European Union (EU) countries, iPhone may warn that you're setting the volume above the EU recommended level for hearing safety. To increase the volume beyond this level, you may need to briefly release the volume control. To limit the maximum headset volume to this level, go to Settings > Music > Volume Limit, then turn on EU Volume Limit. To prevent changes to the volume limit, go to Settings > General > Restrictions.

Use Control Center to adjust the volume. When iPhone is locked or when you're using another app, swipe up from the bottom edge of the screen to open Control Center.

You can also use either volume button to take a picture or record a video. See Take photos and videos on page 93.

Ring/Silent switch

Flip the Ring/Silent switch to put iPhone in ring mode 🔔 or silent mode 🔕.



In ring mode, iPhone plays all sounds. In silent mode, iPhone doesn't ring or play alerts and other sound effects (but iPhone may still vibrate).

Important: Clock alarms, audio apps such as Music, and many games play sounds through the built-in speaker, even when iPhone is in silent mode. In some areas, the sound effects for Camera and Voice Memos are played, even if the Ring/Silent switch is set to silent.

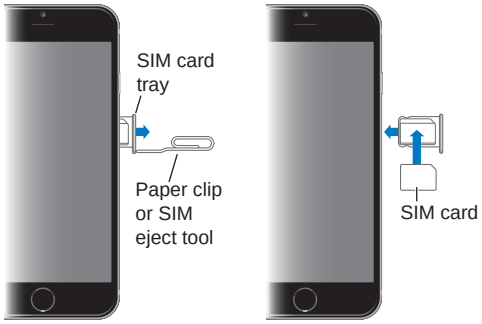
For information about changing sound and vibration settings, see Sounds and silence on page 36.

Use Do Not Disturb. You can also silence calls, alerts, and notifications using Do Not Disturb. Swipe up from the bottom edge of the screen to open Control Center, then tap ☾. See Do Not Disturb on page 37.

SIM card

If you were given a SIM card to install, install it before setting up iPhone.

Important: A Micro-SIM card (iPhone 4s) or a Nano-SIM card (iPhone 5 or later) is required to use cellular services when connecting to GSM networks and some CDMA networks. iPhone that's been activated on a CDMA wireless network may also use a SIM card for connecting to a GSM network, primarily for international roaming. Your iPhone is subject to your wireless service provider's policies, which may include restrictions on switching service providers and roaming, even after conclusion of any required minimum service contract. Contact your wireless service provider for more details. Availability of cellular capabilities depends on the wireless network.



Status icons

The icons in the status bar at the top of the screen give information about iPhone:

Status icon		What it means
●●●●●	Cell signal	You're in range of the cellular network and can make and receive calls. If there's no signal, "No service" appears.
✈	Airplane mode	Airplane mode is on—you can't make phone calls, and other wireless functions may be disabled. See Travel with iPhone on page 47.
LTE	LTE	Your carrier's LTE network is available, and iPhone can connect to the Internet over that network. (iPhone 5 or later. Not available in all areas.) See Cellular settings on page 188.
4G	UMTS	Your carrier's 4G UMTS (GSM) or LTE network (depending on carrier) is available, and iPhone can connect to the Internet over that network. (Not available in all areas.) See Cellular settings on page 188.
3G	UMTS/EV-DO	Your carrier's 3G UMTS (GSM) or EV-DO (CDMA) network is available, and iPhone can connect to the Internet over that network. See Cellular settings on page 188.

Status icon		What it means
E	EDGE	Your carrier's EDGE (GSM) network is available, and iPhone can connect to the Internet over that network. See Cellular settings on page 188.
GPRS	GPRS/1xRTT	Your carrier's GPRS (GSM) or 1xRTT (CDMA) network is available, and iPhone can connect to the Internet over that network. See Cellular settings on page 188.
Wi-Fi	Wi-Fi call	iPhone is making a call over Wi-Fi. See Make a call on page 51.
	Wi-Fi	iPhone is connected to the Internet over a Wi-Fi network. See Connect to Wi-Fi on page 16.
	Do Not Disturb	"Do Not Disturb" is turned on. See Do Not Disturb on page 37.
	Personal Hotspot	iPhone is providing a Personal Hotspot for another device. See Personal Hotspot on page 40.
	Syncing	iPhone is syncing with iTunes. See Sync with iTunes on page 21.
	Network activity	Shows that there's network activity. Some third-party apps may also use it to show an active process.
	Call Forwarding	Call Forwarding is set up. See Call forwarding, call waiting, and caller ID on page 56.
VPN	VPN	You're connected to a network using VPN. See Network access on page 173.
	TTY	iPhone is set to work with a TTY machine. See TTY support on page 172.
	Portrait orientation lock	The iPhone screen is locked in portrait orientation. See Change the screen orientation on page 25.
	Alarm	An alarm is set. See Alarms and timers on page 100.
	Location Services	An item is using Location Services. See Privacy on page 43.
	Bluetooth®	*Blue or white icon:* Bluetooth is on and paired with a device. *Gray icon:* Bluetooth is on. If iPhone is paired with a device, the device may be out of range or turned off. *No icon:* Bluetooth is turned off. See Bluetooth devices on page 42.
	Bluetooth battery	Shows the battery level of a paired Bluetooth device.
	Battery	Shows the iPhone battery level or charging status. See Charge and monitor the battery on page 46.

Get started 2

Set up iPhone

WARNING: To avoid injury, read Important safety information on page 181 before using iPhone.

You can set up iPhone over a Wi-Fi network, or over your carrier's cellular network (not available in all areas). Or connect iPhone to your computer and use iTunes to set up iPhone (see Connect iPhone to your computer on page 20).

Set up iPhone. Turn on iPhone, then follow the Setup Assistant.

The Setup Assistant steps you through the process, including:

- Connecting to a Wi-Fi network
- Signing in with or creating a free Apple ID (needed for many features, including iCloud, FaceTime, the iTunes Store, the App Store, and more)
- Entering a passcode
- Setting up iCloud and iCloud Keychain
- Turning on recommended features such as Location Services
- Adding a credit or debit card to Passbook to use with Apple Pay (iPhone 6 or iPhone 6 Plus)
- Activating iPhone with your carrier

You can also restore iPhone from an iCloud or iTunes backup during setup. See Back up iPhone on page 186.

Note: Find My iPhone is turned on when you sign in to iCloud. Activation Lock is engaged to help prevent anyone else from activating your iPhone, even if it is completely restored. Before you sell or give away your iPhone, you should reset it to erase your personal content and turn off Activation Lock. See Sell or give away iPhone on page 189.

Some carriers let you unlock iPhone for use with their network. To see if your carrier offers this option, see support.apple.com/kb/HT1937. Contact your carrier for authorization and setup information. You need to connect iPhone to iTunes to complete the process. Additional fees may apply. For more information, see support.apple.com/kb/HT5014.

Connect to Wi-Fi

If appears at the top of the screen, you're connected to a Wi-Fi network. iPhone reconnects anytime you return to the same location.

Configure Wi-Fi. Go to Settings > Wi-Fi, then turn Wi-Fi on or off. (You can also turn Wi-Fi on or off in Control Center.)

- *Choose a network:* Tap one of the listed networks, then enter the password, if asked.

- *Ask to join networks:* Turn on Ask to Join Networks to be prompted when a Wi-Fi network is available. Otherwise, you must manually join a network when a previously used network isn't available.
- *Join a closed Wi-Fi network:* Tap Other, then enter the name of the closed network. You need to know the network name, security type, and password.
- *Adjust the settings for a Wi-Fi network:* Tap ⓘ next to a network. You can set an HTTP proxy, define static network settings, turn on BootP, or renew the settings provided by a DHCP server.
- *Forget a network:* Tap ⓘ next to a network you've joined before, then tap Forget this Network.

Set up your own Wi-Fi network. If you have an unconfigured AirPort base station turned on and within range, you can use iPhone to set it up. Go to Settings > Wi-Fi and look for Set up an AirPort base station. Tap your base station and Setup Assistant will do the rest.

Manage an AirPort network. If iPhone is connected to an AirPort base station, go to Settings > Wi-Fi, tap ⓘ next to the network name, then tap Manage this Network. If you haven't yet downloaded AirPort Utility, tap OK to open the App Store, then download it.

Connect to the Internet

iPhone connects to the Internet whenever necessary, using a Wi-Fi connection (if available) or your carrier's cellular network. For information about connecting to a Wi-Fi network, see Connect to Wi-Fi, above.

When an app needs to use the Internet, iPhone does the following, in order:

- Connects over the most recently used available Wi-Fi network
- Shows a list of Wi-Fi networks in range, and connects using the one you choose
- Connects over the cellular data network, if available

Note: If a Wi-Fi connection to the Internet isn't available, apps and services may transfer data over your carrier's cellular network, which may result in additional fees. Contact your carrier for information about your cellular data plan rates. To manage cellular data usage, see Cellular settings on page 188.

Apple ID

Your Apple ID is the account you use for just about everything you do with Apple, including storing your content in iCloud, downloading apps from the App Store, and buying music, movies, and TV shows from the iTunes Store.

If you already have an Apple ID, use it when you first set up iPhone, and whenever you need to sign in to use an Apple service. If you don't already have an Apple ID, you can create one whenever you're asked to sign in. You only need one Apple ID for everything you do with Apple.

For more information, see appleid.apple.com.

iCloud

iCloud offers free mail, contacts, calendar, and other features that you can set up simply by signing in to iCloud with your Apple ID, then making sure that the features you want to use are turned on.

Set up iCloud. Go to Settings > iCloud. Create an Apple ID if needed, or use your existing one.

iCloud stores your photos and videos, documents, music, calendars, contacts, and more. Content stored in iCloud is pushed wirelessly to your other iOS devices and computers signed in to iCloud with the same Apple ID.

iCloud is available on devices with iOS 5 or later, on Mac computers with OS X Lion v10.7.5 or later, and on PCs with iCloud for Windows 4.0 (Windows 7 or Windows 8 is required). You can also sign in to iCloud.com from any Mac or PC to access your iCloud information and features like Photos, Find My iPhone, Mail, Calendar, Contacts, iWork for iCloud, and more.

Note: iCloud may not be available in all areas, and iCloud features may vary by area. For more information, see www.apple.com/icloud/.

iCloud features include:

- *Music, Movies, TV Shows, Apps, and Books:* Automatically get iTunes purchases on all your devices set up with iCloud, or download previous iTunes music and TV show purchases for free, anytime. With an iTunes Match subscription, all your music, including music you've imported from CDs or purchased somewhere other than the iTunes Store, can also be stored in iCloud and played on demand. See iCloud and iTunes Match on page 74. Download previous App Store and iBooks Store purchases to iPhone for free, anytime.
- *Photos:* Use iCloud Photo Library to store all your photos and videos in iCloud, and access them from any iOS 8.1 device, Mac with OS X Yosemite v10.10.3, and on iCloud.com using the same Apple ID. Use iCloud Photo Sharing to share photos and videos with just the people you choose, and let them add photos, videos, and comments. See iCloud Photo Library on page 87. See iCloud Photo Sharing on page 88.
- *Family Sharing:* Up to six family members can share their purchases from the iTunes Store, App Store, and iBooks Store. Pay for family purchases with the same credit card and approve kids' spending right from a parent's device. Plus, share photos, a family calendar, and more. See Family Sharing on page 38.
- *iCloud Drive:* Safely store your presentations, spreadsheets, PDFs, images, and other documents in iCloud, and access them from your iPhone, iPad, iPod touch, Mac, or PC. See About iCloud Drive on page 39.
- *Documents in the Cloud:* For iCloud-enabled apps, keep documents and app data up to date across all your devices set up with iCloud.
- *Mail, Contacts, Calendars:* Keep your mail, contacts, calendars, notes, and reminders up to date across all your devices.
- *Safari Tabs:* See the tabs you have open on your other iOS devices and OS X computers. See Browse the web on page 65.
- *Backup:* Back up iPhone to iCloud automatically when connected to power and Wi-Fi. iCloud data and backups sent over the Internet are encrypted. See Back up iPhone on page 186.

- *Find My iPhone:* Locate your iPhone on a map, display a message, play a sound, lock the screen, temporarily suspend or permanently remove your credit and debit cards in Passbook used for Apple Pay, or remotely wipe your iPhone data. Find My iPhone includes Activation Lock, which requires your Apple ID and password in order to turn off Find My iPhone or erase your device. Your Apple ID and password are also required before anyone can reactivate your iPhone. See Find My iPhone on page 46.
- *Find My Friends:* Share your location with people who are important to you. Download the free app from the App Store.
- *iCloud Keychain:* Keep your passwords and credit card information up to date across all your designated devices. See iCloud Keychain on page 45.

You must have an iCloud account and be signed in to iCloud to use Apple Pay. See Apple Pay on page 130.

With iCloud, you get a free email account and 5 GB of storage for your mail, documents, photos, and backups. Your purchased music, apps, TV shows, and books, as well as your photo streams, don't count against your available space.

Upgrade your iCloud storage. Go to Settings > iCloud > Storage, then tap Change Storage Plan. For information about upgrading your iCloud storage, see help.apple.com/icloud/.

View and download previous purchases, or get purchases shared by your family.

- *iTunes Store purchases:* You can access your purchased songs and videos in the Music and Videos apps. Or, in the iTunes Store, tap More, then tap Purchased.
- *App Store purchases:* Go to the App Store, tap Updates, then tap Purchased.
- *iBooks Store purchases:* Go to iBooks, then tap Purchased.

Turn on Automatic Downloads for music, apps, or books. Go to Settings > iTunes & App Stores.

For more information about iCloud, see www.apple.com/icloud/. For support information, see www.apple.com/support/icloud/.

Set up other mail, contacts, and calendar accounts

iPhone works with Microsoft Exchange, and many of the most popular Internet-based mail, contacts, and calendar services.

Set up an account. Go to Settings > Mail, Contacts, Calendars > Add Account.

You can add contacts using an LDAP or CardDAV account, if your company or organization supports it. See Add contacts on page 146.

You can add calendars using a CalDAV calendar account, and you can subscribe to iCalendar (.ics) calendars or import them from Mail. See Use multiple calendars on page 83.

For information about setting up a Microsoft Exchange account in a corporate environment, see Mail, Contacts, and Calendar on page 173.

Manage content on your iOS devices

You can transfer information and files between your iOS devices and computers, using iCloud or iTunes.

- *iCloud* stores your photos and videos, documents, music, calendars, contacts, and more. It all gets pushed wirelessly to your other iOS devices and computers, keeping everything up to date. See iCloud on page 18.
- *iTunes* syncs music, videos, photos, and more between your computer and iPhone. Changes you make on one device are copied to the other when you sync. You can also use iTunes to sync files and documents. See Sync with iTunes, next.

You can use iCloud or iTunes, or both, depending on your needs. For example, you can use iCloud to automatically keep your contacts and calendars up to date on all your devices, and use iTunes to sync music from your computer to iPhone.

Important: To avoid duplicates, keep contacts, calendars, and notes in sync using iCloud or iTunes, but not both.

You can also manually manage content from iTunes, in the device's Summary pane. This lets you add songs and videos, by choosing a song, video, or playlist from your iTunes library and then dragging it to your iPhone in iTunes. This is useful if your iTunes library contains more items than can fit on your device.

Note: If you use iTunes Match, you can manually manage only video.

Connect iPhone to your computer

Connecting iPhone to your computer lets you sync content from your computer using iTunes. See Sync with iTunes, above.

To use iPhone with your computer, you need:

- An Internet connection for your computer (broadband is recommended)
- A Mac or a PC with a USB 2.0 or 3.0 port, and one of the following operating systems:
  - OS X version 10.6.8 or later
  - Windows 8, Windows 7, Windows Vista, or Windows XP Home or Professional with Service Pack 3 or later

Connect iPhone to your computer. Use the included Lightning to USB Cable or the 30-pin to USB Cable.

Sync with iTunes

Syncing with iTunes copies information from your computer to iPhone, and vice versa. You can sync by connecting iPhone to your computer, or you can set up iTunes to sync wirelessly with Wi-Fi. You can set iTunes to sync music, videos, apps, photos, and more. For help syncing iPhone, open iTunes on your computer, choose Help > iTunes Help, then select Sync your iPod, iPhone, or iPad. iTunes is available at www.itunes.com/download.

Set up wireless syncing. Connect iPhone to your computer. In iTunes on your computer, select your iPhone, click Summary, then select Sync with this iPhone over Wi-Fi.

If Wi-Fi syncing is turned on, iPhone syncs when it's connected to a power source, both iPhone and your computer are on and connected to the same wireless network, and iTunes is open on your computer.

Tips for syncing with iTunes on your computer

Connect iPhone to your computer, select it in iTunes, then set options in the different panes.

- If iPhone doesn't appear in iTunes, make sure you're using the latest version of iTunes, check that the included cable is correctly connected, then try restarting your computer.
- In the Summary pane, you can set iTunes to automatically sync iPhone when it's attached to your computer. To temporarily override this setting, hold down Command and Option (Mac) or Shift and Control (PC) until you see iPhone appear in the iTunes window.
- In the Summary pane, select "Encrypt iPhone backup" if you want to encrypt the information stored on your computer when iTunes makes a backup. Encrypted backups are indicated by a lock icon 🔒, and a password is required to restore the backup. If you don't select this option, other passwords (such as those for mail accounts) aren't included in the backup and you'll have to reenter them if you use the backup to restore iPhone.
- In the Info pane, when you sync mail accounts, only the settings are transferred from your computer to iPhone. Changes you make to a mail account on iPhone don't affect the account on your computer.
- In the Info pane, click Advanced to select options that let you *replace* the information on iPhone with the information from your computer during the next sync.
- In the Music pane, you can sync music using your playlists.
- In the Photos pane, you can sync photos and videos from a supported app or folder on your computer.
- If you use iCloud to store your contacts, calendars, and bookmarks, don't also sync them to iPhone using iTunes.
- If you turn on iCloud Photo Library, you can't use iTunes to sync photos and videos to iPhone.

Date and time

The date and time are usually set for you based on your location—take a look at the Lock screen to see if they're correct.

Set whether iPhone updates the date and time automatically. Go to Settings > General > Date & Time, then turn Set Automatically on or off. If you set iPhone to update the time automatically, it gets the correct time over the cellular network and updates it for the time zone you're in. Some carriers don't support network time, so in some areas iPhone may not be able to automatically determine the local time.

Set the date and time manually. Go to Settings > General > Date & Time, then turn off Set Automatically.

Set whether iPhone shows 24-hour time or 12-hour time. Go to Settings > General > Date & Time, then turn 24-Hour Time on or off. (24-Hour Time may not be available in all areas.)

Apple Watch

Use the Apple Watch app (not available in all areas) to learn more about Apple Watch, and to pair your Apple Watch with iPhone. Just tap the Apple Watch app, and follow the onscreen instructions.

International settings

Go to Settings > General > Language & Region to set:

- The language for iPhone
- The preferred language order for apps and websites
- The region format
- The calendar format
- Advanced settings for dates, times, and numbers

To add a keyboard for another language, go to Settings > General > Keyboard > Keyboards. For more information, see Use international keyboards on page 175.

Your iPhone name

The name of your iPhone is used by both iTunes and iCloud.

Change the name of your iPhone. Go to Settings > General > About > Name.

View this user guide on iPhone

You can view the *iPhone User Guide* on iPhone in Safari, and in the iBooks app.

View the user guide in Safari. Tap 📖, then tap the iPhone User Guide bookmark. (If you don't see a bookmark, go to help.apple.com/iphone/.)

- *Add an icon for the user guide to the Home screen:* Tap ⬆, then tap Add to Home Screen.
- *View the user guide in a different language:* Tap Change Language at the bottom of the home page.

View the user guide in iBooks. Open iBooks, then search for "iPhone user" in the iBooks Store.

For more information about iBooks, see Chapter 24, iBooks, on page 123.

Tips for using iOS 8

The Tips app helps you get the most from iPhone.

Get Tips. Open the Tips app. New tips are added weekly.

Get notified when new tips arrive. Go to Settings > Notifications > Tips.

Basics

3

Use apps

All the apps that come with iPhone—as well as the apps you download from the App Store—are on the Home screen.

Start at home

Tap an app to open it.

Press the Home button anytime to return to the Home screen. Swipe left or right to see other screens.

Multitasking

iPhone helps you manage several tasks at the same time.

View contacts and open apps. Double-click the Home button to reveal the multitasking screen. Swipe left or right to see more. To switch to another app, tap it. To connect with a recent or favorite contact, tap the contact's picture or name, then tap your preferred method of communication.

Close an app. If an app isn't working properly, you can force it to quit. Drag the app up from the multitasking display. Then try opening the app again.

If you have lots of apps, you can use Spotlight to find and open them. Drag down the center of the Home screen to see the search field. See Spotlight Search on page 34.

Look around

Drag a list up or down to see more. Swipe to scroll quickly; touch the screen to stop it. Some lists have an index—tap a letter to jump ahead.

Drag a photo, map, or webpage in any direction to see more.

To quickly jump to the top of a page, tap the status bar at the top of the screen.

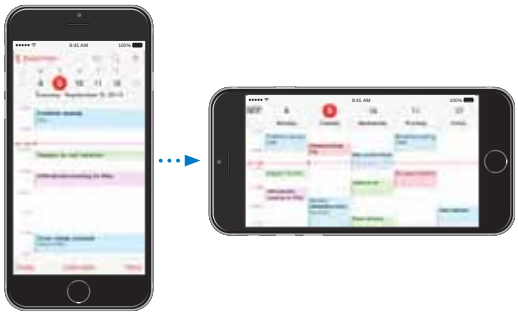
Get a closer look

Pinch open on a photo, webpage, or map for a close-up—then pinch closed to zoom back out. In Photos, keep pinching to see the collection or album the photo's in.

Or double-tap a photo or webpage to zoom in, and double-tap again to zoom out. In Maps, double-tap to zoom in and tap once with two fingers to zoom out.

Change the screen orientation

Many apps give you a different view when you rotate iPhone.



To lock the screen in portrait orientation, swipe up from the bottom edge of the screen to open Control Center, then tap .

The Portrait orientation lock icon appears in the status bar when the screen orientation is locked.

When you use iPhone 6 Plus in landscape orientation, some apps have special layouts. These apps include:

- Mail
- Messages
- Calendar
- Reminders
- Weather
- Notes
- Clock
- Settings
- Contacts
- Voice Memos
- Stocks

Note: These special layouts are not available when Display Zoom is enabled.

Reachability

If you have iPhone 6 or iPhone 6 Plus, and are using it in portrait orientation, lightly tap twice on the Home button to slide the screen down (bringing the top half closer to your thumb).

Disable Reachability. Tap Settings > General > Accessibility, then tap Reachability (below Interaction).

App extensions

Some apps let you extend the functionality of your apps on iPhone. An app extension may appear as a sharing option, action option, a widget in Notification Center, a file provider, or a custom keyboard. For example, if you download Pinterest to iPhone, Pinterest becomes another option for sharing when you click ⬆.

App extensions can also help you edit a photo or video in your Photos app. For example, you can download a photo-related app that lets you apply filters to photos from your Photos app.

Install app extensions. Download the app from the App Store, then open the app and follow the onscreen instructions.

Turn sharing or action options on or off. Tap ⬆, then tap More (drag options to the left if necessary). Turn off third-party sharing or action options (they are on by default).

Organize sharing and action options. Tap ⬆, then tap More (drag icons to the left if necessary). Touch and drag ≡ to rearrange your options.

For more information about Notification Center widgets, see Notification Center on page 36. For more information about Sharing options, see Share from apps on page 37.

Continuity

About Continuity features

Continuity features connect iPhone with your iPad, iPod touch, and Mac so they can work together as one. You can start an email or document on iPhone, for example, then pick up where you left off on your iPad. Or let your iPad or Mac use iPhone to make phone calls or send SMS or MMS text messages.

Continuity features require iOS 8 or OS X Yosemite, and work with iPhone 5 or later, iPod touch (5th generation) or later, iPad (4th generation) or later, and supported Mac computers. For more information, see support.apple.com/kb/HT6337.

Handoff

Pick up on one device where you left off on another. You can use Handoff with Mail, Safari, Pages, Numbers, Keynote, Maps, Messages, Reminders, Calendar, Contacts, and even some third-party apps. For Handoff to work, your devices must be signed in to iCloud using the same Apple ID, and they must be within Bluetooth range of one another (about 33 feet or 10 meters).

Switch devices. Swipe up from the bottom-left edge of the Lock screen (where you see the app's activity icon), or go to the multitasking screen, then tap the app. On your Mac, open the app you were using on your iOS device.

Disable Handoff on your devices. Go to Settings > General > Handoff & Suggested Apps.

Disable Handoff on your Mac. Go to System Preferences > General, then turn off Allow Handoff between this Mac and your devices set up with iCloud.

Phone calls

Make and receive phone calls on your iPad, iPod touch, or Mac (with iOS 8 or OS X Yosemite) as long as your iPhone is on the same Wi-Fi network, and signed in to iCloud and FaceTime with the same Apple ID. (If available on your iPhone, Allow Wi-Fi Calls must be off. Go to Settings > Phone > Wi-Fi Calls.) See Make and receive calls on your iPad, iPod touch, or Mac on page 53.

Make a phone call on your iPad, iPod touch, or Mac. Tap or click a phone number in Contacts, Calendar, or Safari. On iPad or iPod touch, you can also tap a recent contact in the multitasking screen.

Disable iPhone Cellular Calls. Go to Settings > FaceTime, then turn off iPhone Cellular Calls.

Messages

Switch between your iOS devices and Mac computers (with iOS 8 or OS X Yosemite) as you send and receive SMS and MMS text messages. Just sign in to iMessage with the same Apple ID as your iPhone. For more information, see SMS, MMS, and iMessage on page 77.

Instant Hotspot

You can use Instant Hotspot on iPhone to provide Internet access to your other iOS devices and Mac computers (with iOS 8 or OS X Yosemite) that are signed in to iCloud using the same Apple ID. Instant Hotspot uses your iPhone Personal Hotspot, without you having to enter a password or even turn on Personal Hotspot.

Use Instant Hotspot. Go to Settings > Wi-Fi on your other iOS device, then simply choose your iPhone network under Personal Hotspots. On your Mac, choose your iPhone network from your Wi-Fi settings.

When you're not using using the hotspot, your devices disconnect to save battery life. For more information see Personal Hotspot on page 40.

Note: This feature may not be available with all carriers. Additional fees may apply. Contact your carrier for more information.

Customize iPhone

Arrange your apps

Arrange apps. Touch and hold any app on the Home screen until it jiggles, then drag apps around. Drag an app to the edge of the screen to move it to a different Home screen, or to the Dock at the bottom of the screen. Press the Home button to save your arrangement.

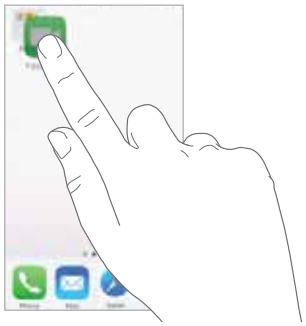
Create a new Home screen. While arranging apps, drag an app to the right edge of the last Home screen. The dots above the Dock show how many Home screens you have, and which one you're viewing.

You can also customize the Home screen using iTunes, when iPhone is connected to your computer. In iTunes, select iPhone, then click Apps.

Start over. Go to Settings > General > Reset, then tap Reset Home Screen Layout to return the Home screen and apps to their original layout. Folders are removed and the original wallpaper is restored.

Organize with folders

Create a folder. While arranging apps, drag one app onto another. Tap the name of the folder to rename it. Drag apps to add or remove them. Press the Home button when you finish.



You can have multiple pages of apps in a folder.

Delete a folder. Drag out all the apps—the folder is deleted automatically.

Change the wallpaper

Wallpaper settings let you set an image or photo as wallpaper for the Lock screen or Home screen. You can choose from dynamic and still images.

Change the wallpaper. Go to Settings > Wallpaper > Choose a New Wallpaper.

When choosing an image for new wallpaper, the Perspective Zoom button determines whether your selected wallpaper is zoomed. For wallpaper you already set, go to the Wallpaper setting, then tap the image of the Lock screen or Home screen to see the Perspective Zoom button.

Note: The Perspective Zoom button doesn't appear if Reduce Motion (in Accessibility settings) is turned on. See Reduce screen motion on page 163.

Adjust the screen brightness

Dim the screen to extend battery life, or use Auto-Brightness.

Adjust the screen brightness. Go to Settings > Display & Brightness, then drag the slider. If Auto-Brightness is on, iPhone adjusts the screen brightness for current light conditions using the built-in ambient light sensor. You can also adjust the brightness in Control Center.

Display Zoom

With iPhone 6 or iPhone 6 Plus you can magnify the screen display. Go to Settings > Display & Brightness. Tap View (below Display Zoom), choose Zoomed, then tap Set. For additional zoom features, see Zoom on page 160.

Type text

The onscreen keyboard lets you enter text when needed.

Enter text

Tap a text field to see the onscreen keyboard, then tap letters to type. If you touch the wrong key, you can slide your finger to the correct key. The letter isn't entered until you release your finger from the key.

Tap Shift to type uppercase, or touch the Shift key and slide to a letter. Double-tap Shift for caps lock. To enter numbers, punctuation, or symbols, tap the Number key 123 or the Symbol key #+=. If you haven't added any keyboards, tap 😀 to switch to the emoji keyboard. If you have several keyboards, tap 🌐 to switch to the last one you used. Continue tapping to access other enabled keyboards, or touch and hold 🌐, then slide to choose a different keyboard. To quickly end a sentence with a period and a space, just double-tap the space bar.

To type an alternate character, touch and hold a key, then slide to choose one of the options.

If you see a word underlined in red, tap it to see suggested corrections. If the word you want doesn't appear, type the correction.

As you write, the keyboard predicts your next word (not available in all languages). Tap a word to choose it, or accept a highlighted prediction by entering a space or punctuation. When you tap a suggested word, a space appears after the word. If you enter a comma, period, or other punctuation, the space is deleted. Reject a suggestion by tapping your original word (shown as the predictive text option with quotation marks).

Predictive text

Hide predictive text. Pull down the suggested words. Drag the bar up when you want to see the suggestions again.

Turn off predictive text. Touch and hold 😀 or 🌐, then slide to Predictive.

If you turn off predictive text, iPhone may still try to suggest corrections for misspelled words. Accept a correction by entering a space or punctuation, or by tapping return. To reject a correction, tap the "x." If you reject the same suggestion a few times, iPhone stops suggesting it.

Set options for typing or add keyboards. Go to Settings > General > Keyboard.

The onscreen keyboard for iPhone 6 and iPhone 6 Plus includes additional keys you may find useful. You can see these keys when you hold iPhone in landscape orientation.

You can also use an Apple Wireless Keyboard to enter text. See Use an Apple Wireless Keyboard on page 32. To dictate instead of typing, see Dictate on page 32.

Edit text

Revise text. Touch and hold the text to show the magnifying glass, then drag to position the insertion point.

Select text. Tap the insertion point to display the selection options. Or double-tap a word to select it. Drag the grab points to select more or less text. In read-only documents, such as webpages, touch and hold to select a word.

r point

You can cut, copy, or paste over selected text. With some apps, you can also get bold, italic, or underlined text (tap B/I/U); get the definition of a word; or have iPhone suggest an alternative. Tap ▶ to see all the options.

Undo the last edit. Shake iPhone, then tap Undo.

Save keystrokes

A shortcut lets you enter a word or phrase by typing just a few characters. For example, type "omw" to enter "On my way!" That one's already set up for you, but you can also add your own.

Create a shortcut. Go to Settings > General > Keyboard, then tap Shortcuts.

Have a word or phrase you use and don't want it corrected? Create a shortcut, but leave the Shortcut field blank.

Use iCloud to keep your personal dictionary up to date on your other devices. Go to Settings > iCloud, then turn on iCloud Drive or Documents & Data.

Use an Apple Wireless Keyboard

You can use an Apple Wireless Keyboard (available separately) to enter text on iPhone. The keyboard connects via Bluetooth, so you must first pair it with iPhone.

Note: The Apple Wireless Keyboard may not support keyboard features that are on your device. For example, it does not anticipate your next word or automatically correct misspelled words.

Pair an Apple Wireless Keyboard with iPhone. Turn on the keyboard, go to Settings > Bluetooth and turn on Bluetooth, then tap the keyboard when it appears in the Devices list.

Once it's paired, the keyboard reconnects to iPhone whenever it's in range—up to about 33 feet (10 meters). When it's connected, the onscreen keyboard doesn't appear.

Save your batteries. Turn off Bluetooth and the wireless keyboard when not in use. You can turn off Bluetooth ᛒ in Control Center. To turn off the keyboard, hold down the On/off switch until the green light goes off.

Unpair a wireless keyboard. Go to Settings > Bluetooth, tap ⓘ next to the keyboard name, then tap Forget this Device.

See Bluetooth devices on page 42.

Add or change keyboards

You can turn typing features, such as spell checking, on or off; add keyboards for writing in different languages; and change the layout of your onscreen keyboard or Apple Wireless Keyboard.

Set typing features. Go to Settings > General > Keyboard.

Add a keyboard for another language. Go to Settings > General > Keyboard > Keyboards > Add New Keyboard.

Switch keyboards. If you haven't added any keyboards, tap 😀 to switch to the emoji keyboard. If you have several keyboards, tap 🌐 to switch to the last one you used. Continue tapping to access other enabled keyboards, or touch and hold 🌐, then slide to choose a different keyboard.

For information about international keyboards, see Use international keyboards on page 175.

Change the keyboard layout. Go to Settings > General > Keyboard > Keyboards, select a keyboard, then choose a layout.

Dictate

If you like, you can dictate instead of typing. Make sure Enable Dictation is turned on (in Settings > General > Keyboard) and iPhone is connected to the Internet.

Note: Dictation may not be available in all languages or in all areas, and features may vary. Cellular data charges may apply. See Cellular settings on page 188.

Dictate text. Tap 🎙 on the onscreen keyboard, then speak. Tap Done when you finish.

Add text. Tap 🎙 again and continue dictating. To insert text, tap to place the insertion point first. You can also replace selected text by dictating.

Add punctuation or format text. Say the punctuation or format. For example, "Dear Mary comma the check is in the mail exclamation mark" becomes "Dear Mary, the check is in the mail!" Punctuation and formatting commands include:

- quote … end quote
- new paragraph
- new line
- cap—to capitalize the next word
- caps on … caps off—to capitalize the first character of each word
- all caps—to make the next word all uppercase
- all caps on … all caps off—to make the enclosed words all uppercase
- no caps on … no caps off—to make the enclosed words all lowercase
- no space on … no space off—to run a series of words together
- smiley—to insert :-)
- frowny—to insert :-(
- winky—to insert ;-)

Voice Control

Voice Control lets you make phone calls and FaceTime calls, and control music playback, if you have Siri turned off. (For information about using Siri to control iPhone by voice, see Chapter 4, Siri, on page 48.)

Note: Voice Control and Voice Control settings aren't available when Siri is turned on.

Use Voice Control. Turn Siri off in Settings > General > Siri, then press and hold the Home button until the Voice Control screen appears and you hear a beep, or press and hold the center button on your headset. See Use an Apple headset on page 41.

For best results:

- Speak clearly and naturally.
- Say only Voice Control commands, names, and numbers. Pause slightly between commands.
- Use full names.

Change the language for Voice Control. By default, Voice Control expects you to speak voice commands in the language that's set for iPhone (in Settings > General > International > Language). To use Voice Control in another language or dialect, go to Settings > General > International > Voice Control.

Voice Control for the Music app is always on, but you can keep Voice Control from dialing when iPhone is locked. Go to Settings > Touch ID & Passcode (iPhone models with Touch ID) or Settings > Passcode (other models), then turn off Voice Dial.

For specific commands, see Make a call on page 51 and Siri and Voice Control on page 73. For more about using Voice Control, including information about using Voice Control in different languages, see support.apple.com/kb/HT3597.

Search

Search apps

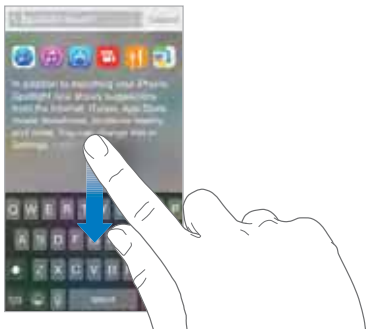
Many apps include a search field where you can type to find something within the app. For example, in the Maps app, you can search for a specific location.

Spotlight Search

Spotlight Search not only searches your iPhone, but also shows suggestions from the App Store and the Internet. You may see suggestions for movie showtimes, nearby locations, and more.

Search iPhone. Drag down the middle of any Home screen to reveal the search field. Results occur as you type; to hide the keyboard and see more results on the screen, tap Search. Tap an item in the list to open it.

You can also use Spotlight Search to find and open apps.



Choose which apps and content are searched. Go to Settings > General > Spotlight Search, then tap to deselect apps or content. To change the search order, touch and drag ≡ to a new position.

Limit Spotlight Search to your iPhone. Go to Settings > General > Spotlight Search, then tap Spotlight Suggestions to deselect it.

Turn off Location Services for Spotlight Suggestions. Go to Settings > Privacy > Location Services. Tap System Services, then turn off Spotlight Suggestions.

Control Center

Control Center gives you instant access to the camera, calculator, AirPlay, control and playback of currently playing audio, and other handy features. You can also adjust the brightness, lock the screen in portrait orientation, turn wireless services on or off, and turn on AirDrop. See AirDrop on page 37.

Open Control Center. Swipe up from the bottom edge of any screen (even the Lock screen).

Open the currently playing audio app. Tap the song title.

Close Control Center. Swipe down, tap the top of the screen, or press the Home button.

Turn off access to Control Center in apps or on the Lock screen. Go to Settings > Control Center.

Alerts and Notification Center

Alerts

Alerts let you know about important events. They can appear briefly at the top of the screen, or remain in the center of the screen until you acknowledge them.

Some apps may include a badge on their Home screen icon, to let you know how many new items await—for example, the number of new email messages. If there's a problem—such as a message that couldn't be sent—an exclamation mark ⓘ appears on the badge. On a folder, a numbered badge indicates the total number of notifications for all the apps inside.

Alerts can also appear on the Lock screen.

Respond to an alert without leaving your current app. Pull down on the alert when it appears at the top of your screen.

Note: This feature works with text and email messages, calendar invitations, and more.

Respond to an alert when iPhone is locked. Swipe the alert from right to left.

Silence your alerts. Go to Settings > Do Not Disturb. You can also use Siri to turn Do Not Disturb on or off. Say "Turn on Do Not Disturb" or "Turn off Do Not Disturb."

Set sounds and vibrations. Go to Settings > Sounds.

Notification Center

Notification Center collects your notifications in one place, so you can review them whenever you're ready. View details about your day—such as the weather forecast, appointments, birthdays, stock quotes, and even a quick summary of what's coming up tomorrow. Tap the Notifications tab to review all your alerts.

Open Notification Center. Swipe down from the top edge of the screen.

