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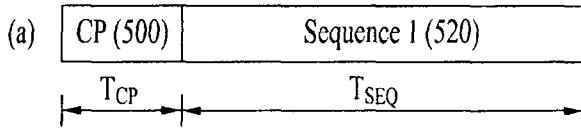
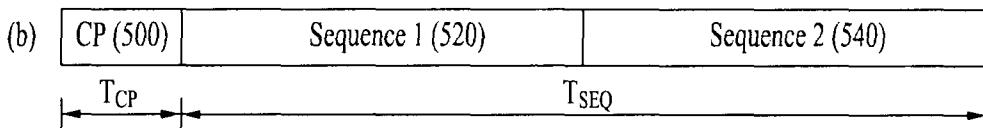


FIG. 5



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(57) **Abstract:** A wireless communication system is disclosed. A method for constructing a RACH preamble according to a cell radius of a base station (BS) irrespective of a guard time (GT) and a method for allocating the RACH preamble are disclosed. A method for constructing a preamble of a random access channel (RACH) includes acquiring time-length information of a predetermined cyclic prefix (CP) for each cell radius of a base station (BS), acquiring sequence time-length information of a single sequence or a repeated sequence, and constructing the preamble using the predetermined CP time-length information and the sequence time-length information, irrespective of a time length of a guard time (GT).

## 【DESCRIPTION】

## 【Invention Title】

METHOD FOR CONSTRUCTING RACH PREAMBLE AND METHOD FOR  
TRANSMITTING RACH SIGNAL

## 5      【Technical Field】

The present invention relates to a wireless communication system, and to a method for constructing a random access channel (RACH) and a method for transmitting a RACH signal.

## 10     【Background Art】

A method for constructing a random access channel (RACH) and a method for transmitting a RACH signal will hereinafter be described in detail.

There is proposed a method for preventing the occurrence of an inter-symbol interference (ISI) while each symbol of the sub-carrier is transmitted over a multi-path channel in either an Orthogonal Frequency Division Multiplexing (OFDM) or a Discrete Multi-Tone (DMT), and a detailed description of the above method will hereinafter be described.

For example, a guard time (GT) longer than a maximum delay spread of a channel is inserted between successive symbols. In brief, this guard time (GT) is called a cyclic extension. The cyclic extension (CE) is 5 classified into a cyclic prefix (CP) and a cyclic suffix (CS). The cyclic prefix (CP) copies the signal of the last time of an effective symbol time, and inserts the copied signal to the front part, such that it prevents orthogonality between sub-carriers from being broken or 10 damaged. The cyclic suffix (CS) copies the signal of a first time of an effective symbol, and attaches the copied signal to the end part.

A single RACH signal may include a CP time, a sequence time, and a guard time. The CP time copies a 15 signal of the last time of the effective symbol time, and inserts the copied signal to the front part, such that it prevents orthogonality between sub-carriers caused by the signals received with different time delays.

The sequence time corresponds to the effective 20 symbol time of the RACH signal. In fact, the sequence time indicates a time interval in which the sequence defined by the RACH signal is actually transmitted. In more detail, the sequence time is a time occupied by an actual transmission end after the defined sequence has

executed necessary steps (e.g., over\_sampling). The guard time (GT) of the RACH signal is indicative of an empty space having no transmission (Tx) signal, such that it prevents the next-symbol orthogonality from being broken 5 or interfered by the signals received with relatively-high time delays.

A general RACH transmission structure and the influence of a frequency offset will hereinafter be described in detail.

10 A random access channel (RACH) is a channel used when a user equipment (UE) acquires initial uplink synchronization. If the user equipment (UE) is firstly powered on, or the terminal (UE) is switched to an active status after it has been in an idle mode for a long 15 period of time, uplink synchronization should be re-established. The RACH is generally adapted to re-establish the uplink synchronization, and need not establish time synchronization or frequency synchronization.

20 The RACH basically supports a multi-user mode. Each user equipment (UE) transmits a specific preamble sequence when accessing the RACH. If a base station (BS) recognizes the preamble sequence received from the user equipment (UE), it transmits the recognized preamble

sequence to a downlink. The user equipment (UE) updates its own time synchronization information using specific information contained in a downlink signal received from the base station (BS). In this case, if the base station 5 (BS) transmits frequency synchronization information along with the time synchronization information, this frequency synchronization information can also be used to correct the user equipment (UE).

The basic requirements for RACH are used to satisfy 10 a round trip delay (RTD) and the condition of a path loss, irrespective of a UE speed, a frequency offset, a cell radius, etc.

For example, the 3GPP LTE communication standard serving as one of current communication system-associated 15 standards has been intensively discussed about the RACH structure which has the length of a 1ms TTI (transmission Timing Interval), a cyclic prefix (CP) of  $102.6 \mu\text{s}$ , a sequence length of 0.8ms, a guard time (GT) of  $97.5 \mu\text{s}$ . In this case, the time length other than the channel delay 20 spread in the cyclic prefix (CP) has been intensively discussed as the length of the guard time (GT).

The cell radius of about 15km can be used as the above-mentioned CP or GT.

In this case, the CP and GT may have different lengths requisite for individual cell radiiuses. However, the cell size may be larger than 15km as necessary. Presently, many developers are conducting an intensive 5 research into a method for covering the length of more than 100km, such that an additional RACH structure is needed.

**【Disclosure】**

**【Technical Problem】**

10 Accordingly, the present invention is directed to a method for constructing a RACH preamble and a method for transmitting a RACH signal that substantially obviate one or more problems due to limitations and disadvantages of the related art.

15 An object of the present invention is to provide a method for generating a fixed CP contained in a RACH signal capable of covering a cell radius required by a base station (BS).

Another object of the present invention is to 20 provide a method for generating a RACH preamble using a predetermined CP and a predetermined sequence.

Another object of the present invention is to provide a method for assigning the RACH preamble sequence to each UE.

Another object of the present invention is to 5 provide a method for constructing a RACH preamble according to a cell radius of a base station (BS) irrespective of a guard time (GT) and a method for allocating the RACH preamble.

#### 【Technical Solution】

10 To achieve these objects and other advantages and in accordance with the purpose of the invention, as embodied and broadly described herein, a method for constructing a preamble of a random access channel (RACH) comprising: acquiring time-length information of a predetermined cyclic 15 prefix (CP) for each cell radius of a base station (BS); acquiring sequence time-length information of a single sequence or a repeated sequence; and constructing the preamble using the predetermined CP time-length information and the sequence time-length information, irrespective of a 20 time length of a guard time (GT).

Preferably, the predetermined CP time-length information is generated by a cell radius supportable by a system, a maximum delay spread, and a maximum round trip

delay (RTD).

Preferably, the predetermined CP time-length information has any one of time-length values  $3152 \times T_s$ ,  $6224 \times T_s$ , and  $21012 \times T_s$  according to the cell radius, where

$$\frac{1}{30.72 \text{MHz}}$$

5 "T<sub>s</sub>" is a sampling interval denoted by .

Preferably, the predetermined CP time-length information satisfies a maximum cell radius request supportable by a system, irrespective of the sequence time-length information.

10 Preferably, the single sequence has a time-length value denoted by  $24576 \times T_s$ , and the repeated sequence has a time-length value denoted by  $2 \times 24576 \times T_s$ , where "T<sub>s</sub>" is a

$$\frac{1}{30.72 \text{MHz}}$$

sampling interval denoted by .

15 Preferably, the preamble includes a first preamble, a second preamble, a third preamble, and a fourth preamble, in which the first preamble includes a cyclic prefix (CP) having a time length of  $3152 \times T_s$  and a sequence having a time length of  $24576 \times T_s$ ; the second preamble includes a cyclic prefix (CP) having a time length of  $21012 \times T_s$  and a sequence having a time length of  $24576 \times T_s$ ; the third preamble includes a cyclic prefix (CP) having a time length of  $6224 \times T_s$  and a sequence having a time length of

$2 \times 24576 \times T_s$ ; and the fourth preamble includes a cyclic prefix (CP) having a time length of  $21012 \times T_s$  and a sequence having a time length of  $2 \times 24576 \times T_s$ , where "T<sub>s</sub>" is a

$$\frac{1}{30.72MHz}$$

sampling interval denoted by .

5 In another aspect of the present invention, there is provided a method for transmitting a random access channel (RACH) signal comprising: receiving information of a predetermined preamble format from a base station (BS); and transmitting a random access channel (RACH) signal to the 10 base station (BS) using a preamble contained in the predetermined preamble format, in which the predetermined preamble format is constructed by a predetermined cyclic prefix (CP), a single sequence, or a repeated sequence according to a cell radius of the base station (BS), 15 irrespective of a time length of a guard time (GT).

Preferably, the predetermined preamble format includes time-length information of the predetermined cyclic prefix (CP) and sequence time-length information.

Preferably, if the sequence time-length information 20 indicates that the sequence contained in the preamble is the single sequence, the predetermined CP time-length information indicates whether the predetermined cyclic prefix (CP) is an extended cyclic prefix (CP).

Preferably, the single sequence has a time-length value denoted by  $24576 \times T_s$ , and if the predetermined cyclic prefix is not the extended cyclic prefix, the predetermined cyclic prefix (CP) has a time-length value denoted by 5  $3152 \times T_s$ , and if the extended cyclic prefix (CP) is the extended cyclic prefix, the predetermined cyclic prefix has a time-length value denoted by  $21012 \times T_s$ , where the "T<sub>s</sub>"

$$\frac{1}{30.72MHz}$$

is a sampling interval denoted by .

Preferably, if the sequence time-length information 10 indicates that the sequence contained in the preamble is the repeated sequence, the predetermined CP time-length information indicates whether the predetermined cyclic prefix (CP) is an extended cyclic prefix (CP) or a middle cyclic prefix (CP).

15 Preferably, the repeated sequence has a time-length value denoted by  $2 \times 24576 \times T_s$ , and if the predetermined cyclic prefix (CP) is the extended cyclic prefix, the predetermined cyclic prefix has a time-length value denoted by  $21012 \times T_s$ , and if the predetermined cyclic prefix is the 20 middle cyclic prefix, the predetermined cyclic prefix has a time-length value denoted by  $6224 \times T_s$ , where the "T<sub>s</sub>" is a

$$\frac{1}{30.72MHz}$$

sampling interval denoted by .

Preferably, the time length of the guard time (GT) is adjusted by the base station (BS) according to the cell radius.

In another aspect of the present invention, there is  
5 provided a method for receiving a random access channel (RACH) signal comprising: receiving information of a predetermined preamble format to each user equipment (UE); and receiving the RACH signal from each user equipment (UE), wherein the predetermined preamble format is constructed by  
10 a predetermined cyclic prefix (CP), a single sequence, or a repeated sequence according to a cell radius, irrespective of a time length of a guard time (GT).

Preferably, the time length of the guard time (GT) is adjusted according to the cell radius.

15 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.

#### **【Advantageous Effects】**

The present invention has the following effects.

Firstly, the present invention uses a fixed number of CPs, such that it reduces the complexity of a hardware design and constructs a less number of RACH preambles.

Secondly, if a base station (BS) uses a 5 predetermined CP within a coverable cell radius, it need not consider the CP length on the basis of the cell radius, such that it can effectively process a system.

Thirdly, the guard time (GT) information is not transmitted to the user, and the base station (BS) 10 arbitrarily establishes the GT information according to the cell radius, such that a variety of cell coverages can be supported by a less number of RACH burst structures.

#### **【Description of Drawings】**

The accompanying drawings, which are included to 15 provide a further understanding of the invention, illustrate embodiments of the invention and together with the description serve to explain the principle of the invention.

