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(54) Title: SEMI-PERSISTENT SCHEDULING RECONFIGURATION IN CARRIER AGGREGATION

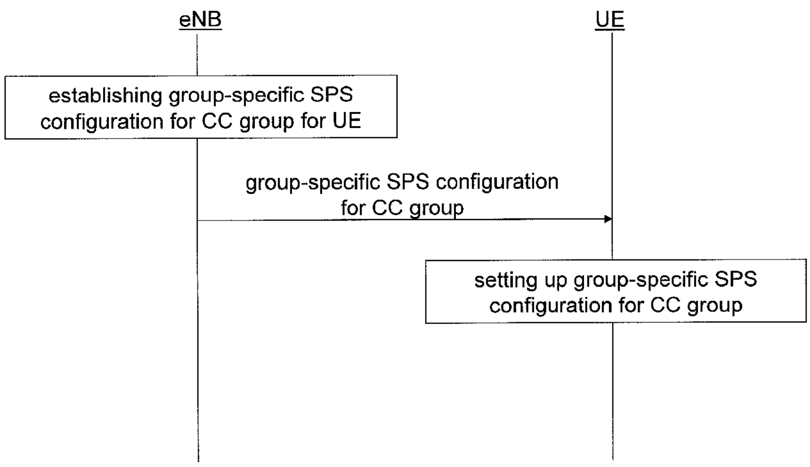

Figure 1

(57) **Abstract**: There are provided measures for enabling semi-persistent scheduling reconfiguration in carrier aggregation. Such measures may exemplarily comprise pre-configuring, by an access point, a terminal with a group-specific semi-persistent scheduling configuration for a group of component carriers for carrier aggregation for the terminal, said group-specific semi-persistent scheduling configuration comprising a carrier-specific semi-persistent scheduling configuration for each component carrier of the group.

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SEMI-PERSISTENT SCHEDULING RECONFIGURATION IN CARRIER AGGREGATION

Field of the invention

The present invention relates to a semi-persistent scheduling reconfiguration in carrier aggregation. More specifically, the present invention relates to measures (including methods, apparatuses and computer program products) for enabling semi-persistent scheduling reconfiguration in carrier aggregation.

Background

In modern communication systems, including wireless and/or cellular communication systems, e.g. LTE and LTE-A, carrier aggregation (CA) is adopted as a technique for extending maximum bandwidth in both uplink (UL) and downlink (DL) directions. To this end, multiple carriers within a frequency band (intra-band CA) or across frequency bands (inter-band CA) are aggregated to be commonly used for a UL/DL communication between a terminal entity, such as a user equipment (UE) and an access point, such as a base station, e.g. an eNB.

Further, utilization of unlicensed (shared) frequency bands is adopted as a technique for coping with increased network traffic. To this end, an unlicensed (shared) frequency band, such as a WiFi (WLAN) spectrum, is utilized for offloading traffic of a licensed frequency band, such as a LTE/LTE-A spectrum, so s to save limited and expensive licensed spectrum.

In the context of carrier aggregation, various approaches are conceivable in terms of unlicensed band traffic offloading. On the one hand, a Primary Cell Carrier (PCC) using LTE/LTE-A technology may be configured on the licensed band for primary access providing e.g. mobility, security and state management for user terminals, while a Secondary Cell Carrier (SCC) using WiFi/WLAN technology may be opportunistically configured on an unlicensed band for secondary access providing e.g. additional data plane transport. Such band utilization approach may be referred to as hybrid utilization, wherein both bands are available for the underlying wireless and/or cellular communication systems, e.g. LTE and LTE-A. On the other hand, both PCC and SCC may be configured using LTE/LTE-A technology. Such band utilization approach may be referred to as standalone utilization, wherein only the unlicensed band is available for the underlying wireless and/or cellular communication systems, e.g. LTE and LTE-A.

Yet, when being operated on an unlicensed band (either partly in terms of hybrid utilization or completely in term of standalone utilization), the underlying wireless and/or cellular communication systems, e.g. LTE and LTE-A, may face totally different operating scenarios as compared to a (usual) operation on the licensed band. This is essentially due to the fact that, in contrast to the licensed band where only standalone e.g. LTE/LTE-A systems exist, various cellular and non-cellular wireless communication systems may coexist on an unlicensed band. Accordingly, for example (more) frequent breaks of CA component carries (CC), e.g. PCC/SCC breaks, may occur due to interference from non-cellular system or some other cellular communication system.

The break of a CC in CA, most importantly the break of a PCC in the DL direction, causes problems for the underlying wireless and/or cellular communication systems, e.g. LTE and LTE-A.

Particularly when being operated on an unlicensed band (either partly in terms of hybrid utilization or completely in term of standalone utilization), corresponding scheduling techniques may be preferably adopted. For example, semi-persistent (packet) scheduling (SPS) may be adopted as a scheduling technique for providing persistent radio resource allocations, i.e. for introducing a persistent PRB allocation, for applications, especially applications with small packets. The SPS is typically used with VoIP to limit impact of many users engaged in an active VoIP session on the control channel signaling. In SPS, resources are configured by a higher layer with some periodicity for the transmission of e.g. VoIP packets, with dynamical packet scheduling used for the re-transmissions of e.g. VoIP packets, if needed, and silence indicator frames.

When using semi-persistent scheduling, the break of a CC in CA, most importantly the break of a PCC in the DL direction, causes specifically severe problems for the underlying wireless and/or cellular communication systems, e.g. LTE and LTE-A.

Accordingly, in order to improve existing techniques for bandwidth extension and band utilization, it is desirable to enable limiting the impact of a break of a component carrier, particularly a break of a DL PCC, on semi-persistent scheduling in a wireless and/or cellular communication system being (at least partly) operated on an unlicensed band.

Thus, there is a desire to enable semi-persistent scheduling reconfiguration in carrier aggregation

Summary

Various exemplary embodiments of the present invention aim at addressing at least part of the above issues and/or problems and drawbacks.

Various aspects of exemplary embodiments of the present invention are set out in the appended claims.

According to an exemplary aspect of the present invention, there is provided a method comprising establishing a group-specific semi-persistent scheduling configuration for a group of component carriers for carrier aggregation for a terminal of a cellular communication system, said group-specific semi-persistent scheduling configuration comprising a carrier-specific semi-persistent scheduling configuration for each component carrier of the group, and signaling the group-specific semi-persistent scheduling configuration to the terminal of a cellular communication system.

According to an exemplary aspect of the present invention, there is provided a method comprising receiving a group-specific semi-persistent scheduling configuration for a group of component carriers for carrier aggregation for a terminal of a cellular communication system from an access point of the cellular communication system, said group-specific semi-persistent scheduling configuration comprising a carrier-specific semi-persistent scheduling configuration for each component carrier of the group, and setting up the group-specific semi-persistent scheduling configuration at the terminal of a cellular communication system.

According to an exemplary aspect of the present invention, there is provided an apparatus comprising at least one processor, at least one memory including computer program code, and at least one interface configured for communication with at least another apparatus, the at least one processor, with the at least one memory and the computer program code, being configured to cause the apparatus to perform: establishing a group-specific semi-persistent scheduling configuration for a group of component carriers for carrier aggregation for a terminal of a cellular communication system, said group-specific semi-persistent scheduling configuration comprising a carrier-specific semi-persistent scheduling configuration for each component carrier of the group, and signaling the group-specific semi-persistent scheduling configuration to the terminal of a cellular communication system.

