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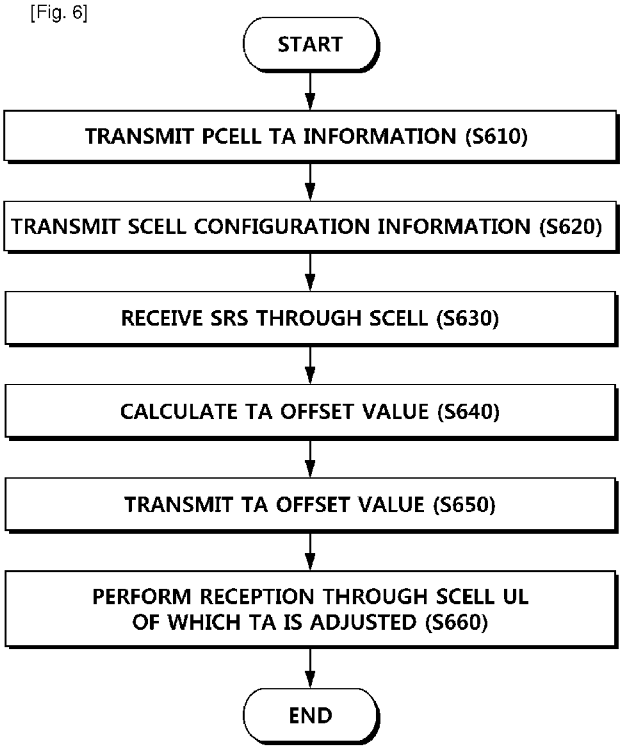
(54) **Title**: APPARATUS AND METHOD FOR TRANSMITTING AND RECEIVING UPLINK SYNCHRONIZATION INFORMATION IN WIRELESS COMMUNICATION SYSTEM

[Fig. 6]



(57) **Abstract**: Accordingly, In accordance with present invention, user equipment may computes timing advance value of each secondary cells based on primary serving cell's timing advance value, or provides timing advance by receiving offset information. Still another aspect of the present invention is User equipment may receives offset information using RRC message or MAC message. So, User equipment may support uplink synchronization in plural serving cells or component carriers.

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Description

Title of Invention: APPARATUS AND METHOD FOR TRANSMITTING AND RECEIVING UPLINK SYNCHRONIZATION INFORMATION IN WIRELESS COMMUNICATION SYSTEM

Technical Field

[1] The present invention relates to a method and an apparatus for transmitting and receiving uplink (UL) synchronization information in a wireless communication system, and more particularly, to a method and apparatus for establishing a UL synchronization with respect to one or more component carriers (CCs).

Background Art

[2] As generally known in the art, synchronization between a user equipment (UE) and an evolved node B (eNB) is an important issue in a wireless communication system since exchange of information between the UE and the eNB may be abnormally performed without synchronization.

[3] Unlike a conventional wireless communication system that supports a single component carrier (CC) or a single service band, a current wireless communication system attempts to satisfy a user demand through use of a plurality of CCs. However, a detailed scheme for providing synchronization information associated with the plurality of CCs has not been provided yet.

[4] Synchronization is a factor that has a great effect on an efficiency of a network. Accordingly, there is a desire for a method of effectively providing information required for uplink (UL) synchronization based on the factor, to perform communication.

Disclosure of Invention

Technical Problem

[5] Accordingly, an aspect of the present invention is to solve the above-mentioned problems occurring in the prior art, and to provide a method and apparatus for effectively establishing an uplink (UL) synchronization in a carrier aggregation (CA) in a wireless communication network environment that uses a plurality of CCs. Here, an efficient synchronization process may increase efficiency of a network and may secure safety of transmission.

[6] Another aspect of the present invention is to provide a method and apparatus for establishing synchronization by providing UL timing information in a wireless communication system.

[7] Still another aspect of the present invention is to provide a method and apparatus for

transmitting and receiving information for UL timing so as to establish synchronization in a wireless communication system.

[8] Yet another aspect of the present invention is to provide a user equipment that provides synchronization information associated with each CC through a radio resource control (RRC) connection reconfiguration procedure, and provides detailed synchronization information so as to establish synchronization with a base station, and a method thereof.

Solution to Problem

[9] In order to solve the above technical problems, there is provided a method of adjusting UL timing synchronization in a wireless communication system, the method including receiving, by a user equipment (UE) from an evolved node B (eNB), timing advance (TA) value of a first cell, transmitting, by the UE, a reference signal in a second cell through use of TA value of the second cell calculated based on the received TA value of the first cell, and receiving, by the UE from the eNB, offset information calculated based on the reference signal, so as to adjust UL TA value of the second cell based on the offset information, and the first cell corresponds to a primary serving cell that performs a random access procedure, and the second cell includes one or more secondary serving cells.

[10] In accordance with another aspect of the present invention, there is provided a method of adjusting UL timing synchronization in a wireless communication system, the method including transmitting, by an eNB to a UE, TA value of a first cell, and receiving, by the eNB, a reference signal transmitted by the UE in a second cell, so as to transmit, to the UE, offset information calculated based on the reference signal, and the first cell corresponds to a primary serving cell that performs a random access procedure, and the second cell includes one or more secondary serving cells.

[11] In accordance with still another aspect of the present invention, there is provided an apparatus for adjusting UL timing synchronization in a wireless communication system, the apparatus including a receiving unit to receive TA value of a first cell from an eNB, a timing controller to compute TA value of a second cell based on the received TA value of the first cell, and a transmitting unit to transmit a reference signal in the second cell, based on the computed TA value of the second cell, and when the receiving unit receives, from the eNB, offset information calculated based on the reference signal, the timing controller adjusts UL TA value of the second cell based on the offset information, and the first cell corresponds to a primary service cell that performs a random access procedure, and the second cell includes one or more secondary serving cells.

[12] In accordance with yet another aspect of the present invention, there is provided an

apparatus for adjusting uplink timing synchronization in a wireless communication system, the apparatus including a transmitting unit to transmit TA value of a first cell to a UE, a receiving unit to receive a reference signal that is transmitted by the UE in a second cell, and a TA information generating unit to compute offset informationbased on the received reference signal, and the transmitting unit transmits the offset information to the UE, the first cell is a primary serving cell that performs random access procedure, and the second cell includes one or more secondary serving cells.

Advantageous Effects of Invention

[13] When a physical medium property is different for each CC, for example, when locations of mean frequencies of CCs are significantly distant from each other, when the CCs are supported by different devices in a network, and the like, TA values of the CCs may be different from each other. Accordingly, the exemplary embodiments may obtain accurate UL synchronization for each CC. Also, a stable and efficient UL communication may be performed for a few CCs that obtain UL synchronization.

Brief Description of Drawings

[14] The above and other objects, features and advantages of the present invention will be more apparent from the following detailed description taken in conjunction with the accompanying drawings, in which:

[15] FIG. 1 is a diagram illustrating an example of a wireless communication system that uses a plurality of component carriers (CCs) according to an exemplary embodiment of the present invention;

[16] FIG. 2 is a diagram illustrating an example of a timing advance (TA) in a synchronization process according to an exemplary embodiment of the present invention;

[17] FIG. 3 is a diagram illustrating a random access procedure performed between a user equipment (UE) and an evolved node B (eNB);

[18] FIG. 4 is a diagram illustrating a process of applying, to an uplink (UL) TA, a downlink (DL) TA value of a primary service cell (Pcell) and a secondary serving cell (Scell);

[19] FIG. 5 is a flowchart illustrating a process where a UE adjusts a TA of an SCell according to an exemplary embodiment of the present invention;

[20] FIG. 6 is a flowchart illustrating a process where an eNB provides TA information of an SCell of a UE to the UE according to an exemplary embodiment of the present invention;

[21] FIG. 7 is a diagram illustrating transmission and reception performed through radio resource control (RRC) according to an exemplary embodiment of the present invention;

[22] FIG. 8 is a diagram illustrating an example where a TA offset value is included in a

predetermine information element (IE) which is included in an RRC connection reconfiguration message so that the TA offset value is transmitted and received through RRC according to an exemplary embodiment of the present invention;

[23] FIG. 9 is a diagram illustrating a structure of a multiple access control (MAC) for providing offset information through use of the MAC according to another exemplary embodiment of the present invention;

[24] FIG. 10 is a diagram illustrating a configuration of a MAC control element (CE) including information that indicates an offset according to an exemplary embodiment of the present invention;

[25] FIG. 11 is a diagram illustrating a configuration of a MAC CE including information that indicates an offset according to another exemplary embodiment of the present invention;

[26] FIG. 12 is a diagram illustrating a process of storing information associated with TA offsets in a MAC protocol data unit (PDU) when currently configured or activated serving cells correspond to CC1, CC2, and CC3 according to an exemplary embodiment of the present invention.

[27] FIG. 13 is a diagram illustrating offset information including indicator information according to another exemplary embodiment of the present invention;

[28] FIG. 14 is a diagram illustrating a configuration of a UE according to an exemplary embodiment of the present invention; and

[29] FIG. 15 is a diagram illustrating a configuration of an eNB according to an exemplary embodiment of the present invention.

Mode for the Invention

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

[31] A user equipment (UE) may be an inclusive concept indicating a user terminal utilized in a wireless communication, including a UE in Wideband Code Division Multiple Access (WCDMA), Long Term Evolution (LTE), High Speed Packet Access (HSPA), and the like, a mobile station (MS), a user terminal (UT), a subscriber station (SS), a wireless device in Global System for Mobile Communication (GSM), and the like. For ease of description, the user terminal may be referred to as a UE.

[32] In general, an evolved Node B (eNB) or base station may refer to a station where communication with the UE is performed, and may also be referred to as a Node-B, a

base transceiver system (BTS), an access point, and the like.

[33] A cell may be an inclusive concept including coverage areas of various cells, such as a megacell, macrocell, a microcell, a picocell, a femtocell, and the like.

[34] The wireless communication system may utilize varied multiple access schemes, such as Code Division Multiple Access (CDMA), Time Division Multiple Access (TDMA), Frequency Division Multiple Access (FDMA), Orthogonal Frequency Division Multiple Access (OFDMA), OFDM-FDMA, OFDM-TDMA, OFDM-CDMA, and the like.

[35] Uplink (UL) transmission and downlink (DL) transmission may be performed based on a time division duplex (TDD) scheme that performs transmission based on different times, or based on a frequency division duplex (FDD) scheme that performs transmission based on different frequencies.

[36] Exemplary embodiments of the present invention may be applicable to resource allocation in an asynchronous wireless communication scheme that is advanced through GSM, WCDMA, and HSPA, to be LTE and LTE-advanced (LTE-A), and may be applicable to resource allocation in a synchronous wireless communication scheme that is advanced through CDMA and CDMA-2000, to be Ultra Mobile Broadband (UMB). Exemplary embodiments of the present invention may not be limited to a specific wireless communication, and may be applicable to all technical fields to which a technical idea of the present invention is applicable.

[37] In the specification, a plurality of component carriers (CCs) may be distinguished from each other by names, for example, CC0, CC1, and the like. However, a number included in a name of a CC may not always match a sequence of a CC or a location of a frequency band of a corresponding CC.

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

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

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

[41] As illustrated in FIG. 1, when five CCs having a maximum bandwidth of 20 MHz are

used, a bandwidth may be expanded up to 100 MHz to support a quality of service. In this example, an allocable frequency band, which may be determined by each CC, may be contiguous or non-contiguous based on a scheduling of the CA.

[42] Referring to FIG. 1, the CA may be configured to include a first CC (CC1) 110, a second CC (CC2) 120, a third CC (CC3) 130, and an NthCC(CCN)140. A UL and a DL allocated to each CC may be different from each other, or may be the same as one another based on a scheduler. The CC may be a single CC. Throughout the specification, one or more CCs may be included in a single group. The one or more CCs included in the group may indicate that one or more CCs configure a single group. Also, a group including a single CC may exist.

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

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

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

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

[47] Conversely, according to a UL, an eNB may receive signals transmitted from a

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

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

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

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

[51] FIG. 2 illustrates an example of a TA in a synchronization process according to an exemplary embodiment of the present invention

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

[53] Accordingly, a TA 230 may be applied to enable the UE to transmit the UL radio frame i 220 a little earlier than the DL frame i 210 by taking the propagation delay into consideration, so that synchronization between the eNB and the UE may be obtained. An equation to calculate the TA 230 may be expressed by Equation 1.

[54] **[Equation 1]**

[55]
$$\mathrm{TA} = \left(N_{\mathrm{TA}} + N_{\mathrm{TA\ offset}}\right) \cdot T_{\mathrm{s}} \quad \text{seconds}$$

[56] Here, N_{TA} denotes a variable value controlled based on TA command information transmitted from the eNB, and $N_{TAoffset}$ denotes a fixed value set based on a frame

structure. T_s denotes a period of sampling. To obtain a UL synchronization, the UE may receive the TA command information provided by the eNB, and may proceed with a TA based on the received TA command information. Accordingly, synchronization for wireless communication with the eNB may be obtained.

