(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
28 January 2016 (28.01.2016)

WIPO | PCT

(10) International Publication Number
WO 2016/012045 A1

(51) International Patent Classification:
H04W 56/00 (2009.01)

(21) International Application Number:
PCT/EP2014/065940

(22) International Filing Date:
24 July 2014 (24.07.2014)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant: **NOKIA SOLUTIONS AND NETWORKS OY** [FI/FI]; Karaportti 3, FI-02610 Espoo (FI).

(72) Inventors: **RATASUK, Rapeepat**; 4250 Forest Glen Drive, Hoffman Estates, Illinois 60192 (US). **ROSA, Claudio**; Krebsen 14, DK-8900 Randers (DK). **FREDERIKSEN, Frank**; Hornbækvej 4, DK-9270 Klarup (DK). **WANG, Xiaoyi**; 1809 Cardinal Ct., Wheeling, Illinois 60090 (US). **CATTONI, Andrea**; Tylervej 22, DK-9240 Nibe (DK). **MANGALVEDHE, Nitin**; 1221 Silver Pine Drive, Hoffman Estates, Illinois 60010 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

WO 2016/012045 A1

(54) Title: DYNAMIC TRIGGER-BASED SYNCHRONIZATION

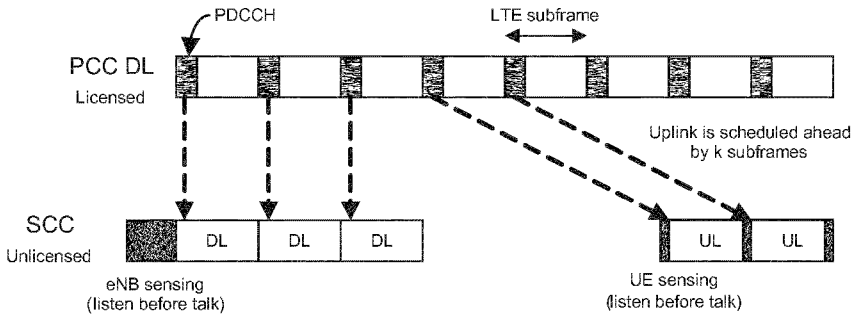


Figure 1

(57) Abstract: Synchronization may be valuable in many communication systems. For example, long term evolution unlicensed may benefit from dynamic trigger-based synchronization. A method can include receiving, at a device, a cell search and/or synchronization command from the network on the primary cell. The method can also include performing, by the device, cell search and/or synchronizing on a secondary cell based on the cell search and/or synchronization command.

DESCRIPTION

TITLE:

Dynamic Trigger-Based Synchronization

BACKGROUND:

Field:

[0001] Synchronization may be valuable in many communication systems. For example, long term evolution unlicensed may benefit from dynamic trigger-based synchronization.

Description of the Related Art:

[0002] The long term evolution (LTE) unlicensed (LTE-U) system may provide for signaling and procedures to support LTE working in unlicensed bands. A typical use case may be to have LTE-U or license-assisted access (LAA) as secondary component carrier (SCC) while the primary component carrier (PCC) is licensed band LTE. The LTE-U or LAA component carrier (CC) can be used either as a complementary downlink CC or a time division duplex (TDD) CC. Thus the primary cell (PCell) of the UE can be in the licensed band and one or more secondary cells (SCells) can be configured in the unlicensed band.

[0003] The first unlicensed based rollout of 3GPP wireless technologies may be in industrial, scientific and medical (ISM) bands that do not require any specific coexistence mechanism with other technologies. The use of unlicensed bands as supplemental downlink of licensed spectrum using carrier aggregation may already be possible using LTE, perhaps with the standardization of radio frequency (RF) requirements for the new band combinations.

[0004] Figure 1 illustrates LTE-U with listen-before-talk. To allow coexistence with WiFi systems, a listen-before-talk scheme can be introduced as shown in Figure 1. In the listen-before-talk scheme, a device can listen to the channel for a predetermined period of time and if no ongoing transmission is observed, the device can start its own transmission. Prior to downlink data transmission, an eNB can sense the channel. If available, the eNB can commence data transmission in the unlicensed band and inform the users of data transmission via cross-carrier scheduling. This method can be transparent to the UE in the downlink.

[0005] An issue with the use of LTE in unlicensed bands can be ensuring coexistence and fairness with already deployed and widely foot printed technologies, such as WiFi and Bluetooth. Moreover, coexistence may need to be guaranteed among operators that might simultaneously attempt to access a specific unlicensed band in the same geographical area,

such as airports, shopping malls, and the like. In particular, Listen-Before-Talk (LBT) methodologies, mentioned above, may be possible coexistence mechanisms. However, LTE in its current status is inadequate to support LBT, making it impossible to be used for unlicensed bands such as ISM without additional specifications.

[0006] LTE is a synchronous system (i.e. users are required to synchronize to the network). Current LTE is designed to work in always synchronized mode. Thus, the UE may need to synchronize to the network using the primary synchronization signal (PSS)/secondary synchronization signal (SSS). In other words, LTE conventionally requires the UE to synchronize to the corresponding carrier before it can receive/transmit data on it. In unlicensed band, eNB has to work in listen before talk mode. On the other hand, with legacy LTE synchronization signals, the time needed for the UE to synchronize might be at least several milliseconds. As such, legacy LTE synchronization may be too long to achieve good coexistence with WiFi. During the time LTE uses for synchronization, WiFi devices could sense the channel as idle and start transmission. In other words, PSS/SSS reception might be disrupted due to strong interference from another system. That will interrupt the UE synchronization procedure. Furthermore, it is wasteful for the UE to maintain synchronization with the eNB in the unlicensed band all the time.

SUMMARY:

[0007] According to a first embodiment, a method can include receiving, at a device, a cell search and/or synchronization command from the network on the primary cell. The method can also include performing, by the device, cell search and/or synchronizing on a secondary cell based on the cell search and/or synchronization command.

[0008] In a variant, the method can further include receiving, at the device, synchronization signals from the network on the secondary cell after receiving the cell search and/or synchronization command.

[0009] In a variant, the cell search and/or synchronization command can also indicate activation of the secondary cell.

[0010] In a variant, the cell search and/or synchronization command can be transmitted by PDCCH or ePDCCH as part of the downlink control information.

[0011] In a variant, the cell search and/or synchronization command can be transmitted as an enhanced scheduling grant.

[0012] In a variant, the cell search and/or synchronization command can be addressed to one or more users.

[0013] In a variant, the synchronizing can include the device synchronizing to the network on

the secondary cell for a predetermined period of time.

[0014] In a variant, the cell search and/or synchronization command can be for one or more channels within the secondary cell.

[0015] In a variant, the cell search and/or synchronization command can be for one or more secondary cells.

[0016] In a variant, the cell search and/or synchronization command can indicate a synchronization signal format.

[0017] In a variant, the method can further include indicating by the device to the network via the primary cell whether the device has achieved synchronization on one or more secondary cell.

[0018] In a variant, the cell search and/or synchronization command can further include an indication of a hopping pattern.

[0019] Any of the above variants can be combined with one another.

[0020] According to a second embodiment, a method can include determining a command to trigger a device to perform cell search and/or synchronization on a secondary cell. The method can also include transmitting, to the device, a cell search and/or synchronization command from the network on the primary cell.

[0021] In a variant, the method can further include receiving an indication by the device via the primary cell as to whether the device has achieved synchronization on one or more secondary cell.

[0022] In a variant, the method can additionally include transmitting a command on the primary cell to activate the one or more secondary cell.

[0023] In a variant, the transmitting the cell search and/or synchronization command can include using an enhanced scheduling grant to indicate activation of the secondary cell.

[0024] In a variant, the cell search and/or synchronization command can further include an indication of a hopping pattern.

[0025] Any of the above variants can be combined with one another.

[0026] According to a third embodiment, the first and second embodiments can be combined together in any of their respective variants. For example, a method can include determining a command to trigger a device to perform cell search and/or synchronization on a secondary cell. The method can also include transmitting, to the device, a cell search and/or synchronization command from the network on the primary cell. The method can further include receiving, at the device, the cell search and/or synchronization command from the network on the primary cell. The method can additionally include performing, by the device, cell search and/or synchronizing on a secondary cell based on the cell search and/or

synchronization command.

[0027] According to a fourth embodiment, an apparatus can include at least one processor and at least one memory including computer program code. The at least one memory and the computer program can be configured to, with the at least one processor, cause the apparatus at least to receive a cell search and/or synchronization command from the network on the primary cell. The at least one memory and the computer program can also be configured to, with the at least one processor, cause the apparatus at least to perform cell search and/or synchronizing on a secondary cell based on the cell search and/or synchronization command.

[0028] In a variant, the at least one memory and the computer program can be configured to, with the at least one processor, cause the apparatus at least toreceive synchronization signals from the network on the secondary cell after receiving the cell search and/or synchronization command.

[0029] In a variant, the cell search and/or synchronization command can also indicate activation of the secondary cell.