According to an exemplary aspect of the present invention, there is provided an apparatus comprising at least one processor, at least one memory including computer program code, and at least one interface configured for communication with at least another apparatus, the at least one processor, with the at least one memory and the computer program code, being configured to cause the apparatus to perform: receiving a group-specific semi-persistent scheduling configuration for a group of component carriers for carrier aggregation for a terminal of a cellular communication system from an access point of the cellular communication system, said group-specific semi-persistent scheduling configuration comprising a carrier-specific semi-persistent scheduling configuration for each component carrier of the group, and setting up the group-specific semi-persistent scheduling configuration at the terminal of a cellular communication system.

According to an exemplary aspect of the present invention, there is provided a computer program product comprising computer-executable computer program code which, when the program is run on a computer (e.g. a computer of an apparatus according to any one of the aforementioned apparatus-related exemplary aspects of the present invention), is configured to cause the computer to carry out the method according to any one of the aforementioned method-related exemplary aspects of the present invention.

Such computer program product may comprise or be embodied as a (tangible) computer-readable (storage) medium or the like on which the computer-executable computer program code is stored, and/or the program may be directly loadable into an internal memory of the computer or a processor thereof.

Advantageous further developments or modifications of the aforementioned exemplary aspects of the present invention are set out in the following.

By virtue of any one of the aforementioned exemplary aspects of the present invention, existing techniques for bandwidth extension and band utilization may be improved. In particular, the impact of a break of a component carrier, particularly a break of a DL PCC, on semi-persistent scheduling in a wireless and/or cellular communication system being (at least partly) operated on an unlicensed band may be limited.

Further, by virtue of any one of the aforementioned exemplary aspects of the present invention, rapid and efficient SPS/CC reconfiguration and/or rapid and efficient SPS/CC deactivation on broken CC and SPS/CC activation on new CC may be provided.

By way of exemplary embodiments of the present invention, there is provided semi-persistent scheduling reconfiguration in carrier aggregation. More specifically, by way of exemplary embodiments of the present invention, there are provided measures and mechanisms for semi-persistent scheduling reconfiguration in carrier aggregation (in/for cellular communication systems).

Thus, enhancements are achieved by methods, apparatuses and computer program products enabling semi-persistent scheduling reconfiguration in carrier aggregation (in/for cellular communication systems).

Brief description of drawings

For a more complete understanding of exemplary embodiments of the present invention, reference is now made to the following description taken in connection with the accompanying drawings in which:

Figure 1 shows a schematic diagram illustrating an exemplary procedure in terms of pre-configuration of a group-specific SPS configuration according to exemplary embodiments of the present invention,

Figure 2 shows a schematic diagram illustrating an exemplary procedure in terms of SPS reconfiguration based on a CC break according to exemplary embodiments of the present invention,

Figure 3 shows a schematic diagram illustrating an exemplary SPS reconfiguration based on a pre-configured group-specific SPS configuration according to exemplary embodiments of the present invention,

Figure 4 shows a schematic diagram illustrating exemplary procedures in terms of SPS reallocation and SPS suspension based on a CC break according to exemplary embodiments of the present invention,

Figure 5 shows a schematic diagram illustrating an exemplary SPS suspension based on a pre-configured group-specific SPS configuration according to exemplary embodiments of the present invention,

Figure 6 shows a schematic diagram illustrating an exemplary procedure in terms of SPS packet HARQ process recovery based on a CC break according to exemplary embodiments of the present invention,

Figure 7 shows a schematic diagram illustrating an exemplary procedure in terms of SPS packet detection failure according to exemplary embodiments of the present invention, and

Figure 8 shows a schematic block diagram illustrating exemplary apparatuses according to exemplary embodiments of the present invention.

Description of exemplary embodiments

Exemplary aspects of the present invention will be described herein below. More specifically, exemplary aspects of the present are described hereinafter with reference to particular non-limiting examples and to what are presently considered to be conceivable embodiments of the present invention. A person skilled in the art will appreciate that the invention is by no means limited to these examples, and may be more broadly applied.

It is to be noted that the following description of the present invention and its embodiments mainly refers to specifications being used as non-limiting examples for certain exemplary network configurations and deployments. Namely, the present invention and its embodiments are mainly described in relation to 3GPP specifications being used as non-limiting examples for certain exemplary network configurations and deployments. In particular, a LTE/LTE-Advanced communication system is used as a non-limiting example for the applicability of thus described exemplary embodiments. As such, the description of exemplary embodiments given herein specifically refers to terminology which is directly related thereto. Such terminology is only used in the context of the presented non-limiting examples, and does naturally not limit the invention in any way. Rather, any other network configuration or system deployment, etc. may also be utilized as long as compliant with the features described herein.

In particular, the present invention and its embodiments may be applicable in any (cellular) communication system and/or network deployment in which techniques carrier aggregation and unlicensed band utilization are operable for bandwidth extension and band utilization.

Hereinafter, various embodiments and implementations of the present invention and its aspects or embodiments are described using several alternatives. It is generally noted that, according to certain needs and constraints, all of the described alternatives may be provided alone or in any conceivable combination (also including combinations of individual features of the various alternatives).

According to exemplary embodiments of the present invention, in general terms, there are provided mechanisms, measures and means for enabling semi-persistent scheduling reconfiguration in carrier aggregation (in/for cellular communication systems).

The present invention and its embodiments are made in consideration of the above-outlined situation as well as the following problems.

Generally, e.g. in a standalone utilization system, an ON-OFF SPS pattern may be determined based on sensing interference measurements on a configured carrier in an ON duration based on corresponding reports of attached UEs at an eNB receiver. Thereby, a SPS configuration may be established for each component carrier (CC), respectively. When a correspondingly SPS-configured CC breaks, the eNB is not capable of shifting the SPS to another CC in an appropriate and efficient manner.

Conventionally, SPS will only be carried on a PCC. Accordingly, when the eNB has to turn off the SPS due to break of the PCC, it is likely that the same problem will happen and actually may be worse on another PCC. This is essentially because a new PCC needs to be configured before SPS configuration/reconfiguration and SPS activation on the new PCC and SPS release on the broken PCC and confirmation by the UE sent on the new PCC.

Further, a PCC may conventionally only be changed by way of a handover and cannot be deactivated as such. A broken PCC will thus require configuration of a new PCC, which can be expected to take relatively long if done in a similar way as would be if the need for a handover occurred. Namely, it is not possible to deactivate the broken PCC and activate a new PCC.

Reconfiguring and activating a new PCC in an ON duration following a broken PCC may take some time, during which the standalone utilization LTE/LTE-A system cannot schedule any packets or the hybrid utilization LTE/LTE-A system can schedule less packets. Once the PCC is repaired, the eNB could schedule packets right away with dynamical PS, but in case of many e.g. VoIP UEs or, more generally, UEs or machines that may preferably be scheduled resources via SPS, this could be an issue. Considering that the ON duration may be small and there may be many UEs or machines configured resources via SPS, there is a problem in enabling SPS configuration/reconfiguration and SPS activation on a new PCC.

In the following, exemplary embodiments of the present invention are described with reference to methods, procedures and functions, as well as with reference to structural arrangements and configurations.