[57] FIG. 3 illustrates a random access procedure performed between a UE and an eNB.

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

[59] The UE 380 may randomly select a preamble signature so as to generate a random access preamble. Subsequently, the UE 380 may transmit the random access preamble to the eNB 390 in step S310. The process of selecting the preamble signature may be contention-based selection or contention-free selection. In this example, the eNB 390 may inform the UE 380 of a previously reserved random access preamble, and the UE 380 may transmit, to the eNB 390, a preamble selected based on received information in step S310. Also, according to the contention-free selection, a procedure of transmitting and receiving a contention resolution (CR) message, which is required in the contention-based selection, may not need to be performed.

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

[61] The eNB 390 may perform random access response (RAR) with respect to the preamble received from the UE 380 (in step S320). In this example, the eNB 390 may transmit an RAR message through a physical downlink shared channel (PDSCH).

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

uplink shared channel (PUSCH), and may perform hybrid automatic repeat request (HARQ).

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

[64] In steps S310 through 330, collision may occur and thus, when the eNB 390 transmits a CR message in step S340, the UE 380 may determine whether a received message corresponds to the UE 380, and may transmit an acknowledgement (ACK) when the received message corresponds to the UE 380 or may not transmit response data when the received message corresponds to another UE. Also, the UE 380 may not transmit the response data when the UE 380 misses DL allocation or fails to decode the message. Also, the CR message may include a C-RNIT, UE identification information, and the like.

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

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

[67] When the UE transmits, based on the same UL synchronization standard, information to CCs of which UL synchronization standards are different from each other, a probability of transmission error may be significantly high, and a time and a resource may be wasted to restore the error. In this example, it is difficult to satisfy a UL quality of service (QoS) for an application program required by a system.

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

[69] Therefore, according to exemplary embodiments, in a wireless communication system that uses a plurality of CCs, information associated with UL synchronization timing may be transmitted, and a UE may generate and apply additional information associated with the UL synchronization timing.

[70] In a CA environment, a UE in an IDLE mode may select a single DL CC for RRC connection, and may receive system information via a broadcasting channel that is transmitted through the selected CC. The selected DL CC and a UL CC connected to the DL CC may be configured as a primary serving cell (PCell), based on the received system information. The UE may transmit, to an eNB, an RRC connection request message through the PCell. In this example, the UE may transfer the RRC connection request message to the eNB through use of an RACH procedure.

[71] Here, the DL CC corresponding to the PCell may be referred to as a DL primary CC (DL PCC), and the UL CC corresponding to the PCell may be referred to as a UL primary CC (UL PCC). Also, a CC corresponding to a secondary serving cell (SCell) in a DL, as opposed to the PCell, may be referred to as a DL secondary CC (DL SCC), and a CC corresponding to the SCell in a UL may be referred to as a UL secondary CC (UL SCC).

[72] A PCell and an SCell have characteristics as follows.

[73] First, a PCell may be used for PUCCH transmission.

[74] Second, a PCell is always activated, whereas an SCell is activated or deactivated based on a predetermined condition.

[75] Third, when radio link failure (RLF) occurs in a PCell, RRC reconnection may be triggered. When RLF occurs in an SCell, RRC reconnection may not be triggered.

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

[77] Fifth, non-access stratum (NAS) information may be received through a PCell.

[78] Sixth, a PCell may be configured to include a pair of a DL PCC and a UL PCC.

[79] Seventh, each UE sets a different CC as a PCell.

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

[81] Technical concept of the PCell and the SCell in exemplary embodiments may not be limited to the descriptions provided in the foregoing, and may include further examples.

[82] When the PCell and the SCell exist, a TA value may be set for each cell as illustrated in FIG. 4.

[83] FIG. 4 illustrates a process of applying, to a UL TA, a DL TA value of a Pcell and an Scell. In FIG. 4, CC1 corresponds to a PCell, and CC2 corresponds to an SCell. When an eNB transmits a frame at a T_send time through a DL CC1 and a DL CC2 as noted from the part indicated by reference numeral 410, a UE may receive the frame through

the DL CC1 and the DL CC2 as noted from the part indicated by reference numeral 420. In this example, the UE may receive the frame at a propagation delay time after the T_send time where the eNB transmits the frame. That is, a propagation delay time of T1 may occur in the DL CC1 and thus, the frame is received after the propagation delay time of T1, and a propagation delay time of T2 may occur in the DL CC2 and thus, the frame is received after the propagation delay time of T2.

[84] When it is assumed that a propagation delay time of DL transmission is the same as a propagation delay time of UL transmission, the UE may apply a TA of T1 and a TA of T2 to a UL CC1 and a UL CC2, respectively, so that the UE may transmit, to the eNB, a frame at a corresponding propagation delay time early, as noted from the part indicated by reference numeral 430. Therefore, the eNB may receive the frame transmitted from the UE through the UL CC1 and the UL CC2 at a T_Receive time that is set for uplink synchronization. In this example, the eNB is assumed to receive the UL CC1 and the UL CC2 through a single receiving device.

[85] Accordingly, when the eNB has a device that independently receives each UL CC, the T_Receive time set by the eNB may not need to be the same for each UL CC. That is, the eNB may set a T_Receive time for each UL CC. However, UL frames transmitted by UEs that use corresponding UL CCs may be received at corresponding T_Receive times set for the UL CCs.

[86] Here, the TA value of the SCell may be calculated based on the PCell through use of offset information. Offset information may selectively include a value of T3. The calculation may be differently performed based on whether the UE measures T3.

[87] When the UE measures T3, the UE may perform a process as follows.

[88] The UE may obtain a TA value of T1 in the PCell through a random access procedure of the PCell (DL CC1). Also, when the UE configures an SCell (TA reference CC being DL CC2) in addition to the PCell, a difference, that is, T3, in reception times between the DL CCs of the PCell and the SCell may be measured.

[89] Subsequently, T1 corresponding to the TA value of the PCell and T3 corresponding to the difference in time between reception times between the DL CCs of the PCell and the SCell may be added to calculate a TA value of the SCell, that is, T2. In addition, an offset value is further taken into consideration. Accordingly, T2 may be calculated by adding the offset to T1 and T3, as shown in equation: T2 = T1 + T3 + offset.

[90] The calculation may be applicable when a propagation delay difference due to a difference in frequency bands between a DL CC and a UL CC is taken into consideration or when T_send times of DL CCs are different from one another. For example, when the DL CC1 and the DL CC2 are transmitted by different transmitting devices, transmitting the DL CC1 and the DL cc2 at the same time may be difficult. In general, a difference in transmission times may be 1.6 microseconds () or more. Also,

the calculation may be applicable when a major UL receiving device is changed.

[91] Changing the major UL receiving device may include changing an eNB to a remote radio head (RRH), changing an eNB to a relay, changing an eNB to a frequency selective repeater (FSR), and the like. In this example, although DL is performed in an eNB, the UL receiving device may be an RRH, a relay, or a FSR and thus, it is difficult to apply, to the UL CC, a TA calculated from the DL CC.

[92] The offset value used for calculating the UL TA may be transmitted through RRC or a medium access control (MAC) control element (CE).

[93] According to another exemplary embodiment, when a UE does not measure T3, an offset may include T3. In this example, the UE may compute T2 by adding T1 and the offset. That is, T2= T1 + offset, which will be described in detail.

[94] The UE may receive, from an eNB, RRC reconfiguration information to be used for reconfiguration of the RRC. The RRC reconfiguration information may include configuration information associated with an SCell including a UL CC.

[95] In this example, a semi-static offset value, that is, a large offset value based on a receiving device, included in UL configuration information may be reflected during uplink transmission.

[96] After configuration of the SCell, the UE may transmit a periodical or aperiodic sounding reference signal (SRS) to the eNB. The eNB may receive the SRS from the UL CC of the SCell, and may calculate a dynamic TA value corresponding to a small offset value to be used for fine adjustment. Subsequently, the eNB may include the calculated dynamic TA value in a MAC CE so as to transmit the calculated dynamic TA value to the UE.

[97] The SRS may be an example of a reference signal (RS). The reference signal may provide information associated with a communication environment and the like to a counterpart device through a UL or a DL. The SRS may correspond to a channel estimation reference signal indicating a channel state of a UE when uplink transmission is performed. Also, the eNB may receive an SRS transmitted by each UE, and may determine a time when the SRS is received, so as to trace whether UL synchronization is obtained and to estimate an error to correct the UL synchronization.

[98] In addition, as a reference signal, a cell-specific reference signal (CRS) may be transmitted, at each sub-frame, so as to recognize channel information when DL transmission is performed. A transmitting device of a reference signal, that is, a UE for a UL reference signal or an eNB for a DL reference signal, may periodically or aperiodically generate reference signals and may transmit the reference signals to a receiving device.

[99] In the exemplary embodiments, similar to the transmission of the SRS, when a UE transmits a reference signal to an eNB, the eNB may determine a state of a network

based on the received reference signal and thus, may compute an offset value required to compute a TA value as described in the foregoing.

[100] Hereinafter, offset corresponding information required when a UE computes a TA value of an SCell based on a TA value of a PCell is defined to be an offset_pcell, and the offset_pcell may be classified into two types based on the following cases.

[101] a) a case where an offset_pcell excludes a difference in TA values of a PCell and an SCell, that is, T3 of FIG. 4 (In this example, the UE may calculate T3.)

[102] b) a case where an offset_pcell includes a value to be added to a TA value of a PCell (In this example, the UE may not compute T3 and may compute T2 by adding the offset_pcell and T1.)

[103] The offset_pcell of the case b) may be computed based on the following two values.

[104] b-i) a case where a semi-static offset value is set in a UL configuration information of an SCell, the semi-static offset being referred to as an offset_pcell_semi

[105] b-ii) a case where an eNB sets a dynamic TA value for fine adjustment after configuring an SCell, the dynamic TA value being referred to as an offset_pcell-dynamic.

[106] The offset_pcell of the case b) may be obtained based on offset_pcell = offset_pcell_semi + offset_pcell_dynamic.

[107] FIG. 5 illustrates a process where a UE adjusts a TA of an SCell according to an exemplary embodiment of the present invention.

[108] The UE may receive TA information of a PCell (PCell TA information) through an RRC connection establishment procedure, so as to obtain a TA value in step S510. The UE may configure an SCell through an RRC connection reconfiguration procedure in step S520. In this step S525, whether a TA offset value is included in SCell configuration information is determined. The TA offset value may correspond to a case where the UE does not calculate a separate delay time associated with the SCell, and an eNB includes a semi-static offset value in information required for RRC reconfiguration, as described in the case b-i). Accordingly, the TA offset value received by the UE may be the offset_pcell_semi of the case b-i).

[109] As a result of the determination in step S525, when the TA offset value is not included in the SCell configuration information, the UE may calculate a reception delay time in a DL CC of the SCell on the basis of a reception delay time in a DL CC of the PCell, based on a primary synchronization signal(PSS)/ secondary synchronization signal (SSS) in the DL CC of the SCell in step S530. T3 of FIG. 4 described in the foregoing may be calculated through the step S530, and the step S530 may correspond to the case a).

[110] The delay time of the SCell calculated, by the UE, on the basis of the PCell in step S530, or the offset information associated with the semi-static delay time received from the eNB in step S525 may be rough TA information or TA information having an

error within a predetermined range.

[111] Therefore, an accurate TA value may need to be calculated. Accordingly, the UE may transmit an SRS through a UL CC of the SCell in step S540. In this example, the SRS may be a periodic or aperiodic SRS. The eNB may receive the SRS transmitted in step S540, may calculate the accurate TA value of the UE, and may transmit a TA offset value to the UE. That is, the UE may receive the TA offset value through a MAC CE or an RRC connection reconfiguration message (*RRCConnectionReconfiguration*)of the eNB in step S550. In this example, the TA offset received by the UE may be an error value to be added to previously received information, or may be an absolute numeric value that is based on the PCell, which depends on settings by the UE and the eNB. The UE may transmit a signal in an SCell UL by applying the received TA offset value in step S560.

[112] FIG. 6 illustrates a process where an eNB provides TA information of an SCell of a UE the the UE according to an exemplary embodiment of the present invention.

[113] The eNB may calculate a TA value of a PCell (PCell TA value) through an RRC connection establishment procedure, and may transmit the calculated PCell TA value to the UE in step S610. The eNB may transmit, to the UE, SCell configuration information through an RRC connection reconfiguration procedure in step S620. In this example, the eNB may selectively include a TA offset value in the SCell configuration information for transmission. Including the TA offset value in the Scell configuration information may correspond to a case where a UE does not calculate a separate delay time associated with the SCell, and an eNB includes a semi-static offset value in the RRC reconfiguration information, as described in the case b-i). Accordingly, the TA offset value that the eNB includes in the SCell configuration information may be the offset_pcell_semi of the case b-i).