In the drawings:

20 FIG. 1 is a conceptual diagram illustrating a RACH structure according to the present invention;

FIGS. 2a~2b are graphs illustrating a variance in CP, GT, or RACH length required for a cell radius of the base station (BS) according to the present invention;

FIGS. 3a~3d are graphs illustrating RACH structures configured when a predetermined CP and a predetermined sequence are used according to the cell radius which should be managed by the base station (BS) according to the present invention;

FIGS. 4a~4b shows GT and RACH lengths required for the cell radius when the CP length is 708.335  $\mu$ s according to the present invention;

FIG. 5 is a conceptual diagram illustrating a method for constructing a RACH preamble using the CP and the sequence without considering the guard time (GT) length according to the present invention;

FIG. 6 is a graph illustrating a variance in CP, GT, or RACH length required for a cell radius according to the present invention; and

FIGS. 7a~7b are graphs illustrating RACH structures configured when a predetermined-length CP and predetermined-length sequence are used according to middle CP values of FIGS. 2b and 6 according to the present invention.

## 【Best Mode】

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

5 Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

The present invention relates to a wireless communication system. Specifically, the present invention relates to a method for constructing a RACH preamble 10 according to a cell radius of a base station (BS) irrespective of a guard time (GT) length and a method for transmitting a RACH signal.

Prior to describing the present invention, it should be noted that most terms disclosed in the present invention 15 correspond to general terms well known in the art, but some terms have been selected by the applicant as necessary and will hereinafter be disclosed in the following description of the present invention. Therefore, it is preferable that the terms defined by the applicant be understood on the 20 basis of their meanings in the present invention.

For the convenience of description and better understanding of the present invention, general structures and devices well known in the art will be omitted or be

denoted by a block diagram or a flow chart. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

The following embodiments are proposed by combining 5 constituent components and characteristics of the present invention according to a predetermined format. The individual constituent components or characteristics should be considered to be optional factors on the condition that there is no additional remark. If required, the individual 10 constituent components or characteristics may not be combined with other components or characteristics. Also, some constituent components and/or characteristics may be combined to implement the embodiments of the present invention. The order of operations to be disclosed in the 15 embodiments of the present invention may be changed to another. Some components or characteristics of any embodiment may also be included in other embodiments, or may be replaced with those of the other embodiments as necessary.

20 The following embodiments of the present invention will be disclosed on the basis of a data communication relationship between the base station (BS) and the user equipment (UE). In this case, the base station (BS) is used as a terminal node of a network via which the base

station (BS) can directly communicate with the user equipment (UE). Specific operations to be conducted by the user equipment (UE) in the present invention may also be conducted by an upper node of the base station (BS) as necessary.

In other words, it will be obvious to those skilled in the art that various operations for enabling the base station (BS) to communicate with the user equipment (UE) in a network composed of several network nodes including the base station (BS) will be conducted by the base station (BS) or other network nodes other than the base station (BS).

The term "Base Station" may be replaced with a fixed station, Node-B, eNode-B (eNB), or an access point as necessary. The user equipment (UE) may be replaced with a mobile station (MS) or a mobile subscriber station (MSS) as necessary.

The following embodiments of the present invention can be implemented by hardware, firmware, software, or a combination of them.

In the case of implementing the present invention by hardware, the present invention can be implemented with ASICs (application specific integrated circuits), DSPs (Digital signal processors), DSPDs (digital signal

processing devices), PLDs (programmable logic devices), FPGAs (field programmable gate arrays), a processor, a controller, a microcontroller, or a microprocessor, etc.

If operations or functions of the present invention 5 are implemented by firmware or software, the present invention can be implemented in the form of a variety of formats, for example, modules, procedures, functions, etc. The software codes may be stored in a memory unit so that it can be driven by a processor. The memory unit is 10 located inside or outside of the processor, so that it can communicate with the aforementioned processor via a variety of well-known parts.

It should be noted that most terminology disclosed in the present invention is defined in consideration of 15 functions of the present invention, and can be differently determined according to intention of those skilled in the art or usual practices. Therefore, it is preferable that the above-mentioned terminology be understood on the basis of all contents disclosed in the present invention.

20 Constructions, operations, and other characteristics of the present invention will be easily understood by the following embodiments shown in the annexed drawings.

FIG. 1 is a conceptual diagram illustrating a RACH structure according to the present invention.

Referring to FIG. 1, a normal RACH preamble includes a CP 100, a sequence 120, and a guard time (GT) 160. The CP 100's length can be represented by  $T_{CP}$ . The sequence 120's length can be represented by  $T_{SEQ}$ . The GT 160's length can be represented by  $T_{GT}$ . A total length of the RACH burst can be represented by  $T_{RA}$  equal to the sum of  $T_{CP}$ ,  $T_{SEQ}$  and  $T_{GT}$ . An extended RACH preamble indicates 5 that the CP 100's length is extended.

Referring to FIG. 1B, the RACH preamble may include 10 a CP 100, a first sequence 120, a second sequence 140, and a guard time (GT) 160. If a cell radius which must be managed by a base station (BS) is wide, a repeated sequence for reliable data transmission can be used.

The RACH preamble may have a variety of formats. 15 Specifically, the sequence can be repeatedly configured. The following embodiment of the present invention describes that the sequence is repeated just once. Needless to say, the sequence may also be repeated one or more times. The RACH preamble may be decided by the CP- 20 or GT-length. However, the GT has no actual information, such that the RACH preamble is decided by the CP.

A variety of methods for calculating a fixed cyclic prefix (CP) length will hereinafter be described in detail.

FIGS. 2a~2b are graphs illustrating a variance in CP, GT, or RACH length required for a cell radius of the base station (BS) according to the present invention.

Numerical values for use in the embodiments of the 5 present invention are disclosed for only illustrative purposes, and it is obvious to those skilled in the art that the numerical values can be changed to others according to user requirements or communication environments.

10 Referring to FIGS. 2a~2b,  $T_{RACH}$  is a TTI allocated to the RACH according to the cell radius. In this case, "1 TTI" has the length of  $1000 \mu s$  (1ms), " $T_{CP}$ " is a CP variance based on the cell radius, " $T_{CP}+T_{SEQ}$ " is a variance of the sum of  $T_{CP}$  and  $T_{SEQ}$  lengths, and " $T_{CP}+T_{SEQ}+T_{GT}$ " is a 15 variance of an actual RACH length based on the cell radius.

Generally, the CP can be decided by a maximum round trip delay (RTD) length and the length of a maximum delay spread. In this case, a normal CP and an extended CP can be considered for an uplink data preamble. However, in 20 order to allow the CP used for any uplink data preambles to stably use the RACH, it is assumed that the present invention uses the extended CP irrespective of the CP length of an uplink data preamble. For the convenience of description and better understanding of the present

invention, in order to calculate the RACH's CP length, it is assumed that a maximum delay spread time is  $16.67\mu s$ .

FIG. 2a shows the length of a CP required by the cell radius when the sequence length is 0.8ms. If the 5 cell radius capable of being covered by the base station (BS) is 100km, it can be recognized that the CP length is  $683.381\mu s$ . In this case, for the RACH signal, 3 TTIs are allocated. However, the interval occupied by an actual RACH is not equal to the 3 TTIs, such that the radio 10 resources corresponding to a difference between the 3TTIs and the actually-occupied part may be wasted.

FIG. 2b shows the length of a CP required for the cell radius when the length of a total sequence is 1.6ms according to a repeated sequence. If the cell radius 15 capable of being covered by the base station (BS) is 100km, the CP length is  $648\mu s$ . In this case, 3 TTIs may be assigned for the RACH signal.

Referring to FIGS. 2a and 2b, if a single sequence is used, the cell radius capable of being managed by 20 2TTIs is about 87km. If the repeated sequence is used, the cell radius capable of being covered by 2TTIs is about 28.75km. If 3TTIs are allocated to cover the cell radius of 100km and a single sequence is used, all of the 3TTIs assigned for the RACH are not used, such that radio

resources may be unnecessarily wasted. In this case, if the repeated sequence is used, it can be recognized that the amount of wasted radio resources of FIG. 2b is less than that of FIG. 2a.

5 FIGS. 3a~3D are graphs illustrating RACH structures configured when a predetermined CP and a predetermined sequence are used according to the cell radius which should be managed by the base station (BS) according to the present invention.

10 Referring to FIGS. 3a~3D,  $T_{RACH}$  is a TTI allocated to the RACH according to the cell radius. In this case, " $T_{CP}$ " is a CP variance based on the cell radius, " $T_{CP}+T_{SEQ}$ " is a variance of the sum of  $T_{CP}$  and  $T_{SEQ}$  lengths, and " $T_{CP}+T_{SEQ}+T_{GT}$ " is a variance of an actual RACH length based 15 on the cell radius.

15 In FIG. 3a, a fixed CP is  $683.381\mu s$ , and a sequence length is 0.8ms. In this case, the base station (BS) can manage or cover the cell radius of 77.48km using 2 TTIs. Also, the base station (BS) can cover the cell radius of 20 100km or more using the 3 TTIs. If the 3TTIs are allocated to cover the cell radius of 100km, radio resources corresponding to "A" may be wasted.

In FIG. 3B, a fixed CP is  $683.381 \mu\text{s}$ , and a total length of the repeated sequence is 1.6ms. In this case, the base station (BS) is unable to manage or cover a desired cell radius of 77.48km using 2 TTIs. However, the 5 base station (BS) is able to manage or cover the cell radius of 100km using 3 TTIs. In this case, the cell radius capable of being covered by the base station (BS) is almost equal to a used TTI size, such that the amount of wasted radio resources of FIG. 3a can be reduced.

10 In FIG. 3C, a fixed CP is  $684 \mu\text{s}$ , and a sequence length is 0.8ms. In this case, the base station (BS) is unable to manage or cover a desired cell radius of 77.48km using 2 TTIs allocated to the RACH. Also, it can be recognized that the cell radius of 100km can be 15 managed or covered by the 3 TTIs. However, if the base station (BS) allocates the 3TTIs to cover the cell radius of 100km, radio resources corresponding to "B" can be wasted.

20 In FIG. 3D, a fixed CP is  $684 \mu\text{s}$ , and a total length of the repeated sequence is 1.6ms. In this case, the base station (BS) is unable to manage or cover a desired cell radius using 2 TTIs. However, the base station (BS) is able to manage or cover the cell radius of 100km or more using 3 TTIs. In this case, the cell radius capable of

being covered by the base station (BS) is almost equal to a used TTI size, such that the amount of wasted radio resources of FIG. 3C can be reduced.

FIGS. 2 and 3 show a method for calculating a fixed 5 CP length of a specific cell radius so as to use a simple RACH structure. In other words, it is preferable that the length of all RACH CPs is set to a specific length supporting the cell radius capable of being covered by the base station (BS). For example, the cell radius may 10 be 100km or higher, and the RACH CP may be able to cover this cell radius of at least 100km.

If the base station (BS) uses a predetermined number of CP lengths within the coverable cell radius, there is no need to consider the CP length for each cell 15 radius, resulting in reduction of the complexity of a hardware design. Although the cell radius is changed to another, the present invention can use only a less number of RACH structures. According to the embodiments of the present invention, it is assumed that the cell radius 20 supportable by the base station (BS) is set to about 100km and the CP length is set to about 30km.

In fact, the guard time (GT) of the RACH has no data therein. Therefore, the user equipment (UE) need not always recognize GT information, whereas it must

recognize the CP- or sequence- length. The GT length is adjusted by the base station (BS) according to the cell radius.

The base station (BS) may allocate 2TTIs or 3TTIs 5 to the RACH according to the cell radius. However, in fact, the GT has no transmission signal, such that the user equipment (UE) need not recognize GT information whereas it must decide whether the CP length or the sequence is repeated and must recognize only the repeated 10 length of the CP or sequence.

FIGS. 4a~4b shows GT and RACH lengths required for the cell radius when the CP length is 708.335  $\mu$ s according to the present invention.