Set Today options. To choose what information appears, tap the Edit key at the end of your information on the Today tab. Tap + or — to add or remove information. To arrange the order of your information, touch ≡, then drag it to a new position.

Set notification options. Go to Settings > Notifications. Tap an app to set its notification options. For example, choose to view a notification from the Lock screen. You can also tap Edit to arrange the order of app notifications. Touch ≡, then drag it to a new position.

Note: To include traffic conditions for your commute in the Today tab, make sure Frequent Locations is turned on in Settings > Privacy > Location Services > System Services > Frequent Locations.

Get government alerts. In some areas, you can turn on alerts in the Government Alerts list. Go to Settings > Notifications.

For example, in the United States, iPhone can receive presidential alerts, and you can turn AMBER and Emergency Alerts (which includes both Severe and Extreme Imminent Threat alerts) on or off (they're on by default). In Japan, iPhone can receive Emergency Earthquake Alerts from the Japan Meteorological Agency. Government alerts vary by carrier and iPhone model, and may not work under all conditions.

Choose whether to show Today and Notifications View on a locked screen. Go to Settings > Touch ID & Passcode (iPhone models with Touch ID) or Settings > Passcode (other models), then choose whether to allow access when locked.

Close Notification Center. Swipe up, or press the Home button.

Sounds and silence

You can change or turn off the sounds iPhone plays when you get a call, text, voicemail, email, tweet, Facebook post, reminder, or other event.

Set sound options. Go to Settings > Sounds for options such as ringtones and alert tones, vibration settings and patterns, and ringer and alert volumes.

Set vibration patterns. Go to Settings > Sounds, then choose an item from the Sounds and Vibration Patterns list. Tap Vibration to select a pattern or create your own.

If you want to temporarily silence incoming calls, alerts, and sound effects, see the following section and Ring/Silent switch on page 13.

Do Not Disturb

Do Not Disturb is an easy way to silence iPhone, whether you're going to dinner or to sleep. It keeps calls and alerts from making any sounds or lighting up the screen.

Turn on Do Not Disturb. Swipe up from the bottom edge of the screen to open Control Center, then tap . When Do Not Disturb is on, appears in the status bar.

Note: Alarms still sound, even when Do Not Disturb is on. To make sure iPhone stays silent, turn it off.

Configure Do Not Disturb. Go to Settings > Do Not Disturb.

You can schedule quiet hours, allow calls from your Favorites or groups of contacts, and allow repeated calls to ring through for those emergency situations. You can also set whether Do Not Disturb silences iPhone only when it's locked, or even when it's unlocked.

Sharing

Share from apps

In many apps, you can tap Share or to choose how to share your information. The choices vary depending on the app you're using. Additional options may appear if you've downloaded apps with sharing options. For more information, see App extensions on page 26.

Use Twitter, Facebook, Flickr, Vimeo or other third-party apps with sharing options. Sign in to your account in Settings. The third-party sharing buttons take you to the appropriate setting if you're not yet signed in.

Customize the different ways you choose to share your information. Tap the More button, then touch and drag to move items to new positions.

AirDrop

AirDrop lets you share your photos, videos, websites, locations, and other items wirelessly with other nearby devices (iOS 7 or later). With iOS 8, you can share with Mac computers with OS X Yosemite. AirDrop transfers information using Wi-Fi and Bluetooth—both must be turned on. To use AirDrop, you need to be signed in to iCloud using your Apple ID. Transfers are encrypted for security.

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Share an item using AirDrop. Tap Share , then tap the name of a nearby AirDrop user.

Receive AirDrop items from others. Swipe up from the bottom edge of the screen to open Control Center. Tap AirDrop, then choose to receive items from Contacts Only or from Everyone. You can accept or decline each request as it arrives.

Family Sharing

With Family Sharing, up to six family members can share their iTunes Store, App Store, and iBooks Store purchases, a family calendar, and family photos, all without sharing accounts.

One adult in your household—the family organizer—invites family members to join the family group and agrees to pay for any iTunes Store, iBooks Store, and App Store purchases those family members initiate while part of the family group. Once set up, family members get immediate access to each other's music, movies, TV shows, books, and eligible apps. In addition, family members can easily share photos in a shared family album, add events to a family calendar, share their location with other family members, and even help locate another family member's missing device.

Children under 13 can participate in Family Sharing, too. As a parent or legal guardian, the family organizer can provide parental consent for a child to have his or her own Apple ID, and create it on the child's behalf. Once the account is created, it's added to the family group automatically.

Family Sharing requires you to sign in to iCloud with your Apple ID. You will also be asked to confirm the Apple ID you use for the iTunes Store, App Store, and iBooks Store. It is available on devices with iOS 8, Mac computers with OS X Yosemite, and PCs with iCloud for Windows 4.0. You can be part of only one family group at a time.

Set up Family Sharing. Go to Settings > iCloud > Set Up Family Sharing. Follow the onscreen instructions to set up Family Sharing as the family organizer, then invite family members to join.

Create an Apple ID for a child. Go to Settings > iCloud > Family, scroll to the bottom of the screen, then tap Create an Apple ID for a child.

Accept an invitation to Family Sharing. Make sure you are signed in to iCloud, and that you can accept a Family Sharing invitation from your iOS device (iOS 8 required), Mac (OS X Yosemite required), or PC (iCloud for Windows 4.0 required). Or, if the organizer is nearby during the setup process, he or she can simply ask you to enter the Apple ID and password you use for iCloud.

Access shared iTunes Store, App Store, and iBooks Store purchases. Open iTunes Store, iBooks Store, or App Store, tap Purchased, then choose a family member from the menu that appears.

When a family member initiates a purchase, it is billed directly to the family organizer's account. Once purchased, the item is added to the initiating family member's account and is shared with the rest of the family. If Family Sharing is ever disabled, each person keeps the items they chose to purchase—even if they were paid for by the family organizer.

Turn on Ask to Buy. The family organizer can require young family members to request approval for purchases or free downloads. Go to Settings > iCloud > Family, then tap the person's name.

Note: Age restrictions for Ask to Buy vary by area. In the United States, the family organizer can enable Ask to Buy for any family member under age 18; for children under age 13, it's enabled by default.

Hide your iTunes Store, App Store, and iBooks Store purchases. Open iTunes on your computer, then click iTunes Store. Under Quick Links, click Purchased, then choose the content type (for example, Music or Movies). Hover over the item you want to hide, then click ⊗. To make purchases visible again, return to Quick Links, then click Account. Scroll down to iTunes in the Cloud, then click Manage (to the right of Hidden Purchases).

Share photos or videos with family members. When you set up Family Sharing, a shared album called "Family" is automatically created in the Photos app on all family members' devices. To share a photo or video with family members, open the Photos app, then view a photo or video or select multiple photos or videos. Tap ⬆, tap iCloud Photo Sharing, add comments, then share to your shared family album. See iCloud Photo Sharing on page 88.

Add an event to the family calendar. When you set up Family Sharing, a shared calendar called "Family" is automatically created in the Calendar app on all family members' devices. To add a family event, open the Calendar app, create an event, then choose to add the event to the family calendar. See Share iCloud calendars on page 84.

Set up a family reminder. When you set up Family Sharing, a shared list is automatically created in the Reminders app on all family members' devices. To add a reminder to the family list, open the Reminders app, tap the family list, then add a reminder to the list. See Reminders at a glance on page 109.

Share your location with family members. Family members can share their location by tapping Settings > iCloud > Share My Location (under Advanced). To find a family member's location, use the Find My Friends app (download it for free from the App Store). Or, use the Messages app (iOS 8 required). For more information about using Messages to share or view locations, see Share photos, videos, your location, and more on page 80.

Keep track of your family's devices. If family members have enabled Share My Location in iCloud, you can help them locate missing devices. Open Find My iPhone on your device or at iCloud.com. For more information, see Find My iPhone on page 46.

Leave Family Sharing. Go to Settings > iCloud > Family, then tap Leave Family Sharing. If you are the organizer, go to Settings > iCloud > Family, tap your name, then tap Stop Family Sharing. For more information, see support.apple.com/kb/HT201081.

iCloud Drive

About iCloud Drive

iCloud Drive stores your presentations, spreadsheets, PDFs, images, and other kinds of documents in iCloud so you can access these documents from any of your devices set up with iCloud. It allows your apps to share documents so you can work on the same file across multiple apps.

iCloud Drive works with devices with iOS 8, Mac computers with OS X Yosemite, PCs with iCloud for Windows 4.0, or on iCloud.com. To access iCloud Drive, you must be signed in to iCloud with your Apple ID. iCloud Drive works with supported apps including Pages, Numbers, Keynote, GarageBand, and some third-party apps. Storage limits are subject to your iCloud storage plan.

Set up iCloud Drive

You can set up iCloud Drive using Setup Assistant when you install iOS 8, or you can set it up later in Settings. iCloud Drive is an upgrade to Documents & Data. When you upgrade to iCloud Drive, your documents are copied to iCloud Drive and become available on your devices using iCloud Drive. You won't be able to access the documents stored in iCloud Drive on your other devices until they are also upgraded to iOS 8 or OS X Yosemite. For more information about upgrading to iCloud Drive, see support.apple.com/kb/HT6345.

Set up iCloud Drive. Go to Settings > iCloud > iCloud Drive, then turn on iCloud Drive and follow the onscreen instructions.

Transfer files

There are several ways to transfer files between iPhone and your computer or other iOS device.

Transfer files using iTunes. Connect iPhone to your computer using the included cable. In iTunes on your computer, select iPhone, then click Apps. Use the File Sharing section to transfer documents between iPhone and your computer. Apps that support file sharing appear in the File Sharing Apps list in iTunes. To delete a file, select it in the Documents list, then press the Delete key.

You can also view files received as email attachments on iPhone.

With some apps, you can transfer files using AirDrop. See AirDrop on page 37.

Personal Hotspot

Use Personal Hotspot to share your iPhone Internet connection. Computers can share your Internet connection using Wi-Fi, Bluetooth, or a USB cable. Other iOS devices can share the connection using Wi-Fi. Personal Hotspot works only if iPhone is connected to the Internet over the cellular data network.

Note: This feature may not be available with all carriers. Additional fees may apply. Contact your carrier for more information.

Share an Internet connection. Go to Settings > Cellular, then tap Personal Hotspot—if it appears—to set up the service with your carrier.

After you turn on Personal Hotspot, other devices can connect in the following ways:

- *Wi-Fi:* On the device, choose your iPhone from the list of available Wi-Fi networks.
- *USB:* Connect iPhone to your computer using the cable that came with it. In your computer's Network preferences, choose iPhone and configure the network settings.
- *Bluetooth:* On iPhone, go to Settings > Bluetooth, then turn on Bluetooth. To pair and connect iPhone with your Bluetooth device, refer to the documentation that came with your device.

Note: When a device is connected, a blue band appears at the top of the iPhone screen. The Personal Hotspot icon appears in the status bar of iOS devices using Personal Hotspot.

Change the Wi-Fi password for iPhone. Go to Settings > Personal Hotspot > Wi-Fi Password, then enter a password of at least 8 characters.

Monitor your cellular data network usage. Go to Settings > Cellular. See Cellular settings on page 188.

AirPlay

Use AirPlay to stream music, photos, and video wirelessly to Apple TV and other AirPlay-enabled devices. If you don't see your AirPlay-enabled devices when you tap , you may also need to make sure everything is on the same Wi-Fi network.

Display the AirPlay controls. Swipe up from the bottom edge of the screen to open Control Center, then tap .

Stream content. Tap , then choose the device you want to stream to.

Switch back to iPhone. Tap , then choose iPhone.

Mirror the iPhone screen on a TV. Tap , choose an Apple TV, then tap Mirroring. A blue bar appears at the top of the iPhone screen when AirPlay mirroring is turned on.

You can also connect iPhone to a TV, projector, or other external display using the appropriate Apple cable or adapter. See support.apple.com/kb/HT4108.

AirPrint

Use AirPrint to print wirelessly to an AirPrint-enabled printer from apps such as Mail, Photos, and Safari. Many apps available on the App Store also support AirPrint.

iPhone and the printer must be on the same Wi-Fi network. For more information about AirPrint, see support.apple.com/kb/HT4356.

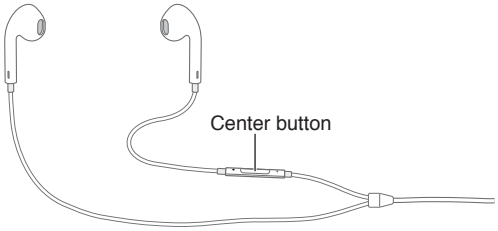
Print a document. Tap or (depending on the app you're using).

See the status of a print job. Double-click the Home button, then tap Print Center. The badge on the icon shows how many documents are in the queue.

Cancel a job. Select it in Print Center, then tap Cancel Printing.

Use an Apple headset

The Apple EarPods with Remote and Mic (iPhone 5 or later) and the Apple Earphones with Remote and Mic (iPhone 4s) feature a microphone, volume buttons, and the center button, which lets you answer and end calls or control audio and video playback, even when iPhone is locked.



Use the center button to control music playback.

- *Pause a song or video:* Press the center button. Press again to resume playback.
- *Skip to the next song:* Press the center button twice quickly.
- *Return to the previous song:* Press the center button three times quickly.
- *Fast-forward:* Press the center button twice quickly and hold.
- *Rewind:* Press the center button three times quickly and hold.

Use the center button to answer or make phone calls.

- *Answer an incoming call:* Press the center button.
- *End the current call:* Press the center button.
- *Decline an incoming call:* Press and hold the center button for about two seconds, then let go. Two low beeps confirm you declined the call.
- *Switch to an incoming or on-hold call, and put the current call on hold:* Press the center button. Press again to switch back to the first call.
- *Switch to an incoming or on-hold call, and end the current call:* Press and hold the center button for about two seconds, then let go. Two low beeps confirm you ended the first call.

Use Siri or Voice Control. Press and hold the center button. See Chapter 4, Siri, on page 48 or Voice Control on page 33.

Bluetooth devices

You can use Bluetooth devices with iPhone, including headsets, car kits, stereo headphones, or an Apple Wireless Keyboard. For supported Bluetooth profiles, see support.apple.com/kb/HT3647.

> *WARNING:* For important information about avoiding hearing loss and avoiding distractions that could lead to dangerous situations, see Important safety information on page 181.

Note: The use of certain accessories with iPhone may affect wireless performance. Not all iPod and iPad accessories are fully compatible with iPhone. Turning on Airplane Mode may eliminate audio interference between iPhone and an accessory. Reorienting or relocating iPhone and the connected accessory may improve wireless performance.

Turn Bluetooth on or off. Go to Settings > Bluetooth. You can also turn Bluetooth ᛒ on or off in Control Center.

Connect to a Bluetooth device. Tap the device in the Devices list, then follow the onscreen instructions to connect to it. See the documentation that came with the device for information about Bluetooth pairing. For information about using an Apple Wireless Keyboard, see Use an Apple Wireless Keyboard on page 32.

iPhone must be within about 33 feet (10 meters) of the Bluetooth device.

Return audio output to iPhone. Turn off or unpair the device, turn off Bluetooth in Settings > Bluetooth, or use AirPlay to switch audio output to iPhone. See AirPlay on page 41. Audio output returns to iPhone whenever the Bluetooth device is out of range.

Bypass your Bluetooth device. To use the iPhone receiver or speaker for phone calls:

- Answer a call by tapping the iPhone screen.
- During a call, tap Audio and choose iPhone or Speaker Phone.
- Turn off the Bluetooth device, unpair it, or move out of range.
- Turn off Bluetooth in Settings > Bluetooth.

Unpair a device. Go to Settings > Bluetooth, tap ⓘ next to the device, then tap Forget this Device. If you don't see the Devices list, make sure Bluetooth is on.

Restrictions

You can set restrictions for some apps, and for purchased content. For example, parents can restrict explicit music from appearing in playlists, or disallow changes to certain settings. Use restrictions to prevent the use of certain apps, the installation of new apps, or changes to accounts or the volume limit.

Turn on restrictions. Go to Settings > General > Restrictions, then tap Enable Restrictions. You'll be asked to define a restrictions passcode that's necessary to change the settings you make. This can be different from the passcode for unlocking iPhone.

Important: If you forget your restrictions passcode, you must restore the iPhone software. See Restore iPhone on page 187.

Privacy

Privacy settings let you see and control which apps and system services have access to Location Services, and to contacts, calendars, reminders, and photos.

Location Services lets location-based apps such as Reminders, Maps, and Camera gather and use data indicating your location. Your approximate location is determined using available information from cellular network data, local Wi-Fi networks (if you have Wi-Fi turned on), and GPS (may not be available in all areas). The location data collected by Apple isn't collected in a form that personally identifies you. When an app is using Location Services, ⌖ appears in the status bar.

Turn Location Services on or off. Go to Settings > Privacy > Location Services. You can turn it off for some or for all apps and services. If you turn off Location Services, you're prompted to turn it on again the next time an app or service tries to use it.

Turn Location Services off for system services. Several system services, such as compass calibration and location-based ads, use Location Services. To see their status, turn them on or off, or show ⌖ in the status bar when these services use your location, go to Settings > Privacy > Location Services > System Services.

Turn off access to private information. Go to Settings > Privacy. You can see which apps and features have requested and been granted access to the following information:

- Contacts
- Calendar
- Reminders
- Photos
- Bluetooth Sharing
- Microphone
- Camera
- HomeKit
- Health
- Motion Activity
- Twitter
- Facebook

You can turn off each app's access to each category of information. Review the terms and privacy policy for each third-party app to understand how it uses the data it's requesting. For more information, see support.apple.com/kb/HT6338.

Security

Security features help protect the information on your iPhone from being accessed by others.

Use a passcode with data protection

For better security, you can set a passcode that must be entered each time you turn on or wake up iPhone.

Set a passcode. Go to Settings > Touch ID & Passcode (iPhone models with Touch ID) or Settings > Passcode (other models), then set a 4-digit passcode.

Setting a passcode turns on data protection, using your passcode as a key to encrypt Mail messages and attachments stored on iPhone, using 256-bit AES encryption. (Other apps may also use data protection.)

Increase security. Turn off Simple Passcode and use a longer passcode. To enter a passcode that's a combination of numbers and letters, you use the keyboard. If you prefer to unlock iPhone using the numeric keypad, set up a longer passcode using numbers only.

Add fingerprints and set options for the Touch ID sensor. (iPhone models with Touch ID) Go to Settings > Touch ID & Passcode. See Touch ID, below.

Allow access to features when iPhone is locked. Go to Settings > Touch ID & Passcode (iPhone models with Touch ID) or Settings > Passcode (other models). Optional features include:

- Today (see Notification Center on page 36)
- Notifications View (see Notification Center on page 36)
- Siri (if enabled, see Siri settings on page 50)
- Passbook (see Chapter 26, Passbook, on page 129)
- Reply with Message (see When someone calls on page 52)

Allow access to Control Center when iPhone is locked. Go to Settings > Control Center. See Control Center on page 35.

Erase data after ten failed passcode attempts. Go to Settings > Touch ID & Passcode (iPhone models with Touch ID) or Settings > Passcode (other models), then tap Erase Data. After ten failed passcode attempts, all settings are reset, and all your information and media are erased by removing the encryption key to the data.

If you forget your passcode, you must restore the iPhone software. See Restore iPhone on page 187.

Touch ID

On iPhone models with Touch ID, you can unlock iPhone by placing a finger on the Home button. Touch ID also lets you:

- Use your Apple ID password to make purchases in the iTunes Store, App Store, or iBooks Store
- Present your credit card or debit card when making a purchase in a store that offers Apple Pay as a method of payment
- Provide debit and credit card info, billing and shipping addresses, and contact info when paying in an app that offers Apple Pay as a method of payment

Set up the Touch ID sensor. Go to Settings > Touch ID & Passcode. Set whether you want to use a fingerprint to unlock iPhone, and to make purchases. Tap Add a Fingerprint, then follow the onscreen instructions. You can add more than one fingerprint (your thumb and forefinger, for example, or one for your spouse).

Note: If you turn iPhone off after setting up the Touch ID sensor, you'll be asked to confirm your passcode when you turn iPhone back on and unlock it the first time. You'll also be asked for your Apple ID password for the first purchase you make in the iTunes Store, App Store, or iBooks Store.

Delete a fingerprint. Tap the fingerprint, then tap Delete Fingerprint. If you have more than one fingerprint, place a finger on the Home button to find out which fingerprint it is.

Name a fingerprint. Tap the fingerprint, then enter a name, such as "Thumb."

Use the Touch ID sensor to make a payment in the iTunes Store, App Store, or iBooks Store. When purchasing from the iTunes Store, App Store, or iBooks Store, follow the prompts to enable purchases with your fingerprint. Or go to Settings > Touch ID & Passcode, then turn on iTunes & App Store.

Use Touch ID for Apple Pay. (iPhone 6 or iPhone 6 Plus) Go to Settings > Touch ID & Passcode to ensure that Apple Pay is enabled with your Touch ID. For more information see Apple Pay on page 130.

iCloud Keychain

iCloud Keychain keeps your Safari website user names and passwords, credit card information, and Wi-Fi network information up to date. iCloud Keychain works on all your approved devices (iOS 7 or later) and Mac computers (OS X Mavericks or later).

iCloud Keychain works with Safari Password Generator and AutoFill. When you're setting up a new account, Safari Password Generator suggests unique, hard-to-guess passwords. You can use AutoFill to have iPhone enter your user name and password info, making login easy. See Fill in forms on page 68.

Note: Some websites do not support AutoFill.

iCloud Keychain is secured with 256-bit AES encryption during storage and transmission, and cannot be read by Apple.

Set up iCloud Keychain. Go to Settings > iCloud > Keychain. Turn on iCloud Keychain, then follow the onscreen instructions. If you set up iCloud Keychain on other devices, you need to approve use of iCloud Keychain from one of those devices, or use your iCloud Security Code.

Important: If you forget your iCloud Security Code, you have to start over and set up your iCloud Keychain again.

Set up AutoFill. Go to Settings > Safari > Passwords & AutoFill. Make sure Names and Passwords, and Credit Cards, are turned on (they're on by default). To add credit card info, tap Saved Credit Cards.

The security code for your credit card is not saved—you have to enter that manually.

To automatically fill in names, passwords, or credit card info on sites that support it, tap a text field, then tap AutoFill.

To protect your personal information, set a passcode if you turn on iCloud Keychain and AutoFill.

Limit Ad Tracking

Restrict or reset Ad Tracking. Go to Settings > Privacy > Advertising. Turn on Limit Ad Tracking to prevent apps from accessing your iPhone advertising identifier. For more information, tap About Advertising & Privacy.

Find My iPhone

Find My iPhone can help you locate and secure your iPhone using the free Find My iPhone app (available in the App Store) on another iPhone, iPad, or iPod touch, or using a Mac or PC web browser signed in to www.icloud.com/find. Find My iPhone includes Activation Lock, which is designed to prevent anyone else from using your iPhone if you ever lose it. Your Apple ID and password are required to turn off Find My iPhone or to erase and reactivate your iPhone.

Turn on Find My iPhone. Go to Settings > iCloud > Find My iPhone.

Important: To use Find My iPhone features, Find My iPhone must be turned on *before* your iPhone is lost. iPhone must be able to connect to the Internet for you to locate and secure the device. iPhone sends its last location prior to the battery running out when Send Last Location in Settings is turned on.

Use Find My iPhone. Open the Find My iPhone app on an iOS device, or go to www.icloud.com/find on your computer. Sign in, then select your device.

- *Play Sound:* Play a sound at full volume for two minutes, even if the ringer is set to silent.
- *Lost Mode:* Immediately lock your missing iPhone with a passcode and send it a message displaying a contact number. iPhone tracks and reports its location, so you can see where it's been when you check the Find My iPhone app. Lost Mode also suspends the use of your credit and debit cards used for Apple Pay (iPhone 6 and iPhone 6 Plus). See Apple Pay on page 130.
- *Erase iPhone:* Protect your privacy by erasing all the information and media on your iPhone and restoring it to its original factory settings. Erase iPhone also removes your credit and debit cards used for Apple Pay (iPhone 6 and iPhone 6 Plus). See Apple Pay on page 130.

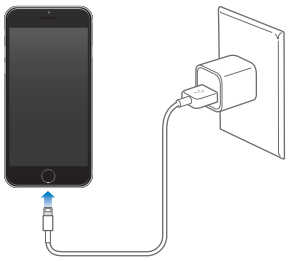
Note: Before selling or giving away your iPhone, you should erase it completely to remove all of your personal data and turn off Find My iPhone to ensure the next owner can activate and use the device normally. Go to Settings > General > Reset > Erase All Content and Settings. See Sell or give away iPhone on page 189.

Charge and monitor the battery

iPhone has an internal, lithium-ion rechargeable battery. For more information about the battery—including tips for maximizing battery life—see www.apple.com/batteries/.

WARNING: For important safety information about the battery and charging iPhone, see Important safety information on page 181.

Charge the battery. Connect iPhone to a power outlet using the included cable and USB power adapter.



Note: Connecting iPhone to a power outlet can start an iCloud backup or wireless iTunes syncing. See Back up iPhone on page 186 and Sync with iTunes on page 21.

You can also charge the battery by connecting iPhone to your computer, which also allows you to sync iPhone with iTunes. See Sync with iTunes on page 21. Unless your keyboard has a high-power USB 2.0 or 3.0 port, you must connect iPhone to a USB 2.0 or 3.0 port on your computer.

Important: The iPhone battery may drain instead of charge if iPhone is connected to a computer that's turned off or is in sleep or standby mode.

See proportion of battery used by each app. Go to Settings > General > Usage, then tap Battery Usage.

The battery icon in the upper-right corner shows the battery level or charging status. To display the percentage of battery charge remaining, go to Settings > General > Usage. When syncing or using iPhone, it may take longer to charge the battery.

Important: If iPhone is very low on power, it may display an image of a nearly depleted battery, indicating that iPhone needs to charge for up to ten minutes before you can use it. If iPhone is extremely low on power, the display may be blank for up to two minutes before the low-battery image appears.

Rechargeable batteries have a limited number of charge cycles and may eventually need to be replaced. The iPhone battery isn't user replaceable; it should be replaced only by Apple or an authorized service provider. See www.apple.com/batteries/service-and-recycling/.

Travel with iPhone

If you travel outside your carrier's network area, you can avoid roaming charges by turning off voice and data roaming services in Settings > Cellular. See Cellular settings on page 188.

Some airlines let you keep your iPhone turned on if you switch to Airplane Mode. You can't make calls or use Bluetooth, but you can listen to music, play games, watch videos, or use other apps that don't require network or phone connections. If the airline allows it, you can turn Wi-Fi or Bluetooth back on to enable those services, even while in Airplane Mode.

Turn on Airplane Mode. Swipe up from the bottom edge of the screen to open Control Center, then tap ✈. You can also turn Airplane Mode on or off in Settings. When Airplane Mode is on, ✈ appears in the status bar at the top of the screen.

You can also turn Wi-Fi and Bluetooth on or off in Control Center.

Siri

4

Make requests

Siri lets you speak to iPhone to send messages, schedule meetings, place phone calls, and much more. Siri understands natural speech, so you don't have to learn special commands or keywords. Ask Siri anything, from "set the timer for 3 minutes" to "what movies are showing tonight?" Open apps, and turn features like Airplane Mode, Bluetooth, Do Not Disturb, and VoiceOver on or off. Siri is great for keeping you updated with the latest sports info, helping you decide on a restaurant, and searching the iTunes Store or App Store for purchases.

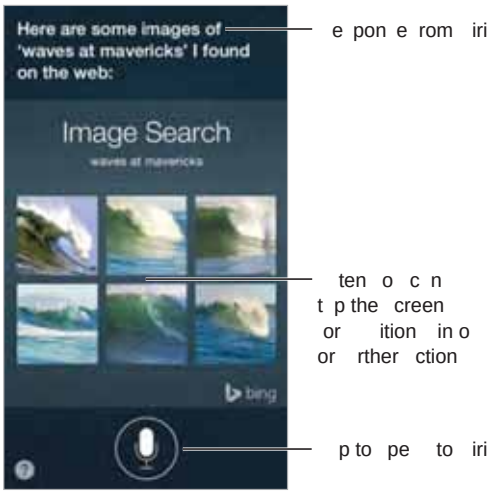
Note: To use Siri, iPhone must be connected to the Internet. See Connect to the Internet on page 17. Cellular charges may apply.

Summon Siri. Press and hold the Home button until Siri beeps, then make your request.

Control when Siri listens. Instead of letting Siri notice when you stop talking, you can continue to hold down the Home button while you speak, and release it when you finish.

Hey Siri. With iPhone connected to a power source (or if you've already started a conversation with Siri), you can use Siri without even pressing the Home button. Just say "Hey Siri," then make your request. To turn Hey Siri on or off, go to Settings > General > Siri > Allow "Hey Siri".

If you're using a headset, you can use the center or call button in place of the Home button.



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For hints, ask Siri "what can you do," or tap ?.

Depending on your request, the onscreen response from Siri often includes information or images that you can tap for additional detail, or to perform some other action like searching the web or opening a related app.

Change the voice gender for Siri. Go to Settings > General > Siri (may not be available in all areas).

Adjust the volume for Siri. Use the volume buttons while you're interacting with Siri.

Siri and apps

Siri works with many of the apps on iPhone, including Phone, Messages, Maps, Clock, Calendar, and more. For example, you can say things like:

- "Call Mom at home"
- "Do I have any new texts from Rick?"
- "I'm running low on gas"
- "Set an alarm for 8 a.m."
- "Cancel all my meetings on Friday"

More examples of how you can use Siri with apps appear throughout this guide.

Tell Siri about yourself

If you tell Siri about yourself—including things like your home and work addresses, and your relationships—you can get personalized service like, "remind me to call my wife when I get home."

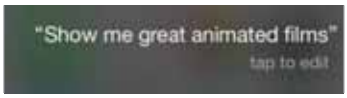
Tell Siri who you are. Fill out your info card in Contacts, then go to Settings > General > Siri > My Info and tap your name.

To let Siri know about a relationship, say something like "Emily Parker is my wife."

Note: Siri uses Location Services when your requests require knowing your location. See Privacy on page 43.

Make corrections

If Siri doesn't get something right, you can tap to edit your request.



Or tap 🎙 again, then clarify your request verbally.

Want to cancel that last command? Say "cancel," tap the Siri icon, or press the Home button.

Siri Eyes Free

With Siri Eyes Free, you can use iPhone features in your car without looking at or touching iPhone—you can control it completely by speaking. To talk with Siri, press and hold the voice command button on your steering wheel until you hear the Siri tone. You can ask Siri to call people, select and play music, hear and compose text messages, get directions, read your notifications, find calendar information, add reminders, and more. Siri Eyes Free is available on select automobiles.

> *WARNING:* For important information about avoiding distractions that could lead to dangerous situations, see Important safety information on page 181.

Use Siri Eyes Free. Connect iPhone to your car using Bluetooth. Refer to the user guide that came with your car.

For more information about using Siri in your car, see About CarPlay on page 178.

Siri settings

To set options for Siri, go to Settings > General > Siri. Options include:

- Turning Siri on or off
- Turning Allow "Hey Siri" on or off
- Language
- Voice gender (may not be available in all areas)
- Voice feedback
- My Info card

Prevent access to Siri when iPhone is locked. Go to Settings > Touch ID & Passcode (iPhone models with Touch ID) or Settings > Passcode (other models). You can also disable Siri by turning on restrictions. See Restrictions on page 43.

Phone

5

Phone calls

Make a call

Making a call on iPhone is as simple as choosing a number in your contacts, or tapping one of your favorites or recent calls.

WARNING: For important information about avoiding distractions that could lead to dangerous situations, see Important safety information on page 181.

Add favorites. With Favorites, you can make a call with a single tap. To add someone to your Favorites list, tap ⊕. You can also add names to Favorites from Contacts. In Contacts, tap Add to Favorites at the bottom of a card, then tap the number to add.

Delete a name or rearrange your Favorites list. Tap Edit.

Return a recent call. Tap Recents, then tap the call. Tap ⓘ to get more info about the call, or the caller. A red badge indicates the number of missed calls.

You can also reach recent and favorite people you've been in contact with from the multitasking screen—just double-click the Home button.

Dial manually. Tap Keypad, enter the number, then tap Call.

- *Paste a number to the keypad:* Tap the screen above the keyboard, then tap Paste.
- *Enter a soft (2-second) pause:* Touch the "*" key until a comma appears.

- *Enter a hard pause (to pause dialing until you tap the Dial button):* Touch the "#" key until a semicolon appears.
- *Redial the last number:* Tap Keypad, tap Call to display the number, then tap Call again.

Use Siri or Voice Control. Press and hold the Home button, say "call" or "dial," then say the name or number. You can add "at home," "work," or "mobile." See Chapter 4, Siri, on page 48 and Voice Control on page 33.

You can say things like:

- "Call Emily's mobile"
- "Call the fire department"
- "Redial that last number"

When voice dialing a number, speak each digit separately—for example, "four one five, five five five…." For the 800 area code in the U.S., you can say "eight hundred."

Call over Wi-Fi. (Not available in all areas. iPhone 5c, iPhone 5s, or later.) To route calls over Wi-Fi, go to Settings > Phone, then turn on Wi-Fi Calling. On iPhone 6 and iPhone 6 Plus, if the Wi-Fi connection is lost, calls switch automatically to your carrier's cellular network using VoLTE (Voice over LTE), if available. (VoLTE calls also switch to Wi-Fi when a Wi-Fi connection becomes available.) On earlier models, a call is dropped if you lose the Wi-Fi connection. Contact your carrier for feature availability.

When someone calls

Tap Accept to answer an incoming call. Or if iPhone is locked, drag the slider. You can also press the center button on your headset.

Silence a call. Press the Sleep/Wake button or either volume button. You can still answer the call after silencing it, until it goes to voicemail.

Decline a call and send it directly to voicemail. Do one of the following:

- Press the Sleep/Wake button twice quickly.
- Press and hold the center button on your headset for about two seconds. Two low beeps confirm that the call was declined.
- Tap Decline (if iPhone is awake when the call comes in).

Note: In some areas, declined calls are disconnected without being sent to voicemail.

Respond with a text message instead of answering. Tap Message, then choose a reply or tap Custom. To create your own default replies, go to Settings > Phone > Respond with Text, then tap any of the default messages and replace it with your own text.

Remind yourself to return the call. Tap Remind Me, then indicate when you want to be reminded.

Make and receive calls on your iPad, iPod touch, or Mac

Continuity (iOS 8 or later) lets you make and receive calls on your iPad or iPod touch, or on your Mac (with OS X Yosemite). Calls are relayed through your iPhone, which must be turned on and connected to a cellular network. Cellular charges may apply. See About Continuity features on page 26.

Your other iOS device or Mac must be connected to the same Wi-Fi network and signed in to FaceTime and iCloud using the same Apple ID as your iPhone.

Enable or disable iPhone Cellular Calls through iPhone. On your iPhone, go to Settings > FaceTime, then turn iPhone Cellular Calls on or off.

Note: If available on your iPhone, Allow Wi-Fi Calls must be off. Go to Settings > Phone > Wi-Fi Calls.

- *Turn iPhone Cellular Calls on or off for another iOS device:* On the device, go to Settings > FaceTime.
- *Turn iPhone Cellular Calls on or off for your Mac:* On your Mac, open FaceTime, then choose FaceTime > Preferences > Settings.

Receive a call on your iPad, iPod touch, or Mac. Swipe or click the notification to answer, ignore, or respond with a quick message.

Make a call from your iPad, iPod touch, or Mac. Tap or click a phone number in Contacts, Calendar, FaceTime, Messages, Spotlight, or Safari, or from a recent contact in the multitasking screen.

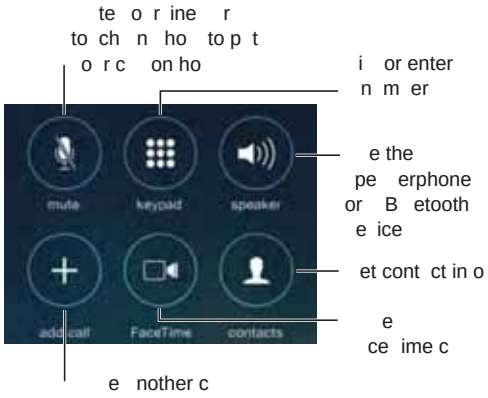
Keep it quiet

Want to go offline for a while? Swipe up from the bottom edge of the screen to open Control Center, then turn on Do Not Disturb or Airplane Mode. See Do Not Disturb on page 37 and Travel with iPhone on page 47.

Block unwanted callers. On a contact card, tap Block this Caller (you can see a caller's contact card from Favorites or Recents by tapping ⓘ). You can also block callers in Settings > Phone > Blocked. You will not receive voice calls, FaceTime calls, or text messages from blocked callers. For more information about blocking calls, see support.apple.com/kb/HT5845.

While on a call

When you're on a call, the screen shows several call options.



End a call. Tap or press the Sleep/Wake button.

Use another app while on a call. Press the Home button, then open the app. To return to the call, tap the green bar at the top of the screen.

Respond to a second call. You can:

- *Ignore the call and send it to voicemail:* Tap Ignore.
- *Put the first call on hold and answer the new one:* Tap Hold + Accept.
- *End the first call and answer the new one:* When using a GSM network, tap End + Accept. With a CDMA network, tap End and when the second call rings back, tap Accept, or drag the slider if iPhone is locked.

With a call on hold, tap Swap to switch between calls or tap Merge Calls to talk with both parties at once. See Conference calls, below.

Note: With CDMA, you can't switch between calls if the second call was outgoing, but you can merge the calls. You can't merge calls if the second call was incoming. If you end the second call or the merged call, both calls are terminated.

Conference calls

With GSM, you can set up a conference call with up to five people (depending on your carrier).

Note: Conference calls may not be available if your call is using VoLTE (Voice over LTE).

Create a conference call. While on a call, tap Add Call, make another call, then tap Merge Calls. Repeat to add more people to the conference.

- *Drop one person:* Tap ⓘ next to a person, then tap End.
- *Talk privately with one person:* Tap ⓘ, then tap Private next to the person. Tap Merge Calls to resume the conference.
- *Add an incoming caller:* Tap Hold Call + Answer, then tap Merge Calls.

Emergency calls

Make an emergency call when iPhone is locked. On the Enter Passcode screen, tap Emergency Call (to dial 911 in the U.S., for example).

Important: You can use iPhone to make an emergency call in many locations, provided that cellular service is available, but you should not rely on it for emergencies. Some cellular networks may not accept an emergency call from iPhone if iPhone is not activated, if iPhone is not compatible with or configured to operate on a particular cellular network, or (when applicable) if iPhone does not have a SIM card or if the SIM card is PIN-locked.

In the U.S., location information (if available) is provided to emergency service providers when you dial 911. Please review your carrier's emergency calling information to understand the limits of emergency calling over Wi-Fi.