[114] The offset_pcell_semi value may be included in the RRC reconfiguration information, or the UE may calculate a reception delay time in a DL CC of the SCell on the basis of a reception delay time in a DL CC of the PCell, based on a PSS/SSS in the DL CC of the SCell in the same manner as step S530 of FIG. 5, which may correspond to calculating T3 of FIG. 4 described in the foregoing and may correspond to the case a). The TA offset value that the UE receives directly or through the eNB may correspond to a difference in a TA of the SCell on the basis of the PCell, and the TA offset value may have an error within a predetermined range due to various reasons described in the foregoing. Accordingly, to remove the error, the eNB may receive an SRS from the UE through the SCell in step S630. The eNB may calculate a TA offset value based on the received SRS in step S640, and may transmit the calculated TA offset value to the UE in step S650. In this example, the transmitted TA offset value may be an error value to be added to previously transmitted information, or may be an

absolute numeric value that is based on the PCell, which depends on settings by the UE and the eNB or a mutually engaged scheme. The UE may transmit a signal in an SCell UL by applying the received TA offset value, and the eNB may receive the signal through the SCell UL of which a TA is adjusted in step S660.

[115] Hereinafter, a process of providing a TA offset in each step will be described according to an exemplary embodiment. The TA offset may be transmitted and received through RRC or a MAC CE.

[116] FIG. 7 illustrates transmission and reception performed through RRC according to an exemplary embodiment of the present invention.

[117] Referring to FIG. 7, a TA offset value is included in SCell configuration information when an eNB provides the SCell configuration information to a UE through an RRC connection reconfiguration procedure. That is, when the eNB configures a UL of the SCell, the eNB may include an offset value in a parameter included in the SCell configuration information so as to transmit the SCell configuration information to the UE through the RRC reconfiguration procedure. The offset value included in the SCell configuration information during the reconfiguration procedure may be applicable to the case a), the case b) (including b-i and b-ii), and the like.

[118] An eNB 790 may transmit an RRC reconfiguration message (RRCConnectionReconfiguration) to a UE 780 in step S710. The UE 780 may transmit, to the eNB 790, a message (RRCConnectionReconfigurationComplete) indicating that RRC reconfiguration is successfully performed based on the received RRCConnectionReconfiguration in step S720 and thus, the RRC reconfiguration procedure is completed.

[119] The reconfiguration procedure is performed to correct an RRC connection, for example, establishing, modifying, or releasing a resource block (RB), performing a handover, setting up, modifying, or releasing a measurement, or adding, modifying, or releasing an SCell. The exemplary embodiments may be applied to adding, modifying, or releasing the SCell.

[120] As described in step S520 of FIG. 5 and step S620 of FIG. 6, an eNB may transmit SCell configuration information to a UE. Accordingly, the eNB may include offset information in the SCell configuration information. That is, the SCell configuration information is information that the eNB provides to the UE during the RRC reconfiguration procedure, and the information is associated with configuration of the SCell.

[121] In a CA environment that uses a plurality of cells, RRCConnectionReconfiguration may use RRCConnectionReconfiguration-v10xy-IEs, that is, an RRC information element (IE), as shown in 730. In this example, to add or modify the SCell, sCellToAddModList-r10 including SCellToAddMod-r10 may be used, and SCellToAddMod-r10 may include radioResourceConfigDedicated-r10 in a form of Ra-

dioResourceConfigDedicatedSCell-r10 including setting information associated with a radio resource allocated to the UE.

[122] RadioResourceConfigDedicatedSCell-r10 may include physicalConfigDedicated that is information required for configuration of the SCell, which is configured of PhysicalConfigDedicatedSCell-r10.

[123]
```
RadioResourceConfigDedicatedSCell-r10 ::=     SEQUENCE {

physicalConfigDedicated     PhysicalConfigDedicatedSCell-r10    OPTIONAL,

...

}
```

[124] The configuration of *PhysicalConfigDedicatedSCell-r10* may include information required to configure a DL and a UL. Accordingly, when TA offset information, described in the foregoing, is included in *PhysicalConfigDedicatedSCell-r10*, the eNB may provide a TA offset value to the UE during a process of adding or modifying the SCell.

[125] FIG. 8 illustrates an example where a TA offset value is included in a predetermined IE included in an RRC connection reconfiguration message so that the TA offset value is transmitted and received through RRC according to an exemplary embodiment of the present invention. When information of FIG. 8 is included in RRCConnectionReconfiguration during an RRC connection reconfiguration procedure, an eNB may provide the TA offset value to a UE. That is, the eNB may provide a TA offset value to the UE through use of a parameter named TA-offset-r11 included in ul-Configuration that is an item associated with configuration of a UL, as shown in 810. This may be an example of PhysicalConfigDedicated, and may be provided as a factor of RRCConnectionReconfiguration by combining with another message or information. That is, FIG. 8 illustrates merely an example of including a TA offset value in RRCConnectionReconfiguration, and exemplary embodiments may not be limited thereto.

[126] The TA offset value transmitted and received in FIGS. 7 and 8 may be applicable when the case b-i) is satisfied, when the both cases b-i) and b-ii) are satisfied, and when a UE calculates a difference in TA values between an SCell and a PCell, and receives a detailed TA value in case a).

[127] FIG. 9 illustrates a structure of a MAC for providing offset information through use of the MAC according to another exemplary embodiment of the present invention.

[128] In FIG. 9, a configuration of MAC protocol data unit (PDU) 910 is illustrated. The MAC PDU may include a MAC header, a plurality of MAC CEs and MAC SDUs, and a padding. The MAC header may include a plurality of sub-headers. A configuration of

a sub-header and an L-field may be configured as shown in FIG. 9 which is indicated by numeral 920 and 930. An L-field is configured to have 7 bits which is indicated by numeral 920, and an L-field is configured to have 15 bits which is indicated by numeral 930. In sub-header which is indicated by numeral 920 and 930, R denotes a reserved bit and may be set to 0. F denotes a field that indicates a format, and L denotes a size of a MAC CE having a variable length or a MAC SDU corresponding to a sub-header. E denotes an extension field, and may indicate whether another MAC header further exists.

[129] LCID denotes a logical channel ID field, and may indicate a channel characteristic of a corresponding MAC SDU or MAC CE. Information indicated by LCID values is described as shown in FIG.9 which is indicated by numeral 940. Here, '11101' denotes a TA command and thus, may be used to provide an offset value. That is, this may be achieved by setting an LCID value to '11101' and including an offset value in a MAC CE.

[130] FIG. 10 illustrates a configuration of a MAC CE including information that indicates an offset according to an exemplary embodiment of the present invention.

[131] The MAC CE is in an octet configuration and thus, may have a size of 8 bits. However, offset information $N_{\text{TA offset}}$ may have varied sizes and thus, may be configured of one octet or at least two octets.

[132] When an octet of 8 bits is used as shown in 1030, 256 pieces of information may be represented through the octet. Accordingly, a range of $N_{\text{TA offset}}$ may be divided into as follows.

[133] i) $$0 \leq N_{\text{TA\_offset}} \leq 255$$

[134] ii) $$-128 \leq N_{\text{TA\_offset}} \leq 127$$

[135] Accordingly, when a value included in the MAC CE is based on the range i), $N_{\text{TA offset}}$ may be computed based on binary number calculation. However, when the value included in the MAC CE is based on the range ii), $N_{\text{TA offset}}$ may be obtained after performing subtraction of 128.

[136] For example, when the MAC CE is set to “1 0 0 1 1 1 0 1”, the binary number may be converted into 157 in a decimal number format, as indicated by numeral 1031. When “1 0 0 1 1 1 0 1” is applied to the range i), $N_{\text{TA offset}}$ may be 157. However, when “1 0 0 1 1 1 0 1” is applied to the range ii), $N_{\text{TA offset}}$ may be 29 that is obtained by subtracting 128 from 157.

[137] The range of $N_{\text{TA offset}}$ may be variously defined and thus, 0 or 128 may not be set as a minimum value. The range of $N_{\text{TA offset}}$ may be determined through use of various numbers, such as -100, 20, and the like, as a base for the range based on a state or a setting of a network.

[138] Also, two or more octets may be allocated for $N_{\text{TA offset}}$. When two octets are used as indicated by numeral 1040, 15 bits may be allocated for $N_{\text{TA offset}}$, and the range of $N_{\text{TA offset}}$ may be divided as follows. In this example, although 15 bits may represent 32768 pieces of information, a part of the range may be utilized based on a TA environment. R denotes a reserved bit which is indicated by numeral 1040.

[139] i) $0 \leq N_{\text{TA\_offset}} \leq 20512$

[140] ii) $-10256 \leq N_{\text{TA\_offset}} \leq 10256$

[141] For example, the MAC CE may include two octets of "0 0 1 1 1 0 1" and "1 1 0 1 1 1 0 1" as indicated by numeral 1041, and a value extracted after combining "0 0 1 1 1 0 1" and "1 1 0 1 1 1 0 1" may be 7645. When 7645 is applied to the range i), $N_{\text{TA offset}}$ may be 7645. When 7645 is applied to the range ii), $N_{\text{TA offset}}$ may be -2611.

[142] FIG. 11 illustrates a configuration of a MAC CE including information that indicates an offset according to another exemplary embodiment of the present invention. Referring to FIG. 10, $N_{\text{TA offset}}$ is determined by utilizing a number included in the MAC CE as is or by modifying the number. However, referring to FIG. 11, the number included in the MAC CE may be increased or decreased based on a predetermined unit, and $N_{\text{TA offset}}$ may have a value larger than a value within an originally allowed range.

[143] That is, when 6 bits are used as indicated by numeral 1130, T_{A_offset} corresponding to the number included in the MAC CE may be in a range of $0 \leq T_{A\_offset} \leq 63$. $N_{\text{TA offset}}$ may be computed by applying T_{A_offset} included in the MAC CE to a following equation.

[144]
$$N_{\text{TA\_offset}} = 16 \cdot (T_{A\_offset} - 31)$$

[145] Accordingly, when the MAC CE includes a value of "0 0 1 1 1 0", T_{A_offset} may be 14. $N_{\text{TA offset}}$ may be -272 when T_{A_offset} is applied to the equation.

[146] When 11 bits are used as indicated by numeral 1140, T_{A_offset} corresponding to the number included in the MAC CE may be in a range of $0 \leq T_{A\_offset} \leq 1282$.

[147]

$N_{\text{TA offset}}$ may be computed by substituting T_{A_offset} included in the MAC CE in the following equation.

[148]
$$N_{\text{TA\_offset}} = 16 \cdot (T_{A\_offset} - 641)$$

[149] Accordingly, when the MAC CE includes values of " 1 1 1 0 1" and " 0 1 1 1 0 1", as indicated by numeral1411, T_{A_offset} may be 1885. $N_{\text{TA offset}}$ may be 19904 when T_{A_offset} is applied to the equation.

[150] The base, such as 31 and 641, may be variously set. That is, the base may vary based on a circumstance of a network.

[151] The MAC CE, described with reference to FIGS. 10 and 11, may include a value required to compute an offset for a TA of a predetermined SCell. The MAC CE may transmit a TA offset value to all service cells where a UL CC is activated and configured.

[152] FIG. 12 illustrates a process of storing information associated with TA offsets in a MAC PDU when currently configured or activated serving cells correspond to CC1, CC2, and CC3 according to an exemplary embodiment of the present invention. Referring to FIG. 12, a MAC PDU 1220 may include, in a header, a sub-header 1210 indicating a MAC CE 1 1215 that provides TA offset information associated with a first CC (CC1), a sub-header 1220 indicating a MAC CE 2 1225 that provides TA offset information associated with a second CC (CC2), and a sub-header 1230 indicating a MAC CE 3 1235 that provides TA offset information associated with a third CC (CC3).

[153] The MAC CE 1 1215 corresponding to the sub-header 1210 may provide offset information in the same manner as 1031 of FIG. 10. The MAC CE 2 1225 corresponding to the sub-header 1220 may provide offset information in the same manner as 1041 of FIG. 10, and the MAC CE 3 1235 corresponding to the sub-header 1230 may provide offset information in the same manner as 1141 of FIG. 11. A UE that receives the MAC PDU 1200 may determine TA offset information associated with the CC1, CC2, and CC3 through use of sub-headers, and may apply corresponding TA offset information to each CC.

[154] TA offset information associated with all CCs may be stored in a single MAC CE. In this example, TA offset information associated with a plurality of CCs may be stored

in a single MAC CE. For example, a header of a MAC PDU 1270 may include a sub-header 1250 associated with a TA, and a MAC CE 1251 corresponds to the sub-header 1250. The MAC CE 1251 is configured in three octets, and the three octets may include TA offset information associated with CC1, CC2, and CC3, respectively.

[155] FIG. 13 illustrates offset information including indicator information according to another exemplary embodiment of the present invention.

[156] When update of a predetermined SCell is required, for example, when the UL synchronization of a few SCells of a predetermined UE, measured by an eNB through use of an SRS, is out of a predetermined threshold, the eNB may release a corresponding SCell and may reconfigure an SCell including a UL CC when it is needed. In this example, a DL CC is also configured in the SCell.