Referring to FIGS. 4a~4b,  $T_{RACH}$  is a TTI allocated 15 to the RACH according to the cell radius. In this case, " $T_{CP}$ " is a CP variance based on the cell radius, " $T_{CP}+T_{SEQ}$ " is a variance of the sum of  $T_{CP}$  and  $T_{SEQ}$  lengths, and " $T_{CP}+T_{SEQ}+T_{GT}$ " is a variance of an actual RACH length based on the cell radius.

20 The cell radius capable of being covered by the base station (BS) can be decided by the RACH CP length and the GT value. If 3 TTIs are allocated to the RACH, the CP length must be adjusted to use all radio resources actually allocated to the RACH.

Therefore, according to this embodiment of the present invention, it is assumed that the RACH CP length is set to the sum of a round trip delay (RTD)  $691.665\ \mu s$  and a maximum delay spread time  $16.67\ \mu s$  in association with the 5 distance of 103.74283 km. In more detail, the CP length is set to  $708.335\ \mu s$ .

If a CP length is  $708.335\ \mu s$  and a sequence length is 0.8ms, FIG. 4a shows the cell radius capable of being covered by the base station (BS). The base station (BS) 10 can cover the distance of 73.78km by allocating 2TTIs to the RACH. If the base station (BS) allocates 3TTIs to the user equipment (UE), it can cover the length of at least 100km. However, in this case, the RACH does not occupy 15 all parts of the 3TTIs, such that wasted radio resources may occur.

If a CP length is  $708.335\ \mu s$  and a sequence length is 1.6ms, FIG. 4b shows the cell radius capable of being covered by the base station (BS). If 2TTIs are allocated to the user equipment (UE), the base station (BS) is 20 unable to cover the cell radius. However, if the base station (BS) allocates 3 TTIs to the user equipment (UE), it can extend the range of the cell coverage to 103.74km. In this case, it is assumed that the cell radius required by the base station (BS) is 100km, such that the present

invention can prevent wasted radio resources from being generated.

Referring to FIGS. 2 to 4, the present invention can fixedly select a predetermined CP according to the 5 cell radius which must be covered by the base station (BS). In more detail, if a CP corresponding to a maximum cell coverage of a base station (BS) is decided and a RACH preamble is constructed by the decided CP, the present invention need not continuously calculate the CP 10 length according to the cell radius, and at the same time need not construct the RACH preamble according to the calculated CP length, resulting in reduction of a hardware complexity. Namely, the present invention can guarantee a cell coverage required for the base station 15 (BS) using a single RACH structure or a small number of RACH structures.

A method for constructing an additional RACH preamble using a predetermined CP will hereinafter be described with reference to FIGS. 2 to 4.

20 FIG. 5 is a conceptual diagram illustrating a method for constructing a RACH preamble using the CP and the sequence without considering the guard time (GT) length according to the present invention.

Referring to FIG. 5, the GT time value is not contained in the RACH preamble. In fact, the GT has no data, such that the base station (BS) is able to adjust the GT length according to the cell radius. Therefore, 5 the user equipment (UE) needs to the time length value of either the CP part or the sequence part, such that the UE can access the RACH. The RACH preamble structure can also be composed of the CP and sequence parts.

Referring to FIG. 5a, a normal RACH preamble 10 includes a CP 500 and a sequence 520. The CP 500's length can be represented by  $T_{CP}$ . The sequence 520's length can be represented by  $T_{SEQ}$ . A total length of the RACH preamble can be represented by the sum of  $T_{CP}$  and  $T_{SEQ}$ . An extended RACH preamble is basically equal to a normal 15 RACH preamble, however, the CP 500's length of the extended RACH preamble is extended.

Referring to FIG. 5b, the repeated RACH preamble may include a CP 500, a first sequence 520, and a second sequence 540. The repeated preamble can be repeatedly 20 used. In other words, if the cell radius which must be managed by the base station (BS) is wide, the repeated RACH preamble can be used to implement reliable communication. Otherwise, although the base station (BS) has a poor channel environment, the repeated RACH

preamble can also be used to the implement reliable communication.

In FIG. 5, the CP of a normal RACH preamble has the length of  $102.6 \mu s$ . It is assumed that the CP of an 5 extended RACH preamble is set to any one of  $683.381 \mu s$ ,  $684 \mu s$ , or  $708.335 \mu s$ .

Therefore, the RACH preamble format having the CP- or sequence- value will hereinafter be described. For the convenience of description and better understanding of 10 the present invention, a system bandwidth is 20MHz and a sampling frequency is 30.72MHz. In this case, a sampling

interval of  $T_s$  is calculated as  $\frac{1}{30.72MHz}$ , such that it may be  $32.55208333ns$ .

In this case, if the maximum delay spread ( $16.67 \mu s$ ) 15 is subtracted from the CP length of  $683.381 \mu s$ , and the subtracted result is divided by "S" km, the supportable cell radius is about 100km (i.e., a round-up value of 99.93746473km). In this case, "S" km is a round trip delay (RTD) item, and indicates a predetermined time during which 20 the light beam is reciprocated per kilometer.

In this way, the CP length can be calculated in different ways according to the rounding-off delay and the

rounding error of the speed of light used by the CP-length calculation.

$T_s$  is very low, such that it can be understood that there is a large difference between the different CP lengths. If the CP length is incorrectly represented by a multiple of the  $T_s$  value, it may be correctly represented by a rounding function, a rounding-up function, and a rounding-down function.

The following table 1 shows RACH parameters acquired when the extended RACH preamble and the sequence-repeated RACH preamble structure use the same CP (e.g., CP=683.381  $\mu$ s).

[Table 1]

Frame Structure	Preamble Type	$T_{RA}$	$T_{CP}$	$T_{SEQ}$
Type 1	Normal	$30720 \times T_s$	$3152 \times T_s$	$24576 \times T_s$
	Extended	$61440 \times T_s$	$20993 \times T_s$	$24576 \times T_s$
		$92160 \times T_s$		
	Repeated	$61440 \times T_s$	$3152 \times T_s$	$2 \times 24576 \times T_s$
		$92160 \times T_s$	$20993 \times T_s$	

15

Table 1 shows parameters of a RACH structure when the cell radius managed by the base station (BS) is 100km.

In Table 1, if the preamble type is indicative of "Normal", "Normal" indicates a normal RACH. In this case, 20 the CP length of the RACH is represented by  $3152 \times T_s$ , and

the sequence length is set to  $24576 \times T_s$ . If the preamble type is indicative of "Normal", the cell radius is shorter than about 15km.

If the preamble type is "Extended", a RACH duration 5 of the base station (BS) is set to 2TTIs (e.g.,  $T_{RA} = 61440 \times T_s$ ) or 3TTIs (e.g.,  $T_{RA} = 92160 \times T_s$ ), such that the selected RACH duration is allocated the user equipment (UE). In this case, the base station (BS) may use an extended CP. In this case, the CP length of the RACH is 10 represented by  $20993 \times T_s$ , and the sequence length is represented by  $24576 \times T_s$ .

If the preamble type is "Repeated" and the base station (BS) uses the CP having the length  $20993 \times T_s$ , the base station (BS) allocates the 3TTIs to the RACH. 15 However, if the cell radius is very small, the base station (BS) may use a short CP (e.g.,  $CP=3152 \times T_s$ ) within the repeated RACH. In this case, the base station (BS) can optionally determine the RACH duration to be 2TTIs (e.g.,  $T_{RA}=61440 \times T_s$ ) or 3TTIs (e.g.,  $T_{RA}=92160 \times T_s$ ) in the 20 same manner as in the extended RACH. In this case, the CP time length of the RACH may be set to  $3152 \times T_s$  or  $20993 \times T_s$ , and the time length of the sequence may be set to  $2 \times 24576 \times T_s$ .

The following table 2 shows RACH parameters acquired when the extended RACH preamble and the sequence-repeated RACH preamble structure use the same CP (e.g., CP=684  $\mu$ s).

5

[Table 2]

Frame structure	Preamble Type	$T_{RA}$	$T_{CP}$	$T_{SEQ}$
Type 1	Normal	30720 x $T_s$	3152 x $T_s$	24576 x $T_s$
	Extended	61440 x $T_s$	21012 x $T_s$	24576 x $T_s$
		92160 x $T_s$		
	Repeated	61440 x $T_s$	3152 x $T_s$	2x24576x $T_s$
		92160 x $T_s$	21012 x $T_s$	

Table 2 is basically similar to Table 1. In more detail, Table 2 shows a RACH structure acquired when the 10 length of a fixed CP used by either the extended RACH or the repeated RACH is 684  $\mu$ s.

The following table 3 shows RACH parameters acquired when the extended RACH preamble and the sequence-repeated RACH preamble structure use the same CP (e.g., 15 CP=708.335  $\mu$ s).

[Table 3]

Frame structure	Preamble Type	$T_{RA}$	$T_{CP}$	$T_{SEQ}$
Type 1	Normal	30720 x $T_s$	3152 x $T_s$	24576 x $T_s$
	Extended	61440 x $T_s$	21760 x $T_s$	24576 x $T_s$
		92160 x $T_s$		
	Repeated	61440 x $T_s$	3152 x $T_s$	2x24576x $T_s$

		92160 x Ts	21760 x Ts	
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The RACH structure shown in Table 3 is basically similar to that of Table 1. In more detail, Table 3 shows a RACH structure acquired when the cell radius managed by 5 the base station (BS) is 103.74km and the RACH CP is 708.335  $\mu$ s.

Referring to Tables 1 ~ 3, the present invention can cover all the RACH preamble structures using two CP lengths (i.e., 3152xTs and 20993xTs, 3152xTs and 21012xTs, 10 or 3152xTs and 21760xTs) according to individual requirements.

A method for allowing the base station (BS) to inform the UE of RACH structure information shown in Tables 1~3 according to the present invention will 15 hereinafter be described in detail.

The base station (BS) may use a variety of methods to inform the UE of the RACH type. For example, the base station (BS) may sequentially assign numbers to preamble types, and may also indicate a number of a preamble type 20 to be used by the UE.

The following table 4 shows an exemplary method for sequentially numbering the preamble types of Table 2.

[Table 4]

Frame structure	Preamble format	$T_{CP}$	$T_{SEQ}$
Type 1	0	$3152 \times T_s$	$24576 \times T_s$
	1	$21012 \times T_s$	$24576 \times T_s$
	2	$21012 \times T_s$	$2 \times 24576 \times T_s$
	3	$3152 \times T_s$	$2 \times 24576 \times T_s$

With reference to Table 4, the base station (BS) may inform the UE of the preamble format using 2 bits.

5 For example, "00" is a preamble format of 0, "01" is a preamble format of 1, "10" is a preamble format of 2, and "11" is a preamble format of 3.

Although the above Table 4 has been disclosed using Table 2 as an example, it should be noted that Table 4 10 may also be applied to other tables 1 and 3 as necessary.

For another example, besides the method of Table 4, another method for numbering the preamble format can also be used.

Furthermore, there is another method for indicating 15 the RACH CP information and the sequence information using one or more bits. In other words, the base station (BS) informs the UE of the RACH CP's length information (or information of CP extension) using a predetermined number of bits, and may inform the UE of information of

the sequence length (or the presence or absence of sequence repetition) using other bits.

The following table 5 shows an example of RACH information using one or more bits (e.g., 2 bits).

5

[Table 5]

Frame structure	Preamble type	$T_{CP}$	$T_{SEQ}$
Type 1	00	$3152 \times T_s$	$24576 \times T_s$
	10	$21012 \times T_s$	$24576 \times T_s$
	01	$3152 \times T_s$	$2 \times 24576 \times T_s$
	11	$21012 \times T_s$	$2 \times 24576 \times T_s$

Table 5 shows an example of the RACH structure of Table 2. Referring to Table 5, the base station (BS) may 10 inform the UE of RACH information using 1 bit indicating the sequence length and 1 bit indicating the CP length. If 2 bits are represented by "XX", the front bit indicates a time length of the CP, and the rear bit indicates a time length of the sequence.