[0030] In a variant, the cell search and/or synchronization command can be transmitted by PDCCH or ePDCCH as part of the downlink control information.

[0031] In a variant, the cell search and/or synchronization command can be addressed to one or more users.

[0032] In a variant, the at least one memory and the computer program can be configured to, with the at least one processor, cause the apparatus at least to synchronize to the network on the secondary cell for a predetermined period of time.

[0033] In a variant, the cell search and/or synchronization command can be for one or more channels within the secondary cell.

[0034] In a variant, the cell search and/or synchronization command can be for one or more secondary cells.

[0035] In a variant, the cell search and/or synchronization command can indicate a synchronization signal format.

[0036] In a variant, the at least one memory and the computer program can also be configured to, with the at least one processor, cause the apparatus at least to indicate to the network via the primary cell whether the apparatus has achieved synchronization on one or more secondary cell.

[0037] In a variant, the cell search and/or synchronization command can further include an indication of a hopping pattern.

[0038] Any of the above variants can be combined with one another.

[0039] According to a fourth embodiment, an apparatus can include at least one processor and at least one memory including computer program code. The at least one memory and the computer program can be configured to, with the at least one processor, cause the apparatus at least to determine a command to trigger a device to perform cell search and/or synchronization on a secondary cell. The at least one memory and the computer program can also be configured to, with the at least one processor, cause the apparatus at least to transmit, to the device, a cell search and/or synchronization command from the network on the primary cell.

[0040] In a variant, the at least one memory and the computer program can be configured to, with the at least one processor, cause the apparatus at least to receive an indication by the device via the primary cell as to whether the device has achieved synchronization on one or more secondary cell.

[0041] In a variant, the at least one memory and the computer program can be configured to, with the at least one processor, cause the apparatus at least to transmit a command on the primary cell to activate the one or more secondary cell.

[0042] In a variant, the at least one memory and the computer program can be configured to, with the at least one processor, cause the apparatus at least to transmit the cell search and/or synchronization command using an enhanced scheduling grant to indicate activation of the secondary cell.

[0043] The above variants can be combined with each other.

[0044] According to a sixth embodiment, a system can include an apparatus according to the fourth embodiment, in any of its variants, in communication with an apparatus according to the fifth embodiment, in any of its variants.

[0045] According to a seventh embodiment, an apparatus can include means for receiving a cell search and/or synchronization command from the network on the primary cell. The apparatus can also include means for performing cell search and/or synchronizing on a secondary cell based on the cell search and/or synchronization command.

[0046] In a variant, the apparatus can include means for receiving, at the device, synchronization signals from the network on the secondary cell after receiving the cell search and/or synchronization command.

[0047] In a variant, the cell search and/or synchronization command can also indicate activation of the secondary cell.

[0048] In a variant, the cell search and/or synchronization command can be transmitted by PDCCH or ePDCCH as part of the downlink control information.

[0049] In a variant, the cell search and/or synchronization command can be addressed to

one or more users.

[0050] In a variant, the synchronizing can include synchronizing to the network on the secondary cell for a predetermined period of time.

[0051] In a variant, the cell search and/or synchronization command are for one or more channels within the secondary cell.

[0052] In a variant, the cell search and/or synchronization command can be for one or more secondary cells.

[0053] In a variant, the cell search and/or synchronization command can indicate a synchronization signal format.

[0054] In a variant, the apparatus can further include means for indicating by the device to the network via the primary cell whether the device has achieved synchronization on one or more secondary cell.

[0055] In a variant, the cell search and/or synchronization command can further include an indication of a hopping pattern.

[0056] Any of the above variants can be combined with one another.

[0057] According to an eighth embodiment, an apparatus can include means for determining a command to trigger a device to perform cell search and/or synchronization on a secondary cell. The apparatus can also include means for transmitting, to the device, a cell search and/or synchronization command from the network on the primary cell.

[0058] In a variant, the apparatus can also include means for receiving an indication by the device via the primary cell as to whether the device has achieved synchronization on one or more secondary cell.

[0059] In a variant, the apparatus can further include means for transmitting a command on the primary cell to activate the one or more secondary cell.

[0060] In a variant, the transmitting the cell search and/or synchronization command can include using an enhanced scheduling grant to indicate activation of the secondary cell.

[0061] Any of the above variants can be combined with one another.

[0062] A computer program product, according to certain embodiments, can encode instructions for performing a process. The process can include the method according to any of the first, second, or third embodiments, in any of their variants.

[0063] A non-transitory computer-readable medium can, in certain embodiments, be encoded with instructions that, when executed in hardware, perform a process. The process can include the method according to any of the first, second, or third embodiments, in any of their variants.

BRIEF DESCRIPTION OF THE DRAWINGS:

[0064] For proper understanding of the invention, reference should be made to the accompanying drawings, wherein:

[0065] Figure 1 illustrates LTE-U with listen-before-talk.

[0066] Figure 2 illustrates a method according to certain embodiments.

[0067] Figure 3 illustrates an example of trigger-based synchronization combined with activation, according to certain embodiments.

[0068] Figure 4 illustrates an example of trigger-based synchronization prior to activation, according to certain embodiments.

[0069] Figure 5 illustrates an example of trigger-based synchronization prior to activation, according to certain embodiments.

[0070] Figure 6 illustrates another method according to certain embodiments.

[0071] Figure 7 illustrates PSS allocation in U-SCell, according to certain embodiments.

[0072] Figure 8 illustrates a system according to certain embodiments.

[0073] Figure 9 illustrates another system according to certain embodiments.

DETAILED DESCRIPTION:

[0074] Certain embodiments set up a dynamic trigger based cell search and/or synchronization procedure to enable secondary component carrier (SCC) synchronization procedure. Figure 2 illustrates a method according to certain embodiments.

[0075] As shown in Figure 2, at 210 an eNB can configure a UE's SCell in LTE-U or LAA using LTE procedure. The UE doesn't need to be continuously synchronized with the eNB unless further instruction is received.

[0076] At 220, the eNB can send a dynamic cell search and/or synchronization trigger to UE by a control channel in PCell. The trigger can be UE-specific. Moreover, a dynamic synchronization trigger could be indicated by some bits in current DCI, e.g. CIF, either as part of a scheduling assignment for the SCell sent in the PCell or in a separate control message. Alternatively, the dynamic synchronization trigger could be a special new DCI. In another alternative, the synchronization trigger could be a MAC message.

[0077] The trigger could also or alternatively be cell specific. For example, the trigger could be in a new DCI format similar to DCI-3A to indicate all UEs configured with a certain SCell to synchronize.

[0078] At 230, upon receiving the trigger at 225, the UE can try to synchronize with the synchronization channel in SCell. The synchronization channel can include existing PSS/SSS, discovery signal, or newly designed synchronization signals and can be delayed

with respect to the synchronization trigger. The UE can keep trying to synchronize with SCell for a certain period of time after the trigger is received.

[0079] After successful synchronization, at 240 the UE can enter the "synchronized" period. UE can stay in the synchronized state for a period of time. The length of the synchronized state can be configurable by eNB. For example, the length may be 20ms. The length can be signaled by trigger and/or pre-configured by RRC signaling. The length of the synchronized period can be counted starting from the subframe in which the UE receives the trigger.

[0080] At 250, depending on the synchronization channel design, the UE may perform time and frequency tracking during the synchronized period using available synchronization and reference signals. If beacon type of SS is used, UE may try to synchronize with the beacon signal. The beacon signal can be used for synchronization after the UE is triggered. After successful synchronization, the UE can assume that the UE is synchronized during the whole active period and can try to decode the control channel.

[0081] If current PSS/SSS or discovery signal is used, the UE can try to synchronize with the PSS/SSS or the discovery signal using current LTE sync procedure for the whole active period defined at 240.

[0082] Then, at the end of the synchronized period, at 260 the UE can stop time and frequency tracking and go back to the "unsynchronized" mode in the SCell. The steps at 220–260 can be repeated whenever SCell operation in LTE-U or LAA is to be enabled.

[0083] Figure 3 illustrates an example of trigger-based synchronization combined with activation, according to certain embodiments. In Figure 3, the triggered based cell search and/or synchronization has been combined into the activation command. In this case, the activation command can be used to implicitly signal the UE to perform synchronization.

[0084] Figure 4 illustrates an example of trigger-based synchronization prior to activation, according to certain embodiments. In Figure 4, the trigger based cell search and/or synchronization command is separate from the SCell activation command. According to certain embodiments, the activation command can be sent after synchronization is achieved on the SCell.

[0085] Figure 5 illustrates an example of trigger-based synchronization prior to activation, according to certain embodiments. In Figure 5, the trigger based cell search and/or synchronization command is separate from the activation command. In this case, the synchronization signal can be sent after the synchronization command. This may be due to, for example, the channel being occupied when the synchronization command is transmitted. However, in general the synchronization signal can be sent any time after the synchronization command.