[157] Accordingly, to provide a TA offset value described in the foregoing, indicator information associated with each CC may be included in a MAC CE. An indicator may function as information that indicates activation or deactivation of a CC. For example, when '1' indicates that a TA offset value of a corresponding CC is to be transmitted, the offset information may be embodied as shown in 1310 of FIG. 13. C0 may be an indicator to indicate activation or deactivation of CC1, C1 is for CC2, ..., and C5 is for CC6. When the offset information includes more bits than an octet configuration, unlike 1310, bits C6, C7, C8, C9, and the like, as opposed to bit C5, may be indicators of CC7, CC8, CC9, CC10, and the like.

[158] An example where TA offset values of CC1, CC2, and CC4 are transmitted according to the configuration of 1310 is provided as shown in 1320. In 1320, TA offset information is set to have 6 bits.

[159] C0, C1, and C3 that are indicators of CC1, CC2, and CC4 are set to 1, and remaining indicators, that is, C2, C4, and C5 are set to 0. TA offset values associated with CC1, CC2, and CC4 may be " 1 0 0 1 0 0", " 0 1 0 1 1 1", " 0 1 0 1 1 1", respectively. A TA offset value may be set with respect to a corresponding SCell that requires updating, through use of the configuration of FIG. 13.

[160] FIG. 14 illustrates a configuration of a UE according to an exemplary embodiment of the present invention. The UE may include a receiving unit 1410, a transmitting unit 1420, and a timing controller 1430.

[161] A device of FIG. 14 may receive offset information required to adjust a UL timing synchronization in a wireless communication system including one or more CCs. Although the device of FIG. 14 also provides other functions for implementing UE, description thereof will be omitted here. The receiving unit 1410 may receive TA information of a first cell from an eNB. The timing controller 1430 may compute TA information of a second cell based on the received TA information of the first cell. The TA information of the second cell may be obtained based on the first cell, such as T2

and T3 as shown in 420 of FIG. 4. As described in FIGS. 7 and 8, the TA information of the second cell may be included in an RRC reconfiguration message. In this example, the timing controller 1430 may extract the TA information of the second cell from the RRC reconfiguration message, so as to use the TA information of the second cell. Also, the UE may directly compare DL delay times of cells. For example, the timing controller 1430 may calculate a DL delay time of the second cell by comparing to the first cell, and may compute the TA information of the second cell by combining the calculated delay time and the TA information of the first cell.

[162] The TA information of the second cell may have an error when compared to accurate UL TA information of the second cell since a propagation delay difference due to a difference in frequency bands between a DL CC and a UL CC may be taken into consideration, a T_send time of each DL CC may be different from one another, a major UL receiving device may be changed, and the like, as described in the foregoing.

[163] Accordingly, the transmitting unit 1420 may transmit a reference signal through the second cell based on the calculated TA information of the second cell. The reference signal may be an SRS as described in the foregoing, and may be transmitted periodically or aperiodically. Subsequently, when the receiving unit 1410 receives, from the eNB, offset information required to adjust an error of the TA information of the second cell, the timing controller 1430 may adjust the UL TA information of the second cell based on the received offset information. The UE may perform UL timing synchronization through use of the UL TA information of the second cell.

[164] The UL TA information of the second cell may enable accurate UL TA by applying the offset information. As described in the foregoing with reference to FIGS. 9 through 13, the offset information may be included in a MAC CE of a MAC PDU.

[165] As described in FIG. 12, the second cell may include two or more cells, and the offset information may sequentially include errors of TA information associated with the two or more cells.

[166] As described in FIG. 13, the second cell may include two or more cells, and the offset information may include indicator information indicating an activated or configured cell from among the two or more cells, and errors of TA information associated with the two or more cells.

[167] In FIG. 14, the first cell may be a PCell and the second cell may be an Scell. Also, as described in FIGS. 12 and 13, one or more SCells may exist.

[168] FIG. 15 illustrates a configuration of an eNB according to an exemplary embodiment of the present invention. The eNB may be configured to include a receiving unit 1510, a transmitting unit 1520, and a TA information generating unit 1530. A device of FIG. 15 may transmit offset information required to adjust UL timing synchronization in a wireless communication system including one or more CCs. Although the device of

FIG. 15 also provides other functions for implementing eNB, description thereof will be omitted here.

[169] The transmitting unit 1520 may transmit TA information of a first cell to a UE, and the receiving unit 1510 may receive a reference signal transmitted from the UE based on TA information of a second cell calculated by the UE.

[170] The TA information of the second cell may be obtained based on the first cell, such as T2 and T3 as shown in 420 of FIG. 4. As described in FIGS. 7 and 8, the TA information of the second cell may be included in an RRC reconfiguration message associated with the second cell. In this example, the UE may include the TA information of the second cell in the RRC reconfiguration message, and may transmit the RRC reconfiguration message. As another example, the UE may directly compare DL delay times of cells. For example, the UE may compare delay times while the UE receives DL frames transmitted through the first cell and the second cell. That is, the timing controller 1430 of the UE of FIG. 14 may calculate a DL delay time of the second cell by comparing to the first cell, and may combine the calculated delay time and the TA information of the first cell so as to compute TA information of the second cell. In this example, the eNB may not need to separately transmit the TA information of the second cell.

[171] The TA information of the second cell may have an error when compared to accurate UL TA information of the second cell since a propagation delay difference due to a difference in frequency bands between a DL CC and a UL CC may be taken into consideration, a T_send time of each DL CC may be different from one another, a major UL receiving device may be changed, and the like, as described in the foregoing. A reference signal may be an SRS as described in the foregoing, and may be received periodically or aperiodically.

[172] The TA information generating unit 1530 may compute offset information required to set the UL TA information of the second cell through use of the received reference signal, and the transmitting unit 1520 may transmit the offset information to the UE. The UL TA information of the second cell may be adjusted based on the offset information, and the UE may perform UL timing synchronization based on the adjusted UL TA information of the second cell.

[173] The UL TA information of the second cell may enable accurate UL TA by applying the offset information. As described in the foregoing with reference to FIGS. 9 through 13, the transmitting unit 1520 may transmit, to the UE, a MAC PDU including a MAC CE that includes the offset information.

[174] As described in FIG. 12, the second cell may include two or more cells, and the offset information may sequentially include errors of TA information associated with the two or more cells.

[175] As described in FIG. 13, the second cell may include two or more cells, and the offset information may include indicator information indicating an activated or configured cell from among the two or more cells, and errors of TA information associated with the two or more cells.

[176] In FIG. 15, the first cell may be a PCell and the second cell may be an Scell. Also, as described in FIGS. 12 and 13, one or more SCells may exist.

[177] In FIGS. 14 and 15, when the second cell include two or more cells, the offset information may sequentially include errors of TA information associated with the two or more cells. According to another exemplary embodiment, the offset information may include indicator information indicating an activated or configured cell from among the two or more cells, and error of TA information associated with the two or more cells.

Industrial Applicability

[178] When a physical medium property is different for each CC, for example, when locations of mean frequencies of CCs are significantly distant from each other, when the CCs are supported by different devices in a network, and the like, TA values of the CCs may be different from each other. Accordingly, the exemplary embodiments may obtain accurate UL synchronization for each CC. Also, a stable and efficient UL communication may be performed for a few CCs that obtain UL synchronization.

[179] **CROSS-REFERENCE TO RELATED APPLICATION**

[180] This application claims priority from and the benefit under 35 U.S.C. §119(a) of Korean Patent Application No.10-2011-0029784, filed on March 31, 2011, which is hereby incorporated by reference for all purposes as if fully set forth here in.

Claims

[Claim 1] A method of adjusting UL timing synchronization in a wireless communication system, the method comprising the steps of:
receiving, by a user equipment (UE) from an evolved node B (eNB), timing advance (TA) value of a first cell;
transmitting, by the UE, a reference signal in a second cell through use of TA value of the second cell calculated based on the received TA value of the first cell; and
receiving, by the UE from the eNB, offset information calculated based on the reference signal, so as to adjust UL TA value of the second cell based on the offset information,
wherein the first cell corresponds to a primary serving cell that performs a random access procedure, and the second cell includes one or more secondary serving cells.

[Claim 2] The method as claimed in claim 1, wherein the TA value of the second cell is included in a radio resource control (RRC) reconfiguration message associated with the second cell.

[Claim 3] The method as claimed in claim 1, wherein the UE calculates a downlink (DL) delay time of the second cell by comparing to the first cell, and computes the TA value of the second cell by combining the calculated delay time and the TA value of the first cell.

[Claim 4] The method as claimed in claim 1, wherein the offset information is included in a multiple access control (MAC) control element (CE) of a MAC protocol data unit (PDU).

[Claim 5] A method of adjusting UL timing synchronization in a wireless communication system, the method comprising the steps of:
transmitting, by an evolved node B (eNB) to a user equipment (UE), timing advance (TA) value of a first cell; and
receiving, by the eNB, a reference signal transmitted by the UE in a second cell, so as to transmit, to the UE, offset information calculated based on the reference signal,
wherein the first cell corresponds to a primary serving cell that performs a random access procedure, and the second cell includes one or more secondary serving cells.

[Claim 6] The method as claimed in claim 5, wherein, after the step of transmitting the TA value of the first cell to the UE, the method further comprises the step of:

transmitting, by the eNB to the UE, a radio resource control (RRC) reconfiguration message associated with the second cell including TA value of the second cell.

[Claim 7] The method as claimed in claim 5, wherein TA value of the second cell is computed by calculating, by the UE, a downlink (DL) delay time of the second cell based on the first cell, and by combining the calculated delay time and the TA value of the first cell.

[Claim 8] The method as claimed in claim 5, wherein the eNB includes the offset information in a multiple access control (MAC) control element (CE) of a MAC protocol data unit (PDU), so as to transmit the offset information.

[Claim 9] An apparatus for adjusting UL timing synchronization in a wireless communication system, the apparatus comprising:
a receiving unit to receive timing advance (TA) value of a first cell from an evolved node B (eNB);
a timing controller to compute TA value of a second cell based on the received TA value of the first cell; and
a transmitting unit to transmit a reference signal in the second cell, based on the computed TA value of the second cell,
wherein:
when the receiving unit receives, from the eNB, offset information calculated based on the reference signal, the timing controller adjusts UL TA value of the second cell based on the offset information, and the first cell corresponds to a primary service cell that performs a random access procedure, and the second cell includes one or more secondary serving cells.

[Claim 10] The apparatus as claimed in claim 9, wherein the timing controller extracts the TA value of the second cell from a radio resource control (RRC) reconfiguration message associated with the second cell.

[Claim 11] The apparatus as claimed in claim 9, wherein the timing controller calculates a downlink (DL) delay time of the second cell by comparing to the first cell, and computes the TA value of the second cell by combining the calculated delay time and the TA value of the first cell.

[Claim 12] The apparatus as claimed in claim 9, wherein the offset information is included in a multiple access control (MAC) control element (CE) of a MAC protocol data unit (PDU).

[Claim 13] An apparatus for adjusting uplink timing synchronization in a wireless communication system, the apparatus comprising:

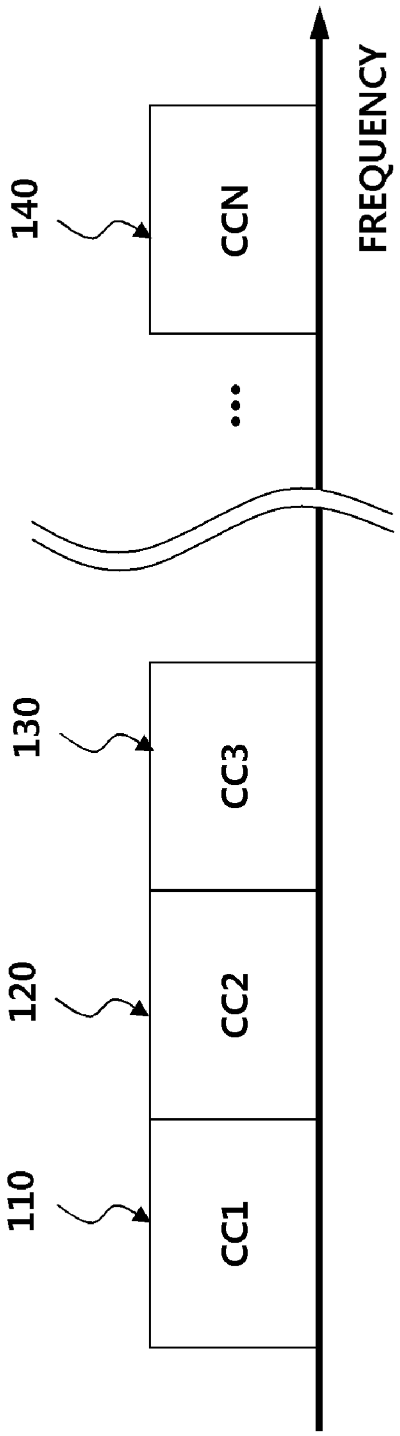
a transmitting unit to transmit timing advance (TA) value of a first cell to a user equipment (UE);
a receiving unit to receive a reference signal that is transmitted by the UE in a second cell; and
a TA information generating unit to compute offset information based on the received reference signal,
wherein the transmitting unit transmits the offset information to the UE, the first cell is a primary serving cell that performs random access procedure, and the second cell includes one or more secondary serving cells.