15 In more detail, "00" indicates that a time length of the sequence is  $24576 \times T_s$  and the CP's time-length is  $3152 \times T_s$ . "10" indicates that a sequence's time-length is  $24576 \times T_s$  and the CP's time-length is  $21012 \times T_s$ . "01" is used to increase the reliability under a poor channel 20 environment. Namely, although the CP is set to  $3152 \times T_s$ ,

the RACH reliability can be increased by the repeated sequence denoted by  $(2 \times 24576 \times T_s)$ . "11" indicates that the time length of the repeated sequence is  $2 \times 24576 \times T_s$  and the CP's time-length is  $21012 \times T_s$ .

5           Although the above Table 5 has been disclosed for only illustrative purposes of Table 2, it should be noted that Table 5 can also be applied to Table 1 or 3. Besides the method of Table 5, another method for numbering the RACH preamble formats can also be used. Needless to say, 10       the base station (BS) may information the UE of the RACH type using other 2 bits, instead of the above-mentioned method.

The above Tables 1~3 can be briefly represented by the following tables 6~8 on the basis of  $T_{CP}$  and  $T_{SEQ}$ .

15       The following table 6 simplifies the above table 1.

[Table 6]

Frame structure	$T_{CP}$	$T_{SEQ}$
Type 1	$3152 \times T_s$	$24576 \times T_s$
	$20993 \times T_s$	$2 \times 24576 \times T_s$

Table 6 does not define the  $T_{RA}$  length of Table 1.

20       In Table 6, the  $T_{RA}$  length is acquired by considering TCP- and TSEQ- lengths and the GT length. In this case, the GT's time-length value can be arbitrarily decided by the

base station, such that there is no need to define the  $T_{RA}$  length on the condition that the time-length values of  $T_{CP}$  and  $T_{SEQ}$  have been recognized.

The following table 7 simplifies the above Table 2.

5

[Table 7]

Frame structure	$T_{CP}$	$T_{SEQ}$
Type 1	$3152 \times T_s$	$24576 \times T_s$
	$21012 \times T_s$	$2 \times 24576 \times T_s$

Table 7 is basically equal to Table 2. In Table 7,  $T_{CP}$  and  $T_{SEQ}$  values can be calculated by the same method as 10 that of Table 2.

The following table 8 simplifies the above Table 3.

[Table 8]

Frame structure	$T_{CP}$	$T_{SEQ}$
Type 1	$3152 \times T_s$	$24576 \times T_s$
	$21760 \times T_s$	$2 \times 24576 \times T_s$

15 In Table 8,  $T_{CP}$  and  $T_{SEQ}$  values can be calculated by the same conditions as in Table 3.

The present invention is able to construct the RACH preamble of FIG. 5 using a predetermined number of CPs and the sequence's time-length of FIGS. 2~4. In more

detail, the present invention can construct the RACH preamble of FIG. 5 using  $T_{CP}$  and  $T_{SEQ}$  values of Tables 1~8.

In the embodiments of the present invention, the CP and sequence of the RACH are constructed, such that the 5 base station (BS) can cover the cell radius of about 100km. However, provided that the repeated sequence is used and the 3TTI RACH signal is used within the cell radius larger than 14.61km, wasted radio resources may occur. Therefore, in order to prevent radio resources 10 from being wasted, a method for calculating a parameter in which a single middle CP is further added to the above-mentioned CP length will hereinafter be described in detail.

FIG. 6 is a graph illustrating a variance in CP, GT, 15 or RACH length required for a cell radius according to the present invention.

Numerical values for use in the embodiments of the present invention are disclosed for only illustrative purposes, and it is obvious to those skilled in the art 20 that the numerical values can be changed to others according to user requirements or communication environments.

Referring to FIG. 6,  $T_{RACH}$  is a TTI allocated to the RACH according to the cell radius. In this case, "1 TTI"

has the length of  $1000 \mu s$  (1ms), " $T_{CP}$ " is a CP variance based on the cell radius, " $T_{CP}+T_{SEQ}$ " is a variance of the sum of  $T_{CP}$  and  $T_{SEQ}$  lengths, and " $T_{CP}+T_{SEQ}+T_{GT}$ " is a variance of an actual RACH length based on the cell radius. In 5 order to calculate the time length of the RACH CP, it is assumed that a maximum delay spread time is set to  $5.21 \mu s$ .

Referring to FIG. 6, the present invention can calculate the CP of the largest cell radius (29.6km) capable of being supported by the  $2000 \mu s$  (i.e., 2TTIs) 10 RACH duration. Namely,  $202.6 \mu s$  may be calculated as a middle CP value. Therefore, the base station (BS) may allocate the 2TTIs to the RACH, simultaneously while applying the repeated sequence to the cell radius of about 29.6km.

15 Differently from FIG. 6, a middle CP value may be calculated. Referring to FIG. 2b, the base station (BS) allocates the 2TTIs to the RACH, such that the largest cell radius capable of being supported is about 28.75km. In this case, the CP value may be about  $208.335 \mu s$ . In 20 this case, a maximum delay spread time of FIG. 2b is  $16.67 \mu s$ .

FIGS. 7a~7b are graphs illustrating RACH structures configured when a predetermined-length CP and

predetermined-length sequence are used according to middle CP values of FIGS. 2b and 6 according to the present invention.

In FIG. 7a, it is assumed that the middle CP value 5 is set to  $202.6 \mu s$  in consideration of the maximum channel delay spread ( $5.21 \mu s$ ). In this case, the middle CP value has a supportable cell-radius smaller than that of the extended CP, such that the present invention can also consider a maximum channel delay spread time shorter than 10 that of the extended CP.

The sequence length may be set to 1.6ms on the condition that the repeated sequence is used. Therefore, although the base station (BS) uses the repeated sequence and the 2TTIs are allocated to the RACH, the base station 15 (BS) can effectively use radio resources. Also, the base station (BS) can elastically adjust the GT value according to the cell radius as shown in FIG. 7a.

As can be seen from FIG. 7b, the middle CP can be exemplarily set to  $208.35 \mu s$  in consideration of the 20 maximum delay spread ( $16.67 \mu s$ ). In this case, the sequence time-length is 1.6ms, and the repeated sequence may be used as the sequence time length. If the base station (BS) allocates 2TTIs to the RACH, the maximum cell radius capable of being covered by the base station (BS) may be

about 28.75km

Referring to FIGS. 7a and 7b, the base station (BS) allocates the 2TTIs to the RACH, such that it is able to cover the cell radius of about 30km. In FIGS. 2~4, if the 5 base station (BS) uses the CP value or the sequence for allowing the base station (BS) to cover the cell radius of 100km, the 3TTIs must be used. In this case, if the cell radius is much smaller than 100km (e.g., if the cell radius is 30km or less) and the 3TTIs are continuously allocated 10 to the RACH, unnecessary radio resources may be wasted.

Therefore, as shown in FIGS. 7a and 7b, if the middle CP value is calculated and the RACH is configured using the calculated CP value, the cell radius of about 30km may use the 2TTIs as the RACH interval simultaneously 15 while using the repeated sequence. In other words, the base station (BS) minimizes the wasted radio resources, and at the same time can cover the cell radius of about 30km.

The following table 9 shows an example of a RACH preamble format including the middle CP value.

[Table 9]

Frame structure	Preamble Type	$T_{RA}$	$T_{CP}$	$T_{SEQ}$
Type 1	Normal	$30720 \times T_s$	$3152 \times T_s$	$24576 \times T_s$
	Extended	$61440 \times T_s$	$20993 \times T_s$	$24576 \times T_s$

		92160 x Ts		
Repeated 1	61440 x Ts	3152 x Ts	2x24576xTs	
	92160 x Ts	20993 x Ts		
Repeated 2	61440 x Ts	3152 x Ts	2x24576xTs	
		6400 x Ts		

Table 9 is basically similar to Table 1. If the

cell radius covered by the base station (BS) is about 100km,

the RACH preamble's parameters are shown in Table 9.

5 Compared with Table 1, Table 9 includes a RACH preamble (i.e., Repeated 2) for a specific case having the cell radius of about 30km.

In Table 9, if the preamble type is indicative of "Normal", "Normal" indicates a normal RACH. In this case,

10 the CP time-length of the RACH is represented by  $3152 \times T_s$ , and the sequence's time-length is set to  $24576 \times T_s$ .

If the preamble type is "Extended", a RACH duration of the base station (BS) is set to 2TTIs (e.g.,  $T_{RA} = 61440 \times T_s$ ) or 3TTIs (e.g.,  $T_{RA} = 92160 \times T_s$ ), such that the 15 selected RACH duration is allocated the user equipment (UE). In this case, the base station (BS) may use an extended CP (e.g.,  $20993 \times T_s$ ). In this case, the CP length of the RACH is represented by  $20993 \times T_s$  (i.e.,  $CP=683.381$ ) and the sequence length is represented by  $24576 \times T_s$ .

20 If the preamble type is "Repeated 1" and the base station (BS) uses the CP having the length  $20993 \times T_s$ , the

base station (BS) allocates the 3TTIs to the RACH. However, if the repeated RACH uses a short CP (e.g.,  $CP=3152 \times T_s$ ), the base station (BS) can optionally determine the RACH duration to be 2TTIs (e.g., 2ms) or 3TTIs (e.g., 3ms) in the same manner as in the extended RACH. In this case, the CP length of the RACH may be set to  $3152 \times T_s$  or  $20993 \times T_s$ , and the time length of the sequence may be set to  $2 \times 24576 \times T_s$ .

If the preamble type is "Repeated 2", this means that the base station (BS) uses the middle CP value as a RACH CP value. Namely, "Repeated 2" is indicative of the RACH structure having the length of  $CP=6400 \times T_s$ . In this case, although the base station (BS) uses the repeated sequence when constructing the RACH, 2TTIs are allocated to the RACH, such that the base station (BS) can cover the cell coverage corresponding to 30km. Namely, "Repeated 2" RACH signal can be effectively used on the condition that the cell coverage is about 30km or less.

The following table 10 shows another example of a RACH preamble format including a middle CP value according to the present invention.

[Table 10]

Frame structure	Preamble Type	T <sub>RA</sub>	T <sub>CP</sub>	T <sub>SEQ</sub>
Type 1	Normal	30720 x T <sub>s</sub>	3152 x T <sub>s</sub>	24576 x T <sub>s</sub>
	Extended	61440 x T <sub>s</sub>	20993 x T <sub>s</sub>	24576 x T <sub>s</sub>
		92160 x T <sub>s</sub>		
	Repeated 1	61440 x T <sub>s</sub>	3152 x T <sub>s</sub>	2x24576xT <sub>s</sub>
		92160 x T <sub>s</sub>	20993 x T <sub>s</sub>	
	Repeated 2	61440 x T <sub>s</sub>	3152 x T <sub>s</sub>	2x24576xT <sub>s</sub>
			6224 x T <sub>s</sub>	

Table 10 includes RACH parameters on the condition that the RACH CP value is 683.381  $\mu$ s (if the cell coverage is about 100km) or 202.6  $\mu$ s (if the cell radius is about 5 30km).

The above-mentioned RACH parameters of Table 10 are similar to those of Table 1. Compared with Table 1, in order to effectively allocate radio resources to the RACH when the cell radius is about 30km, the preamble type of 10 "Repeated 2" is newly established in Table 10. In more detail, a middle CP value (6224xT<sub>s</sub> or 202.6  $\mu$ s) corresponding to 202.06  $\mu$ s is newly established, and associated RACH parameters are defined in Table 10.

The following table 11 shows another example of a 15 RACH preamble format including a middle CP value according to the present invention.