[0086] Figure 6 illustrates another method according to certain embodiments. As shown in Figure 6, a method can include, at 610, receiving a cell search and/or synchronization command from the network on the primary cell. The network, for example an eNB, can transmit the cell search and/or synchronization command from the network on the primary cell at 605. The eNB can determine to transmit the command at 601 based on a variety of considerations. The transmission can use an enhanced scheduling grant to indicate activation of the secondary cell. The enhanced scheduling grant can be used as an implicit synchronization command. Enhanced scheduling grant is illustrated in WO2013167557 (see, for example, Figures 2-6 for a variety of non-limiting examples), which is hereby incorporated herein by reference in its entirety.

[0087] The cell search and/or synchronization command can be part of the secondary cell activation command. For example, the cell search and/or synchronization command can also indicate activation of the secondary cell. The cell search and/or synchronization command can be addressed to one or more users. The cell search and/or synchronization command can be for one or more channels within the secondary cell. The cell search and/or synchronization command can be for one or more secondary cells. For example, the cell search and/or synchronization command can be addressed to all users in a particular cell.

[0088] The cell search and/or synchronization command can indicate the synchronization signal format. This may be used if, for example, different synchronization signals are available, such as legacy PSS/SSS, discovery signal, regular sync signal, extended sync signal for coverage enhancement, or the like. This indication of format can also be used to indicate sync sequence or equivalent so UE does not have to search multiple sequences.

[0089] The method can also include, at 620, receiving synchronization signals from the network on the secondary cell or a secondary cell. The term “secondary cell” can in certain embodiments refer to any secondary carrier. Furthermore, the method can include, at 630, performing cell search and/or synchronizing on the secondary cell. The synchronizing can involve device being synchronized to the network on the secondary cell for a period of time.

[0090] The method can also include, at 640, the UE indicating to the eNB via the primary cell whether the UE has achieved synchronization on one or more secondary cell. This might be useful if, for example, the UE is asked to synchronize on several secondary cells. The indication can be received by the network at 645.

[0091] If a hopping pattern is supported, then the synchronization command may indicate the hopping pattern. For example, each LTE-U or LAA channel can be configured as a secondary cell and the UE can hop from channel to channel. In such a case, the synchronization command can indicate the hopping pattern as well.

[0092] In certain embodiments, a new carrier type can contain a general synchronization signal embedded in the first symbols of the first transmitted subframe in the unlicensed band. The format of the LTE-U or LAA synchronization signal can vary from implementation to implementation, and should not be interpreted in the strict sense as a direct mapping of the PSS/SSS (primary and secondary synchronization sequences) that are defined for HSPA and LTE systems. The repetition and structure of the proposed LTE-U or LAA synchronization signal can be configured case by case and on a per-need basis, as it may be that no UE is allowed to operate in this band without prior configuration.

[0093] Figure 7 illustrates PSS allocation in U-SCell, according to certain embodiments. As shown in Figure 7, a possible implementation can include defining a PSS allocated in the central portion of the carrier bandwidth, embedded in the first symbol of the PDCCH.

[0094] Thus, Figure 7 provides an example of PSS allocation in U-SCell, in which PSS is shown as a logical domain, such that the PDCCH is seen as just some simple resources in the physical domain.

[0095] In a possible implementation, an Enhanced Scheduling Grant is sent in the PCell in order to configure the Unlicensed Secondary Cell (U-SCell), as illustrated in Figure 7. However, other embodiments are not limited to cases where the ESG is transmitted but can also be applicable when other methods are used to configure and activate the use of unlicensed spectrum as secondary cell (U-SCell).

[0096] After some time due to the LBT coexistence mechanism the SCell can start transmitting the PDCCH with the embedded LTE-U or LAA synchronization signal. Alternatively, for example with cross-carrier scheduling from the PCell, the PDCCH could be transmitted on the PCell while the LTE-U or LAA synchronization signal is still transmitted on the U-SCell.

[0097] In the structure discussed above, the synchronization signal can be transmitted in the first OFDM symbol of every subframe, in contrast to legacy structure of synchronization signals where the PSS and SSS are transmitted every 5th subframe. This first OFDM symbol transmission position in every subframe can ensure multiple opportunities for the UE to synchronize if one is missed. Furthermore, providing the synchronization signal in each subframe of the LTE-U or LAA scheduling burst can provide flexibility in potentially assigning different listening times to different UEs, which may permit increase in the UE power efficiency.

[0098] Any UE listening for the U-SCell may know of the existence of the synchronization signal and may derive the physical resources for the control channel (PDCCH) from the resources that are not already taken or reserved for the transmission of the additional

synchronization signal.

[0099] In another possible implementation, the LTE-U or LAA synchronization signal can be transmitted in the first OFDM symbol of every Nth subframe where N is configurable. In such a case, the UE may still know when and how the resources are split between synchronization signal and control channel resources.

[0100] Certain embodiments may have various benefits and/or advantages. For example, in certain embodiments the eNB does not need to send a periodic synchronization signal on LTE-U or LAA and the UE does not need to maintain synchronization on LTE-U or LAA until the eNB is ready to transmit data to the UE. If a new synchronization signal is introduced for LTE-U or LAA, then significantly faster synchronization acquisition time can be achieved on LTE-U or LAA as well.

[0101] From the network perspective, certain embodiments may allow the eNB to save power and reduce potential interference to nearby nodes. Certain embodiments may also allow WiFi nodes to better utilize the unlicensed band, because there is no periodic synchronization signals from nearby LTE-U or LAA nodes.

[0102] From the UE perspective, certain embodiments may allow for UE power saving as the UE may not need to maintain synchronization on LTE-U or LAA until needed.

[0103] Certain embodiments may also provide for fast synchronization. Compared to legacy synchronization signals, in certain embodiments the terminal does not need to receive at least a whole subframe (1 ms) before achieving time and frequency synchronization. Furthermore certain embodiments may provide robust synchronization, as the LTE-U or LAA synchronization signal can be transmitted very often during one scheduling burst on the unlicensed band.

[0104] Certain embodiments may provide for UE power efficiency. By having the synchronization transmitted signals in each subframe, or at least very often, can facilitate power efficient implementations in the terminals. Such gains may be especially pronounced if the UE can be informed *a priori* about the exact timing of its allocation during a LTE-U or LAA scheduling burst.

[0105] Certain embodiments can ensure fair coexistence. Using a fast synchronization mechanism may prevent wasting time in synchronization, especially if this can take up to several milliseconds, since for example WiFi has a maximum allocation time of around 20 ms and a minimum reaction time in the order of 20 microseconds.

[0106] Other features can be used for synchronization. For example, there can be an SCell activation signal in Carrier Aggregation. Certain embodiments can be complementary to the SCell activation in CA. It can be added to the activation signal, or

given prior to the activation signal. Currently, the activation signal assumes that the UE is already synchronized in the SCell and the UE has 8ms to begin normal procedure in SCell such as PDCCH monitoring, CQI reporting, SRS transmission, or the like.

[0107] Synchronization in WiFi is also possible, including beacon signals and preamble. This is traditionally been transmitted subject to channel availability. The beacon signals are periodic while the preamble is transmitting together with the message.

[0108] LTE synchronization signals (PSS/SSS) are synchronization signals that are transmitted periodically and can be used in the U-SCell. Furthermore, an LTE discovery signal can be used for small cell on/off – similar to PSS/SSS.

[0109] Figure 8 illustrates a system according to certain embodiments of the invention. In one embodiment, a system may include multiple devices, such as, for example, at least one UE 810, at least one SCell access point (AP) 820 or other base station or access point, and at least one PCell AP 830 or other base station or access point. The primary cell access point can be an eNB and the secondary cell access point can be an access point for unlicensed spectrum.

[0110] Each of these devices may include at least one processor, respectively indicated as 814, 824, and 834. At least one memory can be provided in each device, and indicated as 815, 825, and 835, respectively. The memory may include computer program instructions or computer code contained therein. The processors 814, 824, and 834 and memories 815, 825, and 835, or a subset thereof, can be configured to provide means corresponding to the various blocks of Figures 2 and/or 6.

[0111] As shown in Figure 8, transceivers 816, 826, and 836 can be provided, and each device may also include an antenna, respectively illustrated as 817, 827, and 837. Other configurations of these devices, for example, may be provided. For example, PCell AP 830 may be configured for wired communication, in addition to wireless communication, and in such a case antenna 837 can illustrate any form of communication hardware, without requiring a conventional antenna.

[0112] Transceivers 816, 826, and 836 can each, independently, be a transmitter, a receiver, or both a transmitter and a receiver, or a unit or device that is configured both for transmission and reception.

[0113] Processors 814, 824, and 834 can be embodied by any computational or data processing device, such as a central processing unit (CPU), application specific integrated circuit (ASIC), or comparable device. The processors can be implemented as a single controller, or a plurality of controllers or processors.

[0114] Memories 815, 825, and 835 can independently be any suitable storage device, such

as a non-transitory computer-readable medium. A hard disk drive (HDD), random access memory (RAM), flash memory, or other suitable memory can be used. The memories can be combined on a single integrated circuit as the processor, or may be separate from the one or more processors. Furthermore, the computer program instructions stored in the memory and which may be processed by the processors can be any suitable form of computer program code, for example, a compiled or interpreted computer program written in any suitable programming language.