[Claim 14] The apparatus as claimed in claim 13, wherein the transmitting unit transmits, to the UE, a radio resource control (RRC) reconfiguration message associated with the second cell including TA value of the second cell, after transmitting the TA value of the first cell to the UE.

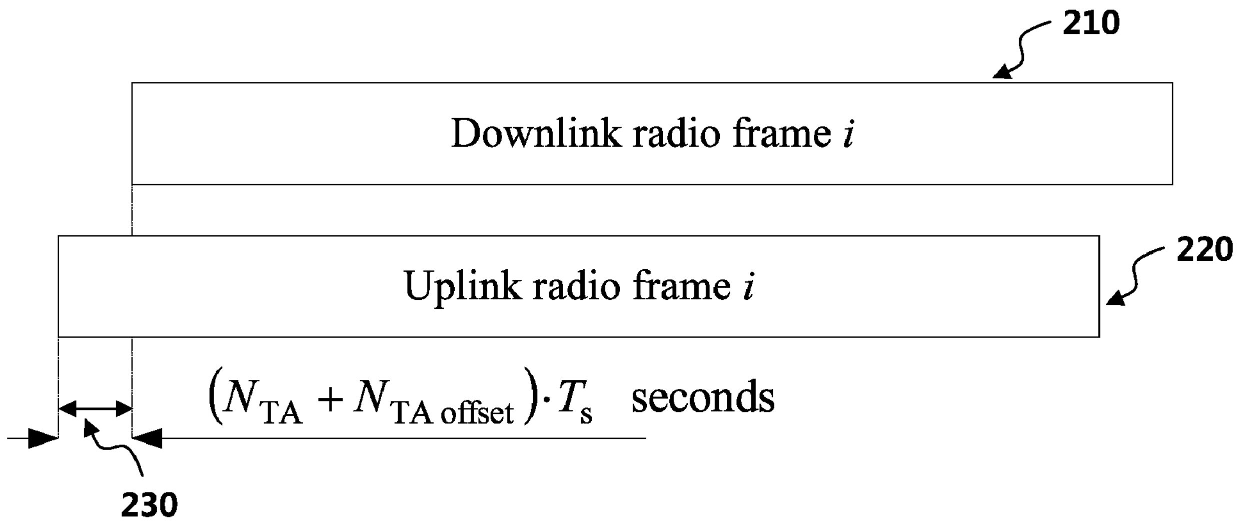
[Claim 15] The apparatus as claimed in claim 13, wherein TA value of the second cell computed by the UE is calculated by calculating a downlink (DL) delay time of the second cell based on the first cell, and by combining the calculated delay time and the TA value of the first cell.

[Claim 16] The apparatus as claimed in claim 13, wherein the transmitting unit includes the offset information in a multiple access control (MAC) control element (CE) of a MAC protocol data unit (PDU), so as to transmit the offset information to the UE.

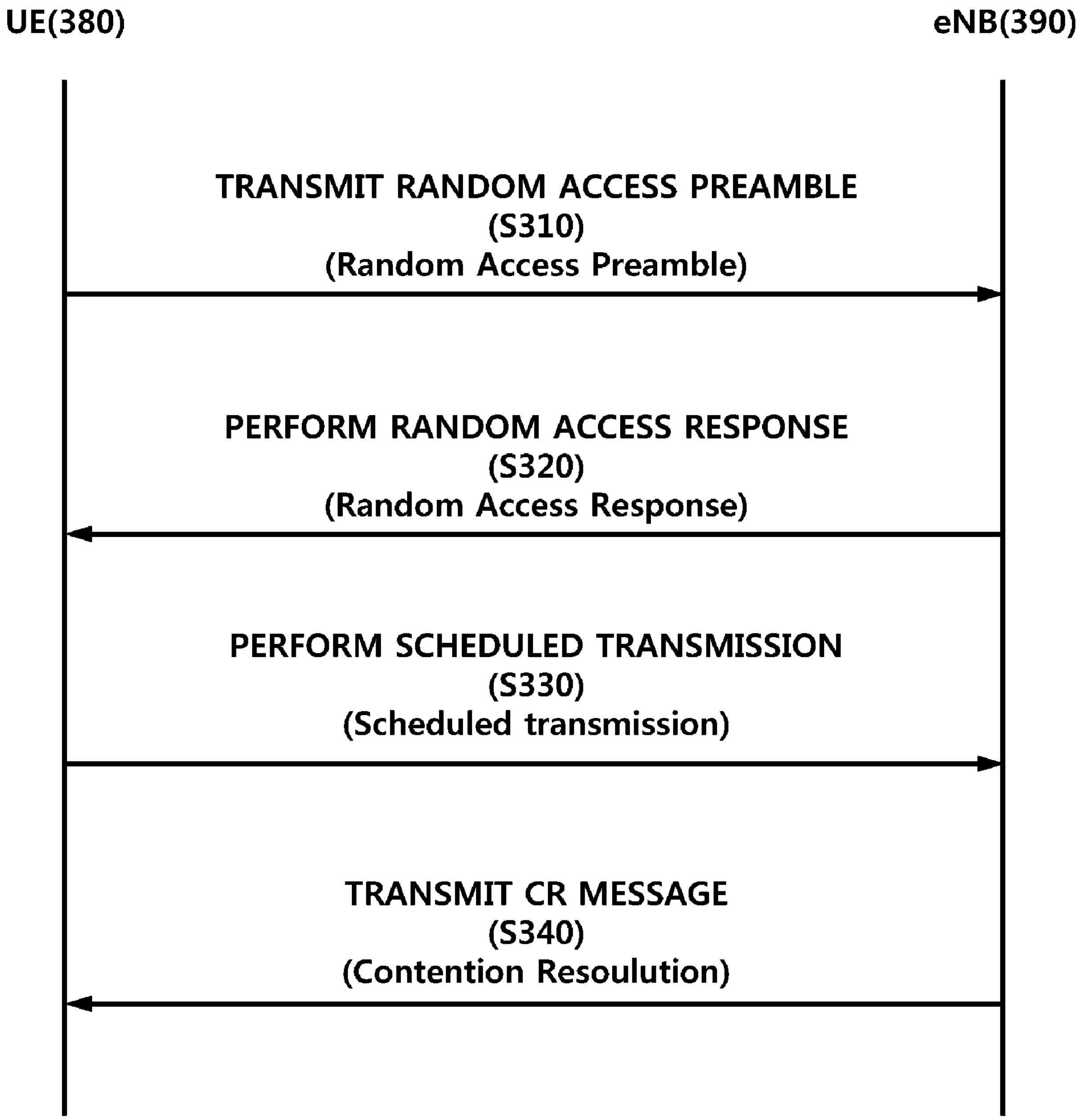
[Fig. 1]



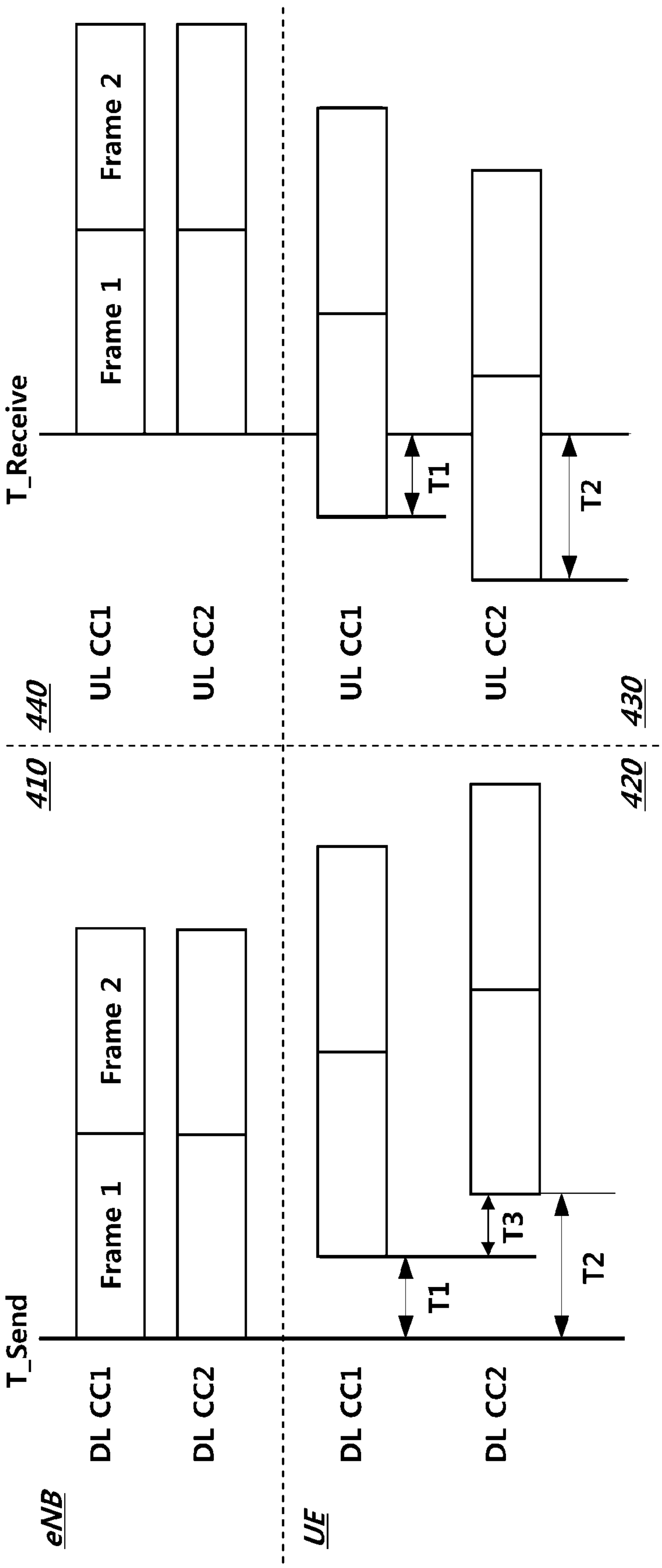
[Fig. 2]


210
Downlink radio frame i
220
Uplink radio frame i
$\left(N_{\mathrm{TA}}+N_{\mathrm{TA\ offset}}\right)\cdot T_{\mathrm{s}}$ seconds
230

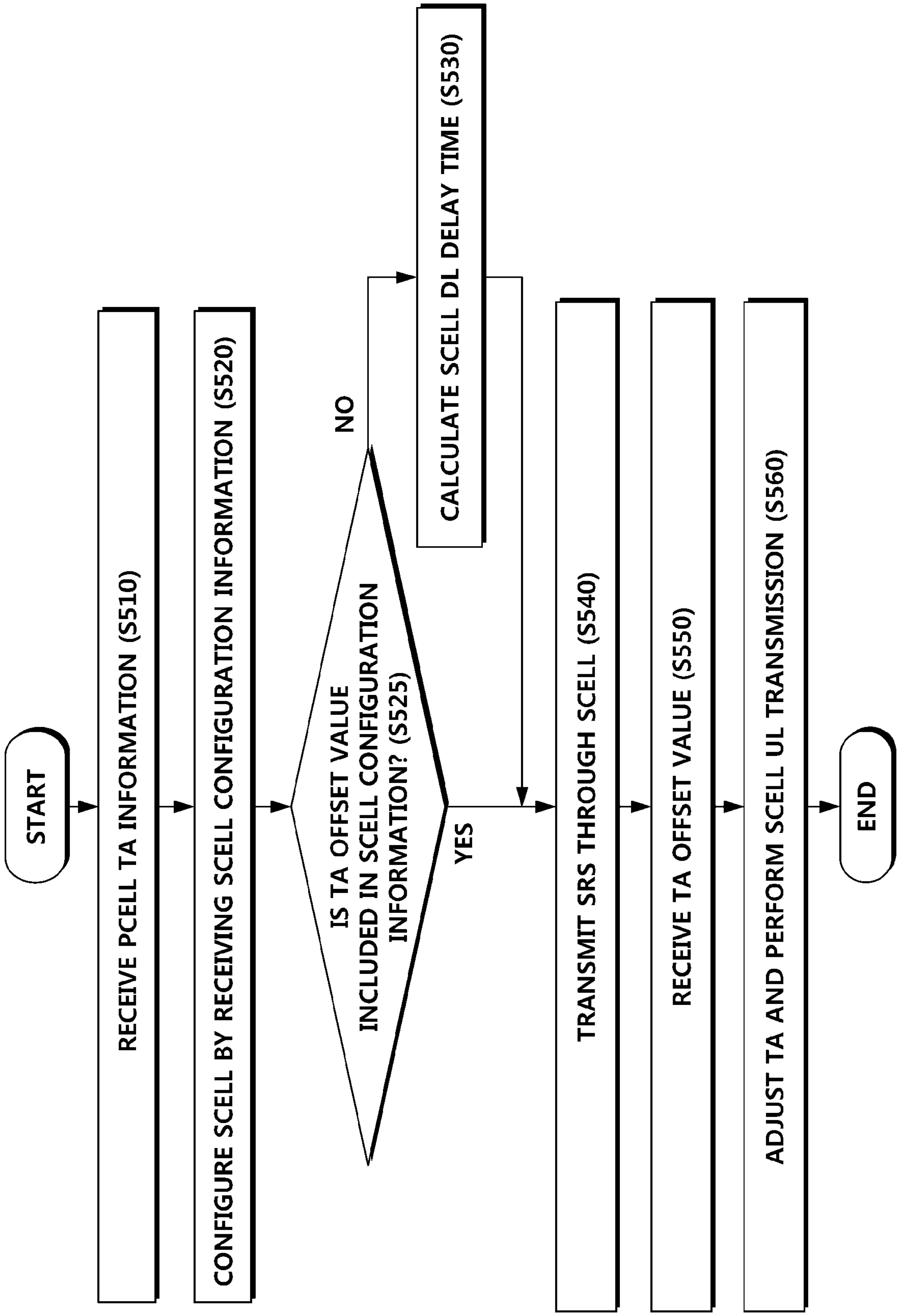
[Fig. 3]