Herein, by way of example and for the sake of clarity of the explanation only, an eNB is adopted as a non-limiting example of an access point (or base station) entity of a communication system, and an UE is adopted as a non-limiting example of a terminal entity of a communication system.

A mechanism according to exemplary embodiments of the present invention relates to pre-configuration of a group-specific SPS configuration.

Figure 1 shows a schematic diagram illustrating an exemplary procedure in terms of pre-configuration of a group-specific SPS configuration according to exemplary embodiments of the present invention.

As shown in Figure 1, a corresponding procedure according to exemplary embodiments of the present invention, at the eNB side, comprises an operation of establishing a group-specific semi-persistent scheduling (SPS) configuration for a group of component carriers (CC) for carrier aggregation (CA) for a terminal (i.e. the UE), said group-specific SPS configuration comprising a carrier-specific SPS configuration for each CC of the group, and an operation of signaling the group-specific SPS configuration to the terminal (i.e. the UE). Further, a corresponding procedure according to exemplary embodiments of the present invention, at the UE side, comprises an operation of receiving the group-specific SPS configuration from an access point (i.e. the eNB), and an operation of setting up the group-specific SPS configuration.

According to exemplary embodiments of the present invention, the eNB pre-configures the UE with a CC-group-specific SPS configuration, i.e. a common SPS configuration for a group of CCs, in this manner. Namely, the eNB pre-configures the UE with the same SPS configuration for a group of CCs, while other UEs are configured different CC-group-specific SPS configurations. The carrier-specific SPS configuration (i.e. the ON duration and the OFF duration) for each CC may be established based on interference measurements from non-cellular systems and/or other cellular systems.

According to exemplary embodiments of the present invention, the CC-group-specific SPS configuration may comprise at least one of DL and UL SPS assignment of physical resource blocks (PRB) on the CCs.

For DL SPS assignment, the CC-group-specific SPS configuration may be established by applying the following formula for all aggregated CCs with same parameters for a given UE (but different parameters for different UEs):

(10 * SFN + subframe) = [(10 * $SFN_{start\ time}$ + $subframe_{start\ time}$) + N * $semiPersistSchedInterval_{DL}$] modulo 10240, for all N>0.

For UL SPS assignment, the CC-group-specific SPS configuration may be established by applying the following formula for all aggregated CCs with same parameters for a given UE (but different parameters for different UEs):

(10 * SFN + subframe) = [(10 * $SFN_{start\ time}$ + $subframe_{start\ time}$) + N * $semiPersistSchedInterval_{UL}$ + Subframe_Offset * (N modulo 2)] modulo 10240, for all N>0.

Another mechanism according to exemplary embodiments of the present invention relates to SPS reconfiguration based on a CC break. Such mechanism may be based on the above mechanism of pre-configuration of a group-specific SPS configuration according to exemplary embodiments of the present invention.

Figure 2 shows a schematic diagram illustrating an exemplary procedure in terms of SPS reconfiguration based on or associated with a CC break according to exemplary embodiments of the present invention.

As shown in Figure 2, a corresponding procedure according to exemplary embodiments of the present invention, at the eNB side, comprises an operation of determining a break of a CC of the UE, and an operation of signaling deactivation of the broken CC and activation of another (new) CC among CCs of a pre-configured SPS configuration, e.g. the CC-group-specific SPS configuration according to exemplary embodiments of the present invention. Further, a corresponding procedure according to exemplary embodiments of the present invention, at the UE side, comprises an operation of determining a break of a CC of the UE, and an operation of deactivating a SPS assignment of PRBs on the broken CC, and activating a SPS assignment of PRBs on another (new) active CC among the CCs of the pre-configured SPS configuration, e.g. the CC-group-specific SPS configuration according to exemplary embodiments of the present invention.

According to exemplary embodiments of the present invention, the CC break determination at the UE side may be based on acquisition/receipt of the signaling of deactivation of the broken CC and activation of another (new) CC from the eNB.

According to exemplary embodiments of the present invention, the broken CC deactivation and the new CC activation may thus be interpreted by the UE as an implicit SPS deactivation and an implicit SPS activation from a broken CC to an unbroken CC. Further, the UE may thus be implicitly scheduled resources via SPS allocation on the active unbroken CCs. In case multiple CCs are active at the time of break of the CC, the SPS activation may move to the next CC according to a predefined order among the group of pre-configured CCs. Accordingly, a corresponding mechanism according to exemplary embodiments of the present invention provides for implicit SPS/CC reconfiguration and/or implicit SPS/CC de-/activation.

According to exemplary embodiments of the present invention, the broken CC deactivation and the new CC activation may for example be signaled via one or more MAC CEs and/or one or more LTE/LTE-A system on or off triggers.

Figure 3 shows a schematic diagram illustrating an exemplary SPS reconfiguration based on a pre-configured group-specific SPS configuration according to exemplary embodiments of the present invention.

In Figure 3, it is exemplarily assumed that four channels (CCs) Ch1, Ch2, Ch3 and Ch4 are included in the group of CCs for which the UE is pre-configured in terms of SPS configuration by the eNB. These four channels may for example be channels on an unlicensed band in the context of a hybrid or standalone utilization LTE/LTE-A system. Each block indicates a PRB of a CC at a certain time T1..T9. Further, the CC-specific SPS configuration for each CC in the group is indicated by dark grey shading for ON durations and light grey shading for OFF durations.

Figure 3 illustrates an example with SPS resources initially configured on PCell on Ch1 (as PCC) during the ON duration of Ch1. At time T4, the SPS allocation is then shifted (indicated by the left vertical arrow) to a PCell on Ch2 (as PCC) during the ON duration of Ch2, and then shifted at time T6 (indicated by the right vertical arrow) to a SCell on CH3 (as SCC) during the ON duration of Ch3. The shift times T4 and T6 may also be times of break of the Ch1 PCC and the Ch2 PCC, respectively. A resulting ongoing SPS allocation is indicated by the horizontal arrows, also illustrating the aforementioned CC shifts.

This example allows shifting on SPS allocation on pre-configured resources on any PCell or SCell within a group of pre-configured CCs (i.e. Ch1, Ch2, Ch3, Ch4). Since the SPS resources are pre-configured, fast allocation during the ON period of one CC can be readily achieved.

In the above example, it is assumed that only one CC at a time can be allocated SPS resources. This could be typically applicable e.g. for a VoIP connection, wherein dynamical PS could be used to provide additional resources for file download or HTML traffic. However, it is also feasible that SPS resources can be allocated to more than on CC at a time. In this case, SPS resources can for example be activated for a UE configured with 2 PCCs and one SCC in a group of e.g. 6 CCs. This could be typically applicable for video streaming with small VoIP packets transmitted on one CC and large video packets transmitted on another CC. In this case, when a broken CC does not allow video packets to be transmitted for some time, the VoIP packets transmitted on the other (relatively more robust) CC allow the VoIP call or session to continue at least in audio mode.

Another mechanism according to exemplary embodiments of the present invention relates to SPS reallocation and/or SPS suspension based on a CC break. Such mechanism may be based on or associated with any one of the above mechanisms of pre-configuration of a group-specific SPS configuration and SPS reconfiguration based on a CC break according to exemplary embodiments of the present invention.