[0115] The memory and the computer program instructions can be configured, with the processor for the particular device, to cause a hardware apparatus such as UE 810, SCell AP 820, and PCell AP 830, to perform any of the processes described herein (see, for example, Figures 2 through 7). Therefore, in certain embodiments, a non-transitory computer-readable medium can be encoded with computer instructions that, when executed in hardware, perform a process such as one of the processes described herein. Alternatively, certain embodiments of the invention can be performed entirely in hardware.

[0116] Furthermore, although Figure 8 illustrates a system including a UE, SCell AP, and PCell AP, embodiments of the invention may be applicable to other configurations, and configurations involving additional elements. For example, not shown, additional UEs may be present, and additional core network elements may be present.

[0117] Figure 9 illustrates another system according to certain embodiments. As shown in Figure 9, a system can include a first apparatus 910 that includes means 912 for determining a command to trigger a device to perform cell search and/or synchronization on a secondary cell. The first apparatus 910 can also include means 914 for transmitting, to the device, a cell search and/or synchronization command from the network on the primary cell.

[0118] The first apparatus 910 can further include means 916 for receiving an indication by the device via the primary cell as to whether the device has achieved synchronization on one or more secondary cell.

[0119] The first apparatus 910 can additionally include means 918 for transmitting a command on the primary cell to activate the one or more secondary cell.

[0120] The transmitting the cell search and/or synchronization command can include using an enhanced scheduling grant to indicate activation of the secondary cell.

[0121] The system can also include a second apparatus 920 in communication with the first apparatus 910 over a communication link 930. The second apparatus 920 can include means 922 for receiving a cell search and/or synchronization command from the network on the primary cell. The second apparatus 920 can include means 924 for

performing cell search and/or synchronizing on a secondary cell based on the cell search and/or synchronization command.

[0122] The second apparatus 920 can further include means 926 for receiving, at the device, synchronization signals from the network on the secondary cell after receiving the cell search and/or synchronization command.

[0123] The cell search and/or synchronization command can also indicate activation of the secondary cell. Moreover, the cell search and/or synchronization command can be transmitted by PDCCH or ePDCCH as part of the downlink control information.

[0124] The cell search and/or synchronization command can be addressed to one or more users. Additionally or alternatively, the cell search and/or synchronization command can be for one or more channels within the secondary cell. Additionally or alternatively, the cell search and/or synchronization command can be for one or more secondary cells.

[0125] The synchronizing can include synchronizing to the network on the secondary cell for a predetermined period of time. The cell search and/or synchronization command can indicate a synchronization signal format.

[0126] The second apparatus 920 can further include means 928 for indicating by the device to the network via the primary cell whether the device has achieved synchronization on one or more secondary cell.

[0127] The cell search and/or synchronization command can further include an indication of a hopping pattern.

[0128] One having ordinary skill in the art will readily understand that the invention as discussed above may be practiced with steps in a different order, and/or with hardware elements in configurations which are different than those which are disclosed. Therefore, although the invention has been described based upon these preferred embodiments, it would be apparent to those of skill in the art that certain modifications, variations, and alternative constructions would be apparent, while remaining within the spirit and scope of the invention. In order to determine the metes and bounds of the invention, therefore, reference should be made to the appended claims.

[0129] Partial Glossary

[0130]	3GPP	3rd generation partnership project
[0131]	eNB	eNodeB
[0132]	ESG	Enhanced scheduling grant
[0133]	HSPA	High speed packet access
[0134]	ISM	Industrial, scientific and medical
[0135]	LAA	License-assisted access
[0136]	LBT	Listen before talk
[0137]	LTE	Long term evolution
[0138]	LTE-U	LTE on unlicensed bands
[0139]	OFDM	Orthogonal frequency division multiplexing
[0140]	PCell	Primary cell
[0141]	PDCCH	Physical downlink control channel
[0142]	SCell	Secondary cell
[0143]	PSS	Primary synchronization signal
[0144]	SS	Synchronization Signals
[0145]	SSS	Secondary synchronization signal
[0146]	UE	User equipment
[0147]	U-SCell	Unlicensed secondary cell

WE CLAIM:

1. A method, comprising:

receiving, at a device, a cell search and/or synchronization command from the network on the primary cell; and

performing, by the device, cell search and/or synchronizing on a secondary cell based on the cell search and/or synchronization command.

2. The method of claim 1, further comprising:

receiving, at the device, synchronization signals from the network on the secondary cell after receiving the cell search and/or synchronization command.

3. The method of claim 1 or claim 2, wherein the cell search and/or synchronization command also indicates activation of the secondary cell.

4. The method of any of claims 1-3, wherein the cell search and/or synchronization command is transmitted by PDCCH or ePDCCH as part of the downlink control information.

5. The method of any of claims 1-4, wherein the cell search and/or synchronization command is transmitted as an enhanced scheduling grant.

6. The method of any of claims 1-5, wherein the cell search and/or synchronization command is addressed to one or more users.

7. The method of any of claims 1-6, wherein the synchronizing comprises the device synchronizing to the network on the secondary cell for a predetermined period of time.

8. The method of any of claims 1-7, wherein the cell search and/or synchronization command are for one or more channels within the secondary cell.

9. The method of any of claims 1-8, wherein the cell search and/or synchronization command are for one or more secondary cells.

10. The method of any of claims 1-9, wherein the cell search and/or synchronization command indicates a synchronization signal format.

11. The method of any of claims 1-10, further comprising:

indicating by the device to the network via the primary cell whether the device has achieved synchronization on one or more secondary cell.

12. The method of any of claims 1-11, wherein the cell search and/or synchronization command further comprises an indication of a hopping pattern.

13. A method, comprising:

determining a command to trigger a device to perform cell search and/or synchronization on a secondary cell; and

transmitting, to the device, a cell search and/or synchronization command from the network on the primary cell.

14. The method of claim 13, further comprising:

receiving an indication by the device via the primary cell as to whether the device has achieved synchronization on one or more secondary cell.

15. The method of claim 13 or claim 14, further comprising:

transmitting a command on the primary cell to activate the one or more secondary cell.

16. The method of any of claims 13-15, wherein the transmitting the cell search and/or synchronization command comprises using an enhanced scheduling grant to indicate activation of the secondary cell.

17. An apparatus, comprising:

at least one processor; and

at least one memory including computer program code,

wherein the at least one memory and the computer program are configured to, with the at least one processor, cause the apparatus at least to

receive a cell search and/or synchronization command from the network on the primary cell; and

perform cell search and/or synchronizing on a secondary cell based on the cell search and/or synchronization command.

18. The apparatus of claim 17, wherein the at least one memory and the computer program are also configured to, with the at least one processor, cause the apparatus at least to receive synchronization signals from the network on the secondary cell after receiving the cell search and/or synchronization command.

19. The apparatus of claim 17 or claim 18, wherein the cell search and/or synchronization command also indicates activation of the secondary cell.

20. The apparatus of any of claims 17-19, wherein the cell search and/or synchronization command is transmitted by PDCCH or ePDCCH as part of the downlink control information.

21. The apparatus of any of claims 17-20, wherein the cell search and/or synchronization command is addressed to one or more users.

22. The apparatus of any of claims 17-21, wherein the at least one memory and the computer program are configured to, with the at least one processor, cause the apparatus at least to synchronize to the network on the secondary cell for a predetermined period of time.

23. The apparatus of any of claims 17-22, wherein the cell search and/or synchronization command are for one or more channels within the secondary cell.

24. The apparatus of any of claims 17-23, wherein the cell search and/or synchronization command are for one or more secondary cells.

25. The apparatus of any of claims 17-24, wherein the cell search and/or synchronization command indicates a synchronization signal format.

26. The apparatus of any of claims 17-25, wherein the at least one memory and the computer program are also configured to, with the at least one processor, cause the apparatus at least to indicate to the network via the primary cell whether the apparatus has achieved synchronization on one or more secondary cell.

27. The apparatus of any of claims 17-26, wherein the cell search and/or synchronization command further comprises an indication of a hopping pattern.

28. An apparatus, comprising

at least one processor; and

at least one memory including computer program code,

wherein the at least one memory and the computer program are configured to, with the at least one processor, cause the apparatus at least to

determine a command to trigger a device to perform cell search and/or synchronization on a secondary cell; and

transmit, to the device, a cell search and/or synchronization command from the network on the primary cell.

29. The apparatus of claim 28, wherein the at least one memory and the computer program are configured to, with the at least one processor, cause the apparatus at least to receive an indication by the device via the primary cell as to whether the device has achieved synchronization on one or more secondary cell.

30. The apparatus of claim 28 or claim 29, wherein the at least one memory and the computer program are configured to, with the at least one processor, cause the apparatus at least to transmit a command on the primary cell to activate the one or more secondary cell.