UE(380)
eNB(390)
TRANSMIT RANDOM ACCESS PREAMBLE
(S310)
(Random Access Preamble)
PERFORM RANDOM ACCESS RESPONSE
(S320)
(Random Access Response)
PERFORM SCHEDULED TRANSMISSION
(S330)
(Scheduled transmission)
TRANSMIT CR MESSAGE
(S340)
(Contention Resoulution)

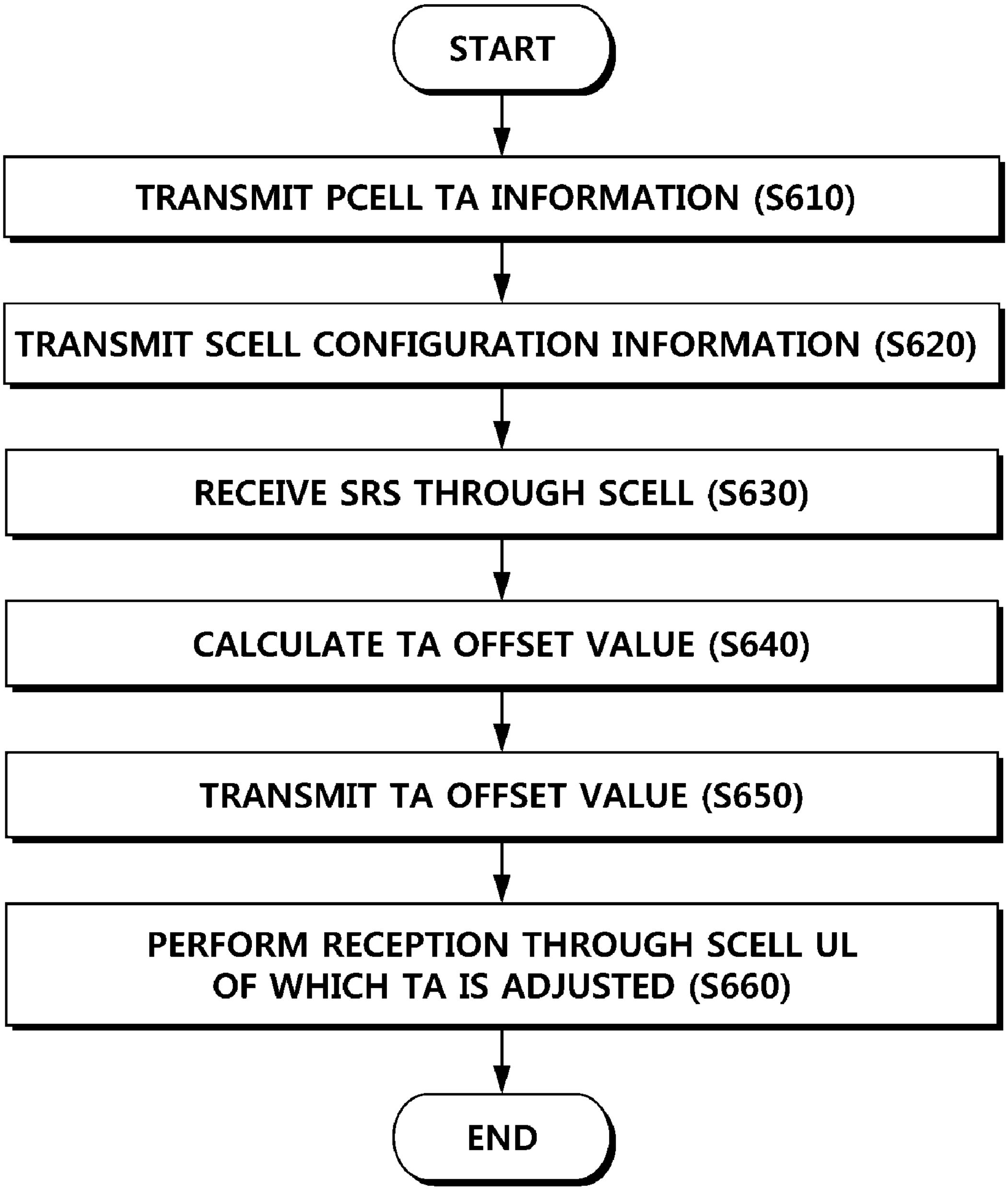
[Fig. 4]


eNB
UE
T_Send
T_Receive
DL CC1
DL CC2
DL CC1
DL CC2
UL CC1
UL CC2
UL CC1
UL CC2
Frame 1
Frame 2
Frame 1
Frame 2
T1
T2
T3
T1
T2
410
420
430
440

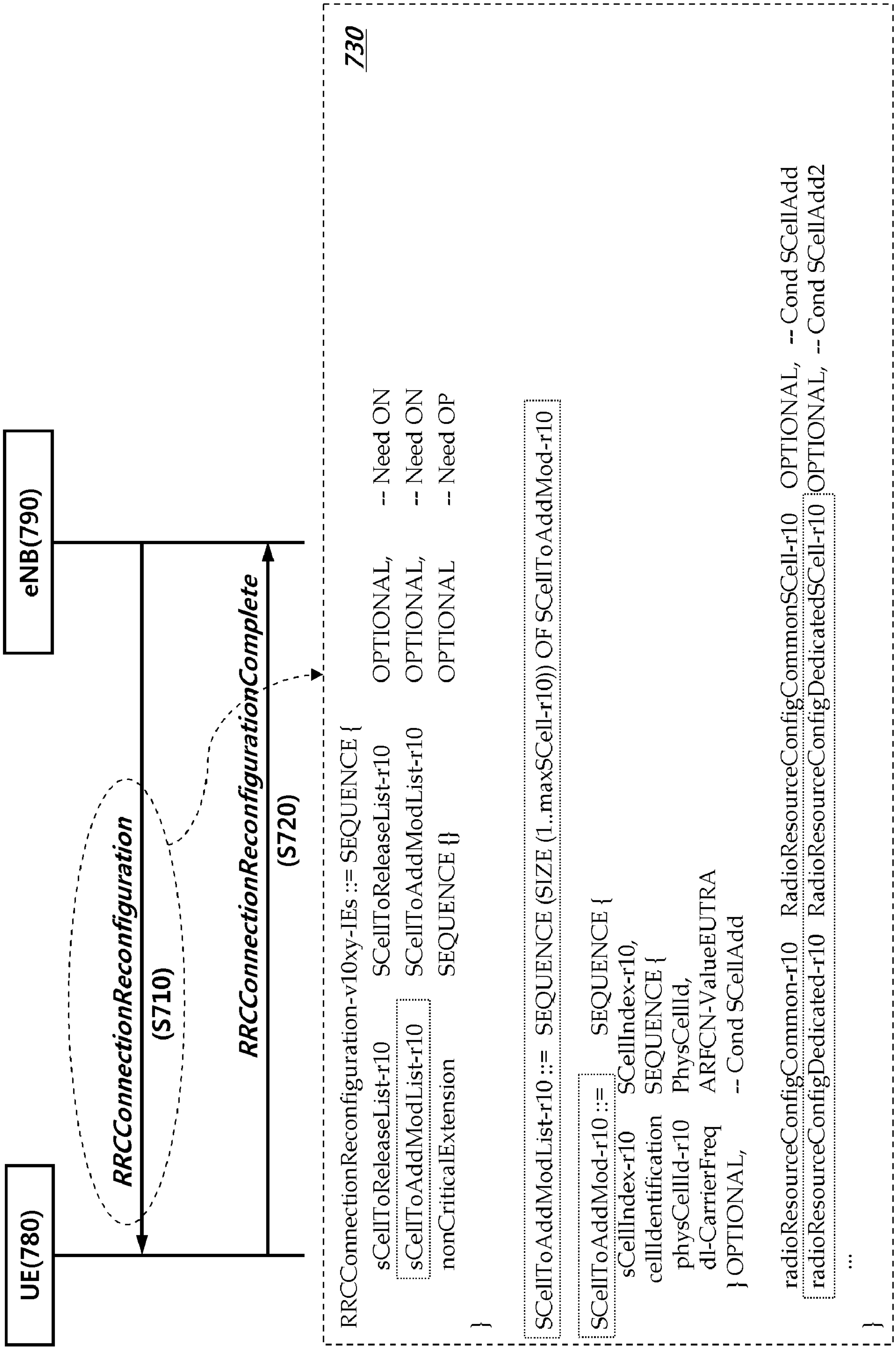
[Fig. 5]


START
RECEIVE PCELL TA INFORMATION (S510)
CONFIGURE SCELL BY RECEIVING SCELL CONFIGURATION INFORMATION (S520)
IS TA OFFSET VALUE INCLUDED IN SCELL CONFIGURATION INFORMATION? (S525)
NO
CALCULATE SCELL DL DELAY TIME (S530)
YES
TRANSMIT SRS THROUGH SCELL (S540)
RECEIVE TA OFFSET VALUE (S550)
ADJUST TA AND PERFORM SCELL UL TRANSMISSION (S560)
END

[Fig. 6]


START
TRANSMIT PCELL TA INFORMATION (S610)
TRANSMIT SCELL CONFIGURATION INFORMATION (S620)
RECEIVE SRS THROUGH SCELL (S630)
CALCULATE TA OFFSET VALUE (S640)
TRANSMIT TA OFFSET VALUE (S650)
PERFORM RECEPTION THROUGH SCELL UL OF WHICH TA IS ADJUSTED (S660)
END

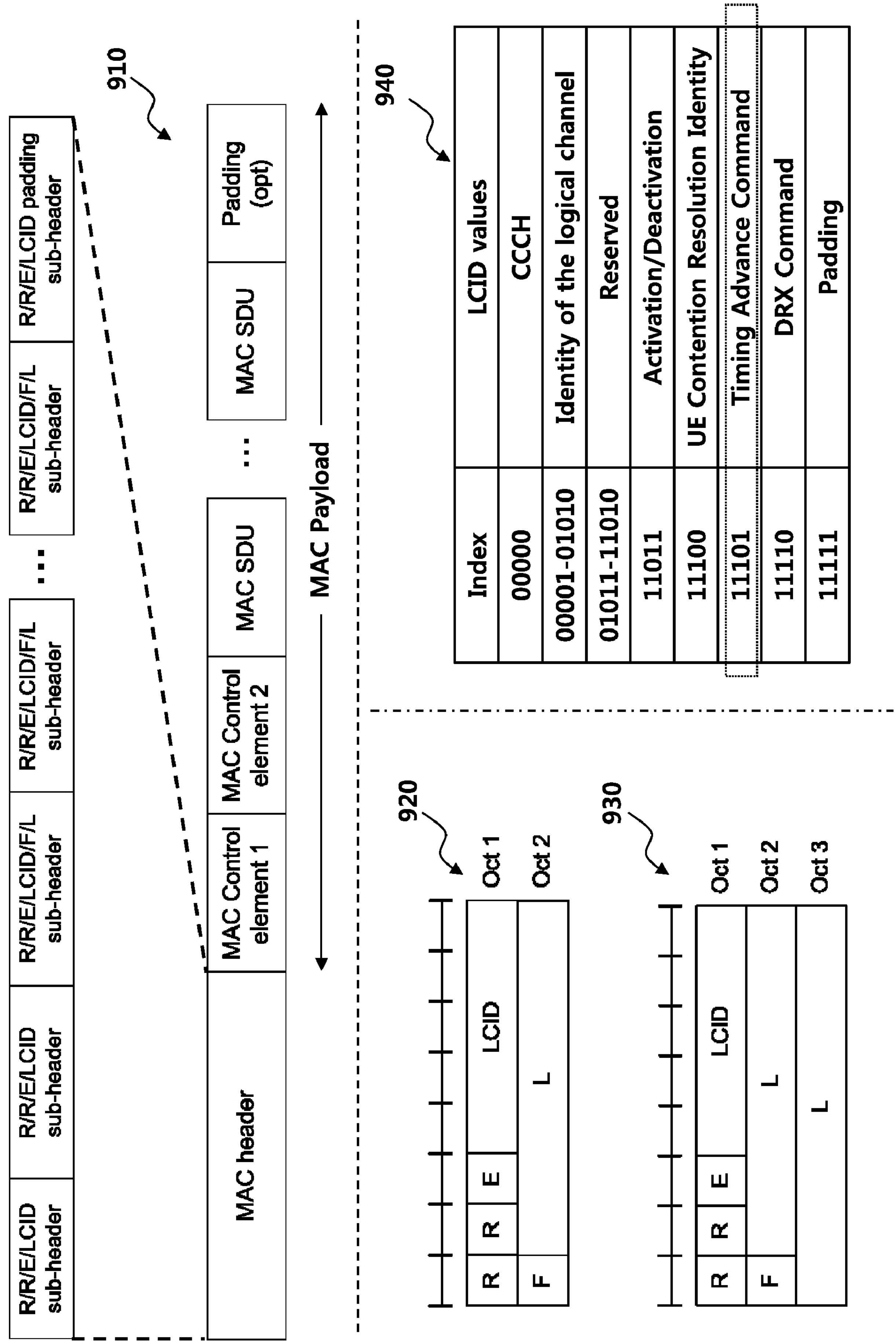
[Fig. 7]