With CDMA, when an emergency call ends, iPhone enters *emergency call mode* for a few minutes to allow a call back from emergency services. During this time, data transmission and text messages are blocked.

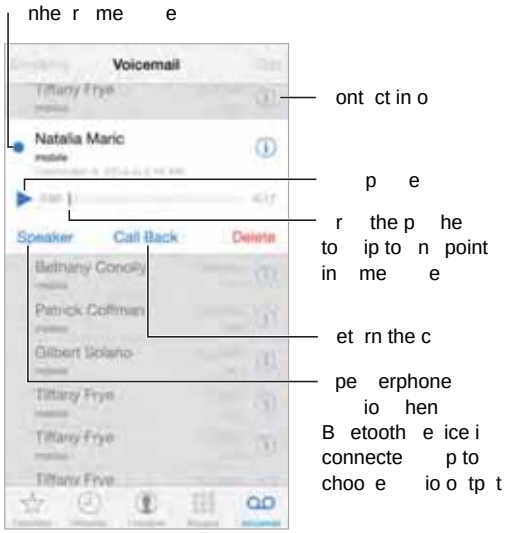
Exit emergency call mode (CDMA). Do one of the following:

- Tap the Back button.
- Press the Sleep/Wake button or the Home button.
- Use the keypad to dial a non-emergency number.

Visual voicemail

Visual voicemail lets you see a list of your messages and choose which one to listen to or delete, without having to wade through all of them. A badge on the Voicemail icon tells you how many unheard messages you have. The first time you tap Voicemail, you're prompted to create a voicemail password and record your voicemail greeting.

Listen to a voicemail message. Tap Voicemail, then tap a message. To listen again, select the message and tap ▶. If visual voicemail isn't available with your service, tap Voicemail and follow the voice prompts.



Messages are saved until you delete them or your carrier erases them.

Use Siri. Say something like:

- "Do I have any new voicemail?"
- "Play the voicemail from Emily"

Delete a message. Swipe or tap the message, then tap Delete.

Note: In some areas, deleted messages may be permanently erased by your carrier. Your voice messages may also be deleted if you change your SIM card.

Manage deleted messages. Tap Deleted Messages (at the end of the messages list), then:

- *Listen to a deleted message:* Tap the message.
- *Undelete a message:* Tap the message and tap Undelete.
- *Delete messages permanently:* Tap Clear All.

Update your greeting. Tap Voicemail, tap Greeting, tap Custom, then tap Record. Or, to use your carrier's generic greeting, tap Default.

Set an alert sound for new voicemail. Go to Settings > Sounds.

Change the password. Go to Settings > Phone > Change Voicemail Password.

Contacts

When viewing a contact's card, a quick tap lets you make a phone call, create an email message, find the contact's location, and more. See Chapter 32, Contacts, on page 145.

Call forwarding, call waiting, and caller ID

Set up call forwarding, call waiting, or caller ID. (GSM) Go to Settings > Phone.

- *Call Forwarding:* The Call Forwarding icon appears in the status bar when call forwarding is on. You must be in range of the cellular network when you set iPhone to forward calls, or calls won't be forwarded.
- *Call Waiting:* If you're on a call and call waiting is turned off, incoming calls go directly to voicemail.
- *Caller ID:* For FaceTime calls, your phone number is displayed even if caller ID is turned off.

For CDMA accounts, contact your carrier for information about enabling and using these features. See support.apple.com/kb/HT4515.

Ringtones and vibrations

iPhone comes with ringtones that sound for incoming calls, Clock alarms, and the Clock timer. You can also purchase ringtones from songs in the iTunes Store. See Chapter 22, iTunes Store, on page 117.

Set the default ringtone. Go to Settings > Sound > Ringtone.

Assign different ringtones for the special people in your life. Go to Contacts, choose a contact, tap edit, then tap Ringtone.

Turn the ringer on or off. Flip the switch on the side of iPhone.

Important: Clock alarms still sound when the Ring/Silent switch is set to silent.

Turn vibrate on or off. Go to Settings > Sounds. See Sounds and silence on page 36.

International calls

For information about making international calls from your home area (including rates and other charges that may apply), contact your carrier.

When traveling abroad, you may be able to use iPhone to make calls, send and receive text messages, get visual voicemail, and use apps that access the Internet, depending on available networks.

Enable international roaming. To turn on Data Roaming and Voice Roaming (CDMA), go to Settings > Cellular. Contact your carrier for information about availability and fees.

Important: Voice, text message, and data roaming charges may apply. To avoid charges while roaming, turn off Data Roaming and Voice Roaming (CDMA).

You may be able to roam on GSM networks, if you have a CDMA account, and your iPhone has a SIM card installed. While roaming on a GSM network, iPhone has access to GSM network features. Charges may apply. Contact your carrier for more information.

Set network options. Go to Settings > Cellular to:

- Turn data roaming on or off
- Turn cellular data on or off
- Turn voice roaming on or off (CDMA)
- Use GSM networks abroad (CDMA)

See Usage information on page 186.

Turn off cellular services. Go to Settings, turn on Airplane Mode, then tap Wi-Fi and turn it on. Incoming phone calls are sent to voicemail. To resume cellular service, turn Airplane Mode off.

Make calls to your contacts and favorites while traveling abroad. (GSM) Go to Settings > Phone, then turn on Dial Assist. Dial Assist automatically adds the prefix or country code for calls to the U.S.

Select a carrier network. Go to Settings > Carrier. This setting appears on GSM networks when you're outside your carrier's network, and other local carrier data networks are available to use for your phone calls, visual voicemail, and cellular network Internet connections. You can make calls only on carriers that have a roaming agreement with your carrier. Additional fees may apply. Roaming charges may be billed to you by the other carrier, through your carrier.

Get voicemail when visual voicemail isn't available. Dial your own number (with CDMA, add # after your number), or touch and hold "1" on the numeric keypad.

Phone settings

Go to Settings > Phone to:

- See the phone number for your iPhone
- Change the default text message replies for incoming calls
- Turn call forwarding, call waiting, and caller ID on or off (GSM)
- Turn TTY on or off
- Change your voicemail password (GSM)
- Require a PIN to unlock your SIM when you turn iPhone on (required by some carriers)

Go to Settings > Sounds to:

- Set ringtones and volume
- Set vibration options
- Set the sound for new voicemail

Once you select a network, iPhone uses only that network. If the network is unavailable, "No service" appears on iPhone.

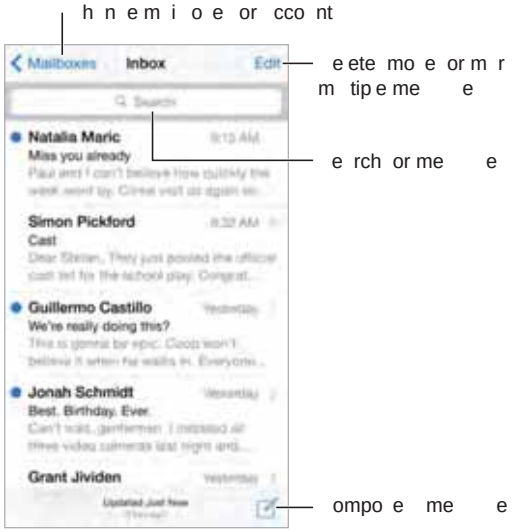
Mail

6

Write messages

Mail lets you access all of your email accounts, on the go.

> *WARNING:* For important information about avoiding distractions that could lead to dangerous situations, see Important safety information on page 181.



Insert a photo or video. Double-tap, then tap Insert Photo or Video. Also see Edit text on page 31.

Quote some text when you reply. Tap the insertion point, then select the text you want to include. Tap ↩, then tap Reply. You can turn off the indentation of the quoted text in Settings > Mail, Contacts, Calendars > Increase Quote Level.

Send a message from a different account. Tap the From field to choose an account.

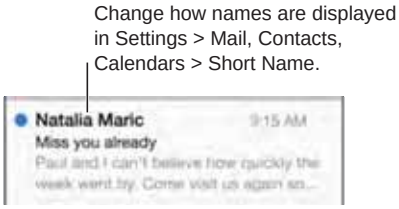
Change a recipient from Cc to Bcc. After you enter recipients, you can drag them from one field to another or change their order.

Mark addresses outside certain domains. When you're addressing a message to a recipient that's not in your organization's domain, Mail can color the recipient's name red to alert you. Go to Settings > Mail, Contacts, Calendars > Mark Addresses, then define the domains that you don't want marked. You can enter multiple domains separated by commas, such as "apple.com, example.org."

Use Siri. Say something like:

- "New email to Jonah Schmidt"
- "Email Simon and say I got the forms, thanks"

Get a sneak peek

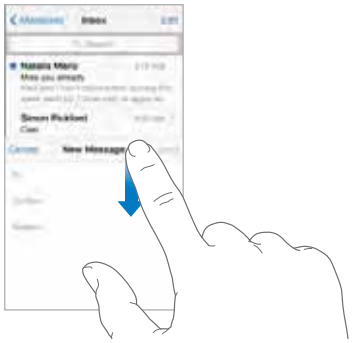


See a longer preview. Go to Settings > Mail, Contacts, Calendars > Preview. You can show up to five lines.

Is this message for me? Go to Settings > Mail, Contacts, Calendars, then turn on Show To/Cc Label. If the label says Cc instead of To, you were just copied. You can also use the To/Cc mailbox, which gathers all mail addressed to you. To show or hide it, swipe to the right (or tap Mailboxes), then tap Edit.

Finish a message later

Look at another message while you're writing one. Swipe down on the title bar of a message you're writing. When you're ready to return to your message, tap its title at the bottom of the screen. If you have more than one message waiting to be finished, tap the bottom of the screen to see them all.



Save a draft for later. If you're writing a message and want to finish it later, tap Cancel, then tap Save Draft. To get it back, touch and hold Compose.

With OS X Yosemite, you can also hand off unfinished messages with your Mac. See About Continuity features on page 26.

See important messages

Get notified of replies to a message or thread. Tap ⚐, then tap Notify Me. While you're writing a message, you can also tap 🔔 in the Subject field. To change how notifications appear, go to Settings > Notifications > Mail > Thread Notifications.

Gather important messages. Add important people to your VIP list, so all their messages appear in the VIP mailbox. Tap the sender's name in a message, then tap Add to VIP. To change how notifications appear, go to Settings > Notifications > Mail > VIP.

Flag a message so you can find it later. Tap ⚐ while reading the message. To change the appearance of the flagged message indicator, go to Settings > Mail, Contacts, Calendars > Flag Style. To see the Flagged mailbox, tap Edit while viewing the Mailboxes list, then tap Flagged.

Search for a message. Scroll to or tap the top of the message list to reveal the search field. Searching looks at the address fields, the subject, and the message body. To search multiple accounts at once, search from a smart mailbox, such as All Sent.

Search by timeframe. Scroll to or tap the top of the messages list to reveal the search field, then type something like "February meeting" to find all messages from February with the word "meeting."

Search by message state. To find all flagged, unread messages from people in your VIP list, type "flag unread vip." You can also search for other message attributes, such as "attachment."

Junk, be gone! Tap ⚐ while you're reading a message, then tap Move to Junk to file it in the Junk folder. If you accidentally move a message, shake iPhone immediately to undo.

Use Siri. Say, for example, "Any new mail from Natalia today?"

Make a favorite mailbox. Favorites appear at the top of the Mailboxes list. To add a favorite, tap Edit while viewing the Mailboxes list. Tap Add Mailbox, then select the mailboxes to add. You'll also get push notifications for your favorite mailboxes.

Show draft messages from all of your accounts. While viewing the Mailboxes list, tap Edit, tap Add Mailbox, then turn on the All Drafts mailbox.

Attachments

Save a photo or video to Photos. Touch and hold the photo or video until a menu appears, then tap Save Image.

Open an attachment with another app. Touch and hold the attachment until a menu appears, then tap the app you want to use to open the attachment. Some attachments automatically show a banner with buttons you can use to open other apps.

See messages with attachments. The Attachments mailbox shows messages with attachments from all accounts. To add it, tap Edit while viewing the Mailboxes list.

Work with multiple messages

Delete, move, or mark multiple messages. While viewing a list of messages, tap Edit. Select some messages, then choose an action. If you make a mistake, shake iPhone immediately to undo.

Manage a message with a swipe. While viewing a list of messages, swipe a message to the left to reveal a menu of actions. Swipe all the way to the left to select the first action. You can also swipe a message to the right to reveal another action. Choose the actions you want to appear in the menus at Settings > Mail, Contacts, Calendars > Swipe Options.

Organize your mail with mailboxes. Tap Edit in the mailboxes list to create a new one, or rename or delete one. (Some built-in mailboxes can't be changed.) There are several smart mailboxes, such as Unread, that show messages from all your accounts. Tap the ones you want to use.

Recover a deleted message. Go to the account's Trash mailbox, open the message, then tap and move the message. Or, if you just deleted it, shake iPhone to undo. To see deleted messages across all your accounts, add the Trash mailbox. To add it, tap Edit in the mailboxes list, then select it in the list.

Archive instead of delete. Instead of deleting messages, you can archive them so they're still around if you need them. Select Archive Mailbox in Settings > Mail, Contacts, Calendars > *account name* > Account > Advanced. To delete a message instead of archiving it, touch and hold , then tap Delete.

Stash your trash. You can set how long deleted messages stay in the Trash mailbox. Go to Settings > Mail, Contacts, Calendars > *account name* > Account > Advanced.

See and save addresses

See who received a message. While viewing the message, tap More in the To field.

Add someone to Contacts or make them a VIP. Tap the person's name or email address, then tap Add to VIP. You can also add their address to a new or existing contact.

Print messages

Print a message. Tap , then tap Print.

Print an attachment or picture. Tap to view it, tap , then choose Print.

See AirPrint on page 41.

Mail settings

Go to Settings > Mail, Contacts, Calendars, where you can:

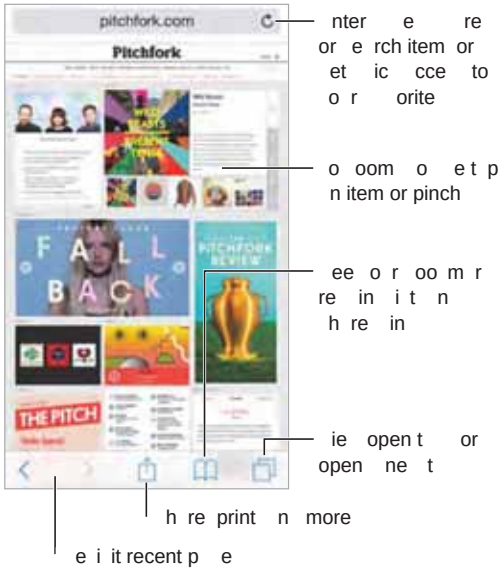
- Create a different mail signature for each account
- Add mail accounts
- Set Out of Office replies for Exchange mail accounts
- Bcc yourself on every message you send
- Turn on Organize by Thread to group related messages together
- Turn off confirmation for deleting a message
- Turn off Push delivery of new messages, to save on battery power
- Temporarily turn off an account

Safari

7

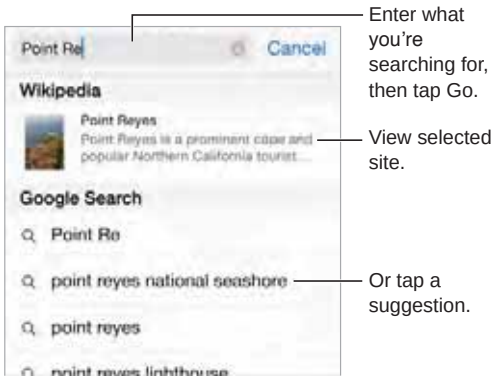
Safari at a glance

Use Safari on iPhone to browse the web, use Reading List to collect webpages to read later, and add page icons to the Home screen for quick access. Use iCloud to see pages you have open on other devices, and to keep your bookmarks, history, and reading list up to date on your other devices.



Search the web

Search the web. Enter a URL or search term in the search field at the top of the page, then tap a search suggestion, or tap Go on the keyboard to search for exactly what you typed. If you don't want to see suggested search terms, go to Settings > Safari, then (under Search) turn off Search Engine Suggestions.



Quickly search a site you've visited before. Enter the name of the site, followed by your search term. For example, enter "wiki einstein" to search Wikipedia for "einstein." Go to Settings > Safari > Quick Website Search to turn this feature on or off.

Have your favorites top the list. Select them in Settings > Safari > Favorites.

Search the page. Scroll to the bottom of the suggested results list, then tap the entry under On This Page. Tap > to see the next occurrence on the page.

Choose your search tool. Go to Settings > Safari > Search Engine.

Browse the web

Look before you leap. To see the URL of a link before you go there, touch and hold the link.

Open a link in a new tab. Touch and hold the link, then tap Open in New Tab. If you'd rather open new pages in the background, go to Settings > Safari > Open Links.

Browse open tabs. Tap ⧉. To close a tab, tap ✕ in the upper-left corner, or swipe the tab to the left.

View tabs open on your other devices. If you turn on Safari in Settings > iCloud, you can view tabs that you have open on your other devices. Tap ⧉, then scroll to the list at the bottom of the page.

Note: If you close the tab on iPhone, the tab also closes on your other devices.

Scroll to the bottom to see tabs open on other devices.

View recently closed tabs. Touch and hold ⊕.

Get back to the top. Tap the top edge of the screen to quickly return to the top of a long page.

See more. Turn iPhone to landscape orientation.

See the latest. Tap ↻ next to the address in the search field to update the page.

See a tab's history. Touch and hold < or >.

View the desktop version of a site. If you want to see the full desktop version of a site instead of the mobile version, tap the search field, pull down the display of your favorites, then tap Request Desktop Site.

Keep bookmarks

Bookmark the current page. Tap ⬆ (or touch and hold 📖), then tap Add Bookmark.

View your bookmarks. Tap 📖, then tap 📖.

Get organized. To create a folder for bookmarks, tap 📖, then tap Edit.

Add a webpage to your favorites. Open the page, tap the search field, drag down, then tap Add to Favorites.

Quickly see your favorite and frequently visited sites. Tap the search field to see your favorites. Scroll down to see frequently visited sites.

Edit your favorites. Tap the search field, then touch and hold a page or folder until the icon gets larger. Then you can delete the item, or tap edit to rename or move it.

Choose which favorites appear when you tap the search field. Go to Settings > Safari > Favorites.

Bookmarks bar on your Mac? Go to Settings > iCloud, then turn on Safari if you want items from the bookmarks bar in Safari on your Mac to appear in Favorites on iPhone.

Save an icon for the current page on your Home screen. Tap ⬆, then tap Add to Home Screen. The icon appears only on the device where you create it.

Save a reading list for later

Save interesting items in your reading list so you can revisit them later. You can read pages in your reading list even when you're not connected to the Internet.

Add the current page to your reading list. Tap ⬆, then tap Add to Reading List.

Add a linked page without opening it. Touch and hold the link, then tap Add to Reading List.

View your reading list. Tap 📖, then tap 👓.

Delete something from your reading list. Swipe left on the item in your reading list.

Don't want to use cellular data to download reading list items? Go to Settings > Safari, then turn off Use Cellular Data.

Shared links and subscriptions

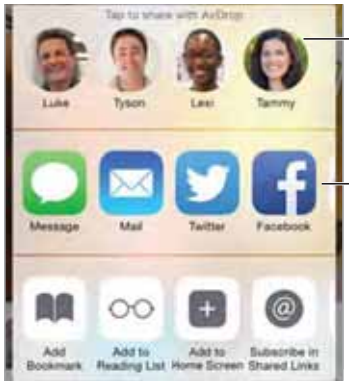
You can view links shared from social media, such as Twitter, or feeds from your subscriptions.

View shared links and subscriptions. Tap 📖, then tap @.

Subscribe to a feed. Go to a site that provides a subscription feed, tap ⬆, tap Add to Shared Links, then confirm by tapping Add to Shared Links.

Delete a subscription. Tap 📖, tap @, tap Subscriptions below the list of your shared links, then tap ⊖ next to the subscription you want to delete.

Spread the news. Tap ⬆.



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Fill in forms

Whether you're logging in to a website, signing up for a service, or making a purchase, you can fill in a web form using the onscreen keyboard or have Safari fill it in for you using AutoFill.

Tired of always having to log in? When you're asked if you want to save the password for the site, tap Yes. The next time you visit, your user name and password will be filled in for you.

Fill in a form. Tap any field to bring up the onscreen keyboard. Tap < or > above the keyboard to move from field to field.

Fill it in automatically. Go to Settings > Safari > Passwords & Autofill, then turn on Use Contact Info. Then, tap AutoFill above the onscreen keyboard when you're filling in the form. Not all websites support AutoFill.

Add a credit card for purchases. Go to Settings > Safari > Passwords & Autofill > Saved Credit Cards > Add Credit Card. To enter the information without typing it, tap Use Camera, then hold iPhone above the card so that the image of the card fits in the frame. You can also add a credit card by accepting when Safari offers to save it when you make an online purchase. See iCloud Keychain on page 45.

Use your credit card information. Look for the AutoFill Credit Card button above the onscreen keyboard whenever you're in a credit card field. Your card's security code isn't stored, so you still enter that yourself. If you're not using a passcode for iPhone, you might want to start; see Use a passcode with data protection on page 44.

Submit a form. Tap Go, Search, or the link on the webpage.

Avoid clutter with Reader

Use Safari Reader to focus on a page's primary content.

Tap to view the page in Reader.

Focus on content. Tap ≡ at the left end of the address field. If you don't see the icon, Reader isn't available for the page you're looking at.

Share just the good stuff. To share just the article text and a link to it, tap ⬆ while viewing the page in Reader.

Return to the full page. Tap the reader icon in the address field again.

Privacy and security

You can adjust Safari settings to keep your browsing activities to yourself and protect yourself from malicious websites.

Want to keep a low profile? Go to Settings > Safari, then turn on Do Not Track. Safari will ask websites you visit not to track your browsing, but beware—a website can choose not to honor the request.

Control cookies. Go to Settings > Safari > Block Cookies. To remove cookies already on iPhone, go to Settings > Safari > Clear History and Website Data.

Let Safari create secure passwords and store them for you. Tap the password field when creating a new account, and Safari will offer to create a password for you.

Erase your browsing history and data from iPhone. Go to Settings > Safari > Clear History and Website Data.

Visit sites without making history. Tap ⧉, then tap Private. Sites you visit won't appear in iCloud Tabs or be added to History on your iPhone. To put away your private sites, tap ⧉, then tap Private again. You can close the pages, or keep them for viewing the next time you use Private Browsing Mode.

Watch for suspicious websites. Go to Settings > Safari, then turn on Fraudulent Website Warning.

Safari settings

Go to Settings > Safari, where you can:

- Choose your search engine and configure search results
- Provide AutoFill information
- Choose which favorites are displayed when you search
- Have links open in a new page or in the background
- Block pop-ups
- Tighten privacy and security
- Clear your history and website data
- Choose whether to use cellular data for Reading List items
- Configure advanced settings and more

Music 8

Get music

Get music and other audio content on to iPhone in the following ways:

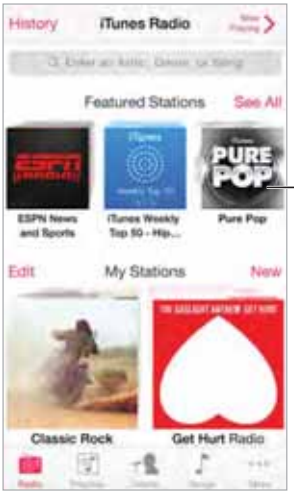
- *Purchase music from the iTunes Store:* Go to iTunes Store. See Chapter 22, iTunes Store, on page 117.
- *iCloud:* Get access to all your iTunes songs, no matter which device you used to purchase them. Use iTunes Match to include CDs and other music you import. See iCloud and iTunes Match on page 74.
- *Family Sharing:* To download songs purchased by other members of your family, go to iTunes Store, tap More, tap Purchased, then choose a family member. See Family Sharing on page 38.
- *Sync content with iTunes on your computer:* See Sync with iTunes on page 21.

WARNING: For important information about avoiding hearing loss, see Important safety information on page 181.

iTunes Radio

Featured stations provide a great way to explore and enjoy new music in a variety of genres. You can also create your own custom stations, based on your pick of artist, song, or genre. See iCloud and iTunes Match on page 74.

Note: iTunes Radio may not be available in all areas. For more information about iTunes Radio, go to support.apple.com/kb/HT5848.



Tap to play a station.

When you pick a station and play a song, the Now Playing screen shows the album art and the playback controls. Tap ⓘ to find out more, create a new station, fine-tune the station, or share it.

Create your own station based on an artist, genre, or song. Tap New on the iTunes Radio screen. Choose a genre, or do a search for your favorite artist, song, or genre. You can also create a station from the Now Playing screen by tapping the Create button.

Edit your stations. Tap Edit. You can include or exclude other artists, songs, or genres, or delete a station.

Influence upcoming song selections. On the Now Playing screen, tap ★, then tap Play More Like This or Never Play This Song. You can also add the song to your iTunes Wish List.

Skip to the next song. On the Now Playing screen, tap ▸▸. You can skip a limited number of songs per hour.

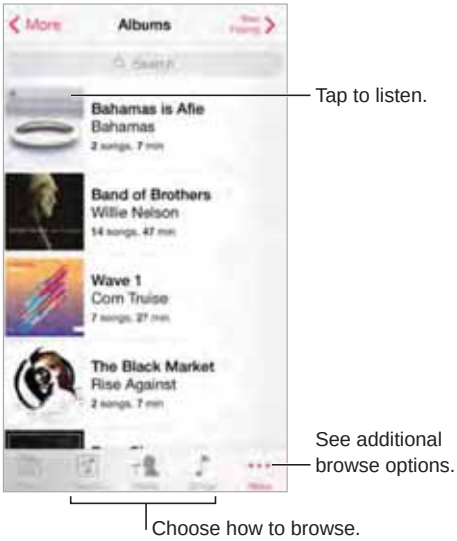
See the songs you've played, or view your wishlist. Tap History, then tap Played or Wishlist. You can purchase songs for your library. Tap a song to preview it.

Purchase songs for your personal library. On the Now Playing screen, tap the price button.

Share a station you created. On the Now Playing screen, tap ⓘ, then tap Share Station.

Browse and play

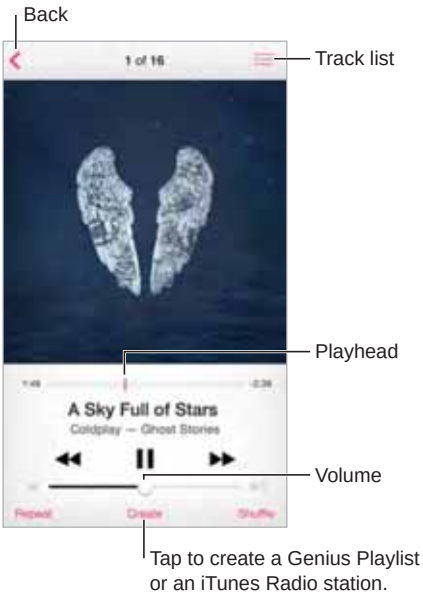
Browse your music by playlist, artist, or other category. For other browse options, tap More. Tap any song to play it.



You can listen to audio from the built-in speaker, from headphones attached to the headset jack, or from wireless Bluetooth stereo headphones paired with iPhone. If headphones are attached or paired, no sound comes from the speaker.

Customize tabs. To rearrange the buttons at the bottom of the screen, tap More, tap Edit, then drag a button onto the one you want to replace.

The Now Playing screen provides playback controls and shows you what's playing.



Skip to any point in a song. Drag the playhead. Slow down the scrub rate by sliding your finger down the screen.

Shuffle. On the Now Playing screen, tap Shuffle to play your tunes in random order.

See all tracks from the album containing the current song. Tap ☰. To play a track, tap it.

Search music. While browsing, drag down to reveal the search field at the top of the screen, then enter your search text. You can also search audio content from the Home screen. See Spotlight Search on page 34.

Rate a song for smart playlists in iTunes. Tap the screen to reveal the rating dots, then tap a dot to assign a rating.

Display lyrics. If you added lyrics to the song, tap the album cover to see them. To add lyrics, use the song's Info window in iTunes on your computer, then sync the song to iPhone.

Get audio controls from the Lock screen or when using another app. Swipe up from the bottom edge of the screen to open Control Center. See Control Center on page 35.

Play music on AirPlay speakers or Apple TV. Swipe up from the bottom edge of the screen to open Control Center, then tap ⎚. See AirPlay on page 41.

Siri and Voice Control

You can use Siri or Voice Control to control music playback. See Chapter 4, Siri, on page 48 and Voice Control on page 33.

Use Siri or Voice Control. Press and hold the Home button.

- *Play or pause music:* Say "play," "play music," or "play iTunes Radio." To pause, say "pause," "pause music," or "stop." You can also say "next song" or "previous song."
- *Play an album, artist, or playlist:* Say "play," then say "album," "artist," or "playlist" and the name.
- *Shuffle the current playlist:* Say "shuffle."
- *Find out more about the current song:* Say "what's playing," "who sings this song," or "who is this song by."
- *Use Genius to play similar songs:* Say "Genius" or "play more songs like this."

Siri can also help you find music in the iTunes Store. See "Find it with Siri" in Browse or search on page 117.

iCloud and iTunes Match

With iCloud, you can access all of the music you purchase in the iTunes Store on all of your devices. The icon shows the songs you have in iCloud. Just tap a song to play it.

Automatically download music purchased on another device. Go to Settings > iTunes & App Store, sign in using your Apple ID, then turn on Music under Automatic Downloads.

Download music if you're going somewhere you won't have Wi-Fi. Tap next to the songs you'll want to play. Or download entire albums and playlists. You can also download previous purchases in the iTunes Store—tap More, tap Purchased, then tap Music.

Remove a song that's been downloaded. Swipe left, then tap Delete. The song is removed from iPhone, but remains available from iCloud.

View only music that's downloaded. Go to Settings > iTunes & App Store. Under Show All, turn off Music.

With an iTunes Match subscription, you can store all your music in iCloud (up to 25,000 songs)—even songs you imported from CDs.

Note: iTunes Match may not be available in all areas. See support.apple.com/kb/HT5085.

Subscribe to iTunes Match. Go to Settings > iTunes & App Store > Subscribe to iTunes Match. See www.apple.com/itunes/itunes-match/.

Turn on iTunes Match. Go to Settings > iTunes & App Store. Sign in if you haven't already.

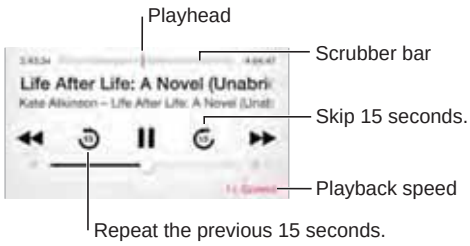
Album Wall

Rotate iPhone to view your entire library by album art.

Swipe left or right to see other albums. Tap an album to see its songs.

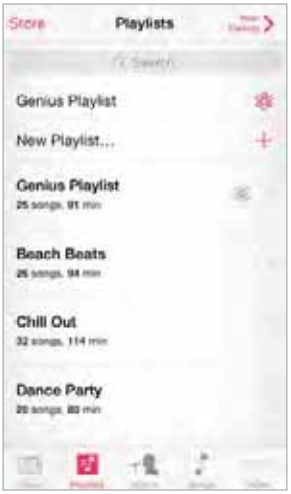
Audiobooks

Audiobook controls and info appear on the Now Playing screen when you begin playback.



Playlists

Create playlists to organize your music. View Playlists, tap New Playlist near the top of the list, then enter a title. Tap ⊕ to add songs or videos.



Edit a playlist. Select the playlist, then tap Edit.

- *Add more songs:* Tap ⊕.
- *Delete a song:* Tap ⊖, then tap Remove. Deleting a song from a playlist doesn't delete it from iPhone.
- *Change the song order:* Drag ≡.

New and changed playlists are copied to your iTunes library the next time you sync iPhone with your computer, or through iCloud if you subscribed to iTunes Match.

Clear or delete a playlist you created on iPhone. Select the playlist, then tap Clear or Delete.

Remove a song from iPhone. Tap Songs, swipe the song, then tap Delete. The song is deleted from iPhone, but not from your iTunes library on your Mac or PC, or from iCloud.

Genius—made for you

A Genius playlist is a collection of songs from your library that go together. Genius is a free service, but it requires an Apple ID.

A Genius Mix is a selection of songs of the same kind of music, re-created from your library each time you listen to the mix.

Turn on Genius. Tap Playlists, tap Genius Playlist, then tap Turn On Genius.

Browse and play Genius Mixes. Tap Genius (tap More first, if Genius isn't visible). Swipe left or right to access other mixes. To play a mix, tap ▶.

Make a Genius playlist. View Playlists, then tap Genius Playlist and choose a song. Or from the Now Playing screen, tap Create, then tap Genius Playlist.

- *Replace the playlist using a different song:* Tap New, then pick a song.
- *Refresh the playlist:* Tap Refresh.
- *Save the playlist:* Tap Save. The playlist is saved with the title of the song you picked, and marked by ⚛.

If you subscribe to iTunes Match, your Genius playlists are stored in iCloud. Genius playlists created on iPhone are copied to your computer when you sync with iTunes.

Note: Once a Genius playlist is synced to iTunes, you can't delete it directly from iPhone. Use iTunes to edit the playlist name, stop syncing, or delete the playlist.

Delete a saved Genius playlist. Tap the Genius playlist, then tap Delete.

Home Sharing

Home Sharing lets you play music, movies, and TV shows from the iTunes library on your Mac or PC. iPhone and your computer must be on the same Wi-Fi network.

Note: Home Sharing requires iTunes 10.2 or later, available at www.itunes.com/download/. Bonus content, such as digital booklets and iTunes Extras, can't be shared.

Play music from your iTunes library on iPhone.

1. In iTunes on your computer, choose File > Home Sharing > Turn On Home Sharing. Log in, then click Create Home Share.
2. On iPhone, go to Settings > Music, then log in to Home Sharing using the same Apple ID and password.
3. In Music, tap More, tap Shared, then choose your computer's library.

Return to content on iPhone. Tap Shared, then choose My iPhone.

Music settings

Go to Settings > Music to set options for Music, including:

- Shake to Shuffle
- Sound Check (to normalize the volume level of your audio content)
- Equalization (EQ)

  Note: EQ settings generally apply only to music played from the Music app, but they affect all sound output, including the headset jack and AirPlay.

  The Late Night setting compresses the dynamic range of the audio output, reducing the volume of loud passages and increasing the volume of quiet passages. You might want to use this setting when listening to music on an airplane or in some other noisy environment. (The Late Night setting applies to all audio output—video as well as music.)
- Volume Limit
- Grouping by album artist

Note: In some European Union (EU) countries, iPhone may indicate when you're setting the volume above the EU-recommended level for hearing safety. To increase the volume beyond this level, you may need to briefly release the volume control. To limit the maximum headset volume to this level, go to Settings > Music > Volume Limit, then turn on EU Volume Limit.

Prevent changes to the volume limit. Go to Settings > General > Restrictions > Volume Limit, then tap Don't Allow Changes.

Messages

9

SMS, MMS, and iMessage

Messages lets you exchange text messages with other SMS and MMS devices using your cellular connection, and with other iOS devices and Mac computers using iMessage.

iMessage is an Apple feature that lets you send messages over Wi-Fi (or cellular connections) to others using iOS 5 or later, or OS X Mountain Lion or later. Messages you send using iMessage don't count against your text messaging plan with your carrier. Messages can include photos, videos, and other info. You can see when other people are typing, and let them know when you've read their messages. If you're signed in to iMessage using the same Apple ID on other iOS devices or a Mac (OS X Mavericks or later), you can start a conversation on one device and continue it on another. For security, messages you send with iMessage are encrypted before they're sent.

With Continuity, you can also send and receive SMS and MMS messages in the Messages app on other iOS devices (with iOS 8) or a Mac (with OS X Yosemite), if they are signed in to iMessage with the same Apple ID as your iPhone. See About Continuity features on page 26.

Sign in to iMessage on an iOS device. Go to Settings > Messages, then turn on iMessage.

Sign in to iMessage on a Mac. On your Mac, open Messages, choose Messages > Preferences, click Accounts, then select iMessage in the Accounts list. Enter your Apple ID and password, then click Sign In.

WARNING: For important information about avoiding distractions while driving, see Important safety information on page 181.

Send and receive messages

Get info, make a voice or FaceTime call, share your location, or mute notifications.

Blue indicates an iMessage conversation.

Add your voice to the conversation.

Send a photo or video.

Start a conversation. Tap ✎, then enter a phone number or email address, or tap ⊕, then choose a contact. You can also start a conversation by tapping a phone number in Contacts, Calendar, or Safari, or from a recent or favorite contact in the multitasking screen.

Note: An alert ⓘ appears if a message can't be sent. Tap the alert in a conversation to try sending the message again.

Use Siri. Say something like:

- "Send a message to Emily saying how about tomorrow"
- "Read my messages"
- "Read my last message from Bob"
- "Reply that's great news"

Resume a conversation. Tap the conversation in the Messages list.

Use picture characters. Go to Settings > General > Keyboard > Keyboards > Add New Keyboard, then tap Emoji to make that keyboard available. When you type a message, tap 🌐 to change to the Emoji keyboard. See Special input methods on page 176.

Tap to Talk. Touch and hold 🎙 to record an audio message, then swipe up to send it. To delete it, swipe left.

To save space, Tap to Talk audio messages that you receive are deleted automatically two minutes after you listen to them, unless you tap Keep. To keep them automatically, go to Settings > Messages > Expire (under Audio Messages), then tap Never.

Raise iPhone to listen or reply to an audio message. Raise iPhone to your ear, as if you were talking on the phone, to play incoming audio messages automatically. Raise iPhone to your ear again to reply to an audio message. Turn this feature on or off at Settings > Messages, under Audio Messages.

See what time a message was sent or received. Drag any bubble to the left.

See a person's contact info. In a conversation, tap Details, then tap ⓘ. Tap the info items to perform actions, such as making a voice or FaceTime call.

Send messages to a group (iMessage and MMS). Tap ✎, then enter multiple recipients. With MMS, group messaging must also be turned on in Settings > Messages, and replies are sent only to you—they aren't copied to the other people in the group.

Give a group a name. While viewing the conversation, tap Details, drag down, then enter the name in the Subject line.

Add someone to a group. Tap the To field, then tap Add Contact.

Leave a group. Tap Details, then tap Leave this Conversation.

Keep it quiet. Tap Details, then turn on Do Not Disturb to mute notifications for the conversation.

Block unwanted messages. On a contact card, tap Block this Caller. You can see someone's contact card while viewing a message by tapping Details, then tapping ⓘ. You can also block callers in Settings > Messages > Blocked. You will not receive voice calls, FaceTime calls, or text messages from blocked callers. For more information about blocking calls, see support.apple.com/kb/HT5845.

Manage conversations

Conversations are saved in the Messages list. A blue dot ● indicates unread messages. Tap a conversation to view or continue it.