[Table 11]

Frame structure	Preamble Type	T <sub>RA</sub>	T <sub>CP</sub>	T <sub>SEQ</sub>
Type 1	Normal	30720 x T <sub>S</sub>	3152 x T <sub>S</sub>	24576 x T <sub>S</sub>
	Extended	61440 x T <sub>S</sub>	21012 x T <sub>S</sub>	24576 x T <sub>S</sub>
		92160 x T <sub>S</sub>		
	Repeated 1	61440 x T <sub>S</sub>	3152 x T <sub>S</sub>	2x24576xT <sub>S</sub>
		92160 x T <sub>S</sub>	21012 x T <sub>S</sub>	
	Repeated 2	61440 x T <sub>S</sub>	3152 x T <sub>S</sub>	2x24576xT <sub>S</sub>
			6400 x T <sub>S</sub>	

Table 11 includes RACH parameters on the condition that the RACH CP value is 684  $\mu$ s (if the cell coverage is about 100km) or 208.335  $\mu$ s (if the cell radius is about 5 30km).

Table 11 is similar to Table 2. Compared with Table 2, the preamble type of "Repeated 2" is newly established in Table 11, such that the RACH can be effectively used when the cell radius is about 30km.

10 The following table 12 shows another example of a RACH preamble format including a middle CP value according to the present invention.

[Table 12]

Frame Structure	Preamble Type	T <sub>RA</sub>	T <sub>CP</sub>	T <sub>SEQ</sub>
Type 1	Normal	30720 x T <sub>S</sub>	3152 x T <sub>S</sub>	24576 x T <sub>S</sub>
	Extended	61440 x T <sub>S</sub>	21012 x T <sub>S</sub>	24576 x T <sub>S</sub>
		92160 x T <sub>S</sub>		
	Repeated 1	61440 x T <sub>S</sub>	3152 x T <sub>S</sub>	2 x 24576xT <sub>S</sub>
		92160 x T <sub>S</sub>	21012 x T <sub>S</sub>	
	Repeated	61440 x T <sub>S</sub>	3152 x T <sub>S</sub>	2x24576xT <sub>S</sub>

	2		6224 x Ts	
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Table 12 includes RACH parameters on the condition that the RACH CP value is  $684 \mu s$  (if the cell coverage is about 100km) or  $202.6 \mu s$  (if the cell radius is about 5 30km).

Table 12 is basically similar to Table 2. Compared with Table 2, in order to effectively use the RACH preamble when the cell radius is about 30km, a new preamble type (i.e., Repeated 2) including a middle CP 10 value is newly established in Table 12.

The following table 13 shows another example of a RACH preamble format including a middle CP value according to the present invention.

15 [Table 13]

Frame structure	Preamble Type	T <sub>RA</sub>	T <sub>CP</sub>	T <sub>SEQ</sub>
Type 1	Normal	30720 x Ts	3152 x Ts	24576 x Ts
	Extended	61440 x Ts	21760 x Ts	24576 x Ts
		92160 x Ts		
	Repeated 1	61440 x Ts	3152 x Ts	2x24576xTs
		92160 x Ts	21760 x Ts	
	Repeated 2	61440 x Ts	3152 x Ts	2x24576xTs
			6400 x Ts	

Table 13 includes RACH parameters on the condition that the RACH CP value is  $708.335 \mu s$  (if the cell coverage

is about 103km) or  $208.335\ \mu s$  (if the cell radius is about 30km).

Table 13 is basically similar to Table 3. Compared with Table 3, in order to effectively use the RACH preamble when the cell radius is about 30km, a new preamble type (i.e., Repeated 2) including a middle CP value is newly established in Table 13.

The following table 14 shows another example of a RACH preamble format including a middle CP value according to the present invention.

[Table 14]

Frame Structure	Preamble Type	$T_{RA}$	$T_{CP}$	$T_{SEQ}$
Type 1	Normal	$30720 \times T_s$	$3152 \times T_s$	$24576 \times T_s$
	Extended	$61440 \times T_s$	$21760 \times T_s$	$24576 \times T_s$
		$92160 \times T_s$		
	Repeated 1	$61440 \times T_s$	$3152 \times T_s$	$2 \times 24576 \times T_s$
		$92160 \times T_s$	$21760 \times T_s$	
	Repeated 2	$61440 \times T_s$	$3152 \times T_s$	$2 \times 24576 \times T_s$
			$6244 \times T_s$	

Table 14 includes RACH parameters on the condition that the RACH CP value is  $708.335\ \mu s$  (if the cell coverage is about 103km) or  $202.6\ \mu s$  (if the cell radius is about 30km).

Table 14 is basically similar to Table 3. Compared with Table 3, in order to effectively use the RACH preamble when the cell radius is about 30km, a new preamble type (i.e., Repeated 2) including a middle CP 5 value is newly established in Table 14.

A method for allowing the base station (BS) to inform the UE of the configuration information of the RACH preamble type shown in Tables 9 to 14 according to the present invention will hereinafter be described in 10 detail.

The base station (BS) may inform the UE of the RACH preamble type in various ways. Firstly, the base station (BS) may sequentially number the preamble types, and may indicate the preamble-type number to be used by the user 15 equipment (UE).

The following table 15 shows an exemplary method for sequentially numbering the preamble types shown in Table 12.

20 [Table 15]

Frame Structure	Preamble Type	$T_{CP}$	$T_{SEQ}$
Type 1	0	$3152 \times T_S$	$24576 \times T_S$
	1	$21012 \times T_S$	$24576 \times T_S$
	2	$6224 \times T_S$	$2 \times 24576 \times T_S$

	3	21012 x Ts	2 x 24576 x Ts
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With reference to Table 15, the base station (BS) may inform the UE of the preamble format using 2 bits. For example, "00" is a preamble format of 0, "01" is a 5 preamble format of 1, "10" is a preamble format of 2, and "11" is a preamble format of 3.

Although the above Table 15 has been disclosed using Table 12 as an example, it should be noted that Table 9 may also be applied to other tables 9, 11, 13, 10 and 14 as necessary. For another example, besides the method of Table 15, another method for numbering the preamble format can also be used.

Furthermore, there is another method for indicating the RACH CP information and the sequence information 15 using one or more bits. In other words, the base station (BS) informs the UE of the RACH CP's length information (or information of CP extension) using a predetermined number of bits, and may inform the UE of information of the sequence length (or the presence or absence of 20 sequence repetition) using other bits.

The following table 16 shows an example of RACH information using one or more bits (e.g., 2 bits).

[Table 16]

Frame Structure	Preamble Type	$T_{CP}$	$T_{SEQ}$
Type 1	00	$3152 \times T_s$	$24576 \times T_s$
	10	$21012 \times T_s$	$24576 \times T_s$
	11	$21012 \times T_s$	$2 \times 24576 \times T_s$
	01	$6224 \times T_s$	$2 \times 24576 \times T_s$

Table 16 shows that the RACH preamble type of Table 12 is established according to the CP time-length and the sequence repetition. In this case, the sequence time-length can be recognized by the bit indicating whether the sequence is repeated.

With reference to Table 16, the base station (BS) may inform the UE of RACH information using 1 bit indicating the sequence length and 1 bit indicating the CP length. If 2 bits are represented by "XX", the front bit indicates a time length of the CP, and the rear bit indicates whether the sequence is repeated.

For example, "00" indicates that a single sequence is used and the CP has a short time length. In more detail, the sequence is not repeated, a time length of the sequence is  $24576 \times T_s$  and the CP's time-length is  $3152 \times T_s$ . "10" indicates that the sequence is not repeated and the CP's time-length is  $3152 \times T_s$ . "11" indicates the repeated sequence is used, such that the sequence time-

length is  $2 \times 24576 \times T_s$  and the CP's time-length is  $21012 \times T_s$ . "01" indicates that the sequence is repeated and the CP's time-length is  $6224 \times T_s$ .

Therefore, although Table 16 shows three CP's time-lengths, three CP's time-lengths are conditionally selected, such that all combinations can be represented by 1 bit indicating whether the sequence is repeated and the other 1 bit indicating the CP's time-length.

Although Table 16 has been disclosed using Table 12 as an example, it should be noted that Table 16 may also be applied to other Tables 9~14 as necessary.

Tables 9~14 can be simplified in the form of Tables 17~22 on the basis of  $T_{CP}$  and  $T_{SEQ}$  values. The time length  $T_{GT}$  can be arbitrarily decided by the base station (BS), and the  $T_{RA}$  length is decided by  $T_{CP}$  and  $T_{SEQ}$  values. Therefore, the RACH preamble can be constructed by only the  $T_{CP}$  and  $T_{SEQ}$  values other than the  $T_{RA}$  length.

The following Table 17 is a simplified format of Table 9.

20

[Table 17]

Frame Structure	$T_{CP}$	$T_{SEQ}$
Type 1	$3152 \times T_s$	$24576 \times T_s$
	$20993 \times T_s$	

	6400 x Ts	2 x 24576 x Ts
--	-----------	----------------

Table 17 is basically equal to Table 9.  $T_{CP}$  and  $T_{SEQ}$  values of Table 17 can be calculated in the same manner as in the method of Table 9.

5 The following Table 18 is a simplified format of Table 10.

[Table 18]

Frame Structure	$T_{CP}$	$T_{SEQ}$
Type 1	3152 x Ts	24576 x Ts
	20993 x Ts	
	6224 x Ts	

10  $T_{CP}$  and  $T_{SEQ}$  values of Table 18 can be calculated in the same manner as in the method of Table 10.

The following Table 19 is a simplified format of Table 11.

15 [Table 19]

Frame Structure	$T_{CP}$	$T_{SEQ}$
Type 1	3152 x Ts	24576 x Ts
	21012 x Ts	
	6400 x Ts	

Table 19 is basically equal to Table 11.  $T_{CP}$  and  $T_{SEQ}$  values of Table 19 can be calculated in the same manner as in the method of Table 11.

5 The following Table 20 is a simplified format of Table 12.

[Table 20]

Frame Structure	$T_{CP}$	$T_{SEQ}$
Type 1	$3152 \times T_S$	$24576 \times T_S$
	$21012 \times T_S$	
	$6224 \times T_S$	

10 Table 20 is basically equal to Table 12.  $T_{CP}$  and  $T_{SEQ}$  values of Table 20 can be calculated in the same manner as in the method of Table 12.

The following Table 21 is a simplified format of Table 13.

15 [Table 21]

Frame Structure	$T_{CP}$	$T_{SEQ}$
Type 1	$3152 \times T_S$	$24576 \times T_S$
	$21760 \times T_S$	
	$6400 \times T_S$	

Table 21 is basically equal to Table 13.  $T_{CP}$  and  $T_{SEQ}$  values of Table 20 can be calculated in the same manner as in the method of Table 13.

The following Table 20 is a simplified format of Table 14.

[Table 22]

Frame Structure	$T_{CP}$	$T_{SEQ}$
Type 1	$3152 \times T_S$	$24576 \times T_S$
	$21760 \times T_S$	
	$6224 \times T_S$	$2 \times 24576 \times T_S$

5

$T_{CP}$  and  $T_{SEQ}$  values of Table 22 can be calculated in the same manner as in the method of Table 14.

As described above, the above embodiment has disclosed the method for establishing a predetermined 10 CP's time-length and the CP type. However, in view of a method for easily supporting a variety of system bandwidths, the CP time-length may be changed to another due to hardware problems. However, although the CP time-length is slightly changed to another, the changed result 15 is not affected on the scope of the present invention irrespective of variation of the CP time-length.

For example, the CP time-length can be adjusted by the relationship between the sampling frequencies. The above-mentioned examples have described that the sampling 20 frequency is exemplarily set to 30.72MHz, but it should

be noted that the CP time-length can also be adjusted at a sampling frequency of 1.92MHz or 3.84MHz.

In this case, the relationship between the above sampling frequencies is denoted by a multiple. In other words, 1.92MHz times 16 (i.e., 1.92MHz multiplied by 16) is 30.72MHz, 1.92MHz times 2 (i.e., 1.92MHz multiplied by 2) is 3.84MHz, and 3.84MHz times 8 (i.e., 1.92MHz multiplied by 8) is 30.72MHz. In this case, it is preferable that the number of CP samples is denoted by a multiple in the same manner as in the multiple relationship between sampling frequencies under various operation bands. Therefore, it is preferable that the number of CP samples may be denoted by a multiple of 8 or 16.