31. The apparatus of any of claims 28-30, wherein the at least one memory and the computer program are configured to, with the at least one processor, cause the apparatus at least to transmit the cell search and/or synchronization command using an enhanced scheduling grant to indicate activation of the secondary cell.

32. An apparatus, comprising

means for receiving a cell search and/or synchronization command from the network on the primary cell; and

means for performing cell search and/or synchronizing on a secondary cell based on the cell search and/or synchronization command.

33. The apparatus of claim 32, further comprising:

means for receiving, at the device, synchronization signals from the network on the

secondary cell after receiving the cell search and/or synchronization command.

34. The apparatus of claim 32 or claim 33, wherein the cell search and/or synchronization command also indicates activation of the secondary cell.

35. The apparatus of any of claims 32-34, wherein the cell search and/or synchronization command is transmitted by PDCCH or ePDCCH as part of the downlink control information.

36. The apparatus of any of claims 32-35, wherein the cell search and/or synchronization command is addressed to one or more users.

37. The apparatus of any of claims 32-36, wherein the synchronizing comprises synchronizing to the network on the secondary cell for a predetermined period of time.

38. The apparatus of any of claims 32-37, wherein the cell search and/or synchronization command are for one or more channels within the secondary cell.

39. The apparatus of any of claims 32-38, wherein the cell search and/or synchronization command are for one or more secondary cells.

40. The apparatus of any of claims 32-39, wherein the cell search and/or synchronization command indicates a synchronization signal format.

41. The apparatus of any of claims 32-40, further comprising:

means for indicating by the device to the network via the primary cell whether the device has achieved synchronization on one or more secondary cell.

42. The apparatus of any of claims 32-41, wherein the cell search and/or synchronization command further comprises an indication of a hopping pattern.

43. An apparatus, comprising

means for determining a command to trigger a device to perform cell search and/or synchronization on a secondary cell; and

means for transmitting, to the device, a cell search and/or synchronization command

from the network on the primary cell.

44. The apparatus of claim 43, further comprising:

means for receiving an indication by the device via the primary cell as to whether the device has achieved synchronization on one or more secondary cell.

45. The apparatus of claim 43 or claim 44, further comprising:

means for transmitting a command on the primary cell to activate the one or more secondary cell.

46. The apparatus of any of claims 43-45, wherein the transmitting the cell search and/or synchronization command comprises using an enhanced scheduling grant to indicate activation of the secondary cell.

47. A method, comprising:

determining a command to trigger a device to perform cell search and/or synchronization on a secondary cell;

transmitting, to the device, a cell search and/or synchronization command from the network on the primary cell;

receiving, at the device, the cell search and/or synchronization command from the network on the primary cell; and

performing, by the device, cell search and/or synchronizing on a secondary cell based on the cell search and/or synchronization command.

48. A computer program product encoding instructions for performing a process, the process comprising the method according to any of claims 1-16 or 47.

49. A non-transitory computer-readable medium encoded with instructions that, when executed in hardware, perform a process, the process comprising the method according to any of claims 1-16 or 47.

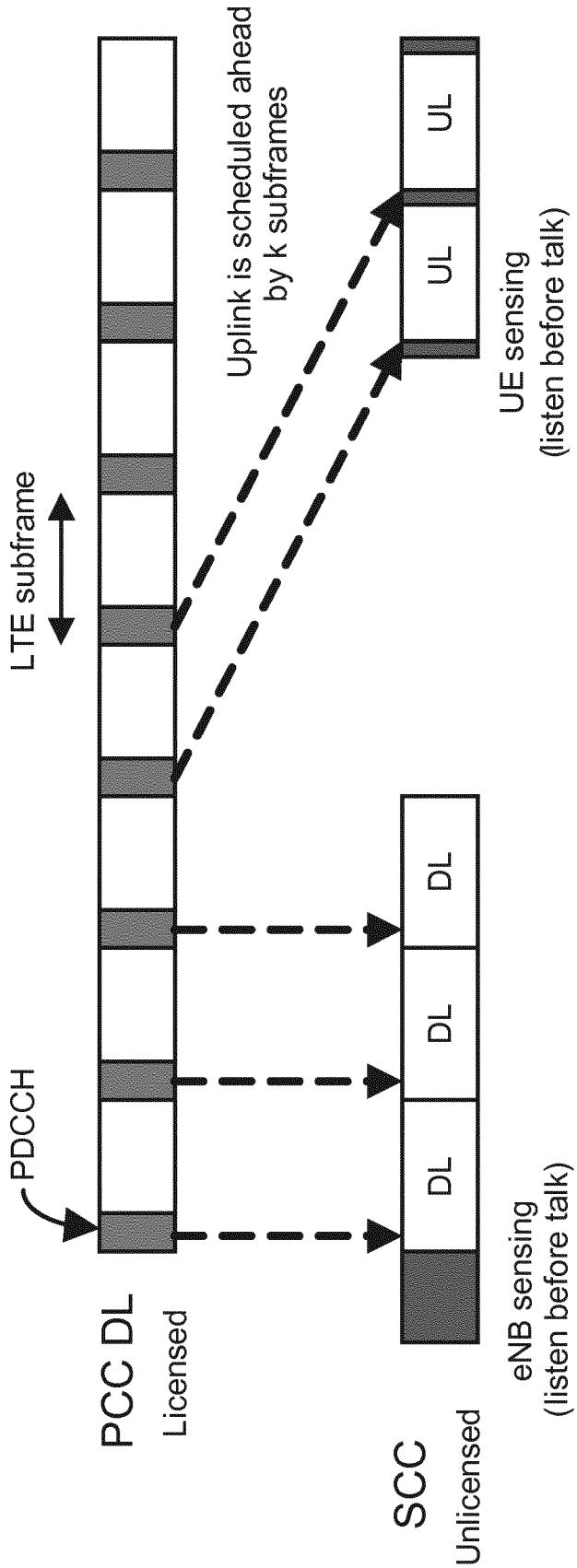

LTE subframe
PDCCH
PCC DL
Licensed
SCC
Unlicensed
Uplink is scheduled ahead by k subframes
UE sensing (listen before talk)
eNB sensing (listen before talk)
DL
DL
DL
UL
UL

Figure 1

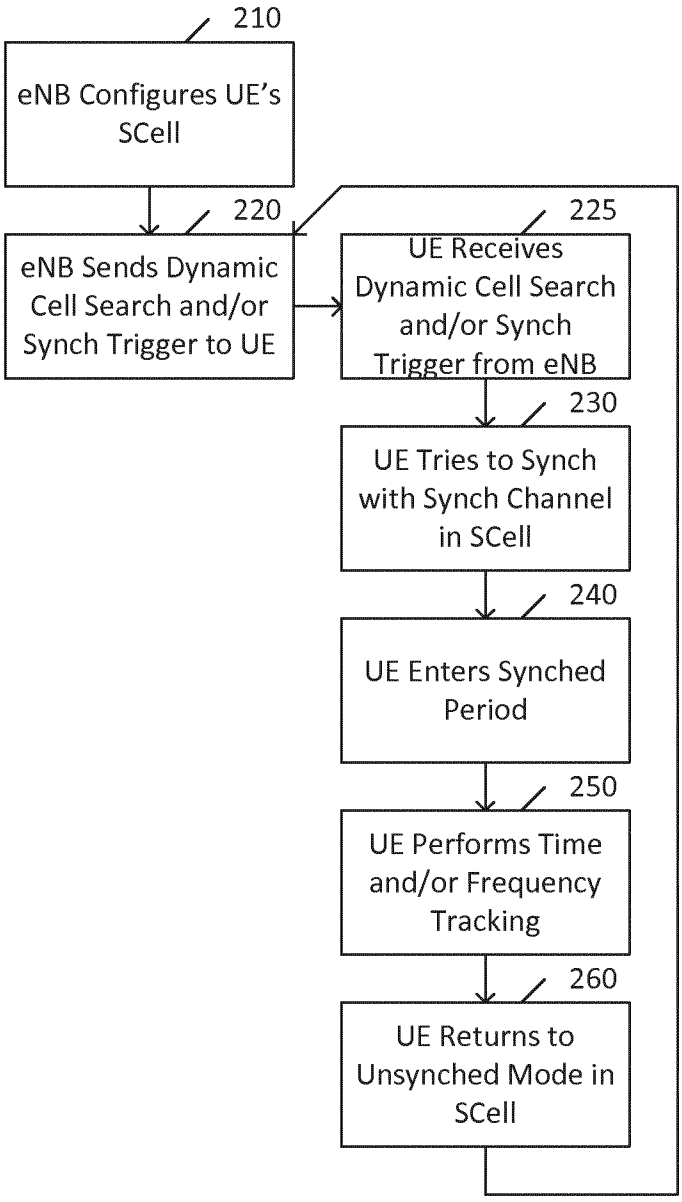

210
eNB Configures UE's SCell
220
eNB Sends Dynamic Cell Search and/or Synch Trigger to UE
225
UE Receives Dynamic Cell Search and/or Synch Trigger from eNB
230
UE Tries to Synch with Synch Channel in SCell
240
UE Enters Synched Period
250
UE Performs Time and/or Frequency Tracking
260
UE Returns to Unsynched Mode in SCell