View the Messages list. From a conversation, tap Messages or swipe to the right. With iPhone 6 Plus, you can also rotate iPhone to landscape orientation to see both the Messages list and the selected conversation.

Forward a message. Touch and hold a message or attachment, tap More, select additional items if desired, then tap ↱.

Delete a message or attachment. Touch and hold a message or attachment, tap More, select additional items if desired, then tap 🗑.

Delete a conversation. In the Messages list, swipe the conversation to the left, then tap Delete.

Search conversations. In the Messages list, tap the top of the screen to display the search field, then enter the text you're looking for. You can also search conversations from the Home screen. See Spotlight Search on page 34.

Share photos, videos, your location, and more

With iMessage or MMS, you can send and receive photos and videos, and send locations, contact info, and voice memos. The size limit of attachments is determined by your service provider—iPhone may compress photo and video attachments when necessary.

Quickly take and send a photo or video. Touch and hold . Then slide to or to take a photo or video. Photos are sent immediately. Tap ▶ to preview your video. To send your Video Message, tap .

To save space, Video Messages that you receive are deleted automatically two minutes after you view them, unless you tap Keep. To keep them automatically, go to Settings > Messages > Expire (under Video Messages), then tap Never.

Send photos and videos from your Photos library. Tap . Recent shots are right there; tap Photo Library for older ones. Select the items you want to send.

View attachments. While viewing a conversation, tap Details. Attachments are shown in reverse chronological order at the bottom of the screen. Tap an attachment to see it in full screen. In full-screen mode, tap to view the attachments as a list.

Send your current location. Tap Details, then tap Send My Current Location to send a map that shows where you are.

Share your location. Tap Details, then tap Share My Location and specify the length of time. The person you're texting can see your location by tapping Details. To turn Share My Location on or off, or to select the device that determines your location, go to Settings > iCloud > Share My Location (under Advanced).

Send items from another app. In the other app, tap Share or , then tap Message.

Share, save, or print an attachment. Tap the attachment, then tap .

Copy a photo or video. Touch and hold the attachment, then tap Copy.

Messages settings

Go to Settings > Messages, where you can:

- Turn iMessage on or off
- Notify others when you've read their messages
- Specify phone numbers, Apple IDs, and email addresses to use with Messages
- Set SMS and MMS options
- Show the Subject field
- Block unwanted messages
- Set how long to keep messages
- Manage the expiration of audio messages and video messages created within Messages (audio or video attachments created outside of Messages are kept until you delete them manually)

Manage notifications for messages. See Do Not Disturb on page 37.

Set the alert sound for incoming text messages. See Sounds and silence on page 36.

Calendar

10

Calendar at a glance

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Add an event. Tap ⊕, then fill in the event details. If you add a location and choose Alert > Time to leave, Calendar reminds you of the event based on the current travel time to get there.

Use Siri. Say, for example, "Set up a meeting with Barry at 9."

Search for events. Tap 🔍, then enter text in the search field. The titles, invitees, locations, and notes for the calendars you're viewing are searched.

View a weekly calendar. Rotate iPhone sideways.

Change your view. Tap a year, month, or day to zoom in or out on your calendar. In week or day view, pinch to zoom in or out.

View a list of events. In month view, tap ☰ to see a day's events. In day view, tap ☰.

Use Siri. Say, for example, "What's on my calendar for Friday?"

Change the color of a calendar. Tap Calendars, tap ⓘ next to the calendar, then choose a color from the list. For some calendar accounts, such as Google, the color is set by the server.

Adjust an event. Touch and hold the event, then drag it to a new time, or adjust the grab points.

Use Siri. Say, for example, "Reschedule my appointment with Barry to next Monday at 9 a.m."

Invitations

iCloud, Microsoft Exchange, and some CalDAV servers let you send and receive meeting invitations.

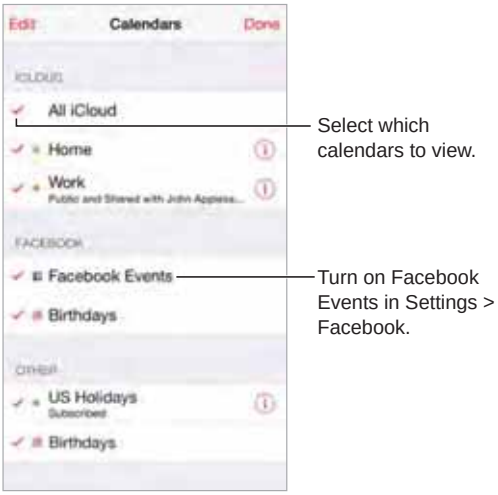
Invite others to an event. Tap an event, tap Edit, then tap Invitees. Type names, or tap ⊕ to pick people from Contacts. If you don't want to be notified when someone declines a meeting, go to Settings > Mail, Contacts, Calendar > Show Invitee Declines.

RSVP. Tap an event you've been invited to, or tap Inbox and tap an invitation. If you add comments (which may not be available for all calendars), your comments can be seen by the organizer but not by other attendees. To see events you declined, tap Calendars, then turn on Show Declined Events.

Schedule a meeting without blocking your schedule. Tap the event, tap Availability, then tap "free." Or if it's an event you created, tap "Show As," then tap "free." The event stays on your calendar, but it doesn't appear as busy to others who send you invitations.

Quickly send an email to attendees. Tap the event, tap Invitees, then tap ✉.

Use multiple calendars



Turn on iCloud, Google, Exchange, or Yahoo! calendars. Go to Settings > Mail, Contacts, Calendars, tap an account, then turn on Calendar.

Subscribe to a calendar. Go to Settings > Mail, Contacts, Calendars, then tap Add Account. Tap Other, then tap Add Subscribed Calendar. Enter the server and filename of the .ics file to subscribe to. You can also subscribe to an iCalendar (.ics) calendar published on the web, by tapping a link to the calendar.

Add a CalDAV account. Go to Settings > Mail, Contacts, Calendars, tap Add Account, then tap Other. Under Calendars, tap Add CalDAV Account.

View the Birthdays calendar. Tap Calendars, then tap Birthdays to include birthdays from Contacts with your events. If you set up a Facebook account, you can also include your Facebook friends' birthdays.

View the Holidays calendar. Tap Calendars, then tap Holidays to include national holidays with your events.

See multiple calendars at once. Tap Calendars, then select the calendars you want to view.

Move an event to another calendar. Tap the event, tap Edit, tap Calendars, then select a calendar to move it to.

Share iCloud calendars

With Family Sharing, a calendar shared with all the members of your family is created automatically. See Family Sharing on page 38. You can also share an iCloud calendar with other iCloud users. When you share a calendar, others can see it, and you can let them add or change events. You can also share a read-only version that anyone can view.

Create an iCloud calendar. Tap Calendars, tap Edit, then tap Add Calendar in the iCloud section.

Share an iCloud calendar. Tap Calendars, tap Edit, then tap the iCloud calendar you want to share. Tap Add Person, then enter a name, or tap ⊕ to browse your Contacts. Those you invite receive an email invitation to join the calendar, but they need an iCloud account to accept.

Change a person's access to a shared calendar. Tap Calendars, tap Edit, tap the shared calendar, then tap the person. You can turn off his or her ability to edit the calendar, resend the invitation to join the calendar, or stop sharing the calendar with that person.

Turn off notifications for shared calendars. When someone modifies a shared calendar, you're notified of the change. To turn off notifications for shared calendars, go to Settings > Mail, Contacts, Calendars > Shared Calendar Changes.

Share a read-only calendar with anyone. Tap Calendars, tap Edit, then tap the iCloud calendar you want to share. Turn on Public Calendar, then tap Share Link to copy or send the URL for your calendar. Anyone can use the URL to subscribe to the calendar using a compatible app, such as Calendar for OS X.

Calendar settings

Several settings in Settings > Mail, Contacts, Calendars affect Calendar and your calendar accounts. These include:

- Syncing of past events (future events are always synced)
- Alert tone played for new meeting invitations
- Default calendar for new events
- Default time for alerts
- Time zone support, to show dates and times using a different time zone
- Which day starts the week
- Display of Chinese, Hebrew, or Islamic dates

Photos

11

View photos and videos

The Photos app lets you view the photos and videos:

- Taken with Camera on iPhone
- Stored in iCloud (see iCloud Photo Library on page 87)
- Shared from others (see iCloud Photo Sharing on page 88)
- Synced from your computer (see Sync with iTunes on page 21)
- Saved from an email, text message, webpage, or screenshot

Tap to view full screen.

The Photos app includes tabs for Photos, Shared, and Albums.

- Tap Photos to see all your photos and videos, organized by Years, Collections, and Moments. To quickly browse the photos in a collection or year, touch and hold for a moment, then drag.
- Tap Shared to see photos and videos you shared with others or that others shared with you. See iCloud Photo Sharing on page 88.
- Tap Albums to see how photos and videos are organized into albums on your iPhone. See Organize photos and videos, next.

View all your photos and videos. By default, Photos displays a representative subset of your photos when you view by year or by collection. To see all your photos and videos, go to Settings > Photos & Camera, then turn off Summarize Photos.

View by location. While viewing by year or by collection, tap >. Photos and videos that include location information appear on a map, showing where they were taken.

While viewing a photo or video, tap to show and hide the controls. Swipe left or right to go forward or backward.

Search photos. From Albums or Photos, tap 🔍 to search by date (month and year), or place (city and state). Search also keeps your Recent Searches on hand and gives you a list of suggested searches.

Zoom in or out. Double-tap, or pinch a photo. When you zoom in, you can drag to see other parts of the photo.

Play a video. Tap ▶. To toggle between full screen and fit-to-screen, double-tap the screen.

Play a slideshow. While viewing a photo, tap ⬆, then tap Slideshow. Select options, then tap Start Slideshow. To stop the slideshow, tap the screen. To set other slideshow options, go to Settings > Photos & Camera.

To stream a slideshow or video to a TV, see AirPlay on page 41.

Organize photos and videos

The Album tab includes albums you create yourself and some albums that are created for you, depending on how you use Photos. For example, videos are automatically added to the Videos album and you see a My Photo Stream album if you use that feature (see My Photo Stream, next). All your photos in iCloud are in the All Photos album if you use iCloud Photo Library (see iCloud Photo Library on page 87). If you don't use iCloud Photo Library, you see the Camera Roll album instead, which includes photos and videos you took with iPhone and from other sources.

Note: If you use iCloud Photo Library, albums are stored in iCloud and are up to date and accessible on any iOS 8.1 or later device, Mac with OS X Yosemite v10.10.3 or later, and on iCloud.com using the same Apple ID. See iCloud Photo Library on page 87.

Create a new album. Tap Albums, tap ⊕, enter a name, then tap Save. Select photos and videos to add to the album, then tap Done.

Add items to an existing album. While viewing thumbnails, tap Select, select items, tap Add To, then select the album.

Manage albums. While viewing your album list, tap Edit.

- *Rename an album:* Select the album, then enter a new name.
- *Rearrange albums:* Drag ≡.
- *Delete an album:* Tap ⊖.

With iCloud Photo Library, you can manage all your albums from any iOS 8.1 or later device set up with iCloud Photo Library.

Mark your favorites. While viewing a photo or video, tap ♡ to automatically add it to the Favorites album. A photo or video can be part of another album as well as Favorites.

Hide photos you want to keep but not show. Touch and hold a photo, then choose Hide. The photo is moved to the Hidden album. Touch and hold a hidden photo to Unhide it.

Remove a photo or video from an album. Tap the photo or video, tap 🗑, then tap Delete Photo. The photo or video is removed from the album and from the Photos tab.

Delete a photo or video from Photos. Tap the Photos tab, tap the photo or video, tap 🗑, then tap Delete Photo or Delete Video. Deleted photos and videos are kept in the Recently Deleted album on iPhone, with a badge showing the remaining days until the item is permanently removed from iPhone. To delete the photo or video permanently before the days expire, tap the item, tap Delete, then tap Delete Photo or Delete Video. If you use iCloud Photo Library, deleted photos and videos are permanently removed from all your devices using iCloud Photo Library with the same Apple ID.

Recover a deleted photo or video. In the Recently Deleted album, tap the photo or video, tap Recover, then tap Recover Photo or Recover Video to move the item to the Camera Roll or, if you use iCloud Photo Library, the All Photos album.

iCloud Photo Library

iCloud Photo Library gives you access to your photos and videos on any iOS 8.1 or later device, Mac with OS X Yosemite v10.10.3 or later, and on iCloud.com using the same Apple ID. You can make changes to photos and videos in the Photos app, preserve both the original and edited versions, and see the changes updated across your devices (see Edit photos and trim videos on page 90). Store as many photos and videos as your iCloud storage plan allows.

Note: If you turn on iCloud Photo Library, you can't use iTunes to sync photos and videos to iPhone.

Turn on iCloud Photo Library. Go to Settings > iCloud > Photos. Or go to Settings > Photos & Camera.

View photos and videos in iCloud Photo Library. In addition to viewing your photos and videos in the Photos tab, organized by Years, Collections, and Moments, you can also view them as a continuous stream, organized by date added, in the All Photos album.

Choose to optimize your storage or keep all your photos and videos in full-resolution on iPhone. If your iCloud storage plan is over 5 GB, Optimize iPod touch Storage is on by default. It intelligently manages your device storage by keeping full-resolution photos and videos in iCloud and lightweight versions on your iPod touch, as space is needed. Tap Download and Keep Originals to keep your full-resolution originals on your iPod touch. Your originals are always stored in iCloud.

Download a full-resolution photo or video. If you're not storing original versions on iPhone, simply pinch to zoom in to 100%, or tap Edit.

Note: To upload photos and videos to iCloud Photo Library, iPhone must be connected to Wi-Fi. Using a cellular connection, you can download up to 100 MB at a time.

If your uploaded photos and videos exceed your storage plan, you can upgrade your iCloud storage. Go to Settings > iCloud > Storage > Change Storage Plan to learn about the available options.

My Photo Stream

My Photo Stream, turned on by default, automatically uploads new photos and videos to your other devices that use My Photo Stream.

Turn My Photo Stream on or off. Go to Settings > Photos & Camera, or Settings > iCloud > Photos.

Note: Photos stored in iCloud count against your total iCloud storage, but photos uploaded to My Photo Stream don't count additionally against your iCloud storage.

Use My Photo Stream without iCloud Photo Library. Photos and videos you take with iPhone are added to the My Photo Stream album when you leave the Camera app and iPhone is connected to Wi-Fi. Any photos you add—including screenshots and photos saved from email, for example—also appear in your My Photo Stream album.

Photos and videos added to My Photo Stream on your other devices appear in your My Photo Stream album on iPhone. iOS devices can keep up to 1000 of your most recent photos in iCloud for 30 days; you can choose to automatically import these photos to your computer, if you want to keep them permanently.

Manage My Photo Stream contents. In the My Photo Stream album, tap Select.

- *Save your best shots on iPhone:* Select the photos, then tap Add To.
- *Share, print, or copy:* Select the photos, then tap ⬆.
- *Delete photos:* Select the photos, then tap 🗑.

Note: Although deleted photos are removed from My Photo Stream on all your devices, the original photos remain in Photos on the device on which they were originally taken. Photos that you save to another album on a device or computer are also not deleted. See support.apple.com/kb/HT4486.

Use My Photo Stream with iCloud Photo Library. If you use iCloud Photo Library on iPhone, you can use My Photo Stream to upload recent photos and videos and view them on other devices that do not have iCloud Photo Library enabled.

iCloud Photo Sharing

With iCloud Photo Sharing, you can create albums of photos and videos to share, and subscribe to other people's shared albums. You can invite others using iCloud Photo Sharing (iOS 6 or later or OS X Mountain Lion or later) to view your albums, and they can leave comments if they wish. If they're using iOS 7 or OS X Mavericks or later, they can add their own photos and videos. You can also publish your album to a website for anyone to view. iCloud Photo Sharing works with or without iCloud Photo Library and My Photo Stream.

Note: To use iCloud Photo Sharing, iPhone must be connected to the Internet. iCloud Photo Sharing works over both Wi-Fi and cellular networks. Cellular data charges may apply. See Usage information on page 186.

Create new shared albums or add photos to existing ones.

Turn on iCloud Photo Sharing. Go to Settings > iCloud > Photos. Or go to Settings > Photos & Camera.

Share photos and videos. While viewing a photo or video, or when you've selected multiple photos or videos, tap ⬆, tap iCloud Photo Sharing, add comments, then share to an existing shared album or create a new one. You can invite people to view your shared album using their email address or the mobile phone number they use for Messages.

Enable a public website. Select the shared album, tap People, then turn on Public Website. Tap Share Link if you want to announce the site.

Add items to a shared album. View a shared album, tap ⊕, select items, then tap Done. You can add a comment, then tap Post.

Delete photos from a shared album. Select the shared album, tap Select, select the photos or videos you want to delete, then tap 🗑. You must be the owner of the shared album, or the owner of the photo.

Delete comments from a shared album. Select the photo or video that contains the comment. Touch and hold the comment, then tap Delete. You must be the owner of the shared album, or the owner of the comment.

Rename a shared album. Tap Shared, tap Edit, then tap the name and enter a new one.

Add or remove subscribers, or turn Notifications on or off. Select the shared album, then tap People.

Subscribe to a shared album. When you receive an invitation, tap the Shared tab ☁, then tap Accept. You can also accept an invitation in an email.

Add items to a shared album you subscribed to. View the shared album, then tap ⊕. Select items, then tap Done. You can add a comment, then tap Post.

See your Family album. When Family Sharing is set up, a shared album called "Family" is automatically created in Photos on all family members' devices. Everyone in the family can contribute photos, videos, and comments to the album, and be notified whenever something new is added. For more information about setting up Family Sharing, see Family Sharing on page 38.

Other ways to share photos and videos

You can share photos and videos in Mail or Messages, or through other apps you install.

Share or copy a photo or video. View a photo or video, then tap ⬆. If you don't see ⬆, tap the screen to show the controls.

Tap More in Sharing to turn on the apps you want to use for sharing.

The size limit of attachments is determined by your service provider. iPhone may compress photo and video attachments, if necessary.

You can also copy a photo or video, then paste it into an email or text message (MMS or iMessage).

Share or copy multiple photos and videos. While viewing by moment, tap Share.

Save or share a photo or video you receive.

- *Email:* Tap to download it if necessary, then touch and hold the item to see sharing and other options.
- *Text message:* Tap the item in the conversation, then tap ⬆.

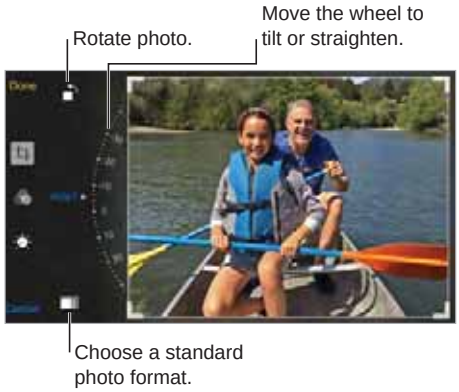
Photos and videos that you receive in messages or save from a webpage are saved to your Photos tab. They can also be viewed in the Camera Roll or, if you're using iCloud Photo Library, the All Photos album.

Edit photos and trim videos

You can edit photos right on iPhone. If your photos are stored in iCloud, your edits are updated across all your devices set up with iCloud, and both your original and edited versions are saved. If you delete a photo, it's deleted from all your devices and iCloud. Photo app extensions can provide special editing options. See App extensions on page 26.

Edit a photo. View the photo full screen, tap Edit, then tap one of the tools. To edit a photo not taken with iPhone, tap the photo, tap Edit, then tap Duplicate and Edit.

- Auto-enhance improves a photo's exposure, contrast, saturation, and other qualities.
- With the Remove Red-eye tool, tap each eye that needs correcting.
- Tap, and Photos suggests an optimal crop, but you can drag the corners of the grid tool to set your own crop. Move the wheel to tilt or straighten the photo. Tap Auto to align the photo with the horizon, and tap Reset to undo alignment changes. Tap to rotate the photo 90 degrees. Tap to choose a standard crop ratio, such as 2:3 or Square.



- Photo filters let you apply different color effects, such as Mono or Chrome.
- Tap Adjustments to set Light, Color, and B&W (black & white) options. Tap the down arrow, then tap next to Light, Color, or B&W to choose the element you want to adjust. Move the slider to the desired effect.

Compare the edited version to the original. Touch and hold the photo to view the original. Release to see your edits.

Don't like the results? Tap Cancel, then tap Discard Changes. Tap Done to save changes.

Revert to original. After you edit a photo and save your edits, you can revert to the original image. Tap the image, tap Edit, then tap Revert.

Trim a video. Tap the screen to display the controls, drag either end of the frame viewer, then tap Trim.

Important: If you choose Trim Original, the trimmed frames are permanently deleted from the original video. If you choose Save as New Clip, a new trimmed video clip is saved in your Videos album and the original video is unaffected.

Set the Slo-Mo section of a video. (iPhone 5s or later) Use the vertical bars beneath the frame viewer to set the section of the video you want to play in slow motion.

Print photos

Print to an AirPrint-enabled printer.

- *Print a single photo:* Tap ⬆, then tap Print.
- *Print multiple photos:* While viewing a photo album, tap Select, select the photos, tap ⬆, then tap Print.

See AirPrint on page 41.

Photos settings

Settings for Photos are in Settings > Photos & Camera. These include:

- iCloud Photo Library, My Photo Stream, iCloud Photo Sharing, and Upload Burst Photos
- Photos Tab
- Slideshow
- Camera Grid
- HDR (High Dynamic Range)

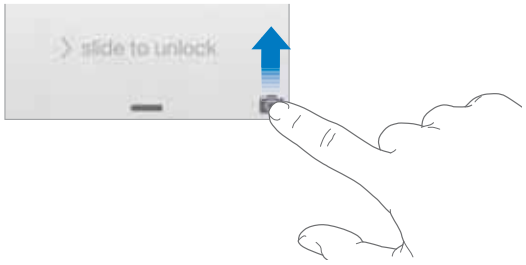
Camera

12

Camera at a glance

Quick! Get the camera! From the Lock screen, just swipe 📷 up. Or swipe up from the bottom edge of the screen to open Control Center, then tap 📷.

Note: When you open Camera from the Lock screen, you can view and edit photos and videos you take while the device is locked by tapping the thumbnail at the lower-left corner of the screen. To share photos and videos, first unlock iPhone.



With iPhone, you can take both still photos and HD videos. And, there are two cameras—in addition to the iSight camera on the back of iPhone, there's a camera on the front that you can use for FaceTime calls and selfies.

The LED flash provides extra light when you need it—even as a flashlight, just a swipe away in Control Center. See Control Center on page 35.

Take photos and videos

Camera offers several photo and video modes, which let you shoot stills, square-format photos, panoramas, time-lapse, videos, and slow-motion videos (iPhone 5s or later).

Choose a mode. Drag the screen left or right, or tap the camera mode labels to choose Time-Lapse, Slo-Mo, Video, Photo, Square, or Pano.

Take a photo. Choose Photo, then tap the Take Picture button or press either volume button.

- *Take Burst shots:* (iPhone 5s or later) Touch and hold the Take Picture button to take rapid-fire photos in bursts (available while in Square or Photo mode). The shutter sound is different, and the counter shows how many shots you've taken, until you lift your finger. To see the suggested shots and select the photos you want to keep, tap the thumbnail, then tap Select. The gray dot(s) mark the suggested photos. To copy a photo from the burst as a separate photo in your Bursts album in Photos, tap the circle in the lower-right corner of the photo. To delete the burst of photos, tap it, then tap 🗑.
- *Apply a filter:* Tap to apply different color effects, such as Mono or Chrome. To turn off a filter, tap , then tap None. You can also apply a filter later, when you edit the photo. See Edit photos and trim videos on page 90.

A rectangle briefly appears where the exposure is set. When you photograph people, face detection balances the exposure across up to 10 faces. A rectangle appears for each face detected.

Note: On iPhone 6 and iPhone 6 Plus, you might not always see an automatic exposure rectangle, but the focus and exposure are being set.

Exposure is automatic, but you can set the exposure manually for the next shot by tapping an object or area on the screen. With an iSight camera, tapping the screen sets the focus and the exposure, and face detection is temporarily turned off. To lock the exposure and focus, touch and hold until the rectangle pulses. Take as many photos as you want. When you tap the screen again, the automatic settings and face detection turn back on.

Adjust the exposure. Tap to see ☀ next to the exposure rectangle, then slide up or down to adjust the exposure.

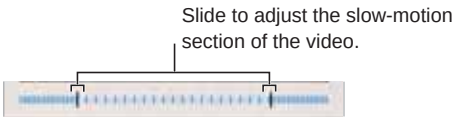
Take a panorama photo. (iSight camera) Choose Pano, tap the Take Picture button, then pan slowly in the direction of the arrow. To pan in the other direction, first tap the arrow. To pan vertically, first rotate iPhone to landscape orientation. You can reverse the direction of a vertical pan, too.

Capture an experience with time-lapse. (iSight camera) Choose Time-Lapse, set up iPhone where you want, then tap the Record Time-Lapse Video button to start capturing a sunset, a flower opening, or other experiences over a period of time. Tap the Record Time-Lapse Video button again to stop. The time-lapse photos are compiled into a short video that you can watch and share.

Shoot some video. Choose Video, then tap the Record Video button or press either volume button to start and stop recording. Video records at 30 fps (frames per second). With iPhone 6 or iPhone 6 Plus, you can switch it to 60 fps in Settings > Photos & Camera.

- *Snap a still while recording:* (iPhone 5 or later) Tap the white Take Picture button in the lower-left corner.
- *Take it slow:* (iPhone 5s or later) Choose Slo-Mo to shoot slow motion video. You can set which section to play back in slow motion when you edit the video. On iPhone 6 and iPhone 6 Plus, you can tap the bottom-right corner of the screen to switch between 120 fps and 240 fps.

Set the slow-motion section of a video. Tap the thumbnail, then use the vertical bars beneath the frame viewer to set the section you want to play back in slow motion.



Use Siri. Say something like:

- "Open Camera"
- "Take a picture"

Zoom in or out. (iSight camera) Pinch the image on the screen. For iPhone 5 or later, zoom works in video mode as well as photo mode.

If Location Services is turned on, photos and videos are tagged with location data that can be used by apps and photo-sharing websites. See Privacy on page 43.

Use the capture timer to put yourself in the shot. Avoid "camera shake" or add yourself to a picture by using the capture timer. To include yourself, first stabilize iPhone and frame your shot. Tap ⏲, tap 3s (seconds) or 10s, then tap the Take Picture button.

Want to capture what's displayed on your screen? Simultaneously press and release the Sleep/Wake and Home buttons. The screenshot is added to the Photos tab in Photos and can also be viewed in the Camera Roll album or All Photos album (if you're using iCloud Photo Library).

Make it better. You can edit photos and trim videos, right on iPhone. See Edit photos and trim videos on page 90.

HDR

HDR (High Dynamic Range) helps you get great shots, even in high-contrast situations. The best parts of three quick shots, taken at different exposures (long, normal, and short), are blended together into a single photo.

Note: On iPhone 6 and iPhone 6 Plus, the FaceTime camera creates high dynamic range photos using the camera's sensor, instead of blending three separate shots. This feature is always on, and only one photo is created (which is *not* labeled HDR).

Use HDR. (iSight cameras and the FaceTime camera on iPhone 5s or later) Tap the HDR button. For best results, keep both iPhone and the subject still.

On iPhone 5s or later, you can choose HDR Auto, and iPhone uses HDR when it's most effective.

Keep the normal photo and the HDR version. Go to Settings > Photos & Camera > Keep Normal Photo. Both the normal and HDR versions of the photo appear in Photos. HDR versions of photos in your albums are marked with "HDR" in the corner.

View, share, and print

Photos and videos you take are saved in Photos. With iCloud Photo Library enabled, all new photos and videos are automatically uploaded and available in Photos on all your iOS 8.1 devices set up with iCloud Photo Library. See iCloud Photo Library on page 87. With iCloud Photo Library turned off, you can collect up to 1,000 of your most recent photos from all of your enabled devices in the My Photo Stream album. See My Photo Stream on page 87.

View your photos. Tap the thumbnail image, then swipe left or right to see the photos you've taken recently. Tap All Photos to see everything in the Photos app.

Tap the screen to show or hide the controls.

Get sharing and printing options. Tap ⬆. See Share from apps on page 37.

Upload photos and videos. Use iCloud Photo Library to upload photos and videos from your iPhone to iCloud and access them on your iOS 8.1 devices signed in to iCloud using the same Apple ID. You can also upload and download your photos and videos from the Photos app on iCloud.com. See iCloud Photo Library on page 87.

Camera settings

Go to Settings > Photos & Camera for camera options, which include:

- iCloud Photo Library, My Photo Stream, and iCloud Photo Sharing
- Burst photos
- Slideshow
- Grid
- HDR

Adjust the volume of the shutter sound with the Ringer and Alerts settings in Settings > Sounds. Or mute the sound using the Ring/Silent switch. (In some countries, muting is disabled.)

Weather

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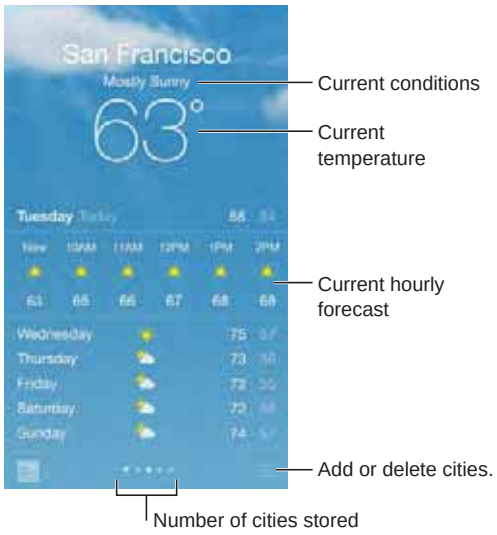
Get the current temperature and ten-day forecast for one or more cities around the world, with hourly forecasts for the next 12 hours. Weather uses Location Services to get the forecast for your current location.



Swipe up to see your detailed forecast. Swipe left or right to see weather for another city, or tap ☰, then choose a city from the list. The leftmost screen shows your local weather when Location Services is on (Settings > Privacy > Location Services).

Add a city or make other changes. Tap ☰.

- *Add a city:* Tap ⊕. Enter a city or zip code, then tap Search.
- *Rearrange the order of cities:* Touch and hold a city, then drag it up or down.
- *Delete a city:* Slide the city to the left, then tap Delete.
- *Choose Fahrenheit or Celsius:* Tap °F or °C.

View the current hourly forecast. Swipe the hourly display left or right.

Use Siri. Say something like:

- "What's the weather for today?"
- "How windy is it out there?"
- "When is sunrise in Paris?"

See all cities at once. Pinch the screen or tap ☰.

Turn local weather on or off. Go to Settings > Privacy > Location Services. See Privacy on page 43.

Use iCloud to push your list of cities to your other iOS devices. Go to Settings > iCloud, then make sure iCloud Drive or Documents & Data is on. See iCloud on page 18.

Clock

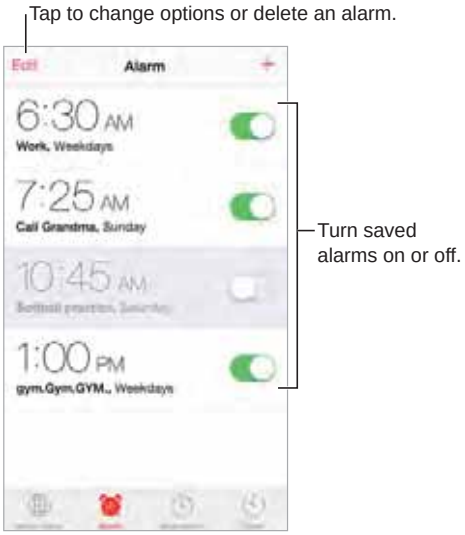
14

Clock at a glance

The first clock displays the time based on your location when you set up iPhone. Add other clocks to show the time in other major cities and time zones.

Alarms and timers

Want iPhone to wake you? Tap Alarm, then tap ⊕. Set your wake-up time and other options, then give the alarm a name (like "Good morning").



No wasting time! You can also use the stopwatch to keep time, record lap times, or set a timer to alert you when time's up.

Want to fall asleep to music or a podcast? Tap Timer, tap When Timer Ends, then choose Stop Playing at the bottom.

Get quick access to clock features. Swipe up from the bottom edge of the screen to open Control Center, then tap ⏲. You can access Timer from Control Center even when iPhone is locked. You can also navigate to the other clock features.

Use Siri. Say something like:

- "Set the timer for 3 minutes"
- "Wake me up tomorrow at 7 a.m."
- "What alarms do I have set?"

Maps

15

Find places

WARNING: For important information about navigation and avoiding distractions that could lead to dangerous situations, see Important safety information on page 181. See also Privacy on page 43.

Move around Maps by dragging the screen. To face a different direction, rotate with two fingers. To return to north, tap the compass in the upper right.

Zoom in or out. Double-tap with one finger to zoom in, and tap with two fingers to zoom out—or pinch open or closed. The scale appears in the upper left while zooming, or if you touch the screen with two fingers. To change how distance is shown (miles or kilometers), go to Settings > Maps.

Search for a location. Tap the search field. You can search for a location in different ways. For example:

- Intersection ("8th and market")
- Area ("greenwich village")
- Landmark ("guggenheim")

- Zip code
- Business (“movies,”“restaurants san francisco ca,”“apple inc new york”)

Maps may also list recent locations, searches, or directions that you can choose from.

Use Siri. Say, for example, “Find coffee near me.”

Find the location of a contact, or of a favorite or recent search. Tap Favorites.

Choose your view. Tap ⓘ, then choose Standard, Hybrid, or Satellite.

Manually mark a location. Touch and hold the map until the dropped pin appears.

Get more info

Get info about a location. Tap a pin to display its banner, then tap >. Info might include Yelp reviews and photos, a phone number (tap to call it), a webpage link, directions, and more.

To share the location, add the location to your Favorites, or use another app you install, tap ⬆. See Share from apps on page 37.

Get directions

Note: To get directions, iPhone must be connected to the Internet. To get directions involving your current location, Location Services must also be on.

Get directions. Tap ↱, enter the starting and ending locations, then tap Route. Or choose a location or a route from the list, if available. Tap to select driving or walking directions, or to use an app for public or other modes of transportation.

If a location banner is showing, directions to that location from your current location appear. To get other directions, tap the search field.

If multiple routes appear, tap the one you want to take.

- *Hear turn-by-turn directions:* Tap Start.

  Maps follows your progress and speaks turn-by-turn directions to your destination. To show or hide the controls, tap the screen.

  If iPhone auto-locks, Maps stays onscreen and continues to announce instructions. You can also open another app and continue to get turn-by-turn directions. To return to Maps, tap the banner across the top of the screen.

  With turn-by-turn directions, night mode automatically adjusts the screen image for easier viewing at night.
- *See the route overview:* Tap Overview.
- *View the directions as a list:* Tap List Steps.
- *Stop turn-by-turn directions:* Tap End. Or ask Siri to “stop navigating.”

Get directions from your current location. Tap 🚗 on the banner of your destination. Tap to select driving or walking directions, or to use an app for public or other modes of transportation.

Use Siri. Say something like:

- “Give me directions home”
- “Directions to my dad’s work”
- “What’s my ETA?”
- “Find a gas station”

Use Maps on your Mac to get directions. Open Maps on your Mac (OS X Mavericks or later), get directions for your trip, then choose File > Share > Send to *your device*. Your Mac and iPhone must both be signed in to iCloud using the same Apple ID.

Find out about traffic conditions. Tap ⓘ, then tap Show Traffic. Orange dots show slowdowns, and red dots show stop-and-go traffic. To see an incident report, tap a marker.

Report a problem. Tap ⓘ, then tap Report a Problem.

3D and Flyover

With 3D and Flyover, you can see three-dimensional views and even fly over many of the world's major cities.

View 3D map. Tap ⓘ, then tap Show 3D Map. Or, drag two fingers up. (Zoom in for a closer look if Show 3D Map doesn't appear.)

Adjust the angle. Drag two fingers up or down.

Take a Flyover Tour. An aerial tour is available for select cities, indicated by 3D next to the city name. (Zoom out if you don't see any 3D markers.) Tap the name of the city to display its banner, then tap Tour to begin the tour. To stop the tour, tap the screen to display the controls, then tap End Flyover Tour. To return to standard view, tap ⓘ.

Maps settings

Go to Settings > Maps. Settings include:

- Navigation voice volume
- Distances in miles or kilometers
- Map labels (these appear in the language specified in Settings > General > International > Language)

Videos

16

Videos at a glance

Open the Videos app to watch movies, TV shows, and music videos. To watch video podcasts, open the Podcasts app—see Podcasts at a glance on page 137. To watch videos you record using Camera on iPhone, open the Photos app.

> *WARNING:* For important information about avoiding hearing loss, see Important safety information on page 181.

Watch a video. Tap the video in the list of videos.

What about videos you shot with iPhone? Open the Photos app.

Stream or download? If ☁ appears on a video thumbnail, you can watch it without downloading it to iPhone, if you have an Internet connection. To download the video to iPhone so you can watch without using a Wi-Fi or cellular connection, tap ☁ in the video details.

Looking for podcasts or iTunes U videos? Open the Podcasts app or download the free iTunes U app from the App Store.

Set a sleep timer. Open the Clock app and tap Timer, then swipe to set the number of hours and minutes. Tap When Timer Ends and choose Stop Playing, tap Set, then tap Start.

Add videos to your library

Buy or rent videos from the iTunes Store. Tap Store in the Videos app, or open the iTunes Store app on iPhone, then tap Movies or TV Shows. The iTunes Store is not available in all areas. See Chapter 22, iTunes Store, on page 117.

Transfer videos from your computer. Connect iPhone, then sync videos from iTunes on your computer. See Sync with iTunes on page 21.

Stream videos from your computer. Turn on Home Sharing in iTunes on your computer. Then, on iPhone, go to Settings > Videos and enter the Apple ID and password you used for Home Sharing on your computer. Then open Videos on iPhone, and tap Shared at the top of the list of videos.

Convert a video for iPhone. If you try to sync a video from iTunes to iPhone and a message says the video can't play on iPhone, you can convert the video. Select the video in your iTunes library, then choose File > Create New Version > Create iPod or iPhone Version. Then sync the converted video to iPhone.

Delete a video. Tap Edit in the upper right of your collection, then tap ⊗ on the video thumbnail. If you don't see the Edit button, look for ☁ on your video thumbnails—those videos haven't been downloaded to iPhone, so you can't delete them. To delete an individual episode of a series, swipe left on the episode in the Episodes list.

Deleting a video (other than a rented movie) from iPhone doesn't delete it from the iTunes library on your computer, and you can sync the video back to iPhone later. If you don't want to sync the video back to iPhone, set iTunes to not sync the video. See Sync with iTunes on page 21.