Figure 4 shows a schematic diagram illustrating exemplary procedures in terms of SPS reallocation and SPS suspension based on a CC break according to exemplary embodiments of the present invention.

As shown in Figure 4, a corresponding procedure according to exemplary embodiments of the present invention, at the eNB side, is based on a deactivation of a broken CC, as indicated e.g. in connection with the mechanism of Figure 2, and comprises an operation of allocating PRBs of a SPS assignment on the broken CC to another terminal (UE) by dynamical scheduling (PS), and/or an operation of suspending, from a time of the deactivation of the broken CC, allocation of PRBs of a SPS assignment of the UE on another (new) CC for a suspension period.

In the operation of re-allocating PRBs, the eNB may allocate the unused SPS resources configured on CCs which are broken (i.e. cannot be used by the UE) to other UEs for which these CCs are not considered broken.

In the operation of suspending allocation, the eNB may suspend DL and UL resource allocation on a new CC for a DL and UL suspension period, respectively.

As shown in Figure 4, a corresponding procedure according to exemplary embodiments of the present invention, at the UE side, is based on a deactivation of a SPS assignment of PRBs on a broken CC, as indicated e.g. in connection with the mechanism of Figure 2, and comprises an operation of suspending, from a time of the deactivation of the SPS assignment of PRBs on the broken CC, communication in PRBs of a SPS assignment on another (new) CC for a suspension period.

In the operation of suspending communication, the UE may suspend DL reception and UL transmission in PRBs of a DL/UL SPS assignment on a new CC for a DL and UL suspension period, respectively.

According to exemplary embodiments of the present invention, the eNB-based suspension and the UE-based suspension may be subject to the same or similar operational principles. Basically, an SPS "pause" state may be defined such that the eNB/UE will still keep record of the start time of this SPS assignment on the CC in question, but does not allocate any resources or perform any transmission/reception during this pause duration on this CC. For a group of CCs, SPS allocation/communication is only active on one CC, while SPS allocations/communications on the other CCs are "paused". The SPS allocations/communications will resume on a CC after it is determined e.g. by activation/deactivation signaling or LTE/LTE-A system on or off triggers or expiry of a certain time. Alternatively, the SPS allocations/communications may be resumed with an explicit SPS activation command.

Below, there is given an example which is equally applicable for an eNB-based suspension according to exemplary embodiments of the present invention and an UE-based suspension according to exemplary embodiments of the present invention.

Following e.g. a DL SCC deactivation (e.g. a corresponding message) at subframe index n, the eNB suspends SPS resource allocation for a SPS DL resource suspension window, W_{DL}. At subframe index $n+W_{DL}$, the UE may further pause, thus suspending SPS transmission, for a SPS UL resource suspension window, W_{UL}. Accordingly, SPS DL resource allocation may resume at $n+W_{DL}$ (W_{DL} thus representing a DL suspension period), and SPS UL transmission may resume at $n+W_{DL}+W_{UL}$ ($W_{DL}+W_{UL}$ thus representing an UL suspension period).

Figure 5 shows a schematic diagram illustrating an exemplary SPS suspension based on a pre-configured group-specific SPS configuration according to exemplary embodiments of the present invention.

In Figure 5, two CCs representing SCCs are exemplarily assumed for UL and DL, wherein these two CCs may be part of the group of CCs for which the CC-group-specific SPS configuration according to exemplary embodiments of the present invention is pre-configured.

Figure 5 illustrates how SPS allocation/communication can be paused for some subframes before being resumed. In this example W_{DL} and W_{UL} are equal to 8 subframes and 4 subframes, respectively. Assuming the point in time at which the eNB stops transmitting on broken SCC1, i.e. subframe n (being indicated by the vertical arrow), can be made known to the UE, the timing can be done without ambiguity.

When the stop of transmission on the broken SCC1 is due to a sudden carrier break condition at subframe index n, the eNB may confirm that the DL SCC broke down by a certain deactivation command (e.g. on some other unbroken SCC2). The UE may need e.g. 8 subframes to deactivate the DL SCC1. The UE does not receive anything during that time. When the UE is ready to receive on DL SCC2 at subframe index n+8, it could receive via SPS at this very instant (say within one millisecond), i.e. at subframe index n+9. On the UL, the UE may transmit on UL SCC2 at subframe index n+12 at the earliest.

The values W_{DL} and W_{UL} may be defined as fixed or terminal-specific values, e.g. a fixed/terminal-specific number of subframes, timer values, and the like.

The above-outlined window-based suspension mechanisms according to exemplary embodiments of the present invention may allow solving any SPS suspension ambiguity immediately following determination of a broken CC and before SPS can be resumed on a new CC. Thereby, sort of an implicit "SPS handover" or SPS de-/activation or the like is enabled without the need for an explicit SPS de-activation (for the broken CC) and an explicit SPS activation (for the new CC).

According to exemplary embodiments of the present invention, resource waste in the context of SPS reconfiguration may be avoided with the above-outlined SPS reallocation and/or SPS suspension mechanism.

Another mechanism according to exemplary embodiments of the present invention relates to SPS packet HARQ process recovery based on a CC break. Such mechanism may be based on or associated with any one of the above mechanisms of pre-configuration of a group-specific SPS configuration, SPS reconfiguration based on a CC break, and SPS reallocation and/or SPS suspension based on a CC break according to exemplary embodiments of the present invention.

Figure 6 shows a schematic diagram illustrating an exemplary procedure in terms of SPS packet HARQ process recovery based on a CC break according to exemplary embodiments of the present invention.

As shown in Figure 6, a corresponding procedure according to exemplary embodiments of the present invention, at the eNB side, comprises an operation of discovering a time of the break of the CC, and an operation of recovering automatic repeat request (e.g. HARQ) processes of unacknowledged SPS packets being transmitted or retransmitted on the broken CC. Further, a corresponding procedure according to exemplary embodiments of the present invention, at the UE side, comprises an operation of discovering a time of the break of the CC, and an operation of recovering automatic repeat request (e.g. HARQ) processes of unacknowledged SPS packets being transmitted or retransmitted on the broken CC.

According to exemplary embodiments of the present invention, the CC break time discovery builds a basis for the subsequent automatic repeat request (e.g. HARQ) processes recovery, i.e. the SPS packet re-transmission recovery.

According to exemplary embodiments of the present invention, the CC break time discovery may be accomplished as follows.

On a DL CC, i.e. in the case of break of a DL CC, the DL CC break time discovery may be accomplished by the UE indicating (on an unbroken UL CC) when it assumed the DL CC as broken. This may readily be done e.g. if the UE fails to detect DL L1 control channels such as PCFICH, PHICH, PDCCH. Accordingly, the eNB may discover the break time of a DL CC by acquiring an indication of a time of failure of control channel detection at the UE from the UE on an UL CC, and the UE may discover the break time of a DL CC by detecting a time of failure of control channel detection at the UE.

On an UL CC, i.e. in the case of break of an UL CC, the UL CC break time discovery may be accomplished by the eNB not detecting higher-layer configured transmissions from the UE (e.g. periodic CQI on PUCCH, ACK/NACK on PUCCH, periodic SRS, etc.), and indicating this to the UE (on an unbroken DL CC). Accordingly, the eNB may discover the break time of an UL CC by detecting a time of failure of higher layer transmission detection from the UE, and the UE may discover the break time of an UL CC by acquiring an indication of a time of failure of higher layer transmission detection at the eNB from the eNB on a DL CC.