Figure 2

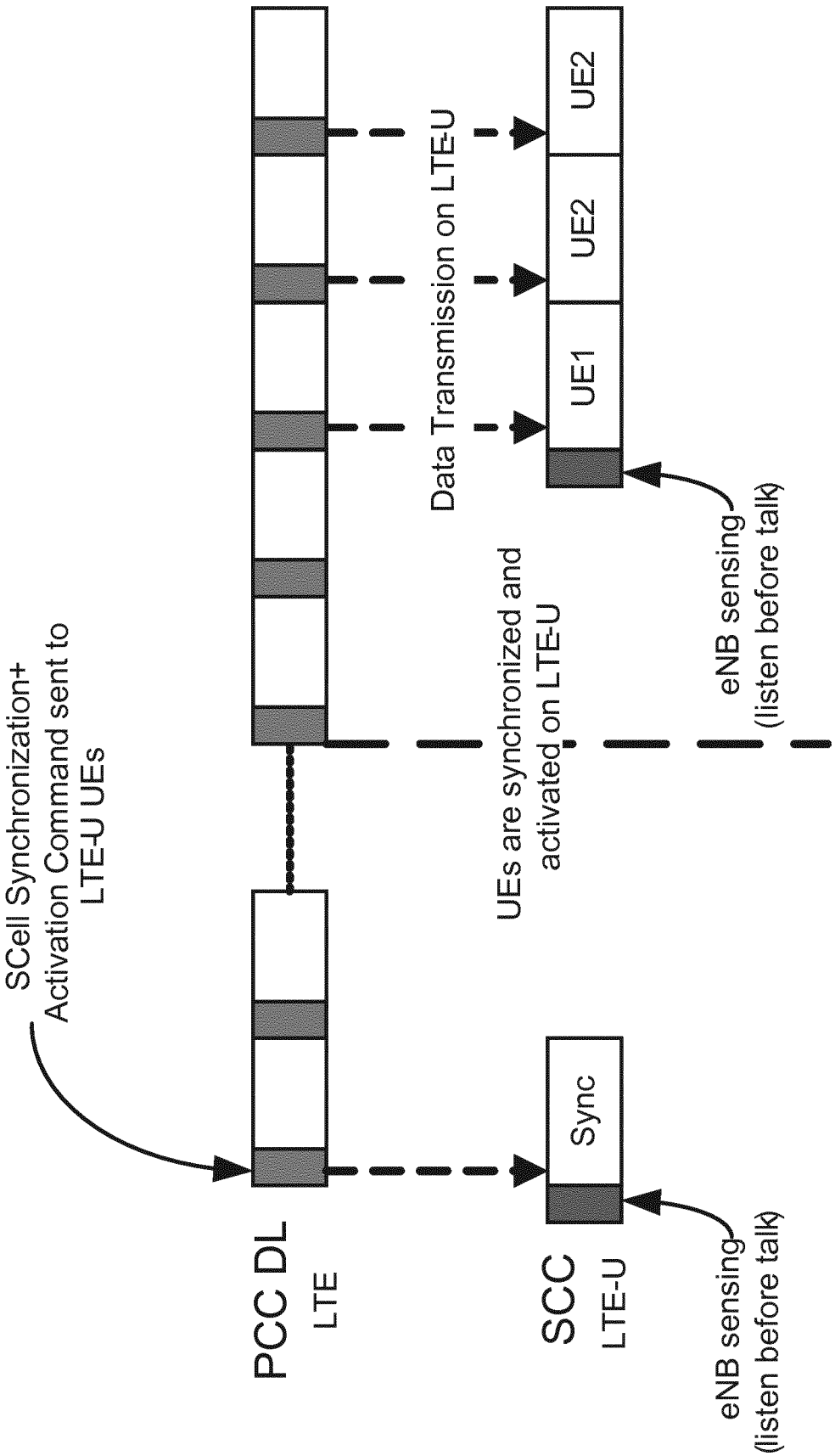

SCell Synchronization+
Activation Command sent to
LTE-U UEs
PCC DL
LTE
SCC
LTE-U
Sync
eNB sensing
(listen before talk)
UEs are synchronized and
activated on LTE-U
Data Transmission on LTE-U
UE1
UE2
UE2
eNB sensing
(listen before talk)

Figure 3

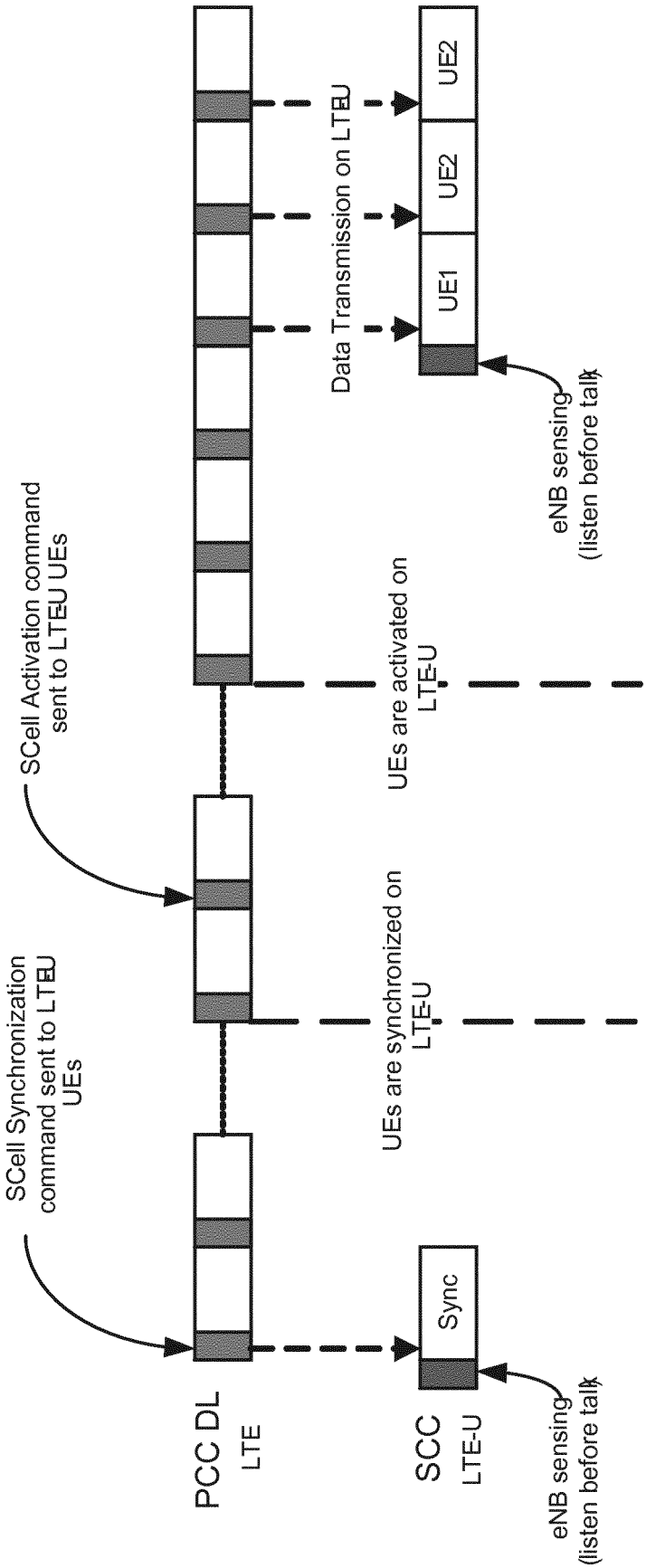

PCC DL
LTE
SCC
LTE-U
Sync
eNB sensing
(listen before talk)
SCell Synchronization command sent to LTE-U UEs
SCell Activation command sent to LTE-U UEs
UEs are synchronized on LTE-U
UEs are activated on LTE-U
Data Transmission on LTE-U
UE1
UE2
UE2
eNB sensing
(listen before talk)