Important: If you delete a rented movie from iPhone, it's deleted permanently and cannot be transferred back to your computer.

Control playback

Scale the video to fill the screen or fit to the screen. Tap ⤢ or ▭. Or double-tap the video. If you don't see the scaling controls, your video already fits the screen perfectly.

Start over from the beginning. If the video contains chapters, drag the playhead along the scrubber bar all the way to the left. If there are no chapters, tap ⏮.

Skip to the next or previous chapter. Tap ⏭ or ⏮. You can also press the center button or equivalent on a compatible headset two times (skip to next) or three times (skip to previous).

Rewind or fast-forward. Touch and hold ⏮ or ⏭. Or drag the playhead left or right. Move your finger toward the bottom of the screen as you drag for finer control.

Select a different audio language. If the video offers other languages, tap , then choose a language from the Audio list.

Show subtitles or closed captions. Tap . Not all videos offer subtitles or closed captions.

Customize the appearance of closed captions. Go to Settings > General > Accessibility > Subtitles & Captioning.

See closed captions and subtitles for the deaf and hard of hearing. Go to Settings > General > Accessibility > Subtitles & Captioning, then turn on Closed Captions + SDH.

Watch the video on a TV. Tap . For more about AirPlay and other ways to connect, see AirPlay on page 41.

Videos settings

Go to Settings > Videos, where you can:

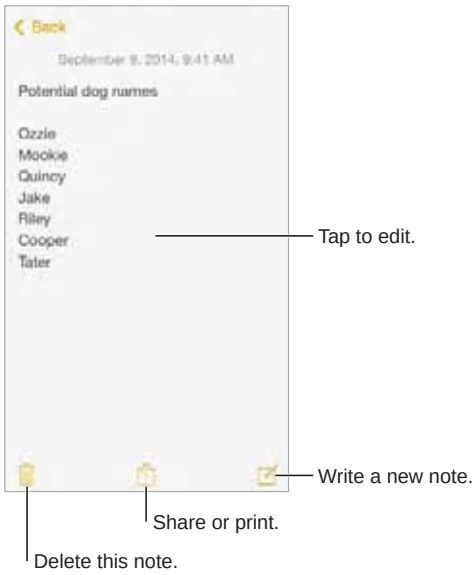
- Choose where to resume playback the next time you open a video
- Choose to show only videos on iPhone
- Log in to Home Sharing

Notes

17

Notes at a glance

Type notes on iPhone, and iCloud automatically makes them available on your other iOS devices and Mac computers. You can also read and create notes in other accounts, such as Gmail or Yahoo!.



See your notes on your other devices. If you use an icloud.com, me.com, or mac.com email address for iCloud, go to Settings > iCloud, then turn on Notes. If you use Gmail or another IMAP account for iCloud, go to Settings > Mail, Contacts, Calendars, then turn on Notes for the account. Your notes appear in Notes on all your other iOS devices and Mac computers that use the same Apple ID.

Search for a note. Scroll to the top of a list of notes (or tap the top of the screen) to reveal the search field, then tap the field and type what you're looking for. You can also search for notes from the Home screen—just drag down the middle of the screen.

Share or print. Tap ⬆ at the bottom of the note. You can share via Messages, Mail, or AirDrop (iPhone 5 or later).

Delete a note. Swipe left over the note in the list of notes.

Use Siri. Say something like:

- "Create new note travel items"
- "Add toothbrush to travel items"
- "Add umbrella"

Use notes in multiple accounts

Share notes with other accounts. You can share notes with other accounts, such as Google, Yahoo!, or AOL. Go to Settings > Mail, Contacts, Calendars, then turn on Notes for the account.

Create a note in a specific account. Tap Accounts at the top of a list of notes, select the account, then tap New. Notes you create in the account on iPhone touch show up in the notes folder of the account.

Choose the default account for new notes. Go to Settings > Notes.

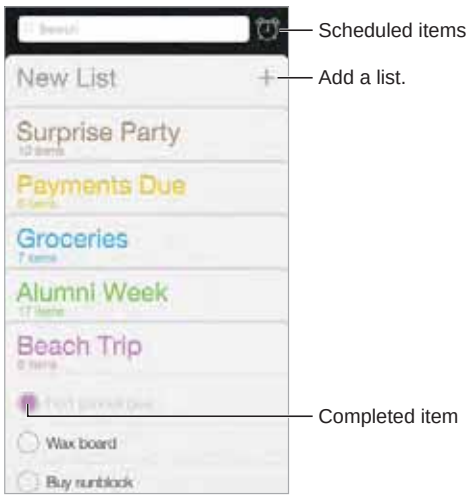
See all notes in an account. Tap Accounts at the top of a list of notes, then choose the account.

Reminders

18

Reminders at a glance

Reminders lets you keep track of all the things you need to do.



Add a reminder. Tap a list, then tap a blank line.

Share a list. Tap a list, then tap Edit. Tap Sharing, then tap Add Person. The people you share with also need to be iCloud users. After they accept your invitation to share the list, you'll all be able to add, delete, and mark items as completed. Family members can also share a list. See Family Sharing on page 38.

Use Siri. Say something like:

- "Remember to take an umbrella"
- "Add artichokes to my groceries list"
- "Read my work to-do list"

Delete a list. While viewing a list, tap Edit, then tap Delete List. All of the reminders in the list are also deleted.

Delete a reminder. Swipe the reminder left, then tap Delete.

Change the order of lists. Touch and hold the list name, then drag the list to a new location. To change the order of items in a list, tap Edit.

What list was that in? Scroll to the top to see the search field. All lists are searched by the reminder name. You can also use Siri to find reminders. For example, say "Find the reminder about milk."

With OS X Yosemite, you can hand off reminders you're editing between your Mac and iPhone. See About Continuity features on page 26.

Scheduled reminders

Scheduled reminders notify you when they're due.

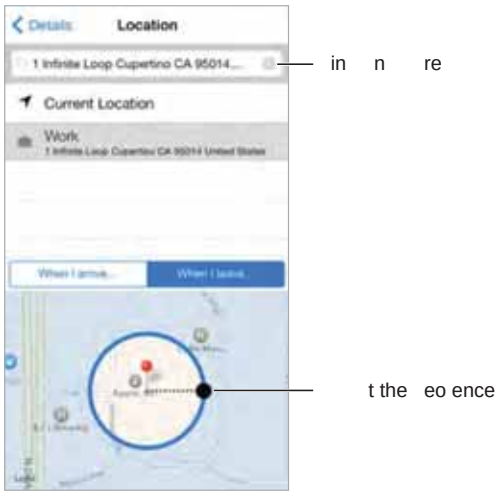
Schedule a reminder. While editing a reminder, tap ⓘ, then turn on "Remind me on a day." Tap Alarm to set the date and time. Tap Repeat to schedule the reminder for regularly occurring intervals.

Use Siri. Say, for example, "Remind me to take my medicine at 6 a.m. tomorrow."

See all scheduled reminders. Tap ⏰ to show the Scheduled list.

Don't bother me now. You can turn off Reminders notifications in Settings > Notifications. To silence notifications temporarily, turn on Do Not Disturb.

Location reminders



Be reminded when you arrive at or leave a location. While editing a reminder, tap ⓘ, then turn on "Remind me at a location." Tap Location, then choose a location from the list, or enter an address. After you define a location, you can drag to change the size of the geofence on the map, which sets the approximate distance at which you want to be reminded. You can't save a location reminder in Outlook or Microsoft Exchange calendars.

Use Siri. Say, for example, "Remind me to stop at the grocery store when I leave here."

Add common locations to your My Info card. When you set a location reminder, locations in the list include addresses from your My Info card in Contacts. Add your work, home, and other favorite addresses to your card for easy access in Reminders.

Reminders settings

Go to Settings > Reminders, where you can:

- Set a default list for new reminders
- Sync past reminders

Keep your reminders up to date on other devices. Go to Settings > iCloud, then turn on Reminders. To keep up to date with Reminders on OS X, turn on iCloud on your Mac, too. Some other types of accounts, such as Exchange, also support Reminders. Go to Settings > Mail, Contacts, Calendars, then turn on Reminders for the accounts you want to use.

Stocks

19

Keep track of the major exchanges and your stock portfolio, see the change in value over time, and get news about the companies you're watching.

Tap to see percent change. Tap again to see market capitalization.

Swipe left or right to see stats or news articles.

Manage your stock list. Tap ☰.

- *Add an item:* Tap ⊕. Enter a symbol, company name, fund name, or index, then tap Search.
- *Delete an item:* Tap ⊖.
- *Rearrange the order of items:* Drag ≡ up or down.

While viewing stock info, you can tap any of the values along the right side of the screen to switch the display to price change, market capitalization, or percentage change. Swipe the info beneath the stock list to see the summary, chart, or news for the selected stock. Tap a news headline to view the article in Safari.

On iPhone 6 Plus, use landscape orientation to see your stock list with news, or with the summary and chart, all at the same time.

You can also see your stocks in the Today tab of Notification Center. See Notification Center on page 36.

Note: Quotes may be delayed 20 minutes or more, depending upon the reporting service.

Add a news article to your reading list. Touch and hold the news headline, then tap Add to Reading List.

Use Siri. Say something like:

- "How are the markets going?"
- "How's Apple stock today?"

Find out more. Tap YAHOO!

View a full-screen chart. Rotate iPhone to landscape orientation. (On iPhone 6 Plus, rotate to landscape orientation, then touch the chart to expand it to the full-screen view.) Swipe left or right to see your other stock charts.

- *See the value for a specific date or time:* Touch the chart with one finger.

- *See the difference in value over time:* Touch the chart with two fingers.

Use iCloud to keep your stock list up to date on your iOS devices. Go to Settings > iCloud, then turn on iCloud Drive or Documents & Data. See iCloud on page 18.

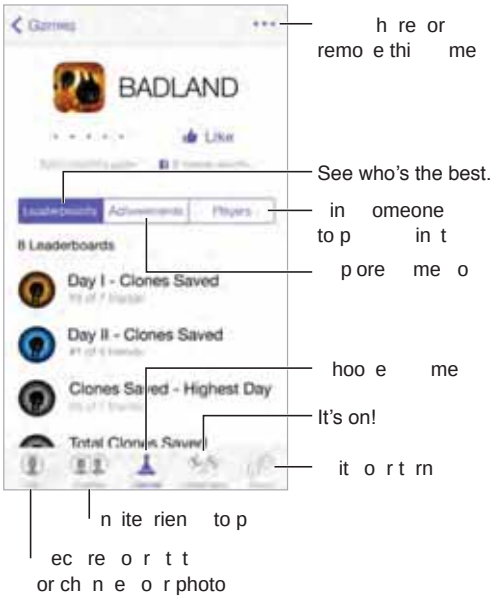
Game Center

20

Game Center at a glance

Game Center lets you play your favorite games with friends who have an iOS device or a Mac (OS X Mountain Lion or later). You must be connected to the Internet to use Game Center.

WARNING: For important information about avoiding repetitive motion injuries, see Important safety information on page 181.



Get started. Open Game Center. If you see your nickname at the top of the screen, you're already signed in. Otherwise, you'll be asked for your Apple ID and password.

Get some games. Tap Games, then tap a recommended game, browse for games in the App Store (look for Supports Game Center in the game details), or get a game one of your friends has (see Play games with friends on page 115).

Play! Tap Games, choose a game, tap ••• in the upper right, then tap Play.

Sign out? No need to sign out when you quit Game Center, but if you want to, go to Settings > Game Center, then tap your Apple ID.

Play games with friends

Invite friends to a multiplayer game. Tap Friends, choose a friend, choose a game, then tap Play. If the game allows or requires more players, choose the players, then tap Next. Send your invitation, then wait for the others to accept. When everyone's ready, start the game. If a friend isn't available or doesn't respond, you can tap Auto-Match to have Game Center find another player for you, or tap Invite Friend to invite someone else.

Send a friend request. Tap Friends, tap ⊕, then enter your friend's email address or Game Center nickname. To browse your contacts, tap ⊕. (To add several friends in one request, type Return after each address.) Or, tap any player you see anywhere in Game Center.

Challenge someone to outdo you. Tap one of your scores or achievements, then tap Challenge Friends.

What are your friends playing and how are they doing? Tap Friends, tap your friend's name, then tap the Games or Points bubble.

Want to purchase a game your friend has? Tap Friends, then tap your friend's name. Tap his or her Games bubble, tap the game in your friend's game list, then tap ••• in the upper right.

Make new friends. To see a list of your friend's friends, tap Friends, tap your friend's name, then tap his or her Friends bubble.

Unfriend a friend. Tap Friends, tap the friend's name, then tap ••• in the upper right.

Keep your email address private. Turn off Public Profile in your Game Center account settings. See Game Center settings below.

Turn off multiplayer activity or friend requests. Go to Settings > General > Restrictions. If the switches are dimmed, first tap Enable Restrictions at the top.

Keep it friendly. To report offensive or inappropriate behavior, tap Friends, tap the person's name, tap ••• in the upper right, then tap Report a Problem.

Game Center settings

Go to Settings > Game Center, where you can:

- Sign out (tap your Apple ID)
- Allow invites
- Let nearby players find you
- Edit your Game Center profile (tap your nickname)
- Get friend recommendations from Contacts or Facebook

Specify which notifications you want for Game Center. Go to Settings > Notifications > Game Center. If Game Center doesn't appear, turn on Notifications.

Change restrictions for Game Center. Go to Settings > General > Restrictions.

Newsstand

21

Newsstand organizes your magazine and newspaper apps, and automatically updates them when iPhone is connected to Wi-Fi.

Note: You need an Internet connection and an Apple ID to download Newsstand apps, but you can read downloaded content without an Internet connection. Newsstand is not available in all areas.

Find Newsstand apps. Tap Newsstand to reveal the shelf, then tap Store. When you purchase a Newsstand app, it's added to the shelf. After the app is downloaded, open it to view its issues and subscription options. Subscriptions are In-App purchases, billed to your Apple ID account.

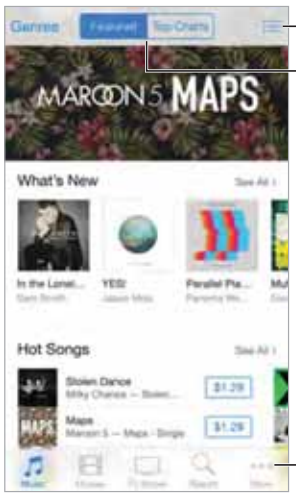
Turn off automatic updates. Apps update automatically over Wi-Fi, unless you turn off the option in Settings > General > Background App Refresh.

iTunes Store

22

iTunes Store at a glance

Use the iTunes Store to add music, movies, TV shows, and more to iPhone.



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n more

Note: You need an Internet connection and an Apple ID to use the iTunes Store. The iTunes Store is not available in all areas.

Browse or search

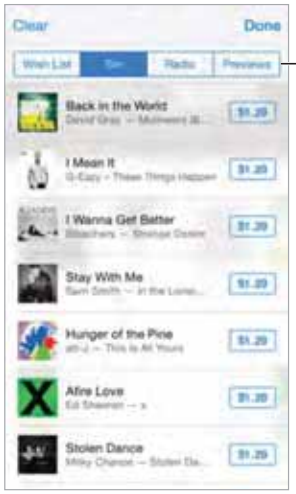
Browse by category or genre. Tap one of the categories (Music, Movies, or TV Shows). Tap Genres to refine the list.

If you know what you're looking for, tap Search. You can tap a search term that's trending among other iTunes users, or enter info in the search field, then tap Search again.

Access family members' purchases. With Family Sharing turned on, you can view and download songs, TV shows, and movies purchased by other family members. Tap Purchased, tap your name or My Purchases, then select a family member from the menu.

Find it with Siri. Siri can search for items and make purchases in the iTunes Store. For example, you can say "Get a new ringtone" or "Purchase *song name* by *band name*." You can also ask Siri to download a podcast or redeem a gift card.

Ask Siri to tag it. When you hear music playing around you, ask Siri "What song is playing?" Siri tells you what the song is and gives you an easy way to purchase it. It also saves it to the Siri tab in the iTunes Store so you can buy it later. Tap Music, tap ☰, then tap the Siri tab to see a list of tagged songs available for preview or purchase.



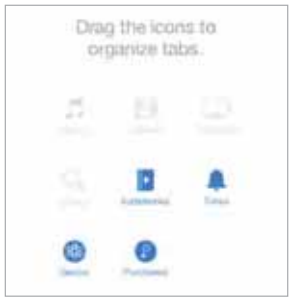
Tap to see your Wish List and recommendations.

Discover great new music on iTunes Radio. When you listen to iTunes Radio, songs you play appear in the Radio tab in the iTunes Store so you can preview or purchase them. Tap Music, tap ☰, then tap Radio.

Preview a song or video. Tap it.

Add to your Wish List. When you hear something you hope to buy from the iTunes Store, tap ⬆, then tap Add to Wish List. To view your Wish List in the iTunes Store, tap Music, Movies, or TV Shows, tap ☰, then tap Wish List.

Pick your favorite buttons To rearrange the buttons, tap More, then tap Edit. To replace an icon, drag another icon over the one you want to replace. Then tap Done.



Purchase, rent, or redeem

Tap an item's price (or tap Free), then tap again to buy it. If you see ☁ instead of a price, you've already purchased the item and you can download it again without a charge.

Approve purchases with Family Sharing. With Family Sharing set up, the family organizer can review and approve purchases made by family members under the age of 18. For example, if Parent/Guardian > Ask to Buy is set for specific minor family members, when those members try to make a purchase, a message is sent to the family organizer for approval. For more information about setting up Family Sharing, see Family Sharing on page 38.

Note: Age restrictions for Ask to Buy vary by area. In the United States, the family organizer can enable Ask to Buy for any family member under age 18; for children under age 13, it's enabled by default.

Hide individual purchases. Using iTunes on a computer, family members can hide any of their purchases so other family members can't view or download them. For more information, see Family Sharing on page 38.

Use a gift card or code. Tap a category (for example, Music), scroll to the bottom, then tap Redeem. Or tell Siri "Redeem an iTunes Store gift card."

Use iTunes Pass. You can add an iTunes Pass to Passbook, which makes it easy to add money to your Apple ID so you can make purchases from the iTunes Store, App Store, and iBooks Store without using a credit or debit card. To add your iTunes Pass in iTunes Store, tap a category, scroll to the bottom, tap Redeem, then tap Get Started under iTunes Pass. You can add money to your iTunes Pass at Apple Retail Stores in most countries.

Send a gift. View the item you want to give, tap ⬆, then tap Gift. Or tap one of the categories (Music, Movies, or TV Shows), scroll to the bottom, then tap Send Gift to send an iTunes gift certificate to someone.

See the progress of a download. Tap More, then tap Downloads.

Bought something on another device? Go to Settings > iTunes & App Store to set up automatic downloads on your iPhone. You can always view your purchased music, movies, and TV shows in the iTunes Store (tap More, then tap Purchased).

Watch your time with rentals. In some areas, you can rent movies. You have 30 days to begin watching a rented movie. After you start watching it, you can play it as many times as you want in the allotted time (24 hours in the U.S. iTunes Store; 48 hours in other countries). Once your time's up, the movie is deleted. Rentals can't be transferred to another device; however, you can use AirPlay and Apple TV to view a rental on your television.

iTunes Store settings

To set options for the iTunes Store, go to Settings > iTunes & App Store.

View or edit your account. Tap your Apple ID, then tap View Apple ID. To change your password, tap the Apple ID field, then tap Password.

Sign in using a different Apple ID. Tap your account name, then tap Sign Out. You can then enter a different Apple ID.

Subscribe to or turn on iTunes Match. You can subscribe to iTunes Match, a service that stores your music and more in iCloud. See iCloud and iTunes Match on page 74. If you're a subscriber, tap iTunes Match so you can access your music on iPhone anywhere. Tap "Learn more" for more information about iTunes Match.

Turn on automatic downloads. Tap Music, Books, or Updates. Content updates automatically over Wi-Fi, unless you turn off the option in Automatic Downloads.

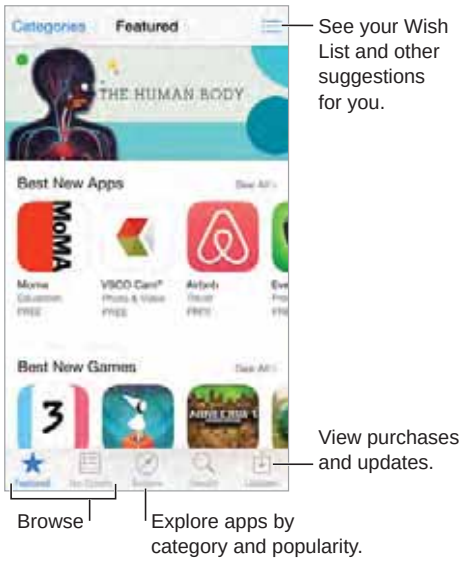
Download purchases over the cellular network. Turn on Use Cellular Data. Downloading purchases and using iTunes Match over the cellular network may incur carrier charges.

App Store

23

App Store at a glance

Use the App Store to browse, purchase, and download apps to iPhone. Your apps update automatically over Wi-Fi (unless you turn off this feature), so you can keep up with the latest improvements and features.



Note: You need an Internet connection and an Apple ID to use the App Store. The App Store is not available in all areas.

Find apps

If you know what you're looking for, tap Search. Or tap Categories to browse by type of app.

Ask Siri to find it. Siri can search for items and make purchases in the App Store. For example, tell Siri to "Find apps by Apple" or "Purchase *app name*."

Access family members' apps. With Family Sharing turned on, you can view and download apps purchased by other family members. Tap Purchased, tap your name or My Purchases, then select a family member from the menu. For more information, see Family Sharing on page 38.

Want to tell a friend about an app? Find the app, tap ⬆, then choose the method. See Share from apps on page 37.

Use Wish List. To track an app you might want to purchase later, tap ⬆ on the app page, then tap Add to Wish List.

Search apps by category. Tap Explore, scroll to Categories, then tap a category to focus on the apps you want, for example, Education, Medical, or Sports. Tap subcategories to further refine your results.

What apps are being used nearby? Tap Explore to find out the most popular apps others around you are using (Location Services must be on in Settings > Privacy > Location Services). Try this at a museum, sporting event, or when you're traveling, to dig deeper into your experience.

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more o n o
or p rch e

hec o t pp
in o r re
o intere t

Delete an app. Touch and hold the app icon on the Home screen until the icon jiggles, then tap ⊗. When you finish, press the Home button. You can't delete built-in apps. Deleting an app also deletes its data. You can download any app you've purchased from the App Store again, free of charge.

For information about erasing all of your apps, data, and settings, see Restart or reset iPhone on page 184.

Purchase, redeem, and download

Tap the app's price, then tap Buy to purchase it. If it's free, tap Free, then tap Install.

If you see ☁ instead of a price, you've already purchased the app and you can download it again, free of charge. While the app is downloading or updating, its icon appears on the Home screen with a progress indicator.

Approve purchases with Family Sharing. With Family Sharing set up, the family organizer can review and approve purchases made by other family members under the age of 18. For example, if Parent/Guardian > Ask to Buy is set for specific minor family members, when those members try to make a purchase, a message is sent to the family organizer for approval. For more information about setting up Family Sharing, see Family Sharing on page 38.

Note: Age restrictions for Ask to Buy vary by area. In the United States, the family organizer can enable Ask to Buy for any family member under age 18; for children under age 13, it's enabled by default.

Find out more about the requested app.

Hide individual purchases. Using iTunes on a computer, family members can hide any of their purchases so other family members can't view or download them. For more information, see Family Sharing on page 38.

Use a gift card or code. Tap Featured, scroll to the bottom, then tap Redeem. Or tell Siri "Redeem an iTunes Store gift card."

Send a gift. View the item you want to give, tap ⬆, then tap Gift. Or tap Featured, scroll to the bottom, then tap Send Gift to send an iTunes gift certificate to someone.

Restrict in-app purchases. Many apps provide extra content or enhancements for a fee. To limit purchases that can be made from within an app, go to Settings > General > Restrictions (make sure Restrictions is enabled), then set options (for example, restrict by age rating or require a password immediately or every 15 minutes). You can turn off In-App Purchases to prevent all purchases. See Restrictions on page 43.

Use iTunes Pass. You can add an iTunes Pass to Passbook, which makes it easy to add money to your Apple ID so you can make purchases from the iTunes Store, App Store, and iBooks Store without using a credit or debit card. To add your iTunes Pass in App Store, tap Featured, scroll to the bottom, tap Redeem, then tap Get Started under iTunes Pass. You can add money to your iTunes Pass at Apple Retail Stores in most countries.

App Store settings

To set options for the App Store, go to Settings > iTunes & App Store.

View or edit your account. Tap your Apple ID, then tap View Apple ID. To change your password, tap the Apple ID field, then tap Password.

Sign in using a different Apple ID. Tap your account name, then tap Sign Out. Then enter the other Apple ID.

Turn off automatic downloads. Tap Apps in Automatic Downloads. Apps update automatically over Wi-Fi, unless you turn off the option.

Download apps using the cellular network. Turn on Use Cellular Data. Downloading apps over the cellular network may incur carrier charges. Newsstand apps update only over Wi-Fi.

iBooks

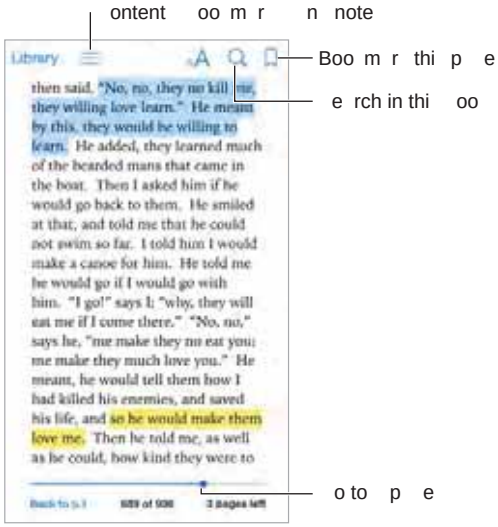
24

Get books

Get books from the iBooks Store. In iBooks, use the buttons at the bottom of the screen to access the iBooks Store. Tap Featured to browse the latest releases, or Top Charts to view the most popular. To find a specific book, tap Search.

Use Siri. Say, for example, "Find books by *author name*."

Read a book



Open a book. Tap the book you want to read. If you don't see it on the bookshelf, swipe left or right to see other collections.

Show the controls. Tap near the center of a page. Not all books have the same controls, but some of the things you can do include searching, viewing the table of contents, and sharing what you're reading.

Close a book. Tap Library, or pinch the page.

Enlarge an image. Double-tap the image. In some books, touch and hold to display a magnifying glass you can use to view an image.

Go to a specific page. Use the page navigation controls at the bottom of the screen. Or tap 🔍 and enter a page number, then tap the page number in the search results.

Get a definition. Double-tap a word, then tap Define in the menu that appears. Definitions aren't available for all languages.

Remember your place. Tap to add a bookmark, or tap again to remove it. You can have multiple bookmarks—to see them all, tap , then tap Bookmarks. You don't need to add a bookmark when you close the book because iBooks remembers where you left off.

Remember the good parts. Some books let you add highlights and notes. To add a highlight, touch and hold a word then move your finger to draw the highlight. To add a note, double-tap a word to select it, move the grab points to adjust the selection, then tap Note in the menu that appears. To see all the highlights and notes you've made, tap , then tap Notes.

Share the good parts. Tap some highlighted text, then, in the menu that appears, tap . If the book is from the iBooks Store, a link to the book is included automatically. (Sharing may not be available in all regions.)

Share a link to a book. Tap near the center of a page to display the controls, then tap . Tap , then tap Share Book.

Change the way a book looks. Some books let you change the font, font size, and color of the page. (Tap AA.) You can also change justification and hyphenation in Settings > iBooks. These settings apply to all books that support them.

Change the brightness. Tap . If you don't see , tap AA first.

Dim the screen when it's dark. Turn on Auto-Night Theme to automatically change the bookshelf, page color, and brightness when using iBooks in low-light conditions. (Not all books support Auto-Night Theme.)

Organize books

View books by title or by cover. Tap ⊞ or ☰.

Organize your books with collections. Tap Select, then select some books to move them into a collection. To edit or create collections, tap the name of the current collection (at the top of the screen). Some built-in collections, such as PDFs, can't be renamed or deleted.

Rearrange books. While viewing books by cover, touch and hold a cover, then drag it to a new location. While viewing books by title, sort the list using the buttons at the top of the screen. The All Books collection is automatically arranged for you; switch to another collection if you want to manually arrange your books.

Search for a book. Pull down to reveal the Search field at the top of the screen. Searching looks for the title and the author's name.

Hide purchased books you haven't downloaded. Tap the name of the current collection (at the top of the screen), then turn on Hide iCloud Books.

Read PDFs

Sync a PDF. On a Mac, add the PDF to iBooks for OS X, open iTunes, select the PDF, then sync. In iTunes on your Windows computer, choose File > Add to Library, select the PDF, then sync. See iTunes Help for more info about syncing.

Add a PDF email attachment to iBooks. Open the email message, then touch and hold its PDF attachment. Choose Open in iBooks from the menu that appears.

Print a PDF. With the PDF open, tap ⬆, then choose Print. You'll need an AirPrint-compatible printer. For more about AirPrint, see AirPrint on page 41.

Email a PDF. With the PDF open, tap ⬆, then choose Email.

iBooks settings

Go to Settings > iBooks, where you can:

- Sync collections and bookmarks (including notes and current page information) with your other devices.
- Display online content within a book. Some books might access video or audio that's stored on the web.
- Change the direction pages turn when you tap in the left margin.

Health

25

Your health at a glance

Use the Health app to keep track of your health and fitness information. Enter data for key parameters, or let the Health app collect data from other apps and devices that monitor your health and activity. You can even share specific data with selected apps, and through apps with some health care providers. And, Health can display important contact and medical information on the iPhone Lock screen for someone attending to you in an emergency.

If you have an Apple Watch, you can send activity, workout, and even heart rate data to your iPhone so you can view it in the Health app.

WARNING: iPhone, Apple Watch, and the Health app are not medical devices. See Important safety information on page 181.

Collect health and fitness data

Enter your own data. If the parameter is in your Dashboard, just tap it there, then tap Add Data Point. Otherwise, tap Health Data at the bottom of the screen, tap the parameter you want to update, then tap Add Data Point.

Collect data from Apple Watch. Once you pair Apple Watch with your iPhone, data is automatically sent to the Health app. For example, to see heart rate data recorded by Apple Watch, open the Health app on iPhone, then tap Health Data > Vitals > Heart Rate.

Collect data from another device. Follow the instructions that can come with the device to set it up. If it's a Bluetooth device, you need to pair it with iPhone—see Bluetooth devices on page 42.

Collect data from an app. Follow the instructions that can come with the app to set it up, then watch for a sharing request where you control whether data is shared with the Health app.

Stop app data collection. Tap Sources at the bottom of the Health screen, then select the app in the Apps list. Or tap the associated parameter in your Dashboard or in the Health Data list, tap Share Data, then choose the app under Data Sources.

Share health and fitness data

Share data. Follow the instructions that can come with the app or the device to set it up, then watch for a sharing request where you control whether data is shared by the Health app. For example, your health care provider might provide an app that sends blood pressure updates to your doctor. You need only install the app, then allow the Health app to share blood pressure data when prompted.

Stop sharing data. Tap Sources at the bottom of the Health screen, then select the app in the Apps list. Or tap the associated parameter in your Dashboard or in the Health Data list, tap Share Data, then choose the app under Share Data With.

Create an emergency medical ID

Your iPhone can display important contact and medical information on the Lock screen, where it's available for someone attending to you in an emergency.

Note: Anyone with physical access to your iPhone can read the information you include in your emergency medical ID.

Set up your medical ID. In the Health app, tap Medical ID in the bottom right of the screen.

View your ID. When you wake iPhone, slide to the passcode screen, then tap Emergency.

Prevent viewing. Tap Medical ID, tap Edit, then turn off Show Medical ID.

Passbook

26

Passbook at a glance

Use Passbook to keep your boarding passes, movie tickets, coupons, loyalty cards, and more, all in one place. Scan a pass on iPhone to check in for a flight, get in to a movie, or redeem a coupon. Passes can include useful information, such as the balance on your coffee card, a coupon's expiration date, or your seat number for a concert.

With iPhone 6 or iPhone 6 Plus, you can add credit and debit cards to Passbook and use them to make purchases in stores that accept contactless payments, and within apps that support Apple Pay (available only in the U.S.). See Apple Pay on page 130.

p to cre it
or e it c r

p cre it or e it
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p to p

p p to ie it

Passbook on the go

Find apps that support Passbook. Tap Apps for Passbook on the Welcome pass. Or, on your computer, go to www.itunes.com/passbookapps/. You can add a pass from an app, an email or a Messages message, or a website when you make a purchase or receive a coupon or gift. Usually, you tap or click the pass or the link to a pass to add it to Passbook. You can also scan codes, which are then downloaded to Passbook, from merchants' ads or receipts.

Scan a code. Tap ⊕, then tap Scan Code. Point your iPhone at the code and frame it to add the pass.

p to ie
c nnin option

Use a pass. If an alert for a pass appears on the Lock screen, slide the alert to display the pass. Or open Passbook, select the pass, then present the barcode on the pass to the scanner.

Share a pass. You can share a pass using Mail, Messages, or AirDrop (iPhone 5 or later). See Share from apps on page 37.

Display a pass based on location. A pass can appear on the Lock screen when you wake iPhone at the right time or place—for example, when you reach the airport for a flight you're taking. Location Services must be turned on in Settings > Privacy > Location Services.

Rearrange passes. Drag a pass in the stack to move it to a new location. The pass order is updated on all your iOS 7 or later devices.

Refresh a pass. Passes are usually updated automatically. To refresh a pass manually, tap the pass, tap ⓘ, then pull the pass downward.

Use iTunes Pass. You can add an iTunes Pass to Passbook, which makes it easy to add money to your Apple ID so you can make purchases from the iTunes Store, App Store, and iBooks Store without using a credit or debit card. To add your iTunes Pass in App Store, tap Featured, scroll to the bottom, tap Redeem, then tap Get Started under iTunes Pass. You can add money to your iTunes Pass at Apple Retail Stores in most countries.

Done with a pass? Tap the pass, tap ⓘ, then tap Delete.

Apple Pay

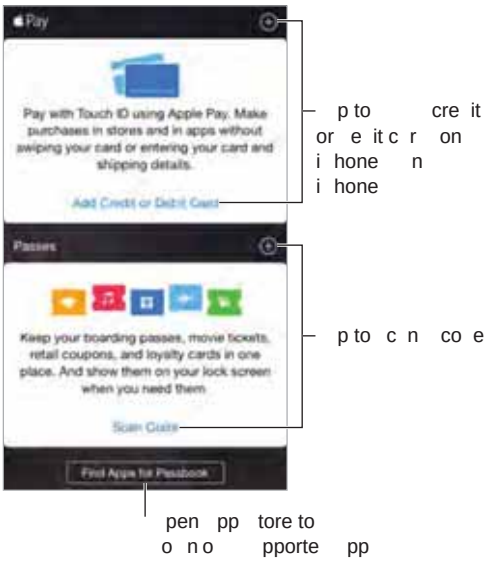
With iPhone 6 or iPhone 6 Plus, you can use Apple Pay (available only in the U.S.). With Apple Pay, you can keep up to eight credit and debit cards available for making contactless payments in stores, and for making payments within apps that support Apple Pay. (Apps supporting Apple Pay sell physical goods and services such as clothing, electronics, health and beauty products, tickets, reservations, and more.)

Credit cards and debit cards appear at the top of your Passbook stack, above your passes. The last four or five digits of your credit or debit card number appear on both the front and the back of a payment card. The front of a card also shows your most recent activity. The back also shows the last four or five digits of the Device Account Number—the number transmitted to stores and apps for the purchase—and may also display up to 10 recent authorizations and other Apple Pay activity such as payment refunds. (Apple Pay activity is included on your credit and debit card statements.)

Use your card on file with iTunes. The first time you add a credit or debit card to Passbook, you may be prompted to use the card you use with iTunes (unless it's the card designated for Family Sharing purchases, and you aren't the primary cardholder—see Family Sharing on page 38). Next to Apple Pay, tap ⊕, then tap Next on the screen that follows. You are presented with the last four digits of the card on file. Enter the security code for the card, then tap Next to verify your card.

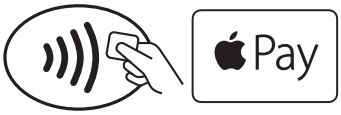
Add a credit or debit card. Next to Apple Pay, tap ⊕, then tap Next on the screen that follows. Then, position iPhone so that your card appears in the frame. Card details are added automatically, but you may be prompted for additional information.

Note: The card issuer determines if your card is eligible to use with Apple Pay, and may ask you to provide additional information to complete the verification process. Many U.S. credit and debit cards can be used with Apple Pay. For information about Apple Pay availability and current card issuers, go to support.apple.com/kb/HT6288.



Set your default card. The first card you add to Passbook becomes your default card for payments. To use a different card as your default, make the change in Settings > Passbook & Apple Pay > Default Card.

Pay at a contactless card reader. Contactless card readers, marked with the following symbol, are usually located near cash registers.



To pay with your default card, hold iPhone 6 or iPhone 6 Plus with your finger on Touch ID about an inch (or 2.5 cm) away from the symbol on the reader, until iPhone vibrates. You see the card onscreen with a Done checkmark when the card information has been transmitted to the merchant. Or you can start by holding iPhone near a reader until the screen asks you to authenticate with Touch ID or your passcode. After you authenticate, hold iPhone near the reader again until it vibrates and you see the Done checkmark.

Note: If you have Location Services turned on, the location of your iPhone at the time you make a purchase may be sent to Apple. See Privacy on page 43.

Use another card. Hold iPhone 6 or iPhone 6 Plus near the reader until your default card appears. Tap the card to reveal all your cards in Passbook, tap the card you want to use, then place your finger on Touch ID and hold iPhone near the reader until you feel it vibrate and see the Done checkmark, indicating that the card information has been transmitted to the merchant.

Pay within an app. Make your selections for goods or services within an app. When checking out, look for the Apple Pay payment option. Tap Apple Pay, then review the information that appears (for example, the card you're using for the payment, your email, and the shipping method). Make any changes before using Touch ID or your passcode to complete the payment.

Activity details appear on the front of the credit card used for the purchase. In addition, you may receive a notification with the merchant name, and the amount authorized for the purchase. Your zip code may be provided to the merchant to calculate tax and shipping costs. Payment information—such as billing and shipping addresses, email address, and phone number—may also be provided to the merchant once you authorize the payment with Touch ID or a passcode.

Note: The authorized amount may be different from the amount of the payment charged to your account. For example, a gas station may authorize $99, even though you only pump $25 worth of gasoline. Always check your credit or debit card statement for the actual charges.

View your recent credit card activity. Tap a credit card. Your most recent activity may appear on the front. Tap ⓘ to view a list of your recent activity on the back of the card.