UE(780)
eNB(790)
RRCConnectionReconfiguration
(S710)
RRCConnectionReconfigurationComplete
(S720)
730
RRCConnectionReconfiguration-v10xy-IEs ::= SEQUENCE {
sCellToReleaseList-r10 SCellToReleaseList-r10 OPTIONAL, -- Need ON
sCellToAddModList-r10 SCellToAddModList-r10 OPTIONAL, -- Need ON
nonCriticalExtension SEQUENCE {} OPTIONAL -- Need OP
}
SCellToAddModList-r10 ::= SEQUENCE (SIZE (1..maxSCell-r10)) OF SCellToAddMod-r10
SCellToAddMod-r10 ::= SEQUENCE {
sCellIndex-r10 SCellIndex-r10,
cellIdentification SEQUENCE {
physCellId-r10 PhysCellId,
dl-CarrierFreq ARFCN-ValueEUTRA
} OPTIONAL, -- Cond SCellAdd
radioResourceConfigCommon-r10 RadioResourceConfigCommonSCell-r10 OPTIONAL, -- Cond SCellAdd
radioResourceConfigDedicated-r10 RadioResourceConfigDedicatedSCell-r10 OPTIONAL, -- Cond SCellAdd2
...
}

[Fig. 8]

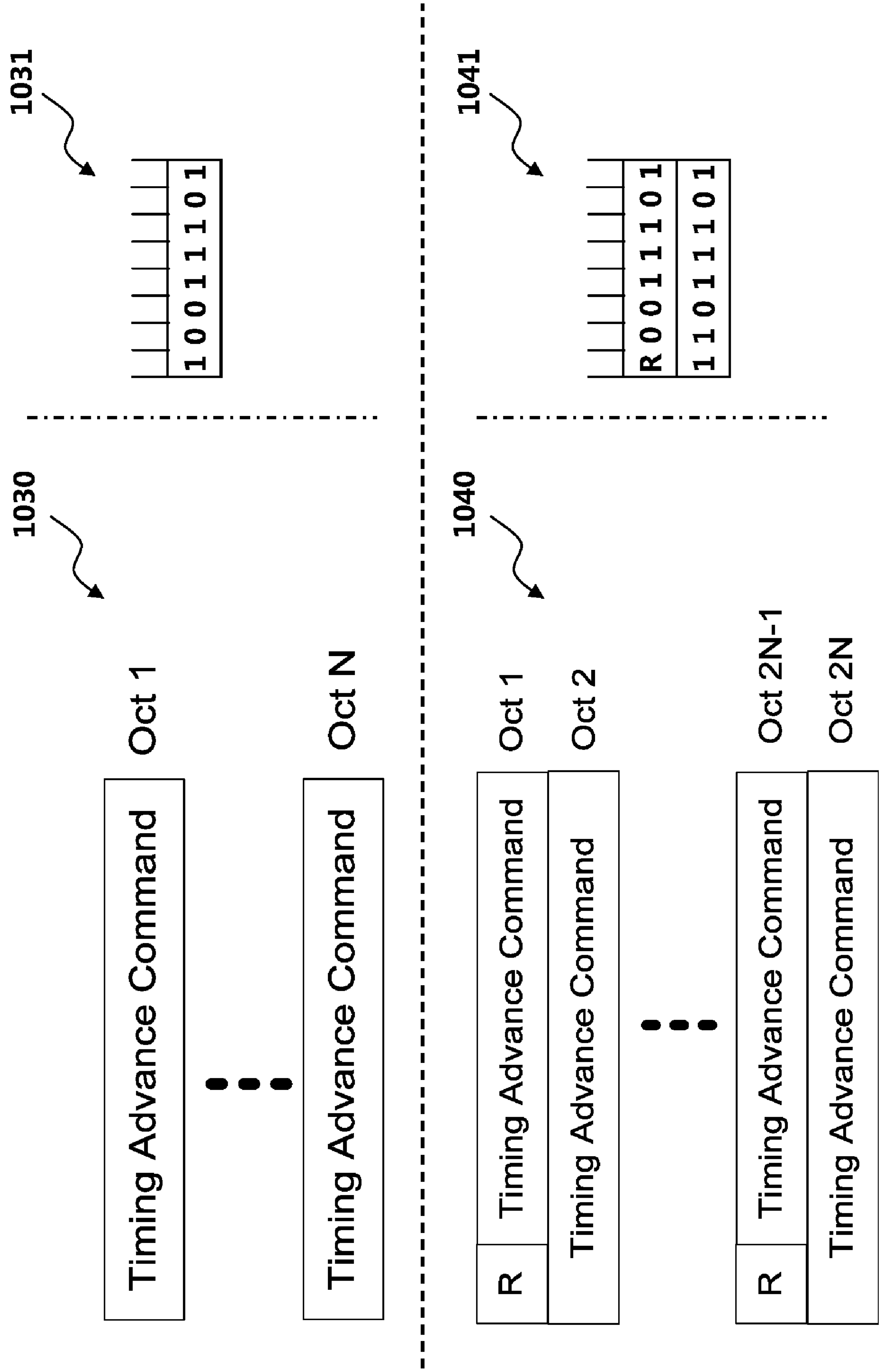
```
PhysicalConfigDedicatedSCell-r10 ::=  SEQUENCE {
   -- DL configuration as well as configuration applicable for DL and UL
   nonUL-Configuration        SEQUENCE {
               antennaInfo-r10                     AntennaInfoDedicated-r10              OPTIONAL,  -- Need ON
               crossCarrierSchedulingConfig-r10    CrossCarrierSchedulingConfig-r10      OPTIONAL,  -- Need ON
               -- FFS whether CSI-RS-Config should be included in physicalConfigDedicated
               csi-RS-Config-r10                   CSI-RS-Config-r10                     OPTIONAL,  -- Need ON
               pdsch-ConfigDedicated-r10           PDSCH-ConfigDedicated                 OPTIONAL   -- Need ON
   }           OPTIONAL,   -- Cond SCellAdd

   -- UL configuration
   ul-Configuration           CHOICE {
               release        NULL,
               setup          SEQUENCE {
                TA-offset-r11                      integer(0…20512)      <- 810
                pusch-ConfigDedicated-r10          PUSCH-ConfigDedicated                 OPTIONAL,  -- Need ON
                pusch-ConfigDedicated-v10x0        PUSCH-ConfigDedicated-v10x0           OPTIONAL,  -- Need ON
                uplinkPowerControlDedicated-r10    UplinkPowerControlDedicatedSCell-r10  OPTIONAL,  -- Need ON

                -- FFS if (part of) tpc-PDCCH-ConfigPUSCH is needed

                cqi-ReportConfig-r10                  CQI-ReportConfigSCell-r10                 OPTIONAL,  -- Need ON
                soundingRS-UL-ConfigDedicated-r10     SoundingRS-UL-ConfigDedicated             OPTIONAL,  -- Need ON
                soundingRS-UL-ConfigDedicated-v10x0   SoundingRS-UL-ConfigDedicated-v10x0       OPTIONAL,  -- Need ON
                soundingRS-UL-ConfigDedicatedAperiodic-r10
                                                      SoundingRS-UL-ConfigDedicatedAperiodic-r10  OPTIONAL,  -- Need ON
                -- The usage of field soundingRS-UL-ConfigDedicatedAperiodic-r10 is FFS
                ul-AntennaInfo-r10                    UL-AntennaInfo-r10                        OPTIONAL   -- Need ON
               }
   }  OPTIONAL,               -- Need ON
   ...
}
```

[Fig. 9]

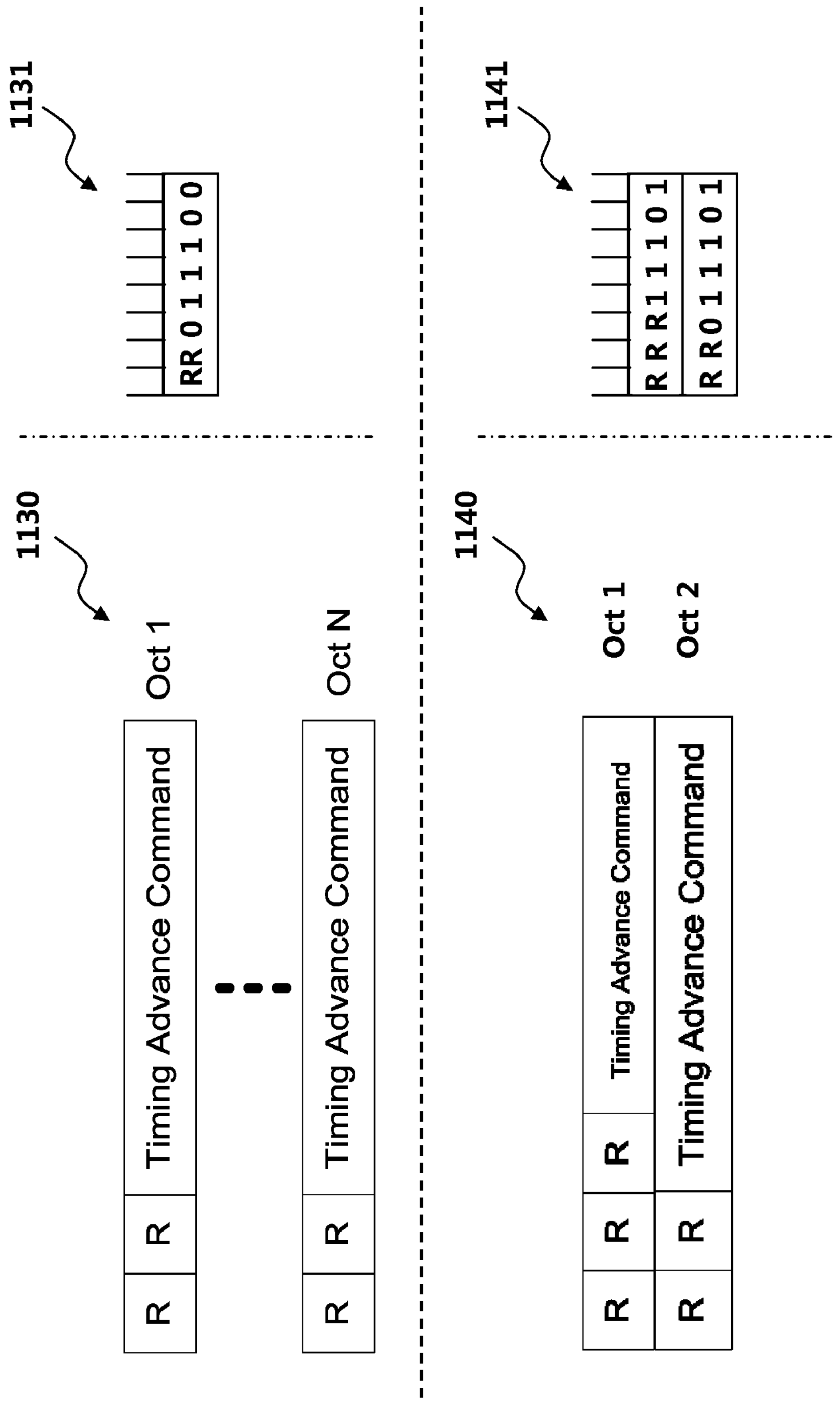


Index	LCID values
00000	CCCH
00001-01010	Identity of the logical channel
01011-11010	Reserved
11011	Activation/Deactivation
11100	UE Contention Resolution Identity
11101	Timing Advance Command
11110	DRX Command
11111	Padding