Figure 4

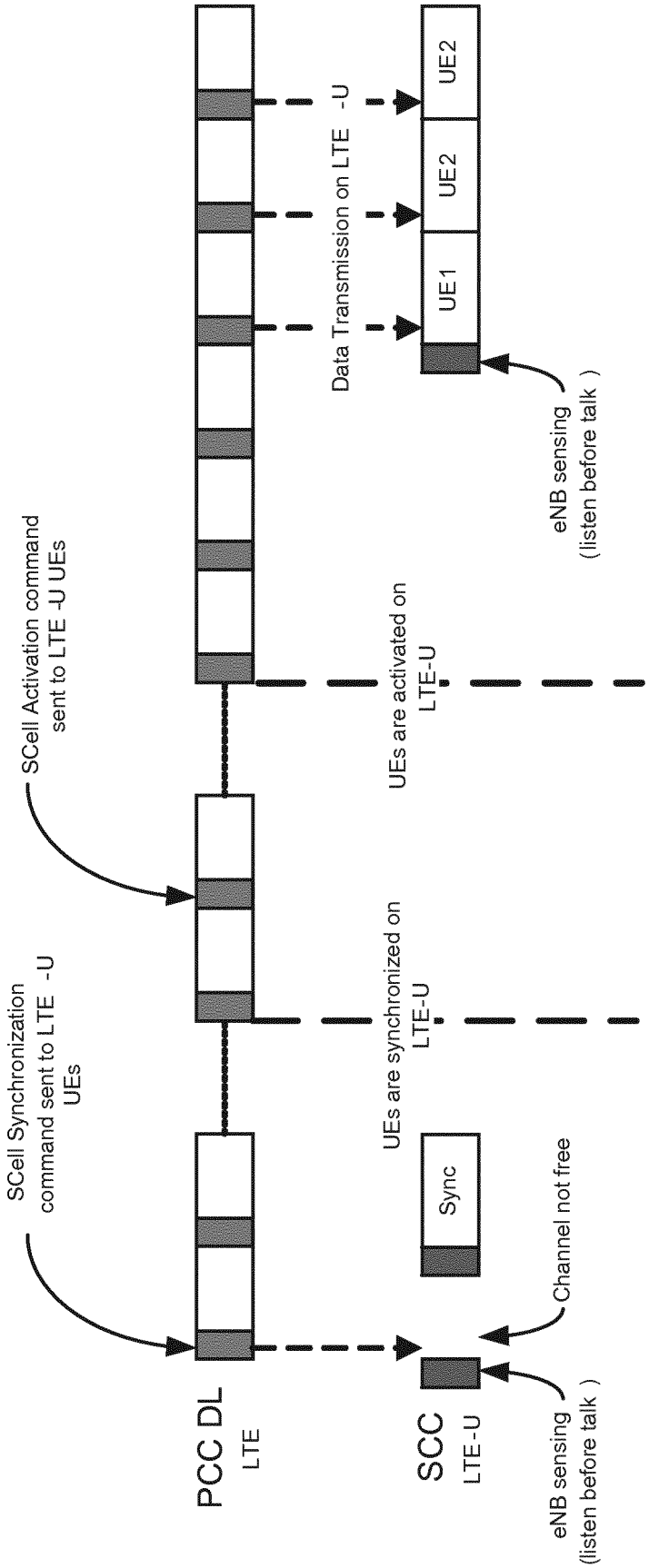

PCC DL
LTE
SCC
LTE-U
SCell Synchronization command sent to LTE -U UEs
SCell Activation command sent to LTE -U UEs
Sync
UEs are synchronized on LTE-U
UEs are activated on LTE-U
Data Transmission on LTE -U
UE1
UE2
UE2
Channel not free
eNB sensing (listen before talk)
eNB sensing (listen before talk)

Figure 5

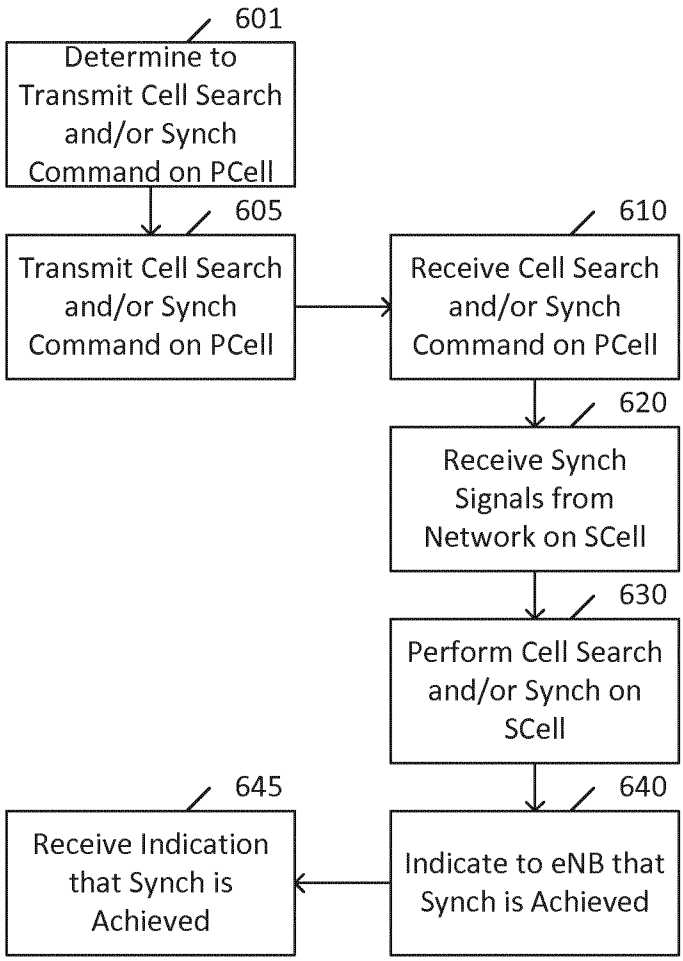

601
Determine to Transmit Cell Search and/or Synch Command on PCell
605
Transmit Cell Search and/or Synch Command on PCell
610
Receive Cell Search and/or Synch Command on PCell
620
Receive Synch Signals from Network on SCell
630
Perform Cell Search and/or Synch on SCell
640
Indicate to eNB that Synch is Achieved
645
Receive Indication that Synch is Achieved

Figure 6

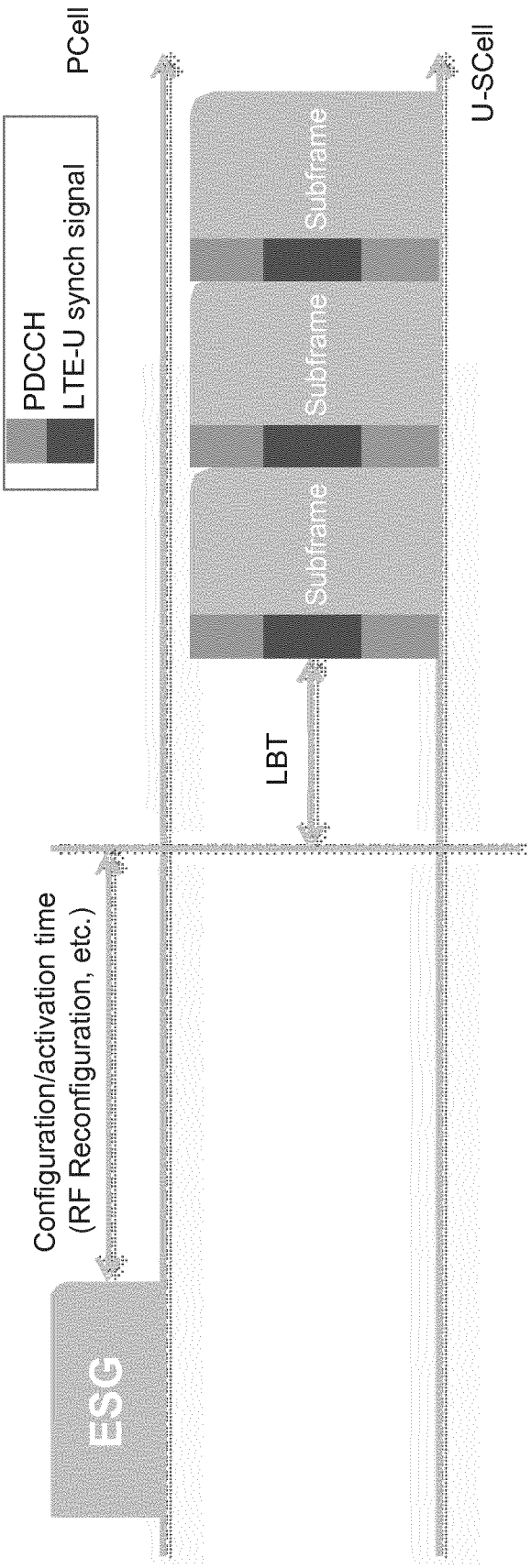

PCell
U-SCell
PDCCH
LTE-U synch signal
Subframe
Subframe
Subframe
LBT
Configuration/activation time
(RF Reconfiguration, etc.)
ESG