Suspend and remove cards. You have several options for suspending or removing credit and debit cards. To remove a credit or debit card from Passbook, tap the card, tap ⓘ, then tap Remove. To remove an inactive card, tap Remove on the front of the card. If your iPhone is lost or stolen and you have enabled Find My iPhone, you can use it to help you locate and secure your iPhone—including suspending or removing your credit and debit cards in Passbook. See Find My iPhone on page 46. You can log in to your account at iCloud.com and remove your cards in Settings > My Devices. You can also call the issuers of your cards.

Passbook & Apple Pay settings

Add and manage credit and debit cards. (iPhone 6 and iPhone 6 Plus) To add credit or debit cards, manage existing cards, change the default payment card, modify the shipping addresses used for Apple Pay purchases, phone number, or change contact information for purchases, go to Settings > Passbook & Apple Pay.

Change billing information. Tap a credit or debit card, tap ⓘ, then tap the billing address to make changes. Tap Enter a New Billing Address to add a new one.

Keep passes from appearing on the Lock screen. Go to Settings > Touch ID & Passcode (iPhone models with Touch ID) or Settings > Passcode (other models), then tap Turn Passcode On. Then, under Allow Access When Locked, turn off Passbook. For passes with notifications, to keep a specific pass from appearing on the Lock screen, tap the pass, tap ⓘ, then turn off Show On Lock Screen.

Set notification options. Go to Settings > Notifications > Passbook.

Include passes on your other iOS devices. Go to Settings > iCloud, then turn on Passbook.

Note: This setting applies only to the passes in Passbook, not to the credit or debit cards.

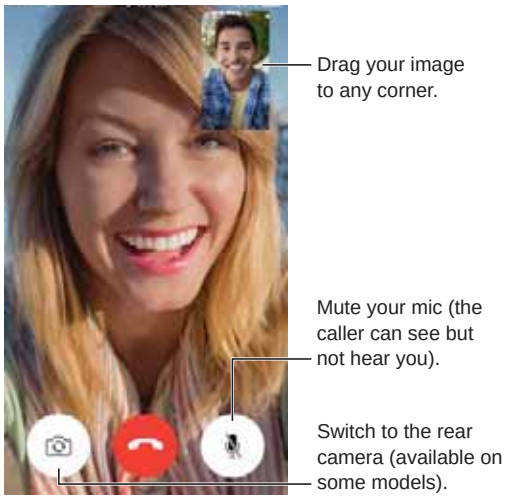
FaceTime

27

FaceTime at a glance

Use FaceTime to make video or audio calls to other iOS devices or computers that support FaceTime. The FaceTime camera lets you talk face-to-face; switch to the rear iSight camera (not available on all models) to share what you see around you.

Note: FaceTime may not be available in all areas.



With a Wi-Fi connection and an Apple ID, you can make and receive FaceTime calls (first sign in using your Apple ID, or create a new account). You can also make FaceTime calls over a cellular data connection, which may incur additional charges. To turn off this feature, go to Settings > Cellular. For more information about cellular usage and settings, see Cellular settings on page 188.

Make and answer calls

Make a FaceTime call. Make sure FaceTime is turned on in Settings > FaceTime. Tap FaceTime, then type the name or number you want to call in the entry field at the top. Tap to make a video call, or tap to make a FaceTime audio call. Or tap to open Contacts and start your call from there.

Tap an icon to start a FaceTime call.

Use your voice to start the call. Press and hold the Home button, then say "FaceTime," followed by the name of the person to call.

Want to call again? Tap FaceTime to see your call history on the screen. Tap Audio or Video to refine your search, then tap a name or number to call again. Tap ⓘ to open the name or number in Contacts.

Delete a call from call history. Tap FaceTime to see your call history on the screen. Swipe to the left, then tap Delete to delete the name or number from your call history.

Can't take a call right now? When a FaceTime call comes in, you can answer, decline, or choose another option.

Use Siri. Say, for example, "Make a FaceTime call."

See the whole gang. Rotate iPhone to use FaceTime in landscape orientation. To avoid unwanted orientation changes, lock iPhone in portrait orientation. See Change the screen orientation on page 25.

Manage calls

Multitask during a call. Press the Home button, then tap an app icon. You can still talk with your friend, but you can't see each other. To return to the video, tap the green bar at the top of the screen.

Juggle calls. FaceTime calls aren't forwarded. If another call comes in while you're on a FaceTime call, you can either end the first call and answer the incoming call, decline the incoming call, or reply with a text message. You can use call waiting with FaceTime audio calls only.

Use call waiting for audio calls. If you're on a FaceTime audio call and another call comes in—either a phone call or another FaceTime audio call—you can decline the call, end the first call and accept the new one, or put the first call on hold and respond to the new call.

Block unwanted callers. Go to Settings > FaceTime > Blocked > Add New. You won't receive voice calls, FaceTime calls, or text messages from blocked callers. For more information about blocking calls, see support.apple.com/kb/HT5845.

Settings

Go to Settings > FaceTime, where you can:

- Turn FaceTime on or off
- Specify a phone number, Apple ID, or email address to use with FaceTime
- Set your caller ID

Calculator

28

Tap numbers and functions in Calculator, just as you would with a standard calculator.

Get to Calculator quickly! Swipe up from the bottom edge of the screen to open Control Center.

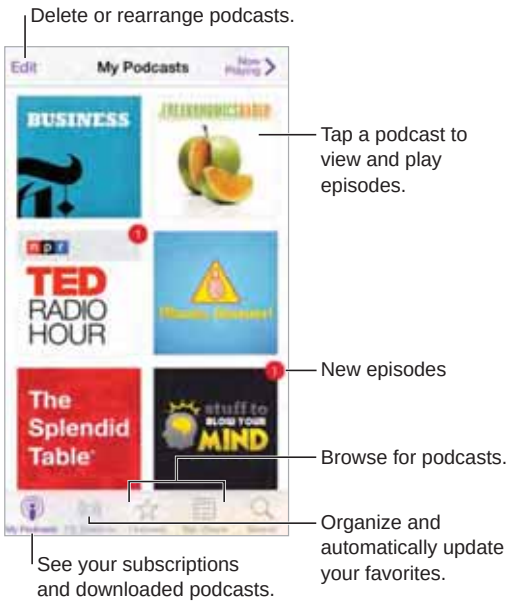
To use the scientific calculator, rotate iPhone to landscape orientation.

Podcasts

29

Podcasts at a glance

Open the Podcasts app, then browse, subscribe to, and play your favorite audio or video podcasts on iPhone.



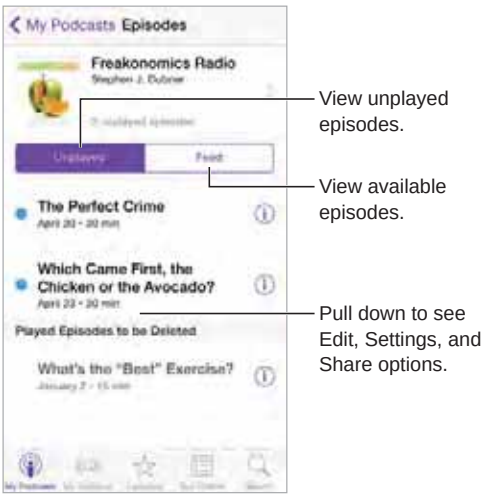
Get podcasts and episodes

Discover more podcasts. Tap Featured or Top Charts at the bottom of the screen.

Search for new podcasts. Tap Search at the bottom of the screen.

Search your library. Tap My Podcasts, then drag down the center of the screen to reveal the Search field.

Preview or stream an episode. Tap the podcast, then tap an episode.



Get more info. Tap ⓘ to get episode details. Tap any link in podcast or episode descriptions to open them in Safari.

Find new episodes. Tap Unplayed to find episodes you haven't yet heard.

Browse episodes. Tap Feed to see episodes available to download or stream.

Download an episode to iPhone. Tap ☁ next to the episode.

Get new episodes as they're released. Subscribe to the podcast. If you're browsing Featured podcasts or Top Charts, tap the podcast, then tap Subscribe. If you've already downloaded episodes, tap My Podcasts, tap the podcast, tap Settings at the top of the episode list, then turn on Subscription.

Save episodes. Tap ⓘ next to an episode, then tap Save Episode. Tap Delete Download to delete a saved episode.

Control playback

Use the playback controls to go forward and back in a podcast, set the speed, skip episodes, and more.

See podcast info while you listen. Tap the podcast image on the Now Playing screen.

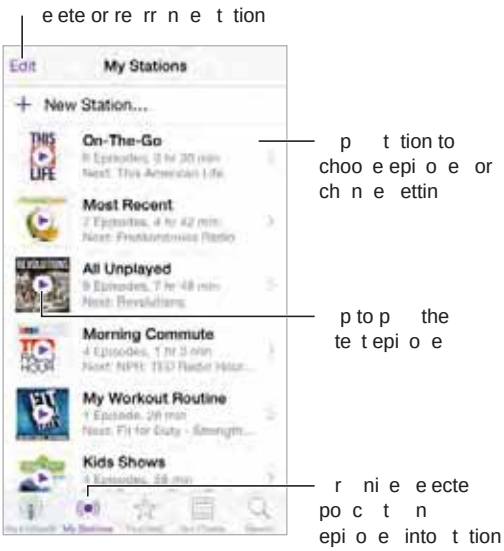
Skip forward or back with greater accuracy. Move your finger toward the top of the screen as you drag the playhead left or right. When you're close to the playback controls, you can scan quickly through the entire episode. When you're close to the top of the screen, you can scan one second at a time.

Use Siri. Say something like:

- "Play podcasts"
- "Play it twice as fast"
- "Skip ahead 10 seconds"

Organize your favorites into stations

Organize your favorite podcasts into custom stations, and update episodes automatically across all your devices.



Pull together episodes from different podcasts. To add episodes to your On-The-Go station, tap My Stations, tap On-The-Go, then tap Add. Or tap ⓘ next to any episode in your library. You can also touch and hold any episode, then tap Add to On-The-Go.

Create a station. Tap My Stations, then tap ⊕.

Change the order of the station list or the podcasts in a station. Tap My Stations, tap Edit above the station list or the episode list, then drag ≡ up or down.

Change the playback order for episodes in a station. Tap the station, then tap Settings.

Rearrange your podcast library. Tap My Podcasts, tap list view in the upper right, tap Edit, then drag ≡ up or down.

List oldest episodes first. Tap My Podcasts, tap a podcast, then tap Settings.

Play podcasts from the station list. Tap ▶ next to the station name.

Podcasts settings

Go to Settings > Podcasts, where you can:

- Choose to keep your podcast subscriptions up to date on all your devices
- Choose how frequently Podcasts checks your subscriptions for new episodes
- Have episodes downloaded automatically
- Choose whether to keep episodes after you finish them

Compass

30

Compass at a glance

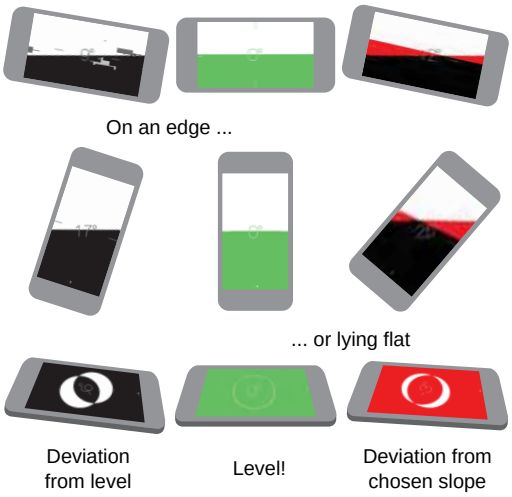
Find a direction, see your latitude and longitude, find level, or match a slope.

See your location. To see your current location, go to Settings > Privacy > Location Services, then turn on Location Services and Compass. For more about Location Services, see Privacy on page 43.

Stay on course. Tap the screen to lock in the current heading, then watch for a red band to see if you're off course.

Important: The accuracy of the compass can be affected by magnetic or environmental interference; even the magnets in the iPhone earbuds can cause a deviation. Use the digital compass only for basic navigation assistance. Don't rely on it to determine precise location, proximity, distance, or direction.

On the level



Show the level. Swipe left on the Compass screen.

Hang it straight. Hold iPhone against a picture frame or other object, then rotate them until you see green. For true level, the deviation is displayed on a black background. If the background is red (indicating relative slope), tap the screen to change it to black.

Level the table. Lay iPhone flat on the table.

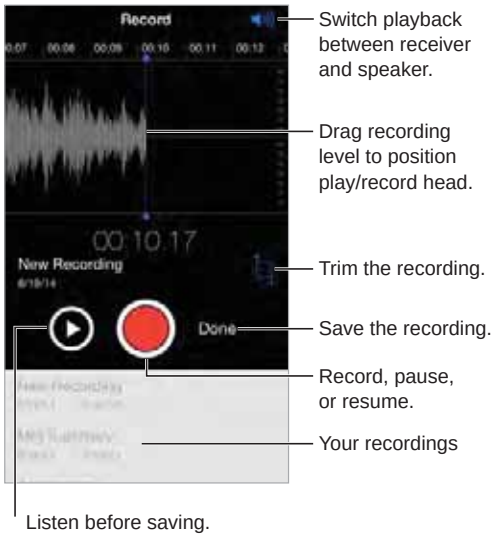
Match that slope. Hold iPhone against the surface you want to match, then tap the screen to capture the slope. The slope you seek is shown in black, with deviation shown in red. Tap again to return to standard level.

Voice Memos

31

Voice Memos at a glance

Voice Memos lets you use iPhone as a portable recording device. Use it with the built-in microphone, an iPhone or Bluetooth headset mic, or a supported external microphone.



Record

Make a recording. Tap ● or press the center button on your headset. Tap again to pause or resume.

Recordings using the built-in microphone are mono, but you can record stereo using an external stereo microphone that works with the iPhone headset jack, or with the Lightning connector (iPhone 5 or later) or 30-pin dock connector (iPhone 4s). Look for accessories marked with the Apple "Made for iPhone" or "Works with iPhone" logo.

Adjust the recording level. Move the microphone closer to what you're recording. For better recording quality, the loudest level should be between –3 dB and 0 dB.

Preview before saving. Tap ▶ to the left of the Record button. To position the play head, drag the recording level display left or right.

Record over a section. Drag the recording level display to position the record/play head, then tap ●.

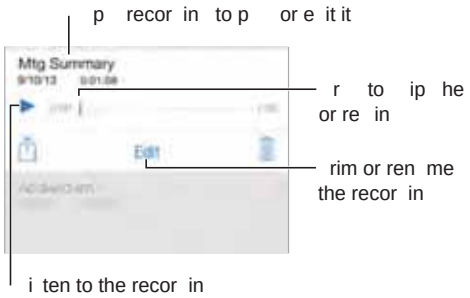
Trim the excess. Tap ⌗, then drag the red trim handles. Tap ▶ to check your edit. Adjust the trim handles if necessary, then tap Trim when you're finished.

Save the recording. Tap Done.

Mute the start and stop tones. Use the iPhone volume buttons to turn the volume all the way down.

Multitask. To use another app while you're recording, press the Home button, then open the other app. To return to Voice Memos, tap the red bar at the top of the screen.

Play it back



Rename a recording. Tap the name of the recording.

Move recordings to your computer

You can sync voice memos with the iTunes library on your computer, then listen to them on your computer or sync them with another iPhone or iPod touch.

When you delete a synced voice memo from iTunes, it stays on the device where it was recorded, but is deleted from any other iPhone or iPod touch you synced. If you delete a synced voice memo on iPhone, it's copied back to iPhone the next time you sync with iTunes, but you can't sync that copy back to iTunes a second time.

Sync voice memos with iTunes. Connect iPhone to your computer. Open iTunes on your computer, then select iPhone. Select Music at the top of the screen (between Apps and Movies), select Sync Music, select "Include voice memos," then click Apply.

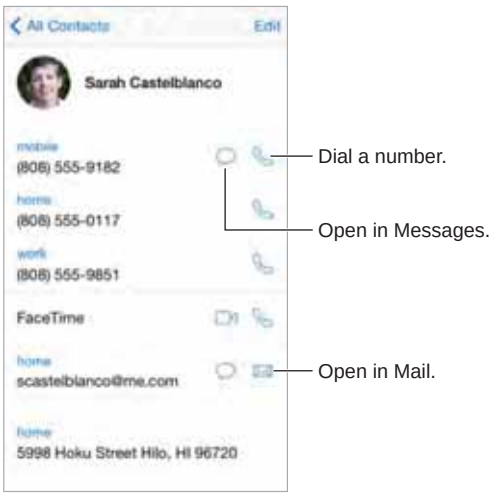
Voice memos synced from iPhone to your computer appear in the Music list and in the Voice Memos playlist in iTunes. Voice memos synced from your computer appear in the Voice Memos app on iPhone, but not in the Music app.

Contacts

32

Contacts at a glance

iPhone lets you access and edit your contact lists from personal, business, and other accounts.



Set your My Info card for Safari, Siri, and other apps. Go to Settings > Mail, Contacts, Calendars, tap My Info, then select the contact card with your name and information.

Let Siri know who's who. On your contact card, tap Add Related Name to define relationships you want Siri to know about, so you can say things like "send a message to my sister."

Use Siri. Say, for example, "Sarah Castelblanco is my sister."

Find a contact. Tap the search field at the top of the contacts list, then enter your search. You can also search your contacts using Spotlight Search (see Spotlight Search on page 34).

Use Siri. Say, for example, "What's my brother's work address?"

Share a contact. Tap a contact, then tap Share Contact. See Share from apps on page 37.

Change a label. If a field has the wrong label, such as Home instead of Work, tap Edit. Then tap the label and choose one from the list, or tap Add Custom Label to create one of your own.

Add your friends' social profiles. While viewing a contact, tap Edit, then tap "add social profile." You can add Twitter, Facebook, LinkedIn, Flickr, Myspace, and Sina Weibo accounts, or create a custom entry.

Delete a contact. Go to the contact's card, then tap Edit. Scroll down, then tap Delete Contact.

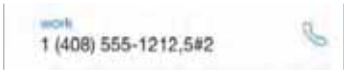
Use Contacts with Phone

Prioritize your contacts. When you add someone to your Favorites list, their calls bypass Do Not Disturb and are added to your Favorites list in Phone for quick dialing. Choose a contact, then scroll down and tap Add to Favorites.

Save the number you just dialed. In Phone, tap Keypad, enter a number, then tap Add to Contacts. Tap Create New Contact, or tap Add to Existing Contact, then choose a contact.

Add a recent caller to Contacts. In Phone, tap Recents, then tap ⓘ next to the number. Then tap Create New Contact, or tap Add to Existing Contact and choose a contact.

Automate dialing an extension or passcode. If the number you're calling requires dialing an extension, iPhone can enter it for you. When editing a contact's phone number, tap + * # to enter pauses in the dialing sequence. Tap Pause to enter a two-second pause, which is represented by a comma. Tap Wait to stop dialing until you tap Dial again, which is represented by a semicolon.



Add contacts

Besides entering contacts, you can:

- *Use your iCloud contacts:* Go to Settings > iCloud, then turn on Contacts.
- *Import your Facebook Friends:* Go to Settings > Facebook, then turn on Contacts in the "Allow These Apps to Use Your Accounts" list. This creates a Facebook group in Contacts.
- *Use your Google contacts:* Go to Settings > Mail, Contacts, Calendars, tap your Google account, then turn on Contacts.
- *Access a Microsoft Exchange Global Address List:* Go to Settings > Mail, Contacts, Calendars, tap your Exchange account, then turn on Contacts.
- *Set up an LDAP or CardDAV account to access business or school directories:* Go to Settings > Mail, Contacts, Calendars > Add Account > Other. Tap Add LDAP account or Add CardDAV account, then enter the account information.
- *Sync contacts from your computer:* In iTunes on your computer, turn on contact syncing in the device info pane. For information, see iTunes Help.
- *Import contacts from a SIM card (GSM):* Go to Settings > Mail, Contacts, Calendars > Import SIM Contacts.
- *Import contacts from a vCard:* Tap a .vcf attachment in an email or message.

Search a directory. Tap Groups, tap the GAL, CardDAV, or LDAP directory you want to search, then enter your search. To save a person's info to your contacts, tap Add Contact.

Show or hide a group. Tap Groups, then select the groups you want to see. This button appears only if you have more than one source of contacts.

Update your contacts using Twitter, Facebook, and Sina Weibo. Go to Settings > Twitter, Settings > Facebook, or Settings > Sina Weibo, then tap Update Contacts. This updates contact photos and social media account names in Contacts.

Unify contacts

When you have contacts from multiple sources, you might have multiple entries for the same person. To keep redundant contacts from appearing in your All Contacts list, contacts from different sources that have the same name are linked and displayed as a single *unified contact*. When you view a unified contact, the title Unified Info appears.

Link contacts. If two entries for the same person aren't linked automatically, you can unify them manually. Edit one of the contacts, tap Edit, tap Link Contact, then choose the other contact entry to link to.

Linked contacts aren't merged. If you change or add information in a unified contact, the changes are copied to each source account where that information already exists.

If you link contacts with different first or last names, the names on the individual cards won't change, but only one name appears on the unified card. To choose which name appears when you view the unified card, tap Edit, tap the linked card with the name you prefer, then tap Use This Name For Unified Card.

Contacts settings

Go to Settings > Mail, Contacts, Calendars, where you can:

- Change how contacts are sorted
- Display contacts by first or last name
- Change how long names are shortened in lists
- Choose to show recent and favorite contacts in the multitasking screen
- Set a default account for new contacts
- Set your My Info card

Accessibility

A Appendix

Accessibility features

iPhone offers many accessibility features:

Vision

- VoiceOver
- Support for braille displays
- Zoom
- Invert Colors and Grayscale
- Speak Selection
- Speak Screen
- Speak Auto-text
- Large, bold, and high-contrast text
- Button Shapes
- Reduce screen motion
- On/off switch labels
- Assignable ringtones and vibrations
- Video Descriptions

Hearing

- Hearing aids
- Call audio routing
- Phone noise cancelation
- LED Flash for Alerts
- Subtitles and closed captions
- Mono audio and balance

Interaction

- Siri
- Widescreen keyboards
- Guided Access
- Switch Control
- AssistiveTouch

Turn on accessibility features. Go to Settings > General > Accessibility, or use the Accessibility Shortcut. See Accessibility Shortcut below.

With your voice, you can also use Siri to open apps, invert colors, read the screen in some apps, and work with VoiceOver. See Chapter 4, Siri, on page 48.

Use iTunes on your computer to configure accessibility on iPhone. You can choose some accessibility options in iTunes on your computer. Connect iPhone to your computer, then select iPhone in the iTunes device list. Click Summary, then click Configure Accessibility at the bottom of the Summary screen.

For more information about iPhone accessibility features, see www.apple.com/accessibility/.

Accessibility Shortcut

Use the Accessibility Shortcut. Press the Home button quickly three times to turn any of these features on or off:

- VoiceOver
- Invert Colors
- Grayscale
- Zoom
- Switch Control
- AssistiveTouch
- Guided Access (The shortcut starts Guided Access if it's already turned on. See Guided Access on page 166.)
- Hearing Aid Control (if you have paired Made for iPhone hearing aids)

Choose the features you want to control. Go to Settings > General > Accessibility > Accessibility Shortcut, then select the accessibility features you use.

Not so fast. To slow down the triple-click speed, go to Settings > General > Accessibility > Home-click Speed. (This also slows down double-clicks.)

VoiceOver

VoiceOver describes aloud what appears onscreen, so you can use iPhone without seeing it.

VoiceOver tells you about each item on the screen as you select it. The VoiceOver cursor (a rectangle) encloses the item and VoiceOver speaks its name or describes it.

Touch the screen or drag your finger over it to hear the items on the screen. When you select text, VoiceOver reads the text. If you turn on Speak Hints, VoiceOver may tell you the name of the item and provide instructions—for example, "double-tap to open." To interact with items, such as buttons and links, use the gestures described in Learn VoiceOver gestures on page 152.

When you go to a new screen, VoiceOver plays a sound, then selects and speaks the first item on the screen (typically in the upper-left corner). VoiceOver also lets you know when the display changes to landscape or portrait orientation, and when the screen becomes dimmed or locked.

Note: VoiceOver speaks in the language specified in Settings > General > Language & Region. VoiceOver is available in many languages, but not all.

VoiceOver basics

Important: VoiceOver changes the gestures you use to control iPhone. When VoiceOver is on, you must use VoiceOver gestures to operate iPhone—even to turn VoiceOver off.

Turn VoiceOver on or off. Go to Settings > General > Accessibility > VoiceOver, or use the Accessibility Shortcut. See Accessibility Shortcut above.

Use Siri. Say:

- "Turn VoiceOver on"
- "Turn VoiceOver off"

Explore. Drag your finger over the screen. VoiceOver speaks each item you touch. Lift your finger to leave an item selected.

- *Select an item:* Tap it, or lift your finger while dragging over it.
- *Select the next or previous item:* Swipe right or left with one finger. Item order is left-to-right, top-to-bottom.
- *Select the item above or below:* Set the rotor to Vertical Navigation, then swipe up or down with one finger. If you don't find Vertical Navigation in the rotor, you can add it; see Use the VoiceOver rotor on page 153.
- *Select the first or last item on the screen:* Tap with four fingers at the top or bottom of the screen.
- *Select an item by name:* Triple-tap with two fingers anywhere on the screen to open the Item Chooser. Then type a name in the search field, or swipe right or left to move through the list alphabetically, or tap the table index to the right of the list and swipe up or down to move quickly through the list of items. You can also use handwriting to select an item by writing its name; see Write with your finger on page 155. To dismiss the Item Chooser without making a selection, do a two-finger scrub (move two fingers back and forth three times quickly, making a "z").
- *Change an item's name so it's easier to find:* Select the item, then double-tap and hold with two fingers anywhere on the screen.
- *Speak the text of the selected item:* Set the rotor to characters or words, then swipe down or up with one finger.
- *Turn spoken hints on or off:* Go to Settings > General > Accessibility > VoiceOver > Speak Hints.
- *Use phonetic spelling:* Go to Settings > General > Accessibility > VoiceOver > Phonetic Feedback.
- *Speak the entire screen, from the top:* Swipe up with two fingers.
- *Speak from the current item to the bottom of the screen:* Swipe down with two fingers.
- *Pause speaking:* Tap once with two fingers. Tap again with two fingers to resume, or select another item.
- *Mute VoiceOver:* Double-tap with three fingers; repeat to unmute. If you're using an external keyboard, press the Control key.
- *Silence sound effects:* Go to Settings > General > Accessibility > VoiceOver, then turn off Use Sound Effects.

Use a larger VoiceOver cursor. Go to Settings > General > Accessibility > VoiceOver, then turn on Large Cursor.

Adjust the speaking voice. You can adjust the VoiceOver speaking voice:

- *Change the volume:* Use the volume buttons on iPhone. You can also add volume to the rotor, then swipe up and down to adjust; see Use the VoiceOver rotor on page 153.
- *Change the speech rate:* Go to Settings > General > Accessibility > VoiceOver, then drag the Speaking Rate slider. You can also set the rotor to Speech Rate, then swipe up or down to adjust.
- *Use pitch change:* VoiceOver uses a higher pitch when speaking the first item of a group (such as a list or table) and a lower pitch when speaking the last item of a group. Go to Settings > General > Accessibility > VoiceOver > Use Pitch Change.
- *Speak punctuation:* Set the rotor to Punctuation, then swipe up or down to select how much you want to hear.

- *Control audio ducking:* To choose whether audio that's playing is turned down while VoiceOver speaks, set the rotor to Audio Ducking, then swipe up or down.
- *Change the language for iPhone:* Go to Settings > General > Language & Region. VoiceOver pronunciation of some languages is affected by the Region Format you choose there.
- *Change pronunciation:* Set the rotor to Language, then swipe up or down. Language is available in the rotor only if you select more than one pronunciation in Settings > General > Accessibility > VoiceOver > Speech > Rotor Languages.
- *Choose which dialects are available in the rotor:* Go to Settings > General > Accessibility > VoiceOver > Speech > Rotor Languages. To adjust voice quality or speaking rate, tap ⓘ next to the language. To remove languages from the rotor or change their order, tap Edit, tap the delete button or drag ≡ up or down, then tap Done.
- *Set the default dialect for the current iPhone language:* Go to Settings > General > Accessibility > VoiceOver > Speech.
- *Download an enhanced quality reading voice:* Go to Settings > General > Accessibility > VoiceOver > Speech, tap a language, then tap Enhanced Quality. If you're using English, you can choose to download Alex (869 MB), the same high-quality U.S. English voice used for VoiceOver on Mac computers.

Use iPhone with VoiceOver

Unlock iPhone. Press either the Home button or the Sleep/Wake button, swipe to select the Unlock button, then double-tap the screen.

Enter your passcode silently. To avoid having your passcode spoken as you enter it, use handwriting; see Write with your finger on page 155.

Open an app, toggle a switch, or tap an item. Select the item, then double-tap the screen.

Double-tap the selected item. Triple-tap the screen.

Adjust a slider. Select the slider, then swipe up or down with one finger.

Use a standard gesture. Double-tap and hold your finger on the screen until you hear three rising tones, then make the gesture. When you lift your finger, VoiceOver gestures resume. For example, to drag a volume slider with your finger instead of swiping up and down, select the slider, double-tap and hold, wait for the three tones, then slide left or right.

Scroll a list or area of the screen. Swipe up or down with three fingers.

- *Scroll continuously through a list:* Double-tap and hold until you hear three rising tones, then drag up or down.
- *Use the list index:* Some lists have an alphabetical table index along the right side. Select the index, then swipe up or down to move through the index. You can also double-tap, hold, then slide your finger up or down.
- *Reorder a list:* You can change the order of items in some lists, such as the Rotor items in Accessibility settings. Select ≡ to the right of an item, double-tap and hold until you hear three rising tones, then drag up or down.

Open Notification Center. Select any item in the status bar, then swipe down with three fingers. To dismiss Notification Center, do a two-finger scrub (move two fingers back and forth three times quickly, making a "z").

Open Control Center. Select any item in the status bar, then swipe up with three fingers. To dismiss Control Center, do a two-finger scrub.

Switch apps. Double-click the Home button to see open apps, swipe left or right with one finger to select an app, then double-tap to switch to it. Or, set the rotor to Actions while viewing open apps, then swipe up or down.

Rearrange your Home screen. Select an icon on the Home screen, double-tap and hold, then drag. Lift your finger when the icon is in its new location. Drag an icon to the edge of the screen to move it to another Home screen. You can continue to select and move items until you press the Home button.

Speak iPhone status information. Tap the status bar at the top of the screen, then swipe left or right to hear information about the time, battery state, Wi-Fi signal strength, and more.

Speak notifications. Go to Settings > General > Accessibility > VoiceOver, then turn on Always Speak Notifications. Notifications, including the text of incoming text messages, are spoken as they occur, even if iPhone is locked. Unacknowledged notifications are repeated when you unlock iPhone.

Turn the screen curtain on or off. Triple-tap with three fingers. When the screen curtain is on, the screen contents are active even though the display is turned off.

Learn VoiceOver gestures

When VoiceOver is on, standard touchscreen gestures have different effects, and additional gestures let you move around the screen and control individual items. VoiceOver gestures include two-, three-, and four-finger taps and swipes. For best results using multi-finger gestures, relax and let your fingers touch the screen with some space between them.

You can use different techniques to perform VoiceOver gestures. For example, you can perform a two-finger tap using two fingers on one hand, or one finger on each hand. You can even use your thumbs. Some people use a split-tap gesture: instead of selecting an item and double-tapping, touch and hold an item with one finger, then tap the screen with another finger.

Try different techniques to discover which works best for you. If a gesture doesn't work, try a quicker movement, especially for a double-tap or swipe gesture. To swipe, try brushing the screen quickly with your finger or fingers.

In VoiceOver settings, you can enter a special area where you can practice VoiceOver gestures without affecting iPhone or its settings.

Practice VoiceOver gestures. Go to Settings > General > Accessibility > VoiceOver, then tap VoiceOver Practice. When you finish practicing, tap Done. If you don't see the VoiceOver Practice button, make sure VoiceOver is turned on.

Here are some key VoiceOver gestures:

Navigate and read

- *Tap:* Select and speak the item.
- *Swipe right or left:* Select the next or previous item.
- *Swipe up or down:* Depends on the rotor setting. See Use the VoiceOver rotor on page 153.
- *Two-finger swipe up:* Read all from the top of the screen.
- *Two-finger swipe down:* Read all from the current position.
- *Two-finger tap:* Stop or resume speaking.
- *Two-finger scrub:* Move two fingers back and forth three times quickly (making a "z") to dismiss an alert or go back to the previous screen.
- *Three-finger swipe up or down:* Scroll one page at a time.

- *Three-finger swipe right or left:* Go to the next or previous page (on the Home screen, for example).
- *Three-finger tap:* Speak additional information, such as position within a list or whether text is selected.
- *Four-finger tap at top of screen:* Select the first item on the page.
- *Four-finger tap at bottom of screen:* Select the last item on the page.

Activate

- *Double-tap:* Activate the selected item.
- *Triple-tap:* Double-tap an item.
- *Split-tap:* As an alternative to selecting an item and double-tapping to activate it, touch an item with one finger, then tap the screen with another.
- *Double-tap and hold (1 second) + standard gesture:* Use a standard gesture. The double-tap and hold gesture tells iPhone to interpret the next gesture as standard. For example, you can double-tap and hold, and then without lifting your finger, drag your finger to slide a switch.
- *Two-finger double-tap:* Answer or end a call. Play or pause in Music, Videos, Voice Memos, or Photos. Take a photo in Camera. Start or pause recording in Camera or Voice Memos. Start or stop the stopwatch.
- *Two-finger double-tap and hold:* Change an item's label to make it easier to find.
- *Two-finger triple-tap:* Open the Item Chooser.
- *Three-finger double-tap:* Mute or unmute VoiceOver.
- *Three-finger triple-tap:* Turn the screen curtain on or off.

Use the VoiceOver rotor

Use the rotor to choose what happens when you swipe up or down with VoiceOver turned on, or to select special input methods such as Braille Screen Input or Handwriting.

Operate the rotor. Rotate two fingers on the screen around a point between them.

Choose your rotor options. Go to Settings > General > Accessibility > VoiceOver > Rotor, then select the options you want to include in the rotor.

The available rotor options and their effects depend on what you're doing. For example, if you're reading an email, you can use the rotor to switch between hearing text spoken word-by-word or character-by-character when you swipe up or down. If you're browsing a webpage, you can set the rotor to speak all the text (either word-by-word or character-by-character), or to jump from one item to another of a certain type, such as headers or links.

When you use an Apple Wireless Keyboard to control VoiceOver, the rotor lets you adjust settings such as volume, speech rate, use of pitch or phonetics, typing echo, and reading of punctuation. See Use VoiceOver with an Apple Wireless Keyboard on page 156.

Use the onscreen keyboard

When you activate an editable text field, the onscreen keyboard appears (unless you have an Apple Wireless Keyboard attached).

Activate a text field. Select the text field, then double-tap. The insertion point and the onscreen keyboard appear.

Enter text. Type characters using the onscreen keyboard:

- *Standard typing:* Select a key on the keyboard by swiping left or right, then double-tap to enter the character. Or move your finger around the keyboard to select a key and, while continuing to touch the key with one finger, tap the screen with another finger. VoiceOver speaks the key when it's selected, and again when the character is entered.
- *Touch typing:* Touch a key on the keyboard to select it, then lift your finger to enter the character. If you touch the wrong key, slide your finger to the key you want. VoiceOver speaks the character for each key as you touch it, but doesn't enter a character until you lift your finger.
- *Direct Touch typing:* VoiceOver is disabled for the keyboard only, so you can type just as you do when VoiceOver is off.
- *Choose typing style:* Go to Settings > General > Accessibility > VoiceOver > Typing Style. Or, set the rotor to Typing Mode, then swipe up or down.

Move the insertion point. Swipe up or down to move the insertion point forward or backward in the text. Use the rotor to choose whether you want to move the insertion point by character, by word, or by line. To jump to the beginning or end, double-tap the text.

VoiceOver makes a sound when the insertion point moves, and speaks the character, word, or line that the insertion point moves across. When moving forward by words, the insertion point is placed at the end of each word, before the space or punctuation that follows. When moving backward, the insertion point is placed at the end of the preceding word, before the space or punctuation that follows it.

Move the insertion point past the punctuation at the end of a word or sentence. Use the rotor to switch back to character mode.

When moving the insertion point by line, VoiceOver speaks each line as you move across it. When moving forward, the insertion point is placed at the beginning of the next line (except when you reach the last line of a paragraph, when the insertion point is moved to the end of the line just spoken). When moving backward, the insertion point is placed at the beginning of the line that's spoken.

Change typing feedback. Go to Settings > General > Accessibility > VoiceOver > Typing Feedback.

Use phonetics in typing feedback. Go to Settings > General > Accessibility > VoiceOver > Phonetic Feedback. Text is read character by character. VoiceOver first speaks the character, then its phonetic equivalent—for example, "f" and then "foxtrot."

Delete a character. Use ⌫ with any of the VoiceOver typing styles. VoiceOver speaks each character as it's deleted. If Use Pitch Change is turned on, VoiceOver speaks deleted characters in a lower pitch.

Select text. Set the rotor to Edit, swipe up or down to choose Select or Select All, then double-tap. If you choose Select, the word closest to the insertion point is selected when you double-tap. To increase or decrease the selection, do a two-finger scrub to dismiss the pop-up menu, then pinch.

Cut, copy, or paste. Set the rotor to Edit, select the text, swipe up or down to choose Cut, Copy, or Paste, then double-tap.

Undo. Shake iPhone, swipe left or right to choose the action to undo, then double-tap.

Enter an accented character. In standard typing style, select the plain character, then double-tap and hold until you hear a sound indicating alternate characters have appeared. Drag left or right to select and hear the choices. Release your finger to enter the current selection. In touch typing style, touch and hold a character until the alternate characters appear.

Change the keyboard language. Set the rotor to Language, then swipe up or down. Choose "default language" to use the language specified in Language & Region settings. The Language rotor item appears only if you select more than one language in Settings > General > Accessibility > VoiceOver > Speech.

Write with your finger

Handwriting mode lets you enter text by writing characters on the screen with your finger. In addition to normal text entry, use handwriting mode to enter your iPhone passcode silently or open apps from the Home screen.

Enter handwriting mode. Use the rotor to select Handwriting. If Handwriting isn't in the rotor, go to Settings > General > Accessibility > VoiceOver > Rotor, then add it.

Choose a character type. Swipe up or down with three fingers to choose lowercase, numbers, uppercase, or punctuation.

Hear the currently selected character type. Tap with three fingers.

Enter a character. Trace the character on the screen with your finger.

Enter a space. Swipe right with two fingers.

Go to a new line. Swipe right with three fingers.

Delete the character before the insertion point. Swipe left with two fingers.