If the CP time-length is adjusted by the relationship between the sampling frequencies,  $(21012 \times T_s)$  samples of Table 11 are not denoted by the multiple of 8 or 16, such that they must be modified into others. In the case where the parameters of Table 11 are adjusted for the relationship between the sampling frequencies, they are shown in the following table 23.

[Table 23]

Frame	Preamble Type	TCP	TSEQ
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structure			
	Normal	$3152 \times T_s$	$24576 \times T_s$
	Extended	$21008 \times T_s$	$24576 \times T_s$
	Repeated 1	$3152 \times T_s$	$2 \times 24576 \times T_s$
		$21008 \times T_s$	
	Repeated 2	$3152 \times T_s$	$2 \times 24576 \times T_s$
		$6224 \times T_s$	

According to another embodiment of the present invention, parameters can be adjusted to others in consideration of the relationship between the sampling frequencies (e.g.,  $f_{IFFT}$ ) of the RACH sequence.

The RACH sequence is generated by a hybrid frequency/time domain generation. In more detail, firstly, a small-sized IDFT is performed, an up-sampling toward a system band is performed, a frequency conversion is performed by an intermediate frequency needed by a time domain.

For example, it is assumed that the sample length of a sequence for use in the RACH is denoted by 839. In this case, the sample length of the sequence is indicative of the length of a sequence generated by the sequence generation equation. If a first IFFT size is 1024, the sampling frequency ( $f_{IFFT}$ ) is 1.28Mbps. According to the above-mentioned reason, the number of CP samples must be denoted by a multiple of 24. In order to simultaneously satisfy two kinds of multiple conditions,

the number of CP samples must be denoted by a multiple of 48. Therefore, the CP length can be adjusted by the sampling frequency and the RACH-sequence sampling frequency.

5 The following Table 24 shows parameters corrected by the relationship between the RACH-preamble sampling frequencies of Table 11.

[Table 24]

Frame Structure	Preamble Type	TCP	TSEQ
	Normal	$3168 \times T_s$	$24576 \times T_s$
	Extended	$21024 \times T_s$	$24576 \times T_s$
	Repeated 1	$3168 \times T_s$	$2 \times 24576 \times T_s$
		$21024 \times T_s$	
	Repeated 2	$3168 \times T_s$	$2 \times 24576 \times T_s$
		$6240 \times T_s$	

10

The above-mentioned embodiments of the present invention use a less number of CPs, resulting in reduction of a hardware complexity. The base station (BS) can manage or cover a desired cell radius using a small 15 number of RACH structures. Also, the base station (BS) arbitrarily decides GT information, such that the present invention can support a variety of cell coverages using a single RACH preamble structure.

It should be noted that most terminology disclosed 20 in the present invention is defined in consideration of

functions of the present invention, and can be differently determined according to intention of those skilled in the art or usual practices. Therefore, it is preferable that the above-mentioned terminology be understood on the basis 5 of all contents disclosed in the present invention.

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 10 present invention cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

#### 【Industrial Applicability】

15 As apparent from the above description, the present invention can be applied to a variety of communication technologies. Specifically, the present invention can be applied to a broadband wireless communication system. The present invention uses the RACH burst structure, such that 20 it can effectively perform the system processing.

## 【CLAIMS】

【Claim 1】 A method for constructing a preamble of a random access channel (RACH) comprising:

5           acquiring time-length information of a predetermined cyclic prefix (CP) for each cell radius of a base station (BS) ;

          acquiring sequence time-length information of a single sequence or a repeated sequence; and

10          constructing the preamble using the predetermined CP time-length information and the sequence time-length information, irrespective of a time length of a guard time (GT) .

15    【Claim 2】 The method according to claim 1, wherein the predetermined CP time-length information is generated by a cell radius supportable by a system, a maximum delay spread, and a maximum round trip delay (RTD) .

20    【Claim 3】 The method according to claim 2, wherein:

          the predetermined CP time-length information has any one of time-length values  $3152 \times T_s$ ,  $6224 \times T_s$ , and  $21012 \times T_s$  according to the cell radius, where

$$\frac{1}{30.72MHz}$$

" $T_s$ " is a sampling interval denoted by .

5       【Claim 4】 The method according to claim 1, wherein the predetermined CP time-length information satisfies a maximum cell radius request supportable by a system, irrespective of the sequence time-length information.

【Claim 5】 The method according to claim 1, wherein:

10      the single sequence has a time-length value denoted by  $24576 \times T_s$ , and  
          the repeated sequence has a time-length value denoted by  $2 \times 24576 \times T_s$ , where

$$\frac{1}{30.72MHz}$$

" $T_s$ " is a sampling interval denoted by .

15      【Claim 6】 The method according to claim 1, wherein the preamble includes a first preamble, a second preamble, a third preamble, and a fourth preamble, in which  
          the first preamble includes a cyclic prefix (CP) having a time length of  $3152 \times T_s$  and a sequence having a  
20      time length of  $24576 \times T_s$ ;

          the second preamble includes a cyclic prefix (CP)

having a time length of  $21012 \times T_s$  and a sequence having a time length of  $24576 \times T_s$ ;

the third preamble includes a cyclic prefix (CP) having a time length of  $6224 \times T_s$  and a sequence having a time length of  $2 \times 24576 \times T_s$ ; and

the fourth preamble includes a cyclic prefix (CP) having a time length of  $21012 \times T_s$  and a sequence having a time length of  $2 \times 24576 \times T_s$ , where

$$\frac{1}{30.72 \text{MHz}}$$

" $T_s$ " is a sampling interval denoted by .

10

**【Claim 7】** A method for transmitting a random access channel (RACH) signal comprising:

receiving information of a predetermined preamble format from a base station (BS); and

15 transmitting a random access channel (RACH) signal to the base station (BS) using a preamble contained in the predetermined preamble format, in which

the predetermined preamble format is constructed by a predetermined cyclic prefix (CP) and one of a single sequence and a repeated sequence according to a cell radius of the base station (BS), irrespective of a time length of a guard time (GT).

【Claim 8】 The method according to claim 7, wherein the predetermined preamble format includes time-length information of the predetermined cyclic prefix (CP) and sequence time-length information.

5

【Claim 9】 The method according to claim 8, wherein, if the sequence time-length information indicates that the sequence contained in the preamble is the single sequence, the predetermined CP time-length information indicates whether the predetermined cyclic prefix (CP) is an extended cyclic prefix (CP).

【Claim 10】 The method according to claim 9, wherein:

the single sequence has a time-length value denoted 15 by  $24576 \times T_s$ ,

if the predetermined cyclic prefix (CP) is not the extended cyclic prefix (CP), the predetermined cyclic prefix has a time-length value denoted by  $3152 \times T_s$ , and

if the predetermined cyclic prefix (CP) is the extended cyclic prefix (CP), the predetermined cyclic prefix (CP) has a time-length value denoted by  $21012 \times T_s$ , where

the " $T_s$ " is a sampling interval denoted by

$$\frac{1}{30.72MHz}$$

5       **【Claim 11】** The method according to claim 8, wherein, if the sequence time-length information indicates that the sequence contained in the preamble is the repeated sequence, the predetermined CP time-length information indicates whether the predetermined cyclic prefix (CP) is an extended cyclic prefix (CP) or a middle cyclic prefix (CP).

10      **【Claim 12】** The method according to claim 11, wherein:  
                  the repeated sequence has a time-length value denoted by  $2 \times 24576 \times T_s$ ,  
                  if the predetermined cyclic prefix is the extended cyclic prefix, the predetermined cyclic prefix has a time-length value denoted by  $21012 \times T_s$ , and  
                  if the predetermined cyclic prefix is the middle cyclic prefix, the predetermined cyclic prefix has a time-value denoted by  $6224 \times T_s$ , where

$$\frac{1}{30.72MHz}.$$

the "T<sub>s</sub>" is a sampling interval denoted by

**【Claim 13】** The method according to claim 7, wherein the

time length of the guard time (GT) is adjusted by the base station (BS) according to the cell radius.

**【Claim 14】** A method for receiving a random access channel

5 (RACH) signal comprising:

transmitting information of a predetermined preamble format to each user equipment (UE); and

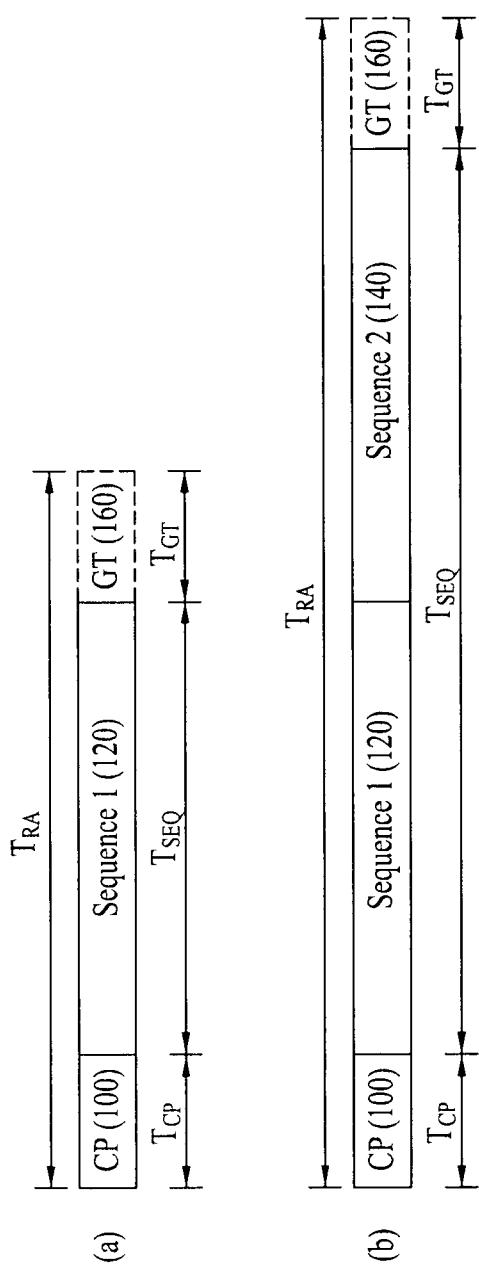
receiving the RACH signal from each user equipment (UE), wherein

10 the predetermined preamble format is constructed by a predetermined cyclic prefix (CP) and a single sequence, or a repeated sequence according to a cell radius, irrespective of a time length of a guard time (GT).

15 **【Claim 15】** The method according to claim 14, wherein the time length of the guard time (GT) is adjusted according to the cell radius.