Figure 7

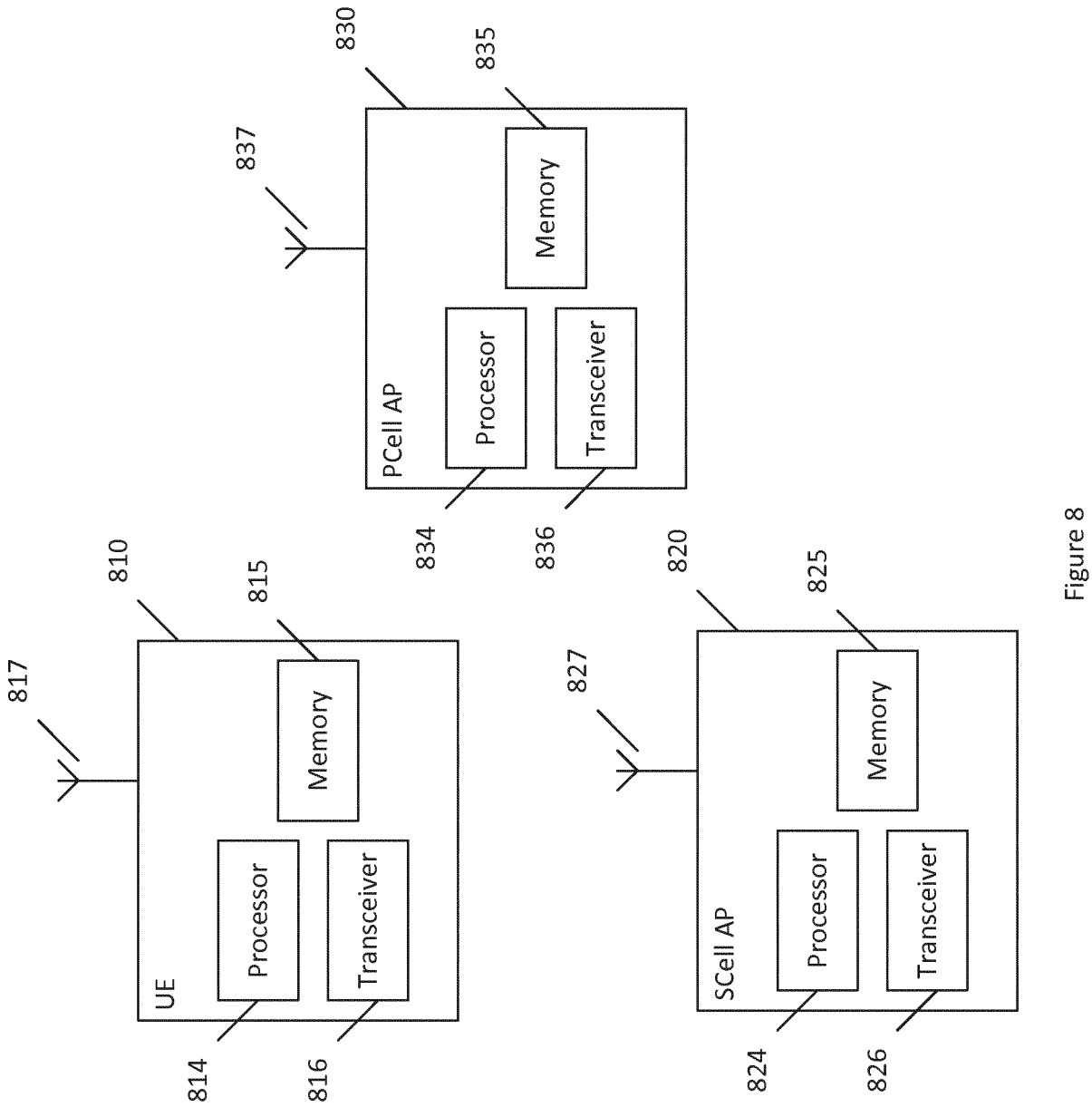
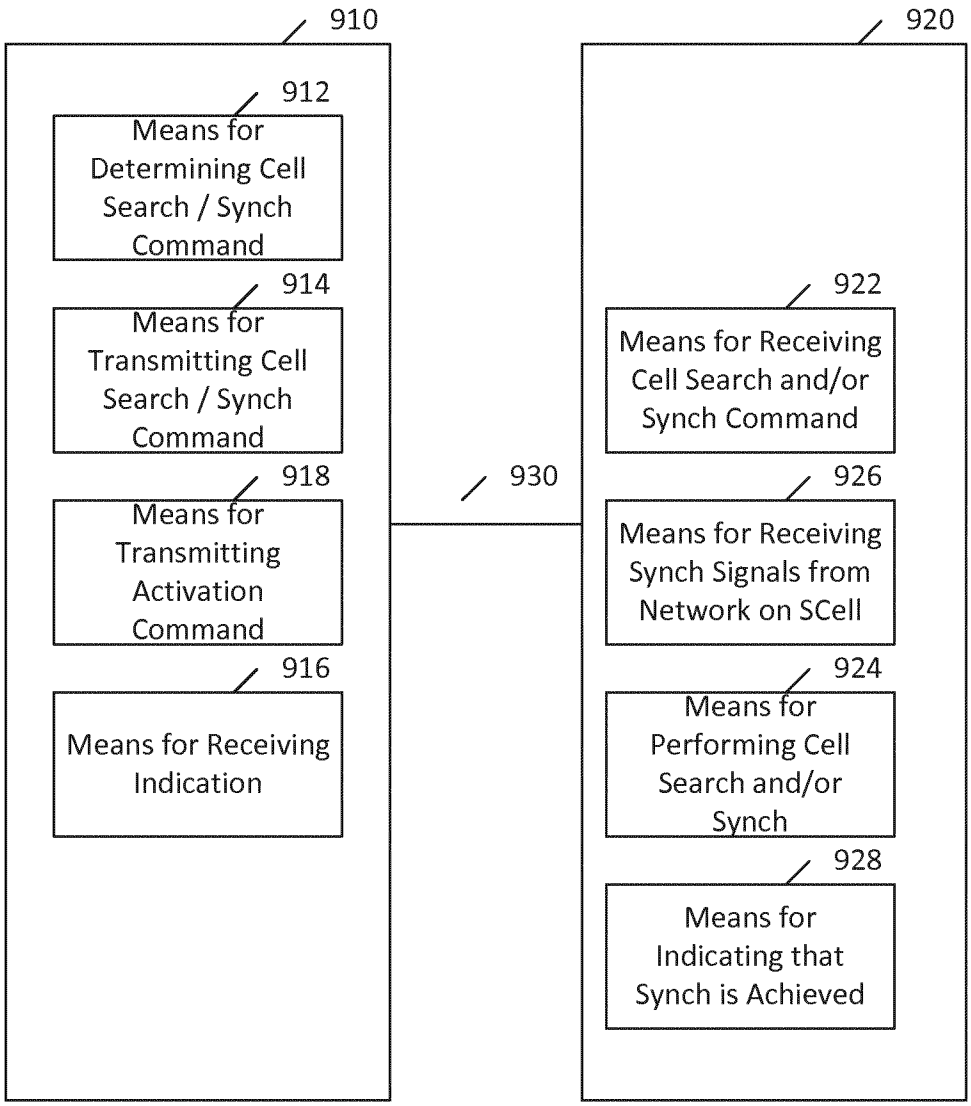

UE
Processor
Transceiver
Memory
810
815
817
814
816
PCell AP
Processor
Transceiver
Memory
830
835
837
834
836
SCell AP
Processor
Transceiver
Memory
820
825
827
824
826

Figure 8


910
912
Means for Determining Cell Search / Synch Command
914
Means for Transmitting Cell Search / Synch Command
918
Means for Transmitting Activation Command
916
Means for Receiving Indication
930
920
922
Means for Receiving Cell Search and/or Synch Command
926
Means for Receiving Synch Signals from Network on SCell
924
Means for Performing Cell Search and/or Synch
928
Means for Indicating that Synch is Achieved

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/065940

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W56/00
ADD.

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)
H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CATT: "Discussion on SCell activation delay", 3GPP DRAFT; R4-125209_DISCUSSION ON SCELL ACTIVATION DELAY, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG4 12 October 2012 (2012-10-12), XP050672912, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_64bis/Docs/ [retrieved on 2012-10-12]	1,13,17, 28,32, 43,47-49
Y	page 1 - page 5	2-12, 14-16, 18-27, 29-31,

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
2 April 2015	14/04/2015

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Bohnhoff, Peter

1

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
		33-42, 44-46

Y	WO 2013/167557 A1 (NOKIA SIEMENS NETWORKS OY [FI]) 14 November 2013 (2013-11-14)	2-12, 14-16, 18-27, 29-31, 33-42, 44-46
	page 13, line 15 - page 15, line 8	

X	WO 2012/040520 A1 (INTERDIGITAL PATENT HOLDINGS [US]; BALA ERDEM [US]; KAUR SAMIAN J [US]) 29 March 2012 (2012-03-29) paragraph [0113] - paragraph [0125]	1,13,17, 28,32, 43,47

X	EP 2 696 530 A2 (BLACKBERRY LTD [CA]) 12 February 2014 (2014-02-12)	1,13,17, 28,32, 43,47
	paragraph [0091] - paragraph [0092]; figure 13	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2014/065940

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2013167557 A1	14-11-2013	NONE	
WO 2012040520 A1	29-03-2012	US 2013294356 A1	07-11-2013
		WO 2012040520 A1	29-03-2012
EP 2696530 A2	12-02-2014	CA 2823450 A1	10-02-2014
		CN 103580840 A	12-02-2014
		EP 2696530 A2	12-02-2014
		US 2014044105 A1	13-02-2014