According to exemplary embodiments of the present invention, the recovering at the eNB comprises recovering automatic repeat request (e.g. HARQ) processes of unacknowledged SPS packets on a broken DL CC, and the recovering at the UE comprises recovering automatic repeat request (e.g. HARQ) processes of unacknowledged SPS packets on a broken UL CC.

The automatic repeat request (e.g. HARQ) processes recovery, i.e. the SPS packet re-transmission recovery, according to exemplary embodiments of the present invention may be accomplished by way of a HARQ buffer flushing rule or an ACK/NACK bitmap rule as follows.

Generally, it is noted that automatic repeat request (e.g. HARQ) processes recovery, i.e. the SPS packet re-transmission recovery, according to exemplary embodiments of the present invention is based on the use of separate HARQ operations per CC (i.e. a mapping of HARQ processes to erroneous packets requiring re-transmission to allow a continuous data flow) for DL HARQ and UL HARQ.

In the HARQ buffer flushing rule according to exemplary embodiments of the present invention, on determination of a broken CC, the packets on the broken CC that were transmitted or re-transmitted following the last ACK/NACK report sent on the CC before determined as broken, i.e. the unacknowledged packets in the HARQ buffer, are transmitted as new transmissions.

If the DL CC is broken, the eNB assumes that all unacknowledged DL packets (e.g. via ACK/NACK on PUCCH or on PUSCH if UE is transmitting data on UL) transmitted or re-transmitted e.g. on the PDSCH on the CC before it was broken would be considered to be not decoded successfully by the UE. The eNB thus transmits these unacknowledged packets e.g. on the PDSCH on the new DL CC as if they were new packets. Accordingly, the eNB may transmit the unacknowledged SPS SL packets being transmitted or retransmitted on the broken DL CC before the DL CC being determined as broken as new transmissions on the other (new) DL CC after the discovered time of the break of the DL CC.

If the UL CC is broken, the UE assumes that all unacknowledged UL packets (e.g. via PHICH) transmitted or re-transmitted e.g. on the PUSCH on the CC before it was broken would be considered to be not decoded successfully by the eNB. The UE thus transmits these unacknowledged packets e.g. on the PUSCH on the new UL CC as if they were new packets. Accordingly, the UE may transmit the unacknowledged SPS UL packets being transmitted or retransmitted on the broken UL CC before the UL CC being determined as broken as new transmissions on the other (new) UL CC after the discovered time of the break of the UL CC.

In this regard, it is noted that, in case unacknowledged packets were successfully decoded at the UE/eNB before broken CC is detected (contrary to the assumptions mentioned above), this does not raise a problem, even if the eNB/UE transmits these packets again on the new CC. This is because the MAC layer multiplexes/demultiplexes the RLC PDUs into/from transport blocks delivered to/from the physical layer on a DL/UL transport (shared) channel, wherein each transport block (TB) is uniquely identified by the

UE/eNB and, hence, they can readily know if a transport block is transmitted again on the new CC (and thus distinguish the newly transmitted transport block from a previously re-/transmitted transport block).

In the ACK/NACK bitmap rule according to exemplary embodiments of the present invention, on determination of a broken CC, a new CC activation message and/or a new CC activation confirmation message contains a bitmap indicating the ACK/NACK for the packets that were transmitted or re-transmitted following CC break determination.

If the DL CC is broken, a new CC activation message sent by the eNB e.g. via MAC CE may contain a bitmap indicating the ACK/NACK for the UL packets transmitted or re-transmitted following the DL CC break determination. Accordingly, the eNB may include, in a signaled activation of another (new) DL CC, an indication of positive and negative acknowledgments for unacknowledged SPS UL packets being transmitted or retransmitted on an UL CC after the DL CC being determined as broken.

If the UL CC is broken, a new CC activation message confirmation from the UE sent e.g. via MAC CE may contain a bitmap indicating the ACK/NACK for the DL packets transmitted or re-transmitted following the UL CC break determination. Accordingly, the UE may include, in an activation confirmation of another (new) UL CC, an indication of positive and negative acknowledgments for unacknowledged SPS DL packets being transmitted or retransmitted on a DL CC after the UL CC being determined as broken.

Another mechanism according to exemplary embodiments of the present invention relates to SPS packet detection failure. Such mechanism may be based on or associated with any one of the above mechanisms of pre-configuration of a group-specific SPS configuration, SPS reconfiguration based on a CC break, SPS reallocation and/or SPS suspension based on a CC break, and SPS packet HARQ process recovery based on a CC break according to exemplary embodiments of the present invention.

Figure 7 shows a schematic diagram illustrating an exemplary procedure in terms of SPS packet detection failure according to exemplary embodiments of the present invention.

As shown in Figure 7, a corresponding procedure according to exemplary embodiments of the present invention, at the eNB side, comprises an operation of recognizing failure to detect SPS packets for an allocation error period, an operation of reconfiguring or releasing the group-specific semi-persistent scheduling configuration (as established in the mechanisms according to Figure 1), and an operation of signaling the reconfigured group-specific semi-persistent scheduling configuration or the release thereof to the terminal (i.e. the UE). Further, a corresponding procedure according to exemplary embodiments of the present invention, at the UE side, comprises an operation of receiving the reconfigured group-specific semi-persistent scheduling configuration or the release thereof from an access point (i.e. the eNB), and an operation of setting up the reconfigured group-specific semi-persistent scheduling configuration or the release thereof.

According to exemplary embodiments of the present invention, the above mechanism may provide for signaling failure or other error case handling.

Such signaling failure or other error case handling according to exemplary embodiments of the present invention is based on the fact that the eNB and the UE will expect to receive some SPS packets when SPS is used. Accordingly, in case the UE fails to get the (CC-group-specific) SPS configuration across aggregated CCs or gets it wrong, no (appropriate) SPS packets will be transmitted to the eNB. Then, after failing to detect SPS packets from the UE for some time, i.e. an allocation error period, the eNB may either reconfigure or release the (CC-group-specific) SPS configuration (i.e. the corresponding resources).

According to exemplary embodiments of the present invention, the allocation error period may be based on an erroneous (CC-group) SPS allocation time/timer, and/or the reconfiguration or release of the (CC-group-specific) SPS configuration may be accomplished via RRC signaling.

In the above description, when reference is made to a component carrier, the component carrier may correspond to any one of a primary and a secondary component carrier for carrier aggregation, and the component carrier may be operable on any one of a licensed and an unlicensed frequency band. Accordingly, exemplary embodiments of the present invention are readily applicable for both hybrid and standalone utilization approaches, i.e. in both hybrid and standalone utilization (e.g. LTE/LTE-A) communication systems. Irrespective thereof, exemplary embodiments of the present invention may be most effective for/in a standalone utilization (e.g. LTE/LTE-A) communication system and/or a hybrid utilization (e.g. LTE/LTE-A) communication system with respect to component carriers being operable on an unlicensed band.

Generally, the above-described procedures and functions may be implemented by respective functional elements, processors, or the like, as described below.

While in the foregoing exemplary embodiments of the present invention are described mainly with reference to methods, procedures and functions, corresponding exemplary embodiments of the present invention also cover respective apparatuses, network nodes and systems, including both software and/or hardware thereof.