Select an item on the Home screen. Start writing the name of the item. If there are multiple matches, continue to spell the name until it's unique, or swipe up or down with two fingers to choose from the current matches.

Enter your passcode silently. Set the rotor to Handwriting on the passcode screen, then write the characters of your passcode.

Use a table index to skip through a long list. Select the table index to the right of the table (for example, next to your Contacts list or in the VoiceOver Item Chooser), then write the letter.

Set the rotor to a web browsing element type. Write the first letter of a page element type. For example, write "l" to have up or down swipes skip to links, or "h" to skip to headings.

Exit handwriting mode. Do a two-finger scrub, or turn the rotor to a different selection.

Type onscreen braille

With Braille Screen Input enabled, you can use your fingers to enter 6-dot or contracted braille codes directly on the iPhone screen. Tap codes with iPhone laying flat in front of you (tabletop mode), or hold iPhone with the screen facing away so your fingers curl back to tap the screen (screen away mode).

Turn on Braille Screen Input. Use the rotor to select Braille Screen Input. If you don't find it in the rotor, go to Settings > General > Accessibility > VoiceOver > Rotor, then add it.

Enter braille codes. Place iPhone flat in front of you or hold it with the screen facing away, then tap the screen with one or several fingers at the same time.

Adjust entry dot positions. To move the entry dots to match your natural finger positions, tap and lift your right three fingers all at once to position dots 4, 5, and 6, followed immediately by your left three fingers for dots 1, 2, and 3.

Switch between 6-dot and contracted braille. Swipe to the right with three fingers. To set the default, go to Settings > General > Accessibility > VoiceOver > Braille > Braille Screen Input.

Enter a space. Swipe right with one finger. (In screen away mode, swipe to *your* right.)

Delete the previous character. Swipe left with one finger.

Move to a new line (typing). Swipe right with two fingers.

Cycle through spelling suggestions. Swipe up or down with one finger.

Select an item on the Home screen. Start entering the name of the item. If there are multiple matches, continue to spell the name until it is unique, or swipe up or down with one finger to select a partial match.

Open the selected app. Swipe right with two fingers.

Turn braille contractions on or off. Swipe to the right with three fingers.

Translate immediately (when contractions are enabled). Swipe down with two fingers.

Stop entering braille. Do a two-finger scrub, or set the rotor to another setting.

Use VoiceOver with an Apple Wireless Keyboard

You can control VoiceOver using an Apple Wireless Keyboard paired with iPhone. See Use an Apple Wireless Keyboard on page 32.

Use VoiceOver keyboard commands to navigate the screen, select items, read screen contents, adjust the rotor, and perform other VoiceOver actions. Most commands use the Control-Option key combination, abbreviated in the list that follows as "VO."

You can use VoiceOver Help to learn the keyboard layout and the actions associated with various key combinations. VoiceOver Help speaks keys and keyboard commands as you type them, without performing the associated action.

VoiceOver keyboard commands

VO = Control-Option

- *Turn on VoiceOver Help:* VO–K
- *Turn off VoiceOver Help:* Escape
- *Select the next or previous item:* VO–Right Arrow or VO–Left Arrow
- *Double-tap to activate the selected item:* VO–Space bar
- *Press the Home button:* VO–H
- *Touch and hold the selected item:* VO–Shift–M
- *Move to the status bar:* VO–M
- *Read from the current position:* VO–A
- *Read from the top:* VO–B
- *Pause or resume reading:* Control
- *Copy the last spoken text to the clipboard:* VO–Shift–C
- *Search for text:* VO–F

- *Mute or unmute VoiceOver:* VO–S
- *Open Notification Center:* Fn–VO–Up Arrow
- *Open Control Center:* Fn–VO–Down Arrow
- *Open the Item Chooser:* VO–I
- *Change the label of the selected item:* VO–/
- *Double-tap with two fingers:* VO–"-"
- *Adjust the rotor:* Use Quick Nav (see below)
- *Swipe up or down:* VO–Up Arrow or VO–Down Arrow
- *Adjust the speech rotor:* VO–Command–Left Arrow or VO–Command–Right Arrow
- *Adjust the setting specified by the speech rotor:* VO–Command–Up Arrow or VO–Command–Down Arrow
- *Turn the screen curtain on or off:* VO–Shift–S
- *Return to the previous screen:* Escape
- *Switch apps:* Command–Tab or Command–Shift–Tab

Quick Nav

Turn on Quick Nav to control VoiceOver using the arrow keys.

- *Turn Quick Nav on or off:* Left Arrow–Right Arrow
- *Select the next or previous item:* Right Arrow or Left Arrow
- *Select the next or previous item specified by the rotor:* Up Arrow or Down Arrow
- *Select the first or last item:* Control–Up Arrow or Control–Down Arrow
- *Tap an item:* Up Arrow–Down Arrow
- *Scroll up, down, left, or right:* Option–Up Arrow, Option–Down Arrow, Option–Left Arrow, or Option–Right Arrow
- *Adjust the rotor:* Up Arrow–Left Arrow or Up Arrow–Right Arrow

You can also use the number keys on an Apple Wireless Keyboard to dial a phone number in Phone or enter numbers in Calculator.

Single-key Quick Nav for web browsing

When you view a webpage with Quick Nav on, you can use the following keys on the keyboard to navigate the page quickly. Typing the key moves to the next item of the indicated type. To move to the previous item, hold the Shift key as you type the letter.

- *Turn on Single-key Quick Nav:* VO-Q
- *Heading:* H
- *Link:* L
- *Text field:* R
- *Button:* B
- *Form control:* C
- *Image:* I
- *Table:* T
- *Static text:* S
- *ARIA landmark:* W
- *List:* X
- *Item of the same type:* M

- *Level 1 heading:* 1
- *Level 2 heading:* 2
- *Level 3 heading:* 3
- *Level 4 heading:* 4
- *Level 5 heading:* 5
- *Level 6 heading:* 6

Text editing

Use these commands (with Quick Nav turned off) to work with text. VoiceOver reads the text as you move the insertion point.

- *Go forward or back one character:* Right Arrow or Left Arrow
- *Go forward or back one word:* Option–Right Arrow or Option–Left Arrow
- *Go up or down one line:* Up Arrow or Down Arrow
- *Go to the beginning or end of the line:* Command–Left Arrow or Command–Down Arrow
- *Go to the beginning or end of the paragraph:* Option–Up Arrow or Option–Down Arrow
- *Go to the previous or next paragraph:* Option–Up Arrow or Option–Down Arrow
- *Go to the top or bottom of the text field:* Command–Up Arrow or Command–Down Arrow
- *Select text as you move:* Shift + any of the insertion point movement commands above
- *Select all text:* Command–A
- *Copy, cut, or paste the selected text:* Command–C, Command–X, or Command–V
- *Undo or redo last change:* Command–Z or Shift–Command–Z

Support for braille displays

You can use a Bluetooth braille display to read VoiceOver output, and you can use a braille display with input keys and other controls to control iPhone when VoiceOver is turned on. For a list of supported braille displays, see www.apple.com/accessibility/ios/braille-display.html.

Connect a braille display. Turn on the display, then go to Settings > Bluetooth and turn on Bluetooth. Then, go to Settings > General > Accessibility > VoiceOver > Braille and choose the display.

Adjust Braille settings. Go to Settings > General > Accessibility > VoiceOver > Braille, where you can:

- Choose contracted, uncontracted 8-dot, or uncontracted 6-dot braille input or output
- Turn on the status cell and choose its location
- Turn on Nemeth code for equations
- Display the onscreen keyboard
- Choose to have the page turned automatically when panning
- Change the braille translation from Unified English

For information about common braille commands for VoiceOver navigation, and for information specific to certain displays, see support.apple.com/kb/HT4400.

Set the language for VoiceOver. Go to Settings > General > Language & Region.

If you change the language for iPhone, you may need to reset the language for VoiceOver and your braille display.

You can set the leftmost or rightmost cell of your braille display to provide system status and other information. For example:

- Announcement History contains an unread message
- The current Announcement History message hasn't been read
- VoiceOver speech is muted
- The iPhone battery is low (less than 20% charge)
- iPhone is in landscape orientation
- The screen display is turned off
- The current line contains additional text to the left
- The current line contains additional text to the right

Set the leftmost or rightmost cell to display status information. Go to Settings > General > Accessibility > VoiceOver > Braille > Status Cell, then tap Left or Right.

See an expanded description of the status cell. On your braille display, press the status cell's router button.

Make phone calls with VoiceOver

Answer or end a call. Double-tap the screen with two fingers.

When a phone call is established with VoiceOver on, the screen displays the numeric keypad by default, instead of showing call options.

Display call options. Select the Hide Keypad button in the lower-right corner and double-tap.

Display the numeric keypad again. Select the Keypad button near the center of the screen and double-tap.

Read math equations

VoiceOver can read aloud math equations encoded using:

- MathML on the web
- MathML or LaTeX in iBooks Author

Hear an equation. Have VoiceOver read the text as usual. VoiceOver says "math" before it starts reading an equation.

Explore the equation. Double-tap the selected equation to display it full screen and move through it one element at a time. Swipe left or right to read elements of the equation. Use the rotor to select Symbols, Small Expressions, Medium Expressions, or Large Expressions, then swipe up or down to hear the next element of that size. You can continue to double-tap the selected element to "drill down" into the equation to focus on the selected element, then swipe left or right, up or down to read one part at a time.

Equations read by VoiceOver can also be output to a braille device using Nemeth code, as well as the codes used by Unified English Braille, British English, French, and Greek. See Support for braille displays on page 158.

Use VoiceOver with Safari

Search the web. Select the search field, enter your search, then swipe right or left to move down or up the list of suggested search phrases. Then double-tap the screen to search the web using the selected phrase.

Skip to the next page element of a particular type. Set the rotor to the element type, then swipe up or down.

Set the rotor options for web browsing. Go to Settings > General > Accessibility > VoiceOver > Rotor. Tap to select or deselect options, or drag ≡ up or down to reposition an item.

Skip images while navigating. Go to Settings > General > Accessibility > VoiceOver > Navigate Images. You can choose to skip all images or only those without descriptions.

Reduce page clutter for easier reading and navigation. Select the Reader item in the Safari address field (not available for all pages).

If you pair an Apple Wireless Keyboard with iPhone, you can use single-key Quick Nav commands to navigate webpages. See Use VoiceOver with an Apple Wireless Keyboard on page 156.

Use VoiceOver with Maps

You can use VoiceOver to explore a region, browse points of interest, follow roads, zoom in or out, select a pin, or get information about a location.

Explore the map. Drag your finger around the screen, or swipe left or right to move to another item.

Zoom in or out. Select the map, set the rotor to Zoom, then swipe down or up with one finger.

Pan the map. Swipe with three fingers.

Browse visible points of interest. Set the rotor to Points of Interest, then swipe up or down with one finger.

Follow a road. Hold your finger down on the road, wait until you hear "pause to follow," then move your finger along the road while listening to the guide tone. The pitch increases when you stray from the road.

Select a pin. Touch a pin, or swipe left or right to select the pin.

Get information about a location. With a pin selected, double-tap to display the information flag. Swipe left or right to select the More Info button, then double-tap to display the information page.

Hear location cues as you move about. Turn on Tracking With Heading in Maps to hear street names and points of interest as you approach them.

Edit videos and voice memos with VoiceOver

You can use VoiceOver gestures to trim Camera videos and Voice Memo recordings.

Trim a video. While viewing a video in Photos, double-tap the screen to display the video controls, then select the beginning or end of the trim tool. Then swipe up to drag to the right, or swipe down to drag to the left. VoiceOver announces the amount of time the current position will trim from the recording. To complete the trim, select Trim, then double-tap.

Trim a voice memo. Select the memo in Voice Memos, tap Edit, then tap Start Trimming. Select the beginning or end of the selection, double-tap and hold, then drag to adjust. VoiceOver announces the amount of time the current position will trim from the recording. Tap Play to preview the trimmed recording. When you've got it the way you want it, tap Trim.

Zoom

Many apps let you zoom in or out on specific items. For example, you can double-tap or pinch to look closer in Photos or expand webpage columns in Safari. There's also a general Zoom feature that lets you magnify the screen no matter what you're doing. You can zoom the entire screen (Full Screen Zoom) or zoom part of the screen in a resizable window and leave the rest of the screen unmagnified (Window Zoom). And, you can use Zoom together with VoiceOver.

Turn Zoom on or off. Go to Settings > General > Accessibility > Zoom. Or, use the Accessibility Shortcut. See Accessibility Shortcut on page 149.

Zoom in or out. With Zoom turned on, double-tap the screen with three fingers.

Adjust the magnification. Double-tap with three fingers, then drag up or down. The tap-and-drag gesture is similar to a double-tap, except you don't lift your fingers on the second tap—instead, drag your fingers on the screen. You can also triple-tap with three fingers, then drag the Zoom Level slider in the controls that appear. To limit the maximum magnification, go to Settings > General > Accessibility > Zoom > Maximum Zoom Level.

Pan to see more. Drag the screen with three fingers. Or, hold your finger near the edge of the screen to pan to that side. Move your finger closer to the edge to pan more quickly.

Switch between Full Screen Zoom and Window Zoom. Triple-tap with three fingers, then tap Window Zoom or Full Screen Zoom in the zoom controls that appear. To choose the mode that's used when you turn on Zoom, go to Settings > General > Accessibility > Zoom > Zoom Region.

Resize the zoom window (Window Zoom). Triple-tap with three fingers, tap Resize Lens, then drag any of the round handles that appear.

Move the zoom window (Window Zoom). Drag the handle at the bottom of the zoom window.

Show the zoom controller. Go to Settings > General > Accessibility > Zoom, then turn on Show Controller, or triple-tap with three fingers, then choose Show Controller. Then you can double-tap the floating Zoom Controls button to zoom in or out, single-tap the button to display the zoom controls, or drag it to pan. To move the Zoom Controls button, tap and hold the button, then drag it to a new location. To adjust the transparency of the zoom controller, go to Settings > General > Accessibility > Zoom > Idle Visibility.

Have Zoom track your selections or the text insertion point. Go to Settings > General > Accessibility > Zoom > Follow Focus. Then, for example, if you use VoiceOver, turning on this option causes the zoom window to magnify each element on the screen as you select it using a swipe in VoiceOver.

Zoom in on your typing without magnifying the keyboard. Go to Settings > General > Accessibility > Zoom, then turn on Follow Focus and turn off Zoom Keyboard. When you zoom in while typing (in Messages or Notes, for example), the text you type is magnified while all of the keyboard remains visible.

Display the magnified part of the screen in grayscale or inverted color. Triple-tap with three fingers, then tap Choose Filter in the zoom controls that appear.

While using Zoom with an Apple Wireless Keyboard, the screen image follows the insertion point, keeping it in the center of the display. See Use an Apple Wireless Keyboard on page 32.

If you have iPhone 6 or iPhone 6 Plus, you can turn on Display Zoom to see larger onscreen controls. Go to Settings > Display & Brightness > View.

Invert Colors and Grayscale

Sometimes, inverting the colors or changing to grayscale on the iPhone screen makes it easier to read.

Invert the screen colors. Go to Settings > General > Accessibility > Invert Colors.

See the screen in grayscale. Go to Settings > General > Accessibility > Grayscale.

Turn on both effects to see inverted grayscale. You can also apply these effects to just the contents of the zoom window—see Zoom on page 160.

Speak Selection

Even with VoiceOver turned off, you can have iPhone read aloud any text you select. iPhone analyzes the text to determine the language, then reads it to you using the appropriate pronunciation.

Turn on Speak Selection. Go to Settings > General > Accessibility > Speech. There you can also:

- Adjust the speaking rate
- Choose to have individual words highlighted as they're read

Have text read to you. Select the text, then tap Speak.

You can also have iPhone read the entire screen to you. See Speak Screen, next.

Speak Screen

iPhone can read the contents of the screen to you, even if you don't use VoiceOver.

Turn on Speak Screen. Go to Settings > General > Accessibility > Speech.

Have iPhone speak the screen. Swipe down from the top of the screen with two fingers. Use the controls that appear to pause speaking or adjust the rate.

Highlight what's being spoken. Turn on Highlight Content, below the Speak Screen switch when it's turned on.

Use Siri. Say "speak screen."

You can also have iPhone read just text you select—see Speak Selection, above.

Speak Auto-text

Speak Auto-text speaks the text corrections and suggestions iPhone makes when you type.

Turn Speak Auto-text on or off. Go to Settings > General > Accessibility > Speech.

Speak Auto-text also works with VoiceOver and Zoom.

Large, bold, and high-contrast text

Display larger text in apps such as Settings, Calendar, Contacts, Mail, Messages, and Notes. Go to Settings > General > Text Size, then adjust the slider. For even larger text, go to Settings > General > Accessibility > Larger Text, then turn on Larger Accessibility Sizes.

Display bolder text on iPhone. Go to Settings > General > Accessibility, then turn on Bold Text.

Increase text contrast where possible. Go to Settings > General > Accessibility, then turn on Increase Contrast.

Button Shapes

iPhone can add a colored background shape or an underline to buttons so they're easier to see.

Emphasize buttons. Go to Settings > General > Accessibility, then turn on Button Shapes.

Reduce screen motion

You can stop the movement of some screen elements, for example, the parallax effect of icons and alerts against the wallpaper, or motion transitions.

Reduce motion. Go to Settings > General > Accessibility, then turn on Reduce Motion.

On/off switch labels

To make it easier to see whether a setting is on or off, you can have iPhone show an additional label on on/off switches.

Add switch-setting labels. Go to Settings > General > Accessibility, then turn on On/Off Labels.

Assignable ringtones and vibrations

You can assign distinctive ringtones to people in your contacts list for audible caller ID. You can also assign vibration patterns for notifications from specific apps, for phone calls, for FaceTime calls or messages from special contacts, and to alert you of a variety of other events, including new voicemail, new mail, sent mail, Tweet, Facebook Post, and reminders. Choose from existing patterns, or create new ones. See Sounds and silence on page 36.

You can purchase ringtones from the iTunes Store on iPhone. See Chapter 22, iTunes Store, on page 117.

Video Descriptions

Video descriptions provide an audible description of video scenes. If you have a video that includes video descriptions, iPhone can play them for you.

Turn on Video Descriptions. Go to Settings > General > Accessibility > Video Descriptions.

Hearing aids

Made for iPhone hearing aids

If you have Made for iPhone hearing aids, you can use iPhone to adjust their settings, stream audio, or use iPhone as a remote mic.

Pair with iPhone. If your hearing aids aren't listed in Settings > General > Accessibility > Hearing Aids, you need to pair them with iPhone. To start, open the battery door on each hearing aid. Next, on iPhone, go to Settings > Bluetooth, then make sure Bluetooth is turned on. Then go to Settings > General > Accessibility > Hearing Aids. Close the battery doors on your hearing aids and wait until their name appears in the list of devices (this could take a minute). When the name appears, tap it and respond to the pairing request.

When pairing is finished, you hear a series of beeps and a tone, and a checkmark appears next to the hearing aids in the Devices list. Pairing can take as long as 60 seconds—don't try to stream audio or otherwise use the hearing aids until pairing is finished.

You should only need to pair once (and your audiologist might do it for you). After that, each time you turn your hearing aids back on, they reconnect to iPhone.

Adjust hearing aid settings and view status. Go to Settings > General > Accessibility > Hearing Aids, or choose Hearing Aids from the Accessibility Shortcut. See Accessibility Shortcut on page 149. Hearing aid settings appear only after you pair your hearing aids with iPhone.

For shortcut access from the Lock screen, go to Settings > General > Accessibility > Hearing Aids, then turn on Control on Lock Screen. Use the settings to:

- Check hearing aid battery status.
- Adjust ambient microphone volume and equalization.
- Choose which hearing aids (left, right, or both) receive streaming audio.
- Control Live Listen.

Stream audio to your hearing aids. Stream audio from Phone, Siri, Music, Videos, and more by choosing your hearing aids from the AirPlay menu .

Use iPhone as a remote microphone. You can use Live Listen to stream sound from the microphone in iPhone to your hearing aids. This can help you hear better in some situations by positioning iPhone nearer the sound source. Triple-click the Home button, choose Hearing Aids, then tap Start Live Listen.

Use your hearing aids with more than one iOS device. If you pair your hearing aids with more than one iOS device (both iPhone and iPad, for example), the connection for your hearing aids automatically switches from one to the other when you do something that generates audio on the other device, or when you receive a phone call on iPhone. Changes you make to hearing aid settings on one device are automatically sent to your other iOS devices. To take advantage of this, all of the devices must be on the same Wi-Fi network and signed in to iCloud using the same Apple ID.

Hearing Aid Mode

iPhone has a Hearing Aid Mode that, when activated, may reduce interference with some hearing aid models. Hearing Aid Mode reduces the transmission power of the cellular radio in the GSM 1900 MHz band and may result in decreased 2G cellular coverage.

Turn on Hearing Aid Mode. Go to Settings > General > Accessibility > Hearing Aids.

Hearing aid compatibility

The FCC has adopted hearing aid compatibility (HAC) rules for digital wireless phones. These rules require certain phones to be tested and rated under the American National Standard Institute (ANSI) C63.19-2007 or C63.19-2011 hearing aid compatibility standards.

The ANSI standard for hearing aid compatibility contains two types of ratings:

- An "M" rating for reduced radio frequency interference to enable acoustic coupling with hearing aids that are not operating in telecoil mode
- A "T" rating for inductive coupling with hearing aids operating in telecoil mode

These ratings are given on a scale from one to four, where four is the most compatible. A phone is considered hearing aid compatible under FCC rules if it is rated M3 or M4 for acoustic coupling and T3 or T4 for inductive coupling.

For iPhone hearing aid compatibility ratings, see www.apple.com/support/hac/.

Hearing aid compatibility ratings don't guarantee that a particular hearing aid works with a particular phone. Some hearing aids may work well with phones that don't meet particular ratings. To ensure interoperability between a hearing aid and a phone, try using them together before purchase.

This phone has been tested and rated for use with hearing aids for some of the wireless technologies it uses. However, there may be some newer wireless technologies used in this phone that have not been tested yet for use with hearing aids. It is important to try the different features of this phone thoroughly and in different locations, using your hearing aid or cochlear implant, to determine if you hear any interfering noise. Consult your service provider or Apple for information on hearing aid compatibility. If you have questions about return or exchange policies, consult your service provider or phone retailer.

Mono audio and balance

Mono Audio combines the sound from the left and right channels into a mono signal played on both channels. This way you can hear everything with either ear, or through both ears with one channel set louder.

Turn Mono Audio on or off. Go to Settings > General > Accessibility > Mono Audio.

Adjust the balance. Go to Settings > General > Accessibility, then drag the Left Right Stereo Balance slider.

Subtitles and closed captions

The Videos app includes an Alternate Track button you can tap to choose subtitles and captions offered by the video you're watching. Standard subtitles and captions are usually listed, but if you prefer special accessible captions, such as subtitles for the deaf and hard of hearing (SDH), you can set iPhone to list them instead, if they're available.

Prefer accessible subtitles and closed captions for the hard of hearing in the list of available subtitles and captions. Go to Settings > General > Accessibility > Subtitles & Captioning, then turn on Closed Captions + SDH. This also turns on subtitles and captions in the Videos app.

Choose from available subtitles and captions. Tap while watching a video in Videos.

Customize your subtitles and captions. Go to Settings > General > Accessibility > Subtitles & Captioning > Style, where you can choose an existing caption style or create a new style based on your choice of:

- Font, size, and color
- Background color and opacity
- Text opacity, edge style, and highlight

Not all videos include closed captions.

Siri

With Siri, you can do things like opening apps just by asking, and VoiceOver can read Siri responses to you. See Chapter 4, Siri, on page 48.

Widescreen keyboards

Many apps, including Mail, Safari, Messages, Notes, and Contacts, let you rotate iPhone when you're typing, so you can use a larger keyboard.

Large phone keypad

Make phone calls simply by tapping entries in your contacts and favorites lists. When you need to dial a number, the large numeric keypad on iPhone makes it easy. See Make a call on page 51.

LED Flash for Alerts

If you can't hear the sounds that announce incoming calls and other alerts, you can have iPhone flash its LED (next to the camera lens on the back of iPhone). This works only when iPhone is locked or asleep.

Turn on LED Flash for Alerts. Go to Settings > General > Accessibility > LED Flash for Alerts.

Call audio routing

You can have the audio of incoming or outgoing calls automatically routed through a headset or speaker phone instead of iPhone.

Reroute audio for calls. Go to Settings > General > Accessibility > Call Audio Routing, then choose how you want to hear and speak your calls.

You can also have audio from calls routed to your hearing aids; see Hearing aids on page 163.

Phone noise cancelation

iPhone uses ambient noise cancelation to reduce background noise.

Turn noise cancelation on or off. Go to Settings > General > Accessibility > Phone Noise Cancelation.

Guided Access

Guided Access helps an iPhone user stay focused on a task. Guided Access dedicates iPhone to a single app, and lets you control which app features are available. Use Guided Access to:

- Temporarily restrict iPhone to a particular app
- Disable areas of the screen that aren't relevant to a task, or areas where an accidental gesture might cause a distraction
- Limit how long someone can use an app
- Disable the iPhone Sleep/Wake or volume buttons

Use Guided Access. Go to Settings > General > Accessibility > Guided Access, where you can:

- Turn Guided Access on or off
- Tap Passcode Settings to set a passcode that controls the use of Guided Access (preventing someone from leaving a session), and turn on Touch ID (as a way to end Guided Access)
- Tap Time Limits to set a sound or have the remaining Guided Access time spoken before time ends
- Set whether other accessibility shortcuts are available during a session

Start a Guided Access session. After turning on Guided Access, open the app you want to run, then triple-click the Home button. Adjust settings for the session, then tap Start.

- *Disable app controls and areas of the app screen:* Draw a circle or rectangle around any part of the screen you want to disable. Drag the mask into position or use the handles to adjust its size.

- *Enable the Sleep/Wake or volume buttons:* Tap Options below Hardware Buttons.
- *Keep iPhone from switching from portrait to landscape or from responding to other motions:* Tap Options, then turn off Motion.
- *Prevent typing:* Tap Options, then turn off Keyboards.
- *Ignore all screen touches:* Turn off Touch at the bottom of the screen.
- *Set a session time limit:* Tap Time Limit Options at the bottom of the screen.

End the session. Triple-click the Home button, then enter the Guided Access passcode, or use Touch ID (if enabled).

Switch Control

Switch Control lets you control iPhone using a single switch or multiple switches. Use any of several methods to perform actions such as selecting, tapping, dragging, typing, and even free-hand drawing. The basic technique is to use a switch to select an item or location on the screen, and then use the same (or different) switch to choose an action to perform on that item or location. Three basic methods are:

- *Item scanning (default),* which highlights different items on the screen until you select one.
- *Point scanning,* which lets you use scanning crosshairs to pick a screen location.
- *Manual selection,* which lets you move from item to item on demand (requires multiple switches).

Whichever method you use, when you select an individual item (rather than a group), a menu appears so you can choose how to act on the selected item (tap, drag, or pinch, for example).

If you use multiple switches, you can set up each switch to perform a specific action and customize your item selection method. For example, instead of automatically scanning screen items, you can set up switches to move to the next or previous item on demand.

You can adjust the behavior of Switch Control in a variety of ways, to suit your specific needs and style.

Add a switch and turn on Switch Control

You can use any of these as a switch:

- *An external adaptive switch:* Choose from a variety of popular USB or Bluetooth switches.
- *The iPhone screen:* Tap the screen to trigger the switch.
- *The iPhone FaceTime camera:* Move your head to trigger the switch. You can use the camera as two switches: one when you move your head to the left, and the other when you move your head to the right.

Add a switch and choose its action. Go to Settings > General > Accessibility > Switch Control > Switches. If you use only one switch, it is your Select Item switch by default.

If you're adding an external switch, you need to connect it to iPhone before it will appear in the list of available switches. Follow the instructions that came with the switch. If it connects using Bluetooth, you need to pair it with iPhone—turn on the switch, go to Settings > Bluetooth, tap the switch, then follow the onscreen instructions. For more information, see Bluetooth devices on page 42.

Turn on Switch Control. Go to Settings > General > Accessibility > Switch Control, or use the Accessibility Shortcut. See Accessibility Shortcut on page 149.

Turn off Switch Control. Use any scanning method to select, then tap Settings > General > Accessibility > Switch Control. Or triple-click the Home button.

Basic techniques

Whether you use item scanning or point scanning, the Switch Control basics are the same.

Select an item. While the item is highlighted, trigger the switch you've set up as your Select Item switch. If you are using a single switch, it is your Select Item switch by default.

Perform an action on the selected item. Choose a command from the control menu that appears when you select the item. The layout of the menu depends on whether you use Auto Tap.

- *With Auto Tap off:* The control menu includes only the Tap button and the More button (two dots at the bottom). If you're in a scrollable area of the screen, a Scroll button also appears. To tap the highlighted item, trigger your Select Item button when Tap is highlighted. To see additional action buttons, choose More at the bottom of the menu. If you have multiple switches, you can set one up specifically for tapping.
- *With Auto Tap on:* To tap the item, do nothing—the item is automatically tapped when the Auto Tap interval expires (0.75 seconds if you haven't changed it). To see the control menu, trigger your Select Item button before the Auto Tap interval expires. The control menu skips the Tap button and goes right to the full set of action buttons.

Turn on Auto Tap. Go to Settings > General > Accessibility > Switch Control > Auto Tap. To tap an item with Auto Tap on, just wait for the Auto Tap interval to expire.

Dismiss the control menu without choosing an action. Tap while the original item is highlighted and all the icons in the control menu are dimmed. Or choose Escape from the control menu. The menu goes away after cycling the number of times you specify at Settings > General > Accessibility > Switch Control > Loops.

Perform screen gestures. Choose Gestures from the control menu.

Scroll the screen. Select an item in a scrollable part of the screen, then:

- *With Auto Tap off:* Choose the Scroll Down button (next to the Tap button) in the control menu. Or, for more scrolling options, choose More, then choose Scroll.
- *With Auto Tap on:* Choose Scroll from the control menu. If many actions are available, you might have to choose More first.

Tap the Home button. Choose Home from the control menu.

Perform other hardware actions. Select any item, then choose Device from the menu that appears. Use the menu to mimic these actions:

- Double-click the Home button for multitasking
- Open Notification Center or Control Center
- Press the Sleep/Wake button to lock iPhone
- Rotate iPhone
- Flip the Ring/Silent switch
- Press the volume buttons
- Hold down the Home button to open Siri
- Triple-click the Home button
- Shake iPhone
- Press the Home and Sleep/Wake buttons simultaneously to take a screenshot
- Swipe down from the top with two fingers to speak the screen (if you have Speak Screen turned on)

Item scanning

Item scanning alternately highlights each item or group of items on the entire screen until you trigger your Select Item switch. If there are many items, Switch Control highlights them in groups. When you select a group, highlighting continues with the items in the group. When you select a unique item, scanning stops and the control menu appears. Item scanning is the default when you first turn on Switch Control.

Select an item or enter a group. Watch (or listen) as items are highlighted. When the item you want to control (or the group containing the item) is highlighted, trigger your Select Item switch. Work your way down in the hierarchy of items until you select the individual item you want to control.

Back out of a group. Trigger your Select Item switch when the dashed highlight around the group or item appears.

Dismiss the control menu without performing an action. Trigger your Select Item switch when the item itself is highlighted. Or choose Escape from the control menu.

Hear the names of items as they are highlighted. Go to Settings > General > Accessibility > Switch Control, then turn on Speech. Or choose Settings from the control menu, then choose Speech On.

Slow down the scanning. Go to Settings > General > Accessibility > Switch Control > Auto Scanning Time.

Point scanning

Point scanning lets you select an item on the screen by pinpointing it with scanning crosshairs.

Switch to point scanning. Use item scanning to choose Point Mode from the control menu. The vertical crosshair appears when you close the menu.

Select an item. Trigger your Select Item switch when the item you want is within the broad, horizontal scanning band, then trigger again when the fine scanning line is on the item. Repeat for vertical scanning.

Refine your selection point. Choose Refine Selection from the control menu.

Return to item scanning. Choose Item Mode from the control menu.

Manual selection

You can select a screen item directly using dedicated switches instead of having iPhone alternately highlight every item.

Stop scanning and highlight items yourself. Add switches *in addition to your Select Item switch* to perform the Move To Next Item and Move To Previous Item actions. (You can use the iPhone FaceTime camera with head-left and head-right movements for these switches.) When you've added the switches, turn off Settings > General > Accessibility > Switch Control > Auto Scanning.

Important: Don't turn off Auto Scanning if you use only one switch. You need at least two: one to move to an item and a second to select the item.

Settings and adjustments

Adjust basic settings. Go to Settings > General > Accessibility > Switch Control, where you can:

- Add switches and specify their function
- Turn off auto scanning (only if you've added a Move to Next Item switch)
- Adjust how rapidly items are scanned

- Set scanning to pause on the first item in a group
- Choose how many times to cycle through the screen before hiding Switch Control
- Turn Auto Tap on or off and set the interval for performing a second switch action to show the control menu
- Set whether a movement action is repeated when you hold down a switch, and how long to wait before repeating
- Set whether and how long you need to hold a switch down before it's accepted as a switch action
- Have Switch Control ignore accidental repeated switch triggers
- Adjust the point scanning speed
- Turn on sound effects or have items read aloud as they are scanned
- Choose what to include in the Switch Control menu
- Set whether items should be grouped while item scanning
- Make the selection cursor larger or a different color
- Save custom gestures to the control menu (in Gestures > Saved)

Fine-tune Switch Control. Choose Settings from the control menu to:

- Adjust scanning speed
- Change the location of the control menu
- Switch between item scan mode and point scan mode
- Choose whether point scan mode displays crosshairs or a grid
- Reverse the scanning direction
- Turn sound or speech accompaniment on or off
- Turn off groups to scan items one at a time

AssistiveTouch

AssistiveTouch helps you use iPhone if you have difficulty touching the screen or pressing the buttons. You can use AssistiveTouch without any accessory to perform gestures that are difficult for you. You can also use a compatible adaptive accessory (such as a joystick) together with AssistiveTouch to control iPhone.

The AssistiveTouch menu lets you perform actions such as these by just tapping (or the equivalent on your accessory):

- Press the Home button
- Summon Siri
- Perform multi-finger gestures
- Access Control Center or Notification Center
- Adjust iPhone volume
- Shake iPhone
- Capture a screenshot

Turn on AssistiveTouch. Go to Settings > General > Accessibility > AssistiveTouch, or use the Accessibility Shortcut. See Accessibility Shortcut on page 149. When AssistiveTouch is on, the floating menu button appears on the screen.

Show or hide the menu. Tap the floating menu button, or click the secondary button on your accessory.

Simulate pressing the Home button. Tap the menu button, then tap Home.

Lock or rotate the screen, adjust iPhone volume, or simulate shaking iPhone. Tap the menu button, then tap Device.

Perform a swipe or drag that uses 2, 3, 4, or 5 fingers. Tap the menu button, tap Device > More > Gestures, then tap the number of digits needed for the gesture. When the corresponding circles appear on the screen, swipe or drag in the direction required by the gesture. When you finish, tap the menu button.

Perform a pinch gesture. Tap the menu button, tap Favorites, then tap Pinch. When the pinch circles appear, touch anywhere on the screen to move the pinch circles, then drag the pinch circles in or out to perform a pinch gesture. When you finish, tap the menu button.

Create your own gesture. You can add your own favorite gestures to the control menu (for example, tap and hold or two-finger rotation). Tap the menu button, tap Favorites, then tap an empty gesture placeholder. Or go to Settings > General > Accessibility > AssistiveTouch > Create New Gesture.

Example 1: To create the rotation gesture, go to Settings > General > Accessibility > AssistiveTouch > Create New Gesture. On the gesture recording screen that prompts you to touch to create a gesture, rotate two fingers on the iPhone screen around a point between them. (You can do this with a single finger or stylus—just create each arc separately, one after the other.) If it doesn't turn out quite right, tap Cancel, then try again. When it looks right, tap Save, then give the gesture a name—maybe "Rotate 90." Then, to rotate the view in Maps, for example, open Maps, tap the AssistiveTouch menu button, and choose Rotate 90 from Favorites. When the blue circles representing the starting finger positions appear, drag them to the point around which you want to rotate the map, then release. You might want to create several gestures with different degrees of rotation.

Example 2: Let's create the touch-and-hold gesture that you use to start rearranging icons on your Home screen. This time, on the gesture recording screen, hold down your finger in one spot until the recording progress bar reaches halfway, then lift your finger. Be careful not to move your finger while recording, or the gesture will be recorded as a drag. Tap Save, then name the gesture. To use the gesture, tap the AssistiveTouch menu button, then choose your gesture from Favorites. When the blue circle representing your touch appears, drag it over a Home screen icon and release.

If you record a sequence of taps or drags, they're all played back at the same time. For example, using one finger or a stylus to record four separate, sequential taps at four locations on the screen creates a simultaneous four-finger tap.

Exit a menu without performing a gesture. Tap anywhere outside the menu. To return to the previous menu, tap the arrow in the middle of the menu.

Move the menu button. Drag it anywhere along the edge of the screen.

Adjust your accessory tracking speed. Go to Settings > General > Accessibility > AssistiveTouch > Touch speed.

Hide the menu button (with an accessory attached). Go to Settings > General > Accessibility > AssistiveTouch > Always Show Menu.

TTY support

You can use the iPhone TTY Adapter cable (sold separately in many areas) to connect iPhone to a TTY machine. Go to www.apple.com/store/ (may not be available in all areas) or check with your local Apple retailer.

Connect iPhone to a TTY machine. Go to Settings > Phone, then turn on TTY. Then connect iPhone to your TTY machine using the iPhone TTY Adapter.

When TTY on iPhone is turned on, the TTY icon appears in the status bar at the top of the screen. For information about using a particular TTY machine, see the documentation that came with the machine.

Note: Continuity features are not available for TTY support.

Visual voicemail

The play and pause controls in visual voicemail let you control the playback of messages. Drag the playhead on the scrubber bar to repeat a portion of the message that's hard to understand. See Visual voicemail on page 55.

Voice Control

Voice Control lets you make phone calls and control Music playback using voice commands. See Make a call on page 51, and Siri and Voice Control on page 73.

Accessibility in OS X

Take advantage of the accessibility features in OS X when you use iTunes to sync information and content from your iTunes library to iPhone. In the Finder, choose Help > Help Center (or Help > Mac Help in OS X Yosemite), then search for "accessibility."

For more information about iPhone and OS X accessibility features, go to www.apple.com/accessibility/.

iPhone in business

B Appendix

With support for secure access to corporate networks, directories, custom apps, and Microsoft Exchange, iPhone is ready to go to work. For detailed information about using iPhone in business, go to www.apple.com/iphone/business/.

Mail, Contacts, and Calendar

To use iPhone with your work accounts, you need to know the settings your organization requires. If you received your iPhone from your organization, the settings and apps you need might already be installed. If it's your own iPhone, your system administrator may provide you with the settings for you to enter, or have you connect to a *mobile device management* server that installs the settings and apps you should have.