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FIG. 1



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FIG. 2A

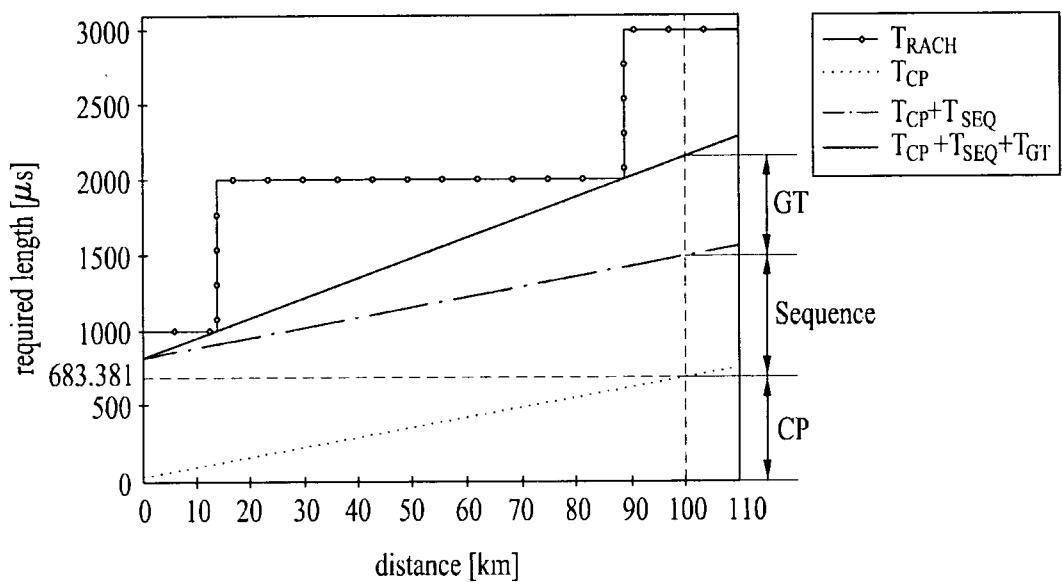
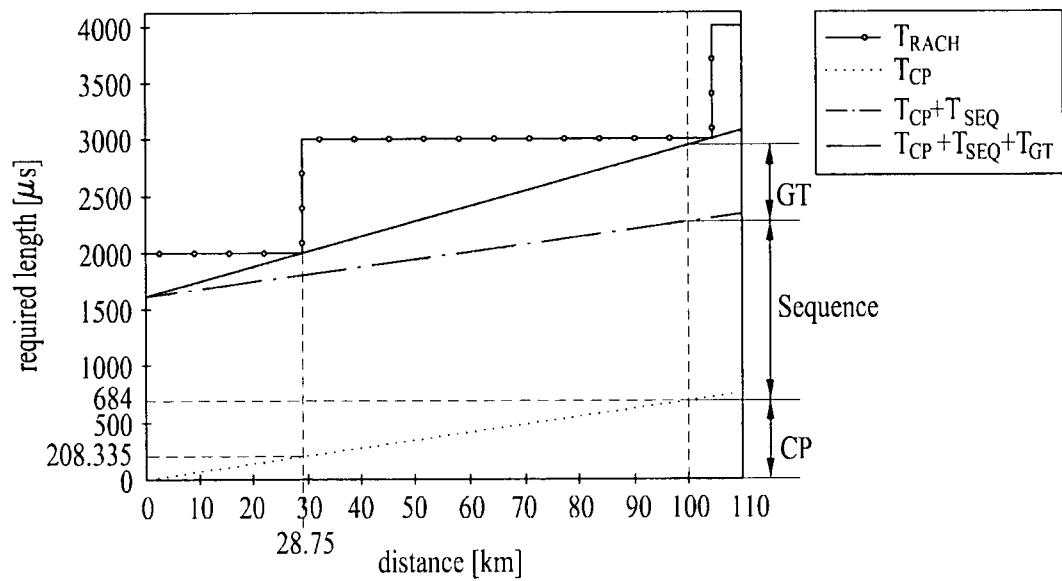


FIG. 2B



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FIG. 3A

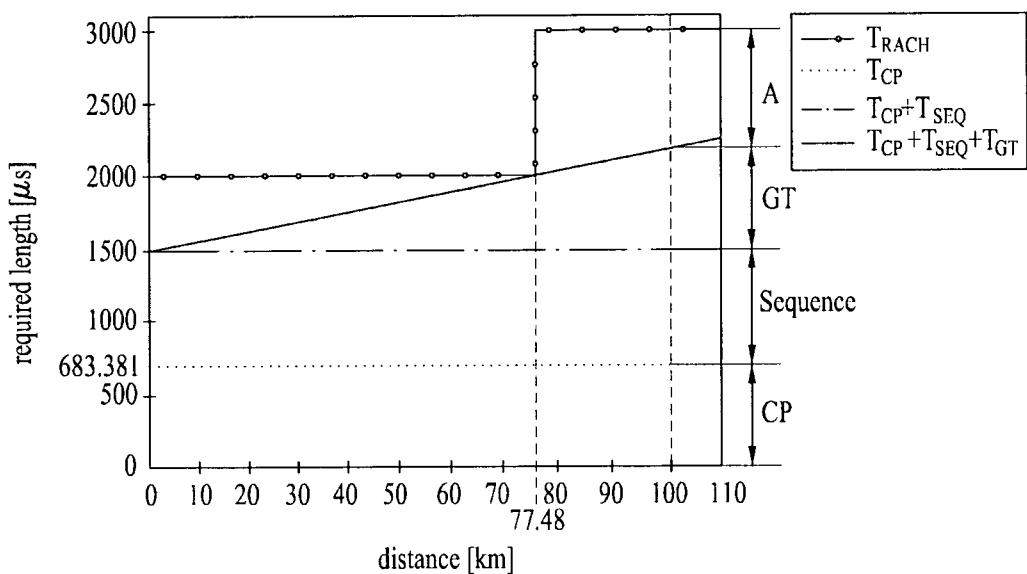
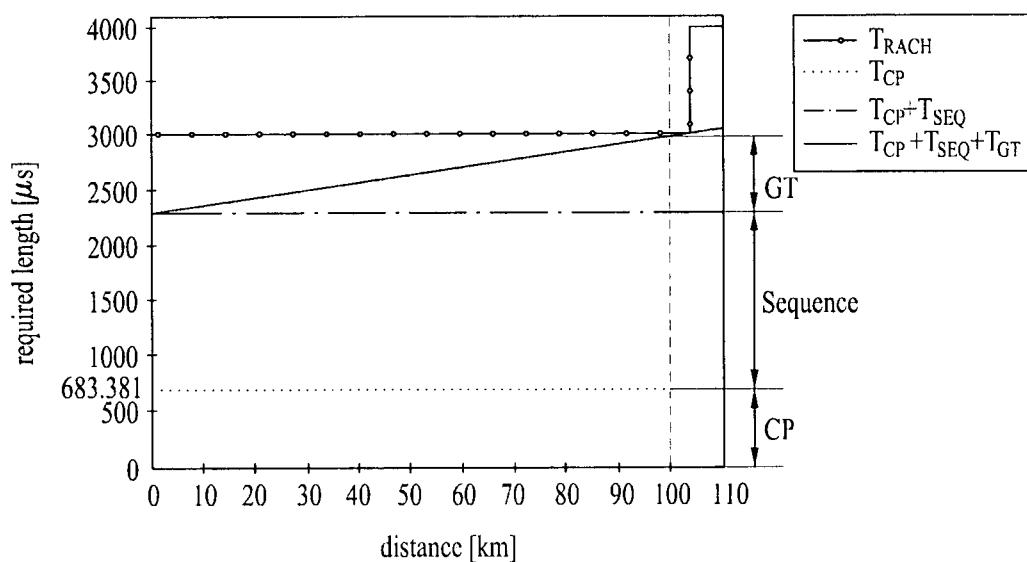


FIG. 3B



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FIG. 3C

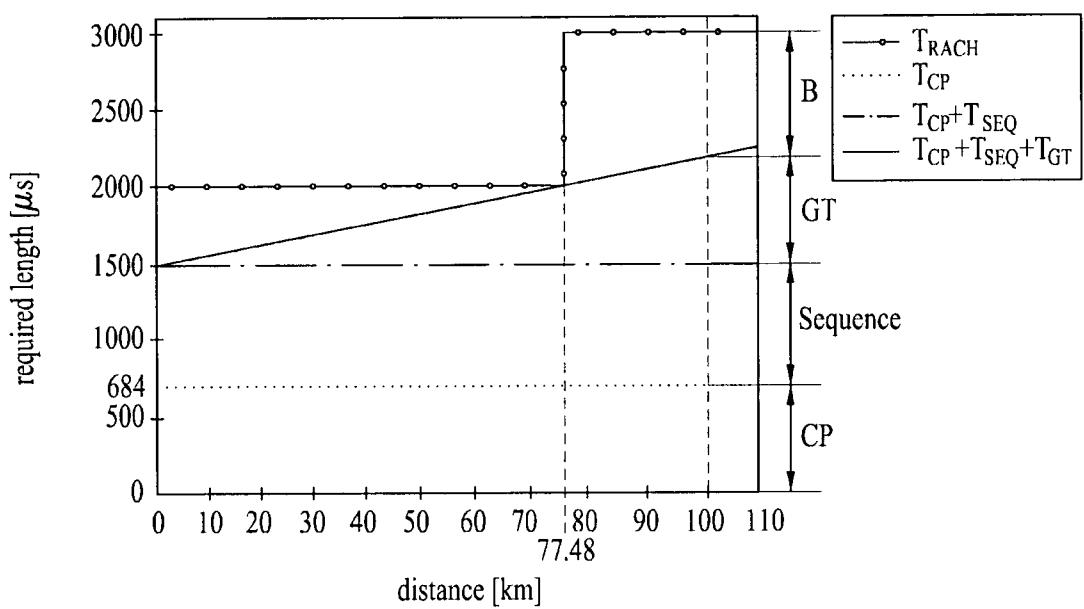
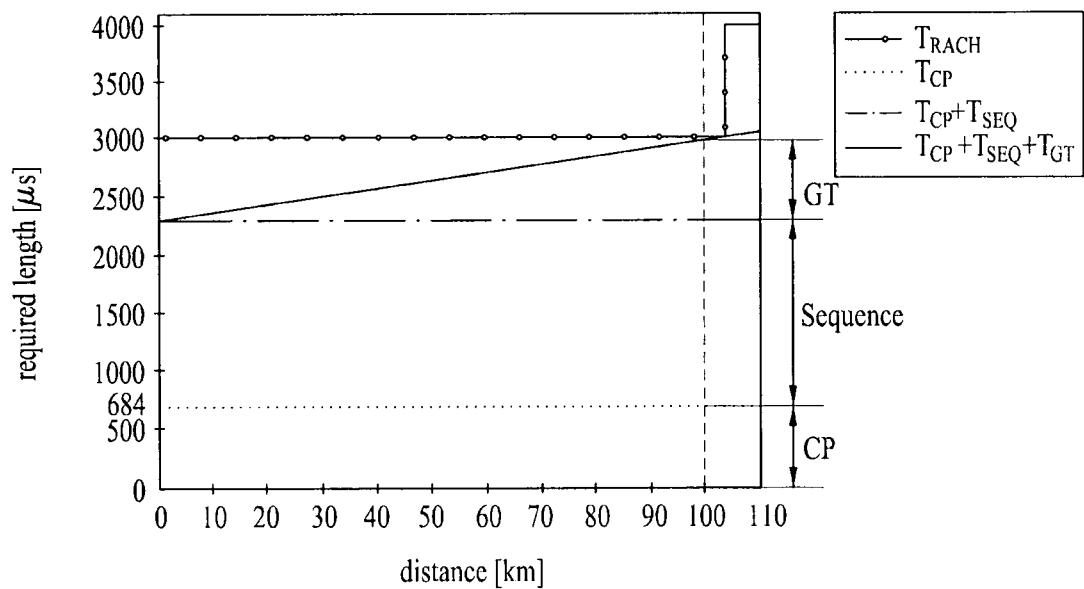