Respective exemplary embodiments of the present invention are described below referring to Figure 8, while for the sake of brevity reference is made to the detailed description with regard to Figures 1 to 7.

In Figure 8 below, which is noted to represent a simplified block diagram, the solid line blocks are basically configured to perform respective operations as described above. The entirety of solid line blocks are basically configured to perform the methods and operations as described above, respectively. With respect to Figure 8, it is to be noted that the individual blocks are meant to illustrate respective functional blocks implementing a respective function, process or procedure, respectively. Such functional blocks are implementation-independent, i.e. may be implemented by means of any kind of hardware or software, respectively. The arrows and lines interconnecting individual blocks are meant to illustrate an operational coupling there-between, which may be a physical and/or logical coupling, which on the one hand is implementation-independent (e.g. wired or wireless) and on the other hand may also comprise an arbitrary number of intermediary functional entities not shown. The direction of arrow is meant to illustrate the direction in which certain operations are performed and/or the direction in which certain data is transferred.

Further, in Figure 8, only those functional blocks are illustrated, which relate to any one of the above-described methods, procedures and functions. A skilled person will acknowledge the presence of any other conventional functional blocks required for an operation of respective structural arrangements, such as e.g. a power supply, a central processing unit, respective memories or the like. Among others, memories are provided for storing programs or program instructions for controlling the individual functional entities to operate as described herein.

Figure 8 shows a schematic block diagram illustrating exemplary apparatuses according to exemplary embodiments of the present invention.

In view of the above, the thus illustrated apparatuses 10 and 20 are suitable for use in practicing the exemplary embodiments of the present invention, as described herein.

The thus illustrated apparatus 10 may represent a (part of a) network entity such as an access point or base station entity, e.g. an eNB or a modem (which may be installed as part of the eNB, but may be also a separate module, which can be attached to various devices, as described above), and may be configured to perform a procedure and/or functionality as described in conjunction with any one of Figures 1 to 7. The thus illustrated apparatus 20 may represent a (part of a) terminal entity such as a terminal or user equipment entity, e.g. an UE or MS or a modem (which may be installed as part of the UE or MS, but may be also a separate module, which can be attached to various devices, as described above), and may be configured to perform a procedure and/or functionality as described in conjunction with any one of Figures 1 to 7.

As indicated in Figure 8, according to exemplary embodiments of the present invention, each of the apparatuses comprises a processor 11/22, a memory 12/22 and an interface 13/23, which are connected by a bus 14/24 or the like, and the apparatuses may be connected via a link 30. The link 30 may be a physical and/or logical coupling, which on the one hand is implementation-independent (e.g. wired or wireless) and on the other hand may also comprise an arbitrary number of intermediary functional entities not shown in Figure 8.

The processor 11/21 and/or the interface 13/23 may be facilitated for communication over a (hardwire or wireless) link, respectively. The interface 13/23 may comprise a suitable receiver or a suitable transmitter-receiver combination or transceiver, which is coupled to one or more antennas or communication means for (hardwire or wireless) communications with the linked or connected device(s), respectively. The interface 13/23 is generally configured to communicate with another apparatus, i.e. the interface thereof.

The memory 12/22 may store respective programs assumed to include program instructions or computer program code that, when executed by the respective processor, enables the respective electronic device or apparatus to operate in accordance with the exemplary embodiments of the present invention. For example, the memory 12 of the apparatus 10 and/or the memory 22 of the apparatus 20 may store the pre-configured CC-group-specific SPS configuration.

In general terms, the respective devices/apparatuses (and/or parts thereof) may represent means for performing respective operations and/or exhibiting respective functionalities, and/or the respective devices (and/or parts thereof) may have functions for performing respective operations and/or exhibiting respective functionalities.

When in the subsequent description it is stated that the processor (or some other means) is configured to perform some function, this is to be construed to be equivalent to a description stating that at least one processor, potentially in cooperation with computer program code stored in the memory of the respective apparatus, is configured to cause the apparatus to perform at least the thus mentioned function. Also, such function is to be construed to be equivalently implementable by specifically configured means for performing the respective function (i.e. the expression "processor configured to [cause the apparatus to] perform xxx-ing" is construed to be equivalent to an expression such as "means for xxx-ing").

According to exemplary embodiments of the present invention, an apparatus representing the apparatus 10 comprises at least one processor 11, at least one memory 12 including computer program code, and at least one interface 13 configured for communication with at least another apparatus. The apparatus 10, i.e. the processor (namely, the at least one processor 11, with the at least one memory 12 and the computer program code), is configured to perform establishing a group-specific semi-persistent scheduling configuration for a group of component carriers for carrier aggregation for a terminal of a cellular communication system, said group-specific semi-persistent scheduling configuration comprising a carrier-specific semi-persistent scheduling configuration for each component carrier of the group, and signaling the group-specific semi-persistent scheduling configuration to the terminal of a cellular communication system.

In its most basic form, stated in other words, the apparatus 10 may thus comprise respective means for establishing and means for signaling.

As outlined above, in enhanced forms, the apparatus 10 may comprise one or more of respective means for determining and means for signaling, means for allocating, means for suspending, means for discovering and means for recovering, means for transmitting, means for including, and means for recognizing and means for reconfiguring or releasing and means for signaling.

According to exemplary embodiments of the present invention, an apparatus representing the apparatus 20 comprises at least one processor 21, at least one memory 22 including computer program code, and at least one interface 23 configured for communication with at least another apparatus. The apparatus 20, i.e. the processor (namely, the at least one processor 21, with the at least one memory 22 and the computer program code), is configured to perform receiving a group-specific semi-persistent scheduling configuration for a group of component carriers for carrier aggregation for a terminal of a cellular communication system from an access point of the cellular communication system, said group-specific semi-persistent scheduling configuration comprising a carrier-specific semi-persistent scheduling configuration for each component carrier of the group, and setting up the group-specific semi-persistent scheduling configuration at the terminal of a cellular communication system.

In its most basic form, stated in other words, the apparatus 20 may thus comprise respective means for receiving and means for setting up.

As outlined above, in enhanced forms, the apparatus 20 may comprise one or more of respective means for determining and means for deactivating and activating, means for suspending, means for discovering and means for recovering, means for transmitting, and means for including.

For further details of specifics regarding functionalities according to exemplary embodiments of the present invention, reference is made to the foregoing description in conjunction with Figures 1 to 7.

According to exemplarily embodiments of the present invention, a system may comprise any conceivable combination of the thus depicted devices/apparatuses and other network elements, which are configured to cooperate as described above.

In general, it is to be noted that respective functional blocks or elements according to above-described aspects can be implemented by any known means, either in hardware and/or software, respectively, if it is only adapted to perform the described functions of the respective parts. The mentioned method steps can be realized in individual functional blocks or by individual devices, or one or more of the method steps can be realized in a single functional block or by a single device.

Generally, any structural means such as a processor or other circuitry may refer to one or more of the following: (a) hardware-only circuit implementations (such as implementations in only analog and/or digital circuitry) and (b) combinations of circuits and software (and/or firmware), such as (as applicable): (i) a combination of processor(s) or (ii) portions of processor(s)/software (including digital signal processor(s)), software, and memory(ies) that work together to cause an apparatus, such as a mobile phone or server, to perform various functions) and (c) circuits, such as a microprocessor(s) or a portion of a microprocessor(s), that require software or firmware for operation, even if the software or firmware is not physically present. Also, it may also cover an implementation of merely a processor (or multiple processors) or portion of a processor and its (or their) accompanying software and/or firmware, any integrated circuit, or the like.