Organizational settings and accounts are typically in *configuration profiles*. You might be asked to install a configuration profile that was sent to you in an email, or one that is downloaded from a webpage. When you open the file, iPhone asks for your permission to install the profile, and displays information about what it contains.

In most cases, when you install a configuration profile that sets up an account for you, some iPhone settings can't be changed. For example, your organization might turn on Auto-Lock and require you to set a passcode in order to protect the information in the accounts you access.

You can see your profiles in Settings > General > Profiles. If you delete a profile, all of the settings and accounts associated with the profile are also removed, including any custom apps your organization provided or had you download. If you need a passcode to delete a profile, contact your system administrator.

Network access

A VPN (virtual private network) provides secure access over the Internet to private resources, such as your organization's network. You may need to install a VPN app from the App Store that configures your iPhone to access a particular network. Contact your system administrator for information about apps and settings you need.

Apps

In addition to the built-in apps and the ones you get from the App Store, your organization may want you to have certain other apps. They might provide you with a pre-paid redemption code for the App Store. When you download an app using a redemption code, you own it, even though your organization purchased it for you.

Your organization can also purchase App Store app licenses that are assigned to you for a period of time, but that the organization retains. You'll be invited to participate in your organization's program in order to access these apps. After you enroll with your Apple ID, you're prompted to install these apps as they're assigned to you. You can also find them in your Purchased list in the App Store. An app you receive this way is removed if the organization assigns it to someone else.

Your organization might also develop custom apps that aren't in the App Store. You install them from a webpage or, if your organization uses mobile device management, you receive a notification asking you to install them over the air. These apps belong to your organization, and they may be removed or stop working if you delete a configuration profile or dissociate iPhone from the mobile device management server.

International keyboards

C Appendix

Use international keyboards

International keyboards let you type text in many different languages, including Asian languages and languages written from right to left. For a list of supported keyboards, go to www.apple.com/iphone/, choose your iPhone, click Tech Specs, then scroll to Languages.

Manage keyboards. Go to Settings > General > Keyboard > Keyboards.

- *Add a keyboard:* Tap Add New Keyboard, then choose a keyboard from the list. Repeat to add more keyboards.
- *Remove a keyboard:* Tap Edit, tap ⊖ next to the keyboard you want to remove, tap Delete, then tap Done.
- *Edit your keyboard list:* Tap Edit, drag ≡ next to a keyboard to a new place in the list, then tap Done.

To enter text in a different language, switch keyboards.

Switch keyboards while typing. Touch and hold the Globe key 🌐 to show all your enabled keyboards. To choose a keyboard, slide your finger to the name of the keyboard, then release. The Globe key 🌐 appears only if you enable more than one keyboard.

You can also just tap 🌐. When you tap 🌐, the name of the newly activated keyboard appears briefly. Continue tapping to access other enabled keyboards.

Many keyboards provide letters, numbers, and symbols that aren't visible on the keyboard.

Enter accented letters or other characters. Touch and hold the related letter, number, or symbol, then slide to choose a variant. For example:

- *On a Thai keyboard:* Choose native numbers by touching and holding the related Arabic number.
- *On a Chinese, Japanese, or Arabic keyboard:* Suggested characters or candidates appear at the top of the keyboard. Tap a candidate to enter it, or swipe left to see more candidates.

Use the extended suggested candidate list. Tap the up arrow on the right to view the full candidate list.

- *Scroll the list:* Swipe up or down.
- *Return to the short list:* Tap the down arrow.

When using certain Chinese or Japanese keyboards, you can create a shortcut for word and input pairs. The shortcut is added to your personal dictionary. When you type a shortcut while using a supported keyboard, the paired word or input is substituted for the shortcut.

Turn shortcuts on or off. Go to Settings > General > Keyboard > Shortcuts. Shortcuts are available for:

- *Simplified Chinese:* Pinyin
- *Traditional Chinese:* Pinyin and Zhuyin
- *Japanese:* Romaji and 50 Key

Reset your personal dictionary. Go to Settings > General > Reset > Reset Keyboard Dictionary. All custom words and shortcuts are deleted, and the keyboard dictionary returns to its default state.

Special input methods

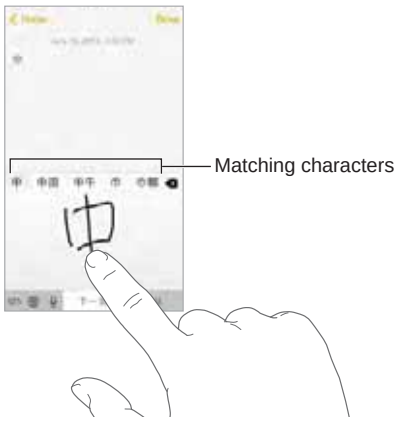
You can use keyboards to enter some languages in different ways. A few examples are Chinese Cangjie and Wubihua, Japanese Kana, and Facemarks. You can also use your finger or a stylus to write Chinese characters on the screen.

Build Chinese characters from the component Cangjie keys. As you type, suggested characters appear. Tap a character to choose it, or continue typing up to five components to see more options.

Build Chinese Wubihua (stroke) characters. Use the keypad to build Chinese characters using up to five strokes, in the correct writing sequence: horizontal, vertical, left falling, right falling, and hook. For example, the Chinese character 圈 (circle) should begin with the vertical stroke 丨.

- As you type, suggested Chinese characters appear (the most commonly used characters appear first). Tap a character to choose it.
- If you're not sure of the correct stroke, enter an asterisk (*). To see more character options, type another stroke, or scroll through the character list.
- Tap the match key (匹配) to show only characters that match exactly what you typed.

Write Chinese characters. Write Chinese characters directly on the screen with your finger when Simplified or Traditional Chinese handwriting input is turned on. As you write character strokes, iPhone recognizes them and shows matching characters in a list, with the closest match at the top. When you choose a character, its likely follow-on characters appear in the list as additional choices.



You can type some complex characters, such as 鱲 (part of the name for the Hong Kong International Airport), by writing two or more component characters in sequence. Tap the character to replace the characters you typed. Roman characters are also recognized.

Type Japanese kana. Use the Kana keypad to select syllables. For more syllable options, drag the list to the left or tap the arrow key.

Type Japanese romaji. Use the Romaji keyboard to type syllables. Alternative choices appear along the top of the keyboard; tap one to type it. For more syllable options, tap the arrow key and select another syllable or word from the window.

Type facemarks or emoticons. Use the Japanese Kana keyboard and tap the ^_^ key. Or you can:

- *Use the Japanese Romaji keyboard (QWERTY-Japanese layout):* Tap 123, then tap the ^_^ key.
- *Use the Chinese (Simplified or Traditional) Pinyin or (Traditional) Zhuyin keyboard:* Tap #+=, then tap the ^_^ key.

CarPlay

D Appendix

About CarPlay

CarPlay puts key iPhone apps—the ones you want to use while driving—on your car's built-in display. With CarPlay, you can get turn-by-turn directions, make phone calls, exchange text messages, listen to music, and more. CarPlay is available on select automobiles and after-market navigation systems, and works with iPhone 6, iPhone 6 Plus, iPhone 5s, iPhone 5c, and iPhone 5.

Note: CarPlay is available only in certain areas. Siri must be enabled on your iPhone. Go to Settings > General > Siri.

WARNING: For important information about avoiding distractions that could lead to dangerous situations, see Important safety information on page 181.

You operate CarPlay using your car's built-in controls—a touchscreen, a rotary knob controller, or both. To learn how to operate your display, see the user guide that came with your car.

Or just use Siri voice control to tell CarPlay what you want. In fact, Siri often steps in automatically to help you, depending on the app you're using.

Get started

Use an Apple approved Lightning to USB Cable to connect iPhone to your car's USB port. It may be labeled with the CarPlay logo, the words CarPlay, or an image of a smartphone.

Depending on your car, the CarPlay Home screen may appear automatically. If not, select the CarPlay logo on your car's display.

Speak to Siri. Press and hold the voice control button on the steering wheel, or touch and hold the Home button on the CarPlay Home screen, until Siri beeps. Then make your request.

Open an app. Tap the app on the touchscreen. Or twist the rotary knob to select the app, then press down on the knob.

Return to the CarPlay Home screen. Tap the Home button on the touchscreen. Or press the "back" button near the rotary knob until you get back to the Home screen.

Return to your car's Home screen. Tap the gray icon with your car's logo if it appears, or press the physical Home button on your radio if your car has one.

View additional apps. If you have more than eight apps, some apps may appear on another page of the Home screen. Swipe left on the touchscreen, or twist the rotary knob.

Return to a phone call or to turn-by-turn directions. (Touchscreen only.) Tap the icon in the upper-left corner of the touchscreen.

Scroll quickly through a list. Slide or tap the letters along the list at the right side of the touchscreen. Or twist or spin the rotary knob.

View and control the current audio source. Tap Now Playing to see the current audio app.

Maps

Get turn-by-turn directions, traffic conditions, and estimated travel time. CarPlay generates likely destinations using addresses from your email, text messages, contacts, and calendars—as well as places you frequent. You can also search for a location, or use locations you bookmarked.

You can use other apps even when getting directions. CarPlay lets you know when it's time to make a turn.

Display likely destinations. Tap Destinations.

Use Siri. Say, for example, "Get directions to the nearest coffee shop."

Phone

CarPlay uses the contacts on your iPhone to help you make calls. Use Show Contacts to bring up your favorites, recent calls, list of contacts, keypad, and voicemail.

Use Siri. Say something like:

- "Call Emily"
- "Return my last call"
- "What voicemails have I gotten?"

Messages

When you open Messages, Siri steps in automatically to read your incoming text messages or let you dictate a new one. Let Siri help you send, hear, and reply to text messages.

Use Siri. Say something like:

- "Read my text messages"
- "Text my wife"
- "Tell Emily I'm in traffic and I'll be 15 minutes late to the meeting"

Music

Use Music to access the music on your iPhone—including songs, artists, albums, and playlists. Or tune in to iTunes Radio. CarPlay also lets you use other audio apps that you download to your iPhone for podcasts, music, and radio. Use the Now Playing screen to control playback, or use the controls on your car's steering wheel.

Use Siri. Say something like:

- "Play some music"
- "Turn on the radio"
- "Let's hear that Mellow playlist"

Podcasts

Use the Podcasts app to listen to podcasts on your iPhone.

Use Siri. Say something like:

- "Play the Serial podcast"
- "Skip ahead 45 seconds"

Other apps

CarPlay works with select third-party audio apps. Compatible apps show up automatically on the CarPlay Home screen. Your car manufacturer may also provide apps that you can use with CarPlay. Ask your dealer what's available.

Safety, Handling, and Support

E Appendix

Important safety information

WARNING: Failure to follow these safety instructions could result in fire, electric shock, injury, or damage to iPhone or other property. Read all the safety information below before using iPhone.

Handling Handle iPhone with care. It is made of metal, glass, and plastic and has sensitive electronic components inside. iPhone can be damaged if dropped, burned, punctured, or crushed, or if it comes in contact with liquid. Don't use a damaged iPhone, such as one with a cracked screen, as it may cause injury. If you're concerned about scratching the surface of iPhone, consider using a case or cover.

Repairing Don't open iPhone and don't attempt to repair iPhone yourself. Disassembling iPhone may damage it or may cause injury to you. If iPhone is damaged, malfunctions, or comes in contact with liquid, contact Apple or an Apple Authorized Service Provider. You can find more information about getting service at www.apple.com/support/iphone/service/faq/.

Battery Don't attempt to replace the iPhone battery yourself—you may damage the battery, which could cause overheating and injury. The lithium-ion battery in iPhone should be replaced only by Apple or an authorized service provider, and must be recycled or disposed of separately from household waste. Don't incinerate the battery. For information about battery service and recycling, see www.apple.com/batteries/service-and-recycling/.

Distraction Using iPhone in some circumstances can distract you and may cause a dangerous situation (for example, avoid using headphones while riding a bicycle and avoid texting while driving a car). Observe rules that prohibit or restrict the use of mobile phones or headphones.

Navigation Maps, directions, Flyover, and location-based apps depend on data services. These data services are subject to change and may not be available in all areas, resulting in maps, directions, Flyover, or location-based information that may be unavailable, inaccurate, or incomplete. Some Maps features require Location Services. Compare the information provided on iPhone to your surroundings and defer to posted signs to resolve any discrepancies. Do not use these services while performing activities that require your full attention. Always comply with posted signs and the laws and regulations in the areas where you are using iPhone and always use common sense.

Charging Charge iPhone with the included USB cable and power adapter, or with other third-party "Made for iPhone" cables and power adapters that are compatible with USB 2.0 or later, or power adapters compliant with applicable country regulations and with one or more of the following standards: EN 301489-34, IEC 62684, YD/T 1591-2009, CNS 15285, ITU L.1000, or another applicable mobile phone power adapter interoperability standard. An iPhone Micro USB Adapter (available separately in some areas) or other adapter may be needed to connect iPhone to some compatible power adapters. Only micro USB power adapters in certain regions that comply with applicable mobile device power adapter interoperability standards are compatible. Please contact the power adapter manufacturer to find out if your micro USB power adapter complies with these standards.

Using damaged cables or chargers, or charging when moisture is present, can cause fire, electric shock, injury, or damage to iPhone or other property. When you use the Apple USB Power Adapter to charge iPhone, make sure the USB cable is fully inserted into the power adapter before you plug the adapter into a power outlet.

Lightning cable and connector Avoid prolonged skin contact with the connector when the Lightning to USB Cable is plugged into a power source because it may cause discomfort or injury. Sleeping or sitting on the Lightning connector should be avoided.

Prolonged heat exposure iPhone and its power adapter comply with applicable surface temperature standards and limits. However, even within these limits, sustained contact with warm surfaces for long periods of time may cause discomfort or injury. Use common sense to avoid situations where your skin is in contact with a device or its power adapter when it's operating or plugged into a power source for long periods of time. For example, don't sleep on a device or power adapter, or place them under a blanket, pillow, or your body, when it's plugged into a power source. It's important to keep iPhone and its power adapter in a well-ventilated area when in use or charging. Take special care if you have a physical condition that affects your ability to detect heat against the body.

Hearing loss Listening to sound at high volumes may damage your hearing. Background noise, as well as continued exposure to high volume levels, can make sounds seem quieter than they actually are. Turn on audio playback and check the volume before inserting anything in your ear. For more information about hearing loss, see www.apple.com/sound/. For information about how to set a maximum volume limit on iPhone, see Music settings on page 76.

To avoid hearing damage, use only compatible receivers, earbuds, headphones, speakerphones, or earpieces with iPhone. The headsets sold with iPhone 4s or later in China (identifiable by dark insulating rings on the plug) are designed to comply with Chinese standards and are only compatible with iPhone 4s or later, iPad 2 or later, and iPod touch 5th generation.

WARNING: To prevent possible hearing damage, do not listen at high volume levels for long periods.

Radio frequency exposure iPhone uses radio signals to connect to wireless networks. For information about radio frequency (RF) energy resulting from radio signals and steps you can take to minimize exposure, go to Settings > General > About > Legal > RF Exposure or visit www.apple.com/legal/rfexposure/.

Radio frequency interference Observe signs and notices that prohibit or restrict the use of mobile phones (for example, in healthcare facilities or blasting areas). Although iPhone is designed, tested, and manufactured to comply with regulations governing radio frequency emissions, such emissions from iPhone can negatively affect the operation of other electronic equipment, causing them to malfunction. Turn off iPhone or use Airplane Mode to turn off the iPhone wireless transmitters when use is prohibited, such as while traveling in aircraft, or when asked to do so by authorities.

Medical device interference iPhone contains components and radios that emit electromagnetic fields. iPhone also contains magnets and the included headphones also have magnets in the earbuds. These electromagnetic fields and magnets may interfere with pacemakers, defibrillators, or other medical devices. Maintain a safe distance of separation between your medical device and iPhone and the earbuds. Consult your physician and medical device manufacturer for information specific to your medical device. If you suspect iPhone is interfering with your pacemaker, defibrillator, or any other medical device, stop using iPhone.

Not a medical device iPhone and the Health app are not designed or intended for use in the diagnosis of disease or other conditions, or in the cure, mitigation, treatment, or prevention of disease.

Medical conditions If you have any medical condition that you believe could be affected by iPhone (for example, seizures, blackouts, eyestrain, or headaches), consult with your physician prior to using iPhone.

Explosive atmospheres Charging or using iPhone in any area with a potentially explosive atmosphere, such as areas where the air contains high levels of flammable chemicals, vapors, or particles (such as grain, dust, or metal powders), may be hazardous. Obey all signs and instructions.

Repetitive motion When you perform repetitive activities such as typing or playing games on iPhone, you may experience discomfort in your hands, arms, wrists, shoulders, neck, or other parts of your body. If you experience discomfort, stop using iPhone and consult a physician.

High-consequence activities This device is not intended for use where the failure of the device could lead to death, personal injury, or severe environmental damage.

Choking hazard Some iPhone accessories may present a choking hazard to small children. Keep these accessories away from small children.

Important handling information

Cleaning Clean iPhone immediately if it comes in contact with anything that may cause stains—such as dirt, ink, makeup, or lotions. To clean:

- Disconnect all cables and turn iPhone off (press and hold the Sleep/Wake button, then slide the onscreen slider).
- Use a soft, lint-free cloth.
- Avoid getting moisture in openings.
- Don't use cleaning products or compressed air.

The front or back cover of iPhone may be made of glass with a fingerprint-resistant oleophobic (oil repellant) coating. This coating wears over time with normal usage. Cleaning products and abrasive materials will further diminish the coating, and may scratch the glass.

Using connectors, ports, and buttons Never force a connector into a port or apply excessive pressure to a button, because this may cause damage that is not covered under the warranty. If the connector and port don't join with reasonable ease, they probably don't match. Check for obstructions and make sure that the connector matches the port and that you have positioned the connector correctly in relation to the port.

Lightning to USB Cable Discoloration of the Lightning connector after regular use is normal. Dirt, debris, and exposure to moisture may cause discoloration. If your Lightning cable or connector become warm during use or iPhone won't charge or sync, disconnect it from your computer or power adapter and clean the Lightning connector with a soft, dry, lint-free cloth. Do not use liquids or cleaning products when cleaning the Lightning connector.

Certain usage patterns can contribute to the fraying or breaking of cables. The Lightning to USB Cable, like any other metal wire or cable, is subject to becoming weak or brittle if repeatedly bent in the same spot. Aim for gentle curves instead of angles in the cable. Regularly inspect the cable and connector for any kinks, breaks, bends, or other damage. Should you find any such damage, discontinue use of the Lightning to USB Cable.

Operating temperature iPhone is designed to work in ambient temperatures between 32° and 95° F (0° and 35° C) and stored in temperatures between -4° and 113° F (-20° and 45° C). iPhone can be damaged and battery life shortened if stored or operated outside of these temperature ranges. Avoid exposing iPhone to dramatic changes in temperature or humidity. When you're using iPhone or charging the battery, it is normal for iPhone to get warm.

If the interior temperature of iPhone exceeds normal operating temperatures (for example, in a hot car or in direct sunlight for extended periods of time), you may experience the following as it attempts to regulate its temperature:

- iPhone stops charging.
- The screen dims.
- A temperature warning screen appears.
- Some apps may close.

Important: You may not be able to use iPhone while the temperature warning screen is displayed. If iPhone can't regulate its internal temperature, it goes into deep sleep mode until it cools. Move iPhone to a cooler location out of direct sunlight and wait a few minutes before trying to use iPhone again.

For more information, see support.apple.com/kb/HT2101.

iPhone Support site

Comprehensive support information is available online at www.apple.com/support/iphone/. To contact Apple for personalized support (not available in all areas), see www.apple.com/support/contact/.

Restart or reset iPhone

If something isn't working right, try restarting iPhone, forcing an app to quit, or resetting iPhone.

Restart iPhone. Hold down the Sleep/Wake button until the slider appears. Slide your finger across the slider to turn off iPhone. To turn iPhone back on, hold down the Sleep/Wake button until the Apple logo appears.

Force an app to quit. From the Home screen, double-click the Home button and swipe upwards on the app screen.

If you can't turn off iPhone or if the problem continues, you may need to reset iPhone. Do this only if you're unable to restart iPhone.

Reset iPhone. Hold down the Sleep/Wake button and the Home button at the same time for at least ten seconds, until the Apple logo appears.

You can reset the network settings, keyboard dictionary, home screen layout, and location and privacy settings. You can also erase all of your content and settings.

Reset iPhone settings

Reset iPhone settings. Go to Settings > General > Reset, then choose an option:

- *Reset All Settings:* All your preferences and settings are reset.
- *Erase All Content and Settings:* Your information and settings are removed. iPhone cannot be used until it's set up again.
- *Reset Network Settings:* When you reset network settings, previously used networks and VPN settings that weren't installed by a configuration profile are removed. (To remove VPN settings installed by a configuration profile, go to Settings > General > Profile, select the profile, then tap Remove. This also removes other settings or accounts provided by the profile.) Wi-Fi is turned off and then back on, disconnecting you from any network you're on. The Wi-Fi and "Ask to Join Networks" settings remain turned on.
- *Reset Keyboard Dictionary:* You add words to the keyboard dictionary by rejecting words iPhone suggests as you type. Resetting the keyboard dictionary erases all words you've added.
- *Reset Home Screen Layout:* Returns the built-in apps to their original layout on the Home screen.
- *Reset Location & Privacy:* Resets the location services and privacy settings to their defaults.

Get information about your iPhone

See information about iPhone. Go to Settings > General > About. The items you can view include:

- Name
- Network addresses
- Number of songs, videos, photos, and apps
- Capacity and available storage space
- iOS version
- Carrier
- Model number
- Serial number
- Wi-Fi and Bluetooth addresses
- IMEI (International Mobile Equipment Identity)
- ICCID (Integrated Circuit Card Identifier, or Smart Card) for GSM networks
- MEID (Mobile Equipment Identifier) for CDMA networks
- Modem firmware
- Legal (including legal notices and license, warranty, regulatory marks, and RF exposure information)

To copy the serial number and other identifiers, touch and hold the identifier until Copy appears.

To help Apple improve products and services, iPhone sends diagnostic and usage data. This data doesn't personally identify you, but may include location information.

View or turn off diagnostic information. Go to Settings > Privacy > Diagnostics & Usage.

Usage information

View cellular usage. Go to Settings > Cellular. See Cellular settings on page 188.

View other usage information. Go to Settings > General > Usage to:

- See Battery Usage, including the elapsed time since iPhone has been charged and usage by app
- Display battery level as a percentage
- View overall storage availability and storage used per app
- View and manage iCloud storage

Disabled iPhone

If iPhone is disabled because you forgot your passcode or entered an incorrect passcode too many times, you can restore iPhone from an iTunes or iCloud backup and reset the passcode. For more information, see Restore iPhone on page 187.

If you get a message in iTunes that your iPhone is locked and you must enter a passcode, see support.apple.com/kb/HT1212.

Back up iPhone

You can use iCloud or iTunes to automatically back up iPhone. If you choose to back up using iCloud, you can't also use iTunes to automatically back up to your computer, but you can use iTunes to manually back up to your computer. iCloud backs up to iPhone daily over Wi-Fi, when it's connected to a power source and is locked. The date and time of the last backup is listed at the bottom of the Backup screen.

iCloud backs up your:

- Purchased music, movies, TV shows, apps, and books
- Photos and videos taken with iPhone (if you use iCloud Photo Library, your photos and videos are already stored in iCloud, so they won't also be part of an iCloud backup)
- iPhone settings
- App data
- Home screen, folders, and app layout
- Messages (iMessage, SMS, and MMS)
- Ringtones

Note: Purchased content is not backed up in all areas.

Turn on iCloud backups. Go to Settings > iCloud, then sign in with your Apple ID and password if required. Go to Backup, then turn on iCloud Backup. To turn on backups in iTunes on your computer, go to File > Devices > Back Up.

Back up immediately. Go to Settings > iCloud > Backup, then tap Back Up Now.

Encrypt your backup. iCloud backups are encrypted automatically so that your data is protected from unauthorized access both while it's transmitted to your devices and when it's stored in iCloud. If you're using iTunes for your backup, select "Encrypt iPhone backup" in the iTunes Summary pane.

Manage your backups. Go to Settings > iCloud. You can manage which apps are backed up to iCloud by tapping them on or off. Go to Settings > iCloud > Storage > Manage Storage to remove existing backups and manage iCloud Drive or Documents & Data. In iTunes, remove backups in iTunes Preferences.

View the devices being backed up. Go to Settings > iCloud > Storage > Manage Storage.

Stop iCloud backups. Go to Settings > iCloud > Backup, then turn off iCloud Backup.

Music not purchased in iTunes isn't backed up in iCloud. Use iTunes to back up and restore that content. See Sync with iTunes on page 21.

Important: Backups for music, movies, or TV show purchases are not available in all countries. Previous purchases may not be restored if they are no longer in the iTunes Store, App Store, or iBooks Store.

Purchased content, iCloud Photo Sharing, and My Photo Stream content don't count against your 5 GB of free iCloud storage.

For more information about backing up iPhone, see support.apple.com/kb/HT5262.

Update and restore iPhone software

About update and restore

You can update iPhone software in Settings, or by using iTunes. You can also erase or restore iPhone, and then use iCloud or iTunes to restore from a backup.

Update iPhone

You can update software in iPhone Settings or by using iTunes.

Update wirelessly on iPhone. Go to Settings > General > Software Update. iPhone checks for available software updates.

Update software in iTunes. iTunes checks for available software updates each time you sync iPhone using iTunes. See Sync with iTunes on page 21.

For more information about updating iPhone software, see support.apple.com/kb/HT4623.

Restore iPhone

You can use iCloud or iTunes to restore iPhone from a backup.

Restore from an iCloud backup. Reset iPhone to erase all content and settings, then choose Restore from a Backup and sign in to iCloud in Setup Assistant. See Restart or reset iPhone on page 184.

Restore from an iTunes backup. Connect iPhone to the computer you normally sync with, select iPhone in the iTunes window, then click Restore in the Summary pane.

When the iPhone software is restored, you can either set it up as a new iPhone, or restore your music, videos, app data, and other content from a backup.

For more information about restoring iPhone software, see support.apple.com/kb/HT1414.

Cellular settings

Use Cellular settings to turn cellular data and roaming on or off, set which apps and services use cellular data, see call time and cellular data usage, and set other cellular options.

If iPhone is connected to the Internet via the cellular data network, the LTE, 4G, 3G, E, or GPRS icon appears in the status bar.

LTE, 4G, and 3G service on GSM cellular networks support simultaneous voice and data communications. For all other cellular connections, you can't use Internet services while you're talking on the phone unless iPhone also has a Wi-Fi connection to the Internet. Depending on your network connection, you may not be able to receive calls while iPhone transfers data over the cellular network—when downloading a webpage, for example.

- *GSM networks:* On an EDGE or GPRS connection, incoming calls may go directly to voicemail during data transfers. For incoming calls that you answer, data transfers are paused.
- *CDMA networks:* On EV-DO connections, data transfers are paused when you answer incoming calls. On 1xRTT connections, incoming calls may go directly to voicemail during data transfers. For incoming calls that you answer, data transfers are paused.

Data transfer resumes when you end the call.

If Cellular Data is off, all data services use only Wi-Fi—including email, web browsing, push notifications, and other services. If Cellular Data is on, carrier charges may apply. For example, using certain features and services that transfer data, such as Siri and Messages, could result in charges to your data plan.

Turn Cellular Data on or off. Go to Settings > Cellular, then tap Cellular Data. The following options may also be available:

- *Turn Voice Roaming on or off (CDMA):* Turn Voice Roaming off to avoid charges from using other carrier's networks. When your carrier's network isn't available, iPhone won't have cellular (data or voice) service.
- *Turn Data Roaming on or off:* Data Roaming permits Internet access over a cellular data network when you're in an area not covered by your carrier's network. When you're traveling, you can turn off Data Roaming to avoid roaming charges. See Phone settings on page 58.
- *Enable or disable 4G/LTE (varies by carrier):* Using 4G or LTE loads Internet data faster in some cases, but may decrease battery performance. If you're making a lot of phone calls, you may want to turn 4G/LTE off to extend battery life. This option is not available in all areas. On iPhone 6 and iPhone 6 Plus, there are options for turning off 4G/LTE, selecting Voice & Data (VoLTE), or Data Only.
- *Voice & Data (some carriers):* Choose LTE to load data faster. Choose slower speeds to increase battery life.
- *Set up Personal Hotspot:* Personal Hotspot shares the Internet connection on iPhone with your computer and other iOS devices. See Personal Hotspot on page 40.

Set whether cellular data is used for apps and services. Go to Settings > Cellular, then turn cellular data on or off for any app that can use cellular data. If a setting is off, iPhone uses only Wi-Fi for that service. The iTunes setting includes both iTunes Match and automatic downloads from the iTunes Store and the App Store.

Sell or give away iPhone

Before you sell or give away your iPhone, be sure to erase all content and your personal information. If you've enabled Find My iPhone (see Find My iPhone on page 46), Activation Lock is on. You need to turn off Activation Lock before the new owner can activate iPhone under his or her own account.

Erase iPhone and remove Activation Lock. Go to Settings > General > Reset > Erase All Content and Settings.

See support.apple.com/kb/HT5661.

Learn more, service, and support

Refer to the following resources to get more iPhone-related safety, software, and service information.

To learn about	Do this
Using iPhone safely	See Important safety information on page 181.
iPhone service and support, tips, forums, and Apple software downloads	Go to www.apple.com/support/iphone/.
Service and support from your carrier	Contact your carrier or go to your carrier's website.
The latest information about iPhone	Go to www.apple.com/iphone/.
Managing your Apple ID account	Go to appleid.apple.com.
Using iCloud	Go to help.apple.com/icloud/.
Using iTunes	Open iTunes, then choose Help > iTunes Help. For an online iTunes tutorial (may not be available in all areas), go to www.apple.com/support/itunes/.
Using other Apple iOS apps	Go to www.apple.com/support/ios/.
Finding your iPhone serial number, IMEI, ICCID, or MEID	You can find your iPhone serial number, International Mobile Equipment Identity (IMEI), ICCD, or Mobile Equipment Identifier (MEID) on the iPhone packaging. Or, on iPhone, choose Settings > General > About. For more information, go to support.apple.com/kb/ht4061.
Obtaining warranty service	First follow the advice in this guide. Then go to www.apple.com/support/iphone/.
Viewing iPhone regulatory information	On iPhone, go to Settings > General > About > Legal > Regulatory.
Battery service	Go to www.apple.com/batteries/service-and-recycling/.
Using iPhone in an enterprise environment	Go to www.apple.com/iphone/business/.

FCC compliance statement

This device complies with part 15 of the FCC rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment to an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Important: Changes or modifications to this product not authorized by Apple could void the electromagnetic compatibility (EMC) and wireless compliance and negate your authority to operate the product. This product has demonstrated EMC compliance under conditions that included the use of compliant peripheral devices and shielded cables between system components. It is important that you use compliant peripheral devices and shielded cables between system components to reduce the possibility of causing interference to radios, televisions, and other electronic devices.

Canadian regulatory statement

This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Operation in the band 5150-5250 MHz is only for indoor use to reduce the potential for harmful interference to co-channel mobile satellite systems.

Users are advised that high-power radars are allocated as primary users (i.e., priority users) of the bands 5250-5350 MHz and 5650-5850 MHz and that these radars could cause interference and/or damage to LE-LAN devices.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

La bande 5 150-5 250 MHz est réservés uniquement pour une utilisation à l'intérieur afin de réduire les risques de brouillage préjudiciable aux systèmes de satellites mobiles utilisant les mêmes canaux.

Les utilisateurs êtes avisés que les utilisateurs de radars de haute puissance sont désignés utilisateurs principaux (c.-à-d., qu'ils ont la priorité) pour les bandes 5 250-5 350 MHz et 5 650-5 850 MHz et que ces radars pourraient causer du brouillage et/ou des dommages aux dispositifs LAN-EL.

CAN ICES-3 (B)/NMB-3(B)

Disposal and recycling information

Apple Recycling Program (available in some areas): For free recycling of your old mobile phone, a prepaid shipping label, and instructions, see www.apple.com/recycling/.

iPhone disposal and recycling: You must dispose of iPhone properly according to local laws and regulations. Because iPhone contains electronic components and a battery, iPhone must be disposed of separately from household waste. When iPhone reaches its end of life, contact local authorities to learn about disposal and recycling options, or simply drop it off at your local Apple retail store or return it to Apple. The battery will be removed and recycled in an environmentally friendly manner. For more information, see www.apple.com/recycling/.

Battery replacement: The lithium-ion battery in iPhone should be replaced by Apple or an authorized service provider, and must be recycled or disposed of separately from household waste. For more information about battery service and recycling, go to www.apple.com/batteries/service-and-recycling/.

Dispose of batteries according to your local environmental laws and guidelines.

California Battery Charger Energy Efficiency

BC

Türkiye

Türkiye Cumhuriyeti: AEEE Yönetmeliğine Uygundur.

台灣

廢電池請回收

Taiwan Battery Statement

警告：請勿戳刺或焚燒。此電池不含汞。

China Battery Statement

警告：不要刺破或焚烧。该电池不含水银。

European Union—Disposal Information

The symbol above means that according to local laws and regulations your product and/or its battery shall be disposed of separately from household waste. When this product reaches its end of life, take it to a collection point designated by local authorities. The separate collection and recycling of your product and/or its battery at the time of disposal will help conserve natural resources and ensure that it is recycled in a manner that protects human health and the environment.

Union Européenne—informations sur l'élimination: Le symbole ci-dessus signifie que, conformément aux lois et réglementations locales, vous devez jeter votre produit et/ou sa batterie séparément des ordures ménagères. Lorsque ce produit arrive en fin de vie, apportez-le à un point de collecte désigné par les autorités locales. La collecte séparée et le recyclage de votre produit et/ou de sa batterie lors de sa mise au rebut aideront à préserver les ressources naturelles et à s'assurer qu'il est recyclé de manière à protéger la santé humaine et l'environnement.

Europäische Union—Informationen zur Entsorgung: Das oben aufgeführte Symbol weist darauf hin, dass dieses Produkt und/oder die damit verwendete Batterie den geltenden gesetzlichen Vorschriften entsprechend und vom Hausmüll getrennt entsorgt werden muss. Geben Sie dieses Produkt zur Entsorgung bei einer offiziellen Sammelstelle ab. Durch getrenntes Sammeln und Recycling werden die Rohstoffreserven geschont und es ist sichergestellt, dass beim Recycling des Produkts und/oder der Batterie alle Bestimmungen zum Schutz von Gesundheit und Umwelt eingehalten werden.

Unione Europea—informazioni per lo smaltimento: Il simbolo qui sopra significa che, in base alle leggi e alle normative locali, il prodotto e/o la sua batteria dovrebbero essere riciclati separatamente dai rifiuti domestici. Quando il prodotto diventa inutilizzabile, portalo nel punto di raccolta stabilito dalle autorità locali. La raccolta separata e il riciclaggio del prodotto e/o della sua batteria al momento dello smaltimento aiutano a conservare le risorse naturali e assicurano che il riciclaggio avvenga nel rispetto della salute umana e dell'ambiente.

Europeiska unionen—information om kassering: Symbolen ovan betyder att produkten och/eller dess batteri enligt lokala lagar och bestämmelser inte får kastas tillsammans med hushållsavfallet. När produkten har tjänat ut måste den tas till en återvinningsstation som utsetts av lokala myndigheter. Genom att låta den uttjänta produkten och/eller dess batteri tas om hand för återvinning hjälper du till att spara naturresurser och skydda hälsa och miljö.

Brasil—Informações sobre descarte e reciclagem

O símbolo indica que este produto e/ou sua bateria não devem ser descartadas no lixo doméstico. Quando decidir descartar este produto e/ou sua bateria, faça-o de acordo com as leis e diretrizes ambientais locais. Para informações sobre substâncias de uso restrito, o programa de reciclagem da Apple, pontos de coleta e telefone de informações, visite www.apple.com/br/environment/.

Información sobre eliminación de residuos y reciclaje

El símbolo indica que este producto y/o su batería no debe desecharse con los residuos domésticos. Cuando decida desechar este producto y/o su batería, hágalo de conformidad con las leyes y directrices ambientales locales. Para obtener información sobre el programa de reciclaje de Apple, puntos de recolección para reciclaje, sustancias restringidas y otras iniciativas ambientales, visite www.apple.com/la/environment/.

Apple and the environment

At Apple, we recognize our responsibility to minimize the environmental impacts of our operations and products. For more information, go to www.apple.com/environment/.

Apple
1 Infinite Loop
Cupertino, CA 95014-2084
408-996-1010
www.apple.com

019-00126/2015-04

Appendix A

LTE Devices

1. iPad
2. iPad Air
3. iPad Air 2
4. iPad Mini
5. iPad Mini 2
6. iPad Mini 3
7. iPhone 5
8. iPhone 5c
9. iPhone 5s
10. iPhone 6
11. iPhone 6+

LTE Device Model Numbers

1. A1403
2. A1428
3. A1429
4. A1430
5. A1453
6. A1454
7. A1455
8. A1456
9. A1459
10. A1460
11. A1475
12. A1490
13. A1522 (CDMA)
14. A1522 (GSM)
15. A1524 (CDMA)
16. A1524 (GSM)
17. A1532 (CDMA)
18. A1532 (GSM)
19. A1533 (CDMA)
20. A1533 (GSM)
21. A1549 (CDMA)
22. A1549 (GSM)
23. A1567
24. A1586 (CDMA)
25. A1586 (GSM)
26. A1600

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

Evolved Wireless, LLC

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

(c) Attorneys *(Firm Name, Address, and Telephone Number)*
Brian E. Farnan, Farnan LLP
919 N. Market Street, 12th Floor
Wilmington, DE 19801

DEFENDANTS

Apple, Inc.

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

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

Attorneys *(If Known)*

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

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

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

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

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

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

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

TORTS

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

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

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

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

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

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

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

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

PROPERTY RIGHTS
- ❒ 820 Copyrights
- ☒ 830 Patent
- ❒ 840 Trademark

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

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

OTHER STATUTES
- ❒ 375 False Claims Act
- ❒ 400 State Reapportionment
- ❒ 410 Antitrust
- ❒ 430 Banks and Banking
- ❒ 450 Commerce
- ❒ 460 Deportation
- ❒ 470 Racketeer Influenced and Corrupt Organizations
- ❒ 480 Consumer Credit
- ❒ 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

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

VI. CAUSE OF ACTION

Cite the U.S. Civil Statute under which you are filing ***(Do not cite jurisdictional statutes unless diversity)***:
35 USC § 271

Brief description of cause:
Infringement of U.S. Patents

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
06/25/2015

SIGNATURE OF ATTORNEY OF RECORD
/s/ Brian E. Farnan

FOR OFFICE USE ONLY

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