FIG. 3D



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FIG. 4A

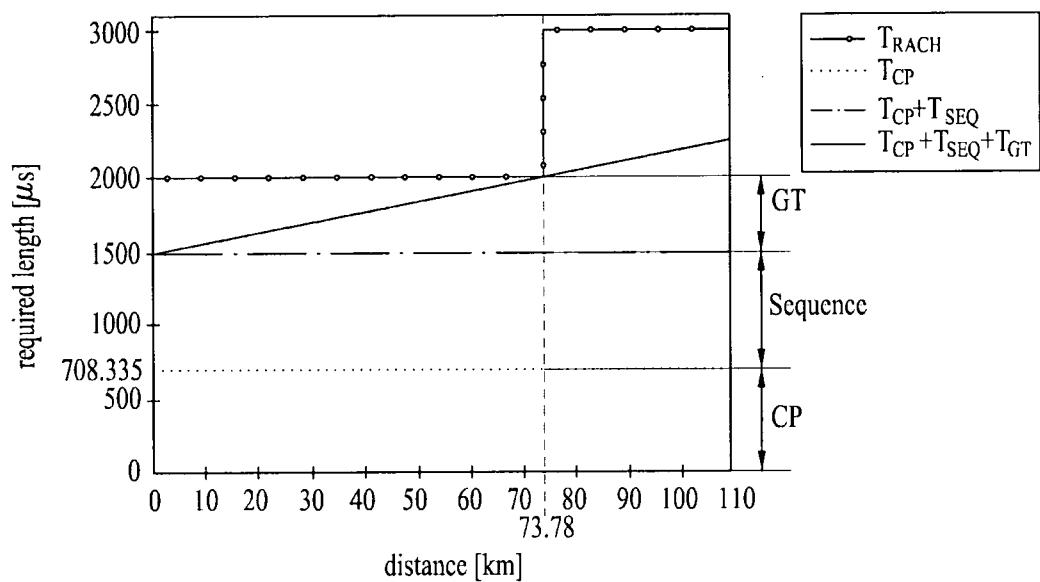
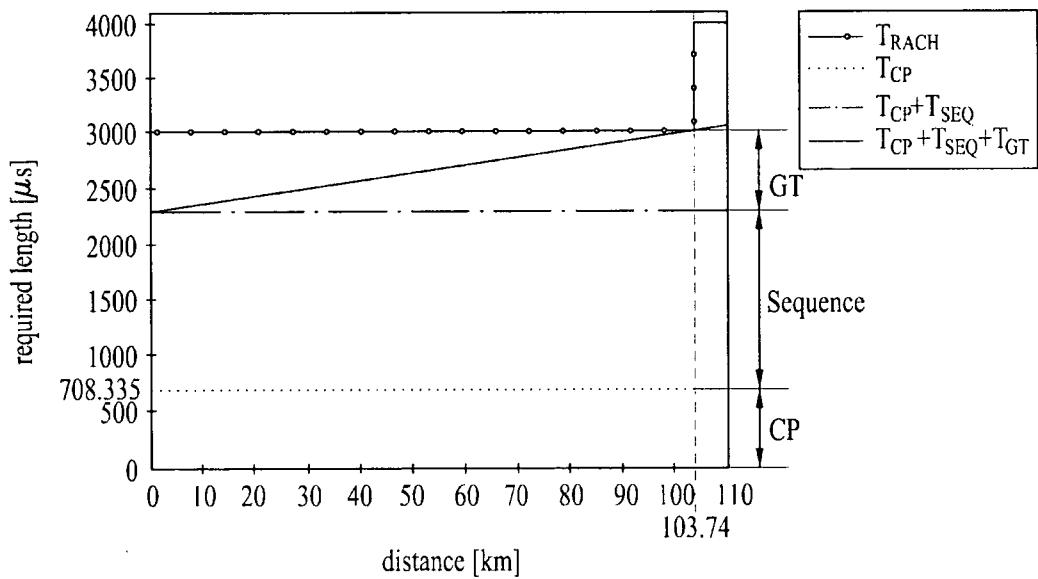
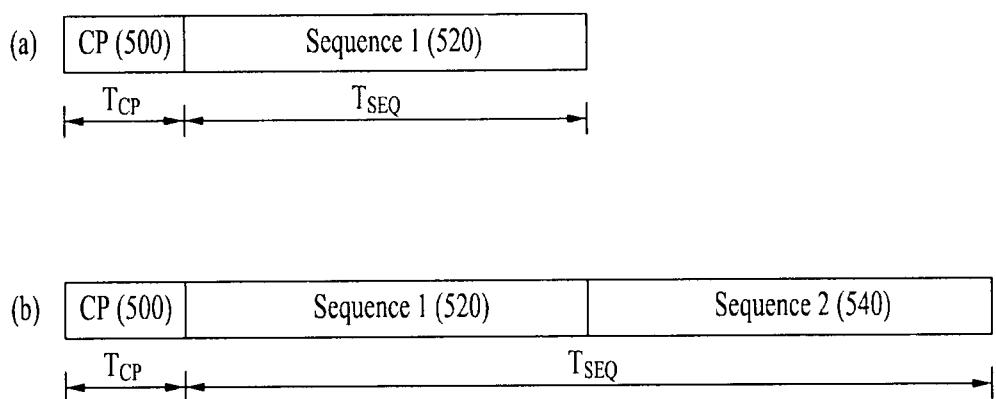


FIG. 4B



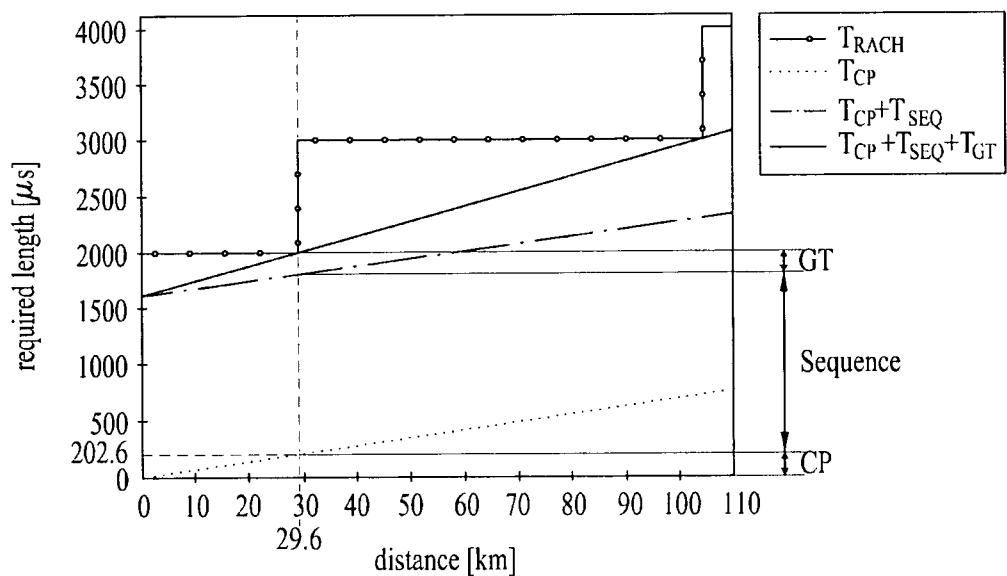
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FIG. 5



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FIG. 6



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FIG. 7A

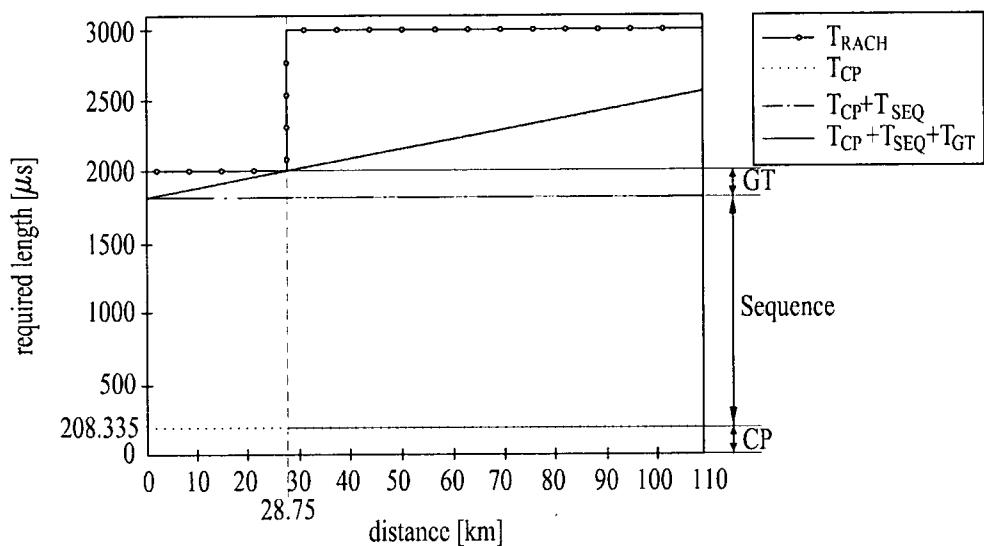
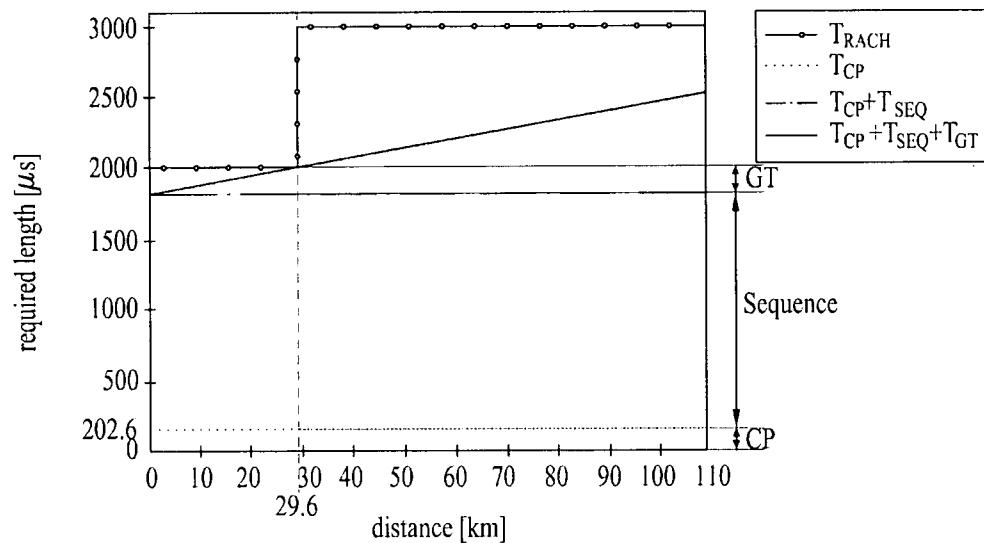


FIG. 7B



## INTERNATIONAL SEARCH REPORT

International application No.  
**PCT/KR2008/004129****A. CLASSIFICATION OF SUBJECT MATTER****H04B 7/26(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 8 H04B 7/26, H04Q 7/00, 7/20

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  
KOREAN UTILITY MODELS AND APPLICATIONS FOR UTILITY MODELS SINCE 1975  
JAPANESE UTILITY MODELS AND APPLICATIONS FOR UTILITY MODELS SINCE 1975Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
eKIPASS, DELPHION, ESPACENET & Keywords : RACH, preamble, CP, sequence, GT and similar terms.**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JICHAO LIU et al.; 'Preamble Design Based on Complete Complementary Sets for Random Access in MIMO-OFDM Systems'; Wireless Communications and Networking Conference, 2007.WCNC 2007. IEEE; 11-15 March 2007; pp. 858 - 862	1-15
A	POPOVIC, B.M. et al.; 'Random Access Preambles for Evolved UTRA Cellular System'; Spread Spectrum Techniques and Applications, 2006 IEEE Ninth International Symposium on; 28-31 August 2006; pp. 488 - 492	1-15
A	US2007-165567 A1 (TAN et al.) 19 July 2007 * abstract *	1-15
A	WO2007-1222 A1 (TELEFONAKTIEBOLAGET LM ERICSSON (publ) et al.) 4 January 2007 * abstract *	1-15

 Further documents are listed in the continuation of Box C. See patent family annex.

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Date of the actual completion of the international search  
10 DECEMBER 2008 (10.12.2008)

Date of mailing of the international search report

**11 DECEMBER 2008 (11.12.2008)**Name and mailing address of the ISA/KR  
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Facsimile No. 82-42-472-7140

Authorized officer

KIM, Sang Woo

Telephone No. 82-42-481-8324



**INTERNATIONAL SEARCH REPORT**

Information on patent family members

International application No.

**PCT/KR2008/004129**

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2007-165567 A1	19.07.2007	NONE	
WO 2007-001222 A1	04.01.2007	KR 2008-0031347 A US 2008-0207196 A1	08.04.2008 28.08.2008