Generally, any procedural step or functionality is suitable to be implemented as software or by hardware without changing the idea of the present invention. Such software may be software code independent and can be specified using any known or future developed programming language, such as e.g. Java, C++, C, and Assembler, as long as the functionality defined by the method steps is preserved. Such hardware may be hardware type independent and can be implemented using any known or future developed hardware technology or any hybrids of these, such as MOS (Metal Oxide Semiconductor), CMOS (Complementary MOS), BiMOS (Bipolar MOS), BiCMOS (Bipolar CMOS), ECL (Emitter Coupled Logic), TTL (Transistor-Transistor Logic), etc., using for example ASIC (Application Specific IC (Integrated Circuit)) components, FPGA (Field-programmable Gate Arrays) components, CPLD (Complex Programmable Logic Device) components or

DSP (Digital Signal Processor) components. A device/apparatus may be represented by a semiconductor chip, a chipset, system in package, or a (hardware) module comprising such chip or chipset; this, however, does not exclude the possibility that a functionality of a device/apparatus or module, instead of being hardware implemented, be implemented as software in a (software) module such as a computer program or a computer program product comprising executable software code portions for execution/being run on a processor. A device may be regarded as a device/apparatus or as an assembly of more than one device/apparatus, whether functionally in cooperation with each other or functionally independently of each other but in a same device housing, for example.

Apparatuses and/or means or parts thereof can be implemented as individual devices, but this does not exclude that they may be implemented in a distributed fashion throughout the system, as long as the functionality of the device is preserved. Such and similar principles are to be considered as known to a skilled person.

Software in the sense of the present description comprises software code as such comprising code means or portions or a computer program or a computer program product for performing the respective functions, as well as software (or a computer program or a computer program product) embodied on a tangible medium such as a computer-readable (storage) medium having stored thereon a respective data structure or code means/portions or embodied in a signal or in a chip, potentially during processing thereof.

The present invention also covers any conceivable combination of method steps and operations described above, and any conceivable combination of nodes, apparatuses, modules or elements described above, as long as the above-described concepts of methodology and structural arrangement are applicable.

In view of the above, the present invention and/or exemplary embodiments thereof provide measures for enabling semi-persistent scheduling reconfiguration in carrier aggregation. Such measures may exemplarily comprise pre-configuring, by an access point, a terminal with a group-specific semi-persistent scheduling configuration for a group of component carriers for carrier aggregation for the terminal, said group-specific semi-persistent scheduling configuration comprising a carrier-specific semi-persistent scheduling configuration for each component carrier of the group.

The measures according to exemplary embodiments of the present invention may be applied for any kind of network environment, such as for example for communication systems in accordance with any one of 3GPP standards, LTE standards of release 10/11/12/... (including LTE-Advanced and its evolutions), UMTS standards, and WCDMA standards. In particular, the measures according to exemplary embodiments of the present invention may be applied to carrier aggregation which is a feature e.g. of 3GPP LTE standards of release 10/11/12 and onwards.

Even though the present invention and/or exemplary embodiments are described above with reference to the examples according to the accompanying drawings, it is to be understood that they are not restricted thereto. Rather, it is apparent to those skilled in the art that the present invention can be modified in many ways without departing from the scope of the inventive idea as disclosed herein.

List of acronyms and abbreviations

3GPP	Third Generation Partnership Project
CC	Component Carrier
CCE	Channel Element
CQI	Channel Quality Information
DL	Downlink
eNB	evolved Node B (E-UTRAN base station)
HARQ	Hybrid Automatic Repeat Request
HTML	Hypertext Markup Language
IP	Internet Protocol
LTE	Long Term Evolution

LTE-A	Long Term Evolution Advanced
MAC	Medium Access Control
MS	Mobile Station
PCC	Primary Cell Carrier
PCFICH	Physical Control Format Indicator Channel
PDCCH	Physical Downlink Control Channel
PDSCH	Physical Downlink Shared Channel
PDU	Packet Data Unit
PHICH	Physical HARQ Indicator Channel
PRB	Physical Resource Block
PS	Packet Scheduling
PUCCH	Physical UL Control Channel
PUSCH	Physical UL Shared Channel
RLC	Radio Link Control
RRC	Radio Resource Control
SCC	Secondary Cell Carrier
SFN	System Frame Number
SPS	Semi-persistent (Packet) Scheduling
SRS	Sounding Reference Signal
TB	Transport Block
UE	User Equipment
UL	Uplink
UMTS	Universal Mobile Telecommunications System
VoIP	Voice over IP
WCDMA	Wideband Code Division Multiple Access

What is claimed is:

1. A method comprising

establishing a group-specific semi-persistent scheduling configuration for a group of component carriers for carrier aggregation for a terminal of a cellular communication system, said group-specific semi-persistent scheduling configuration comprising a carrier-specific semi-persistent scheduling configuration for each component carrier of the group, and

signaling the group-specific semi-persistent scheduling configuration to the terminal of a cellular communication system.

2. The method according to claim 1, wherein the group-specific semi-persistent scheduling configuration comprises at least one of downlink and uplink semi-persistent scheduling assignment of physical resource blocks on the component carriers.

3. The method according to claim 1 or 2, further comprising

determining a break of a component carrier of the terminal, and

signaling deactivation of the broken component carrier and activation of another component carrier among the component carriers of the group-specific semi-persistent scheduling configuration.

4. The method according to claim 3, further comprising

allocating physical resource blocks of a semi-persistent scheduling assignment on the broken component carrier to another terminal of the cellular communication system by dynamical scheduling.

5. The method according to claim 3 or 4, further comprising

suspending, from a time of the deactivation of the broken component carrier, allocation of physical resource blocks of a downlink semi-persistent scheduling assignment on the other component carrier for a downlink suspension period and allocation of physical resource blocks of an uplink semi-persistent scheduling assignment on the other component carrier for an uplink suspension period.

6. The method according to claim 5, wherein

the uplink suspension period is longer than the downlink suspension period, and/or

the uplink suspension period and the downlink suspension period represent a fixed or terminal-specific value of a number of physical resource blocks or a time for semi-persistent scheduling suspension.

7. The method according to any one of claims 3 to 6, further comprising

discovering a time of the break of the component carrier,

recovering automatic repeat request processes of unacknowledged semi-persistent scheduling packets being transmitted or retransmitted on the broken component carrier.

8. The method according to claim 7, wherein the break time discovering comprises

discovering the break time of a downlink component carrier by acquiring an indication of a time of failure of control channel detection at the terminal from the terminal on an uplink component carrier, and/or

discovering the break time of an uplink component carrier by detecting a time of failure of higher layer transmission detection from the terminal.