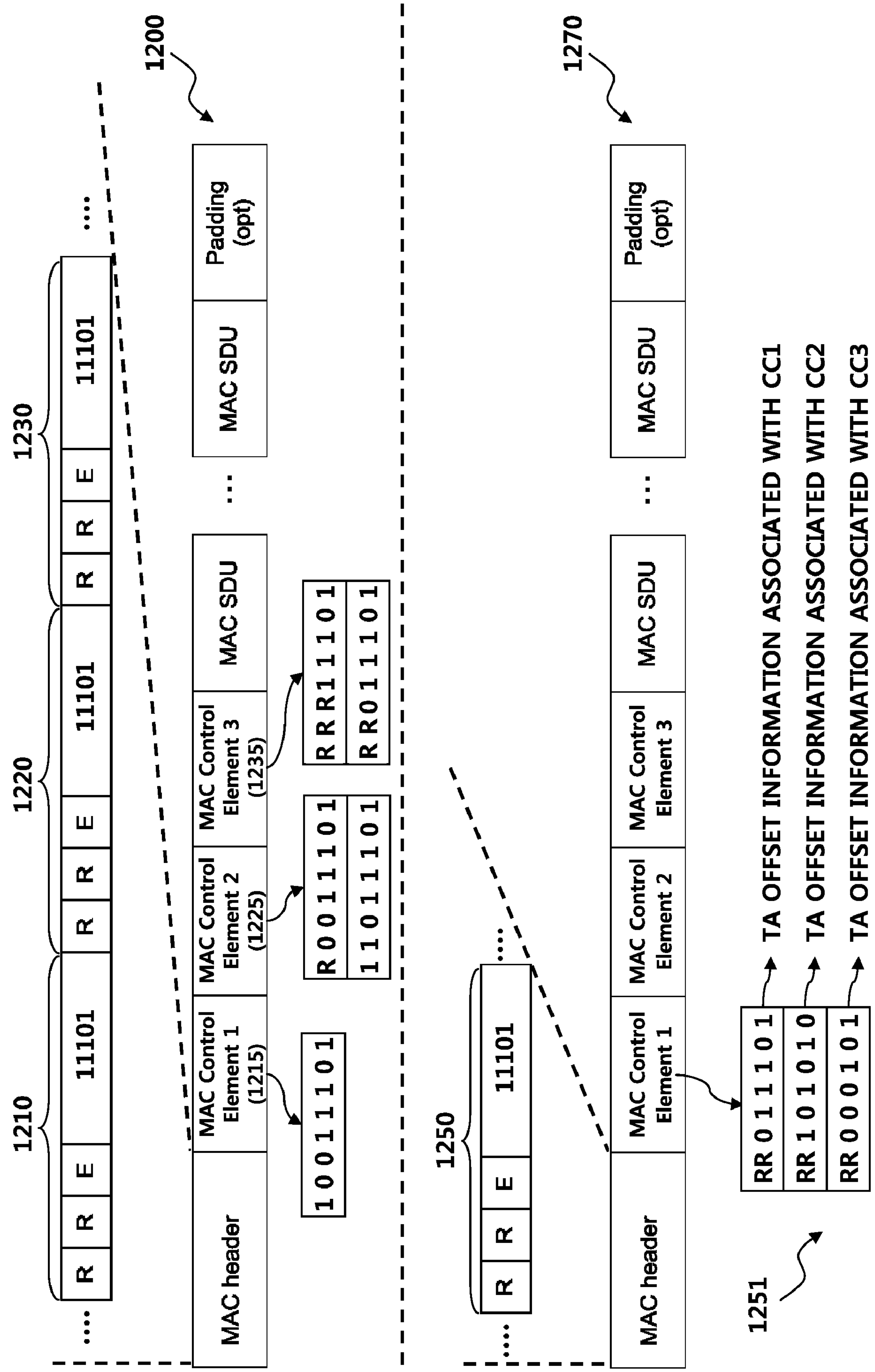
[Fig. 10]


1031
1 0 0 1 1 1 0 1
1030
Timing Advance Command
Oct 1
Timing Advance Command
Oct N
1041
R 0 0 1 1 1 0 1
1 1 0 1 1 1 0 1
1040
R
Timing Advance Command
Oct 1
Timing Advance Command
Oct 2
R
Timing Advance Command
Oct 2N-1
Timing Advance Command
Oct 2N

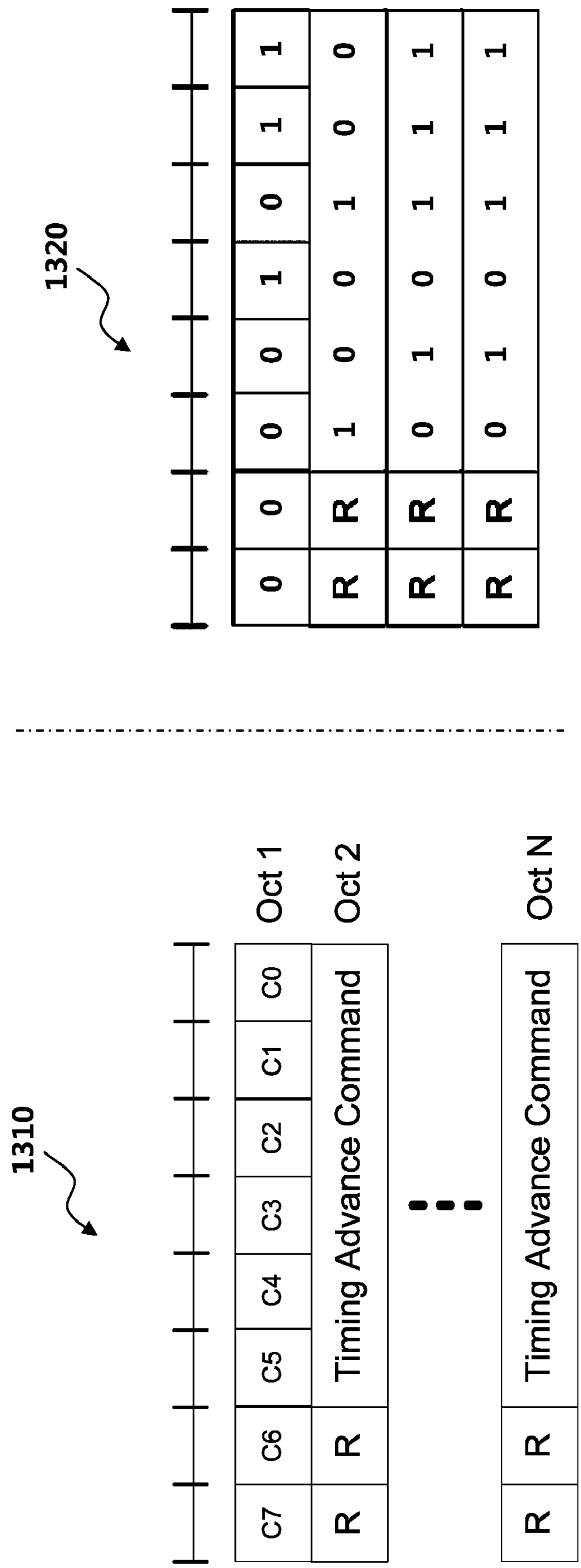
[Fig. 11]


1131
R R 0 1 1 1 0 0
1141
R R R 1 1 1 0 1
R R 0 1 1 1 0 1
1130
Oct 1
R R Timing Advance Command
Oct N
R R Timing Advance Command
1140
Oct 1
R R R Timing Advance Command
Oct 2
R R Timing Advance Command

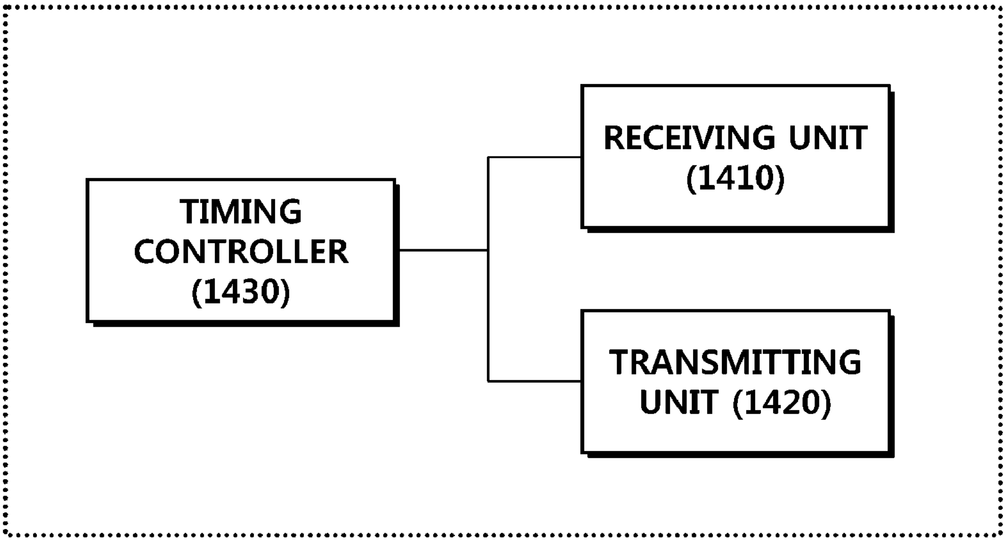
[Fig. 12]


1200
1210
1220
1230
R R E 11101
R R E 11101
R R E 11101
MAC header
MAC Control Element 1 (1215)
MAC Control Element 2 (1225)
MAC Control Element 3 (1235)
MAC SDU
MAC SDU
Padding (opt)
1 0 0 1 1 1 0 1
R 0 0 1 1 1 0 1
1 1 0 1 1 1 0 1
R R R 1 1 1 0 1
R R 0 1 1 1 0 1
1270
1250
R R E 11101
MAC header
MAC Control Element 1
MAC Control Element 2
MAC Control Element 3
MAC SDU
MAC SDU
Padding (opt)
RR 0 1 1 1 0 1
RR 1 0 1 0 1 0
RR 0 0 0 1 0 1
TA OFFSET INFORMATION ASSOCIATED WITH CC1
TA OFFSET INFORMATION ASSOCIATED WITH CC2
TA OFFSET INFORMATION ASSOCIATED WITH CC3
1251

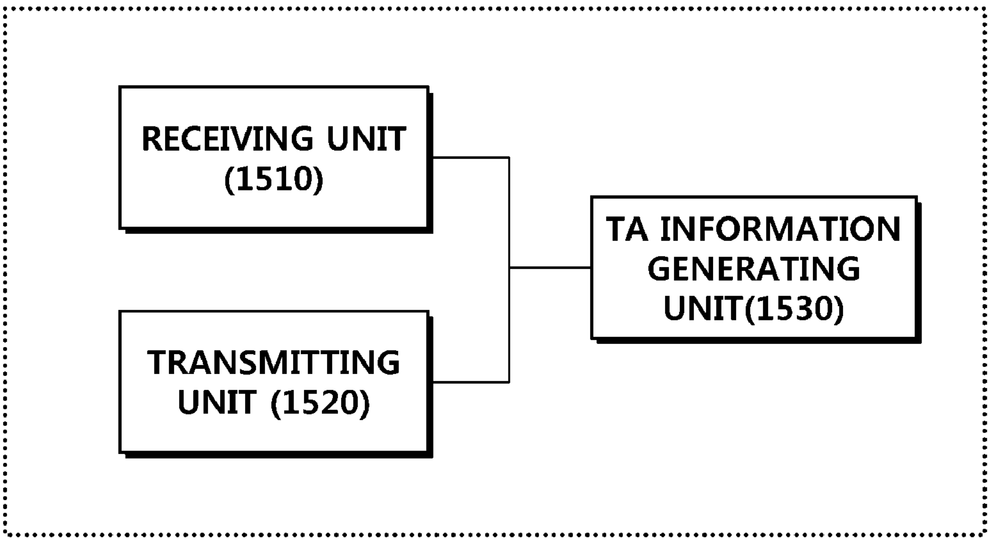
[Fig. 13]


1320
0 0 0 0 1 0 1 1
R R 1 0 0 1 0 0
R R 0 1 0 1 1 1
R R 0 1 0 1 1 1
1310
Oct 1
Oct 2
Oct N
C7 C6 C5 C4 C3 C2 C1 C0
R R Timing Advance Command
R R Timing Advance Command

[Fig. 14]


RECEIVING UNIT (1410)
TIMING CONTROLLER (1430)
TRANSMITTING UNIT (1420)

[Fig. 15]


RECEIVING UNIT (1510)
TA INFORMATION GENERATING UNIT(1530)
TRANSMITTING UNIT (1520)