9. The method according to claim 7 or 8, wherein the recovering comprises recovering automatic repeat request processes of unacknowledged semi-persistent scheduling packets on a broken downlink component carrier by

transmitting the unacknowledged semi-persistent scheduling downlink packets being transmitted or retransmitted on the broken downlink component carrier before the downlink component carrier being determined as broken as new transmissions on the other downlink component carrier after the discovered time of the break of the downlink component carrier, or

including, in the signaled activation of the other component carrier, an indication of positive and negative acknowledgments for unacknowledged semi-persistent scheduling uplink packets being transmitted or retransmitted on an uplink component carrier after the downlink component carrier being determined as broken.

10. The method according to any one of claims 1 to 9, further comprising

recognizing failure to detect semi-persistent scheduling packets for an allocation error period,

reconfiguring or releasing the group-specific semi-persistent scheduling configuration, and

signaling the reconfigured group-specific semi-persistent scheduling configuration or the release thereof to the terminal.

11. The method according to any one claims 1 to 10, wherein

the method is operable at or by an access node, base station or modem of the cellular communication system, and/or

the method is operable in at least one of a LTE and a LTE-A cellular system, and/or

the component carriers correspond to primary and/or secondary component carriers for carrier aggregation, and/or

the component carriers comprise component carriers operable on an unlicensed frequency band.

12. A method comprising

receiving a group-specific semi-persistent scheduling configuration for a group of component carriers for carrier aggregation for a terminal of a cellular communication system from an access point of the cellular communication system, said group-specific semi-persistent scheduling configuration comprising a carrier-specific semi-persistent scheduling configuration for each component carrier of the group, and

setting up the group-specific semi-persistent scheduling configuration at the terminal of a cellular communication system.

13. The method according to claim 12, wherein the group-specific semi-persistent scheduling configuration comprises at least one of downlink and uplink semi-persistent scheduling assignment of physical resource blocks on the component carriers.

14. The method according to claim 12 or 13, further comprising

determining a break of a component carrier of the terminal, and

deactivating a semi-persistent scheduling assignment of physical resource blocks on the broken component carrier, and activating a semi-persistent scheduling assignment of physical resource blocks on another active component carrier among the component carriers of the group-specific semi-persistent scheduling configuration.

15. The method according to claim 14, further comprising

suspending, from a time of the deactivation of the semi-persistent scheduling assignment of physical resource blocks on the broken component carrier, reception in physical resource blocks of a downlink semi-persistent scheduling assignment on the other active component carrier for a downlink suspension period and transmission in physical resource blocks of an uplink semi-persistent scheduling assignment on the other active component carrier for an uplink suspension period.

16. The method according to claim 15, wherein

the uplink suspension period is longer than the downlink suspension period, and/or

the uplink suspension period and the downlink suspension period represent a fixed or terminal-specific value of a number of physical resource blocks or a time for semi-persistent scheduling suspension.

17. The method according to any one of claims 14 to 16, further comprising

discovering a time of the break of the component carrier,

recovering automatic repeat request processes of unacknowledged semi-persistent scheduling packets being transmitted or retransmitted on the broken component carrier.

18. The method according to claim 17, wherein the break time discovering comprises

discovering the break time of a downlink component carrier by detecting a time of failure of control channel detection at the terminal, and/or

discovering the break time of an uplink component carrier by acquiring an indication of a time of failure of higher layer transmission detection at the access point from the access point on a downlink component carrier.

19. The method according to claim 17 or 18, wherein the recovering comprises recovering automatic repeat request processes of unacknowledged semi-persistent scheduling packets on a broken uplink component carrier by

transmitting the unacknowledged semi-persistent scheduling uplink packets being transmitted or retransmitted on the broken uplink component carrier before the uplink component carrier being determined as broken as new transmissions on the other uplink component carrier after the discovered time of the break of the uplink component carrier, or

including, in an activation confirmation of the other component carrier being signaled to the access point, an indication of positive and negative acknowledgments for unacknowledged semi-persistent scheduling downlink packets being transmitted or retransmitted on a downlink component carrier after the uplink component carrier being determined as broken.

20. The method according to any one claims 12 to 19, wherein

the method is operable at or by a terminal or user equipment or modem of the cellular communication system, and/or

the method is operable in at least one of a LTE and a LTE-A cellular system, and/or

the component carriers correspond to primary and/or secondary component carriers for carrier aggregation, and/or

the component carriers comprise component carriers operable on an unlicensed frequency band.

21. An apparatus comprising

at least one processor,

at least one memory including computer program code, and

at least one interface configured for communication with at least another apparatus,

the at least one processor, with the at least one memory and the computer program code, being configured to cause the apparatus to perform:

establishing a group-specific semi-persistent scheduling configuration for a group of component carriers for carrier aggregation for a terminal of a cellular communication system, said group-specific semi-persistent scheduling configuration comprising a carrier-specific semi-persistent scheduling configuration for each component carrier of the group, and

signaling the group-specific semi-persistent scheduling configuration to the terminal of a cellular communication system.

22. The apparatus according to claim 21, wherein the group-specific semi-persistent scheduling configuration comprises at least one of downlink and uplink semi-persistent scheduling assignment of physical resource blocks on the component carriers.

23. The apparatus according to claim 21 or 22, further configured to perform:

determining a break of a component carrier of the terminal, and

signaling deactivation of the broken component carrier and activation of another component carrier among the component carriers of the group-specific semi-persistent scheduling configuration.

24. The apparatus according to claim 23, further configured to perform:

allocating physical resource blocks of a semi-persistent scheduling assignment on the broken component carrier to another terminal of the cellular communication system by dynamical scheduling.

25. The apparatus according to claim 23 or 24, further configured to perform:

suspending, from a time of the deactivation of the broken component carrier, allocation of physical resource blocks of a downlink semi-persistent scheduling assignment on the other component carrier for a downlink suspension period and allocation of physical resource blocks of an uplink semi-persistent scheduling assignment on the other component carrier for an uplink suspension period.

26. The apparatus according to claim 25, wherein

the uplink suspension period is longer than the downlink suspension period, and/or

the uplink suspension period and the downlink suspension period represent a fixed or terminal-specific value of a number of physical resource blocks or a time for semi-persistent scheduling suspension.

27. The apparatus according to any one of claims 23 to 26, further configured to perform:

discovering a time of the break of the component carrier,

recovering automatic repeat request processes of unacknowledged semi-persistent scheduling packets being transmitted or retransmitted on the broken component carrier.

28. The apparatus according to claim 27, further configured to perform in the break time discovering:

discovering the break time of a downlink component carrier by acquiring an indication of a time of failure of control channel detection at the terminal from the terminal on an uplink component carrier, and/or

discovering the break time of an uplink component carrier by detecting a time of failure of higher layer transmission detection from the terminal.

29. The apparatus according to claim 27 or 28, further configured to perform, in the recovering, recovering automatic repeat request processes of unacknowledged semi-persistent scheduling packets on a broken downlink component carrier by

transmitting the unacknowledged semi-persistent scheduling downlink packets being transmitted or retransmitted on the broken downlink component carrier before the downlink component carrier being determined as broken as new transmissions on the other downlink component carrier after the discovered time of the break of the downlink component carrier, or

including, in the signaled activation of the other component carrier, an indication of positive and negative acknowledgments for unacknowledged semi-persistent scheduling uplink packets being transmitted or retransmitted on an uplink component carrier after the downlink component carrier being determined as broken.

30. The apparatus according to any one of claims 21 to 29, configured to perform:

recognizing failure to detect semi-persistent scheduling packets for an allocation error period,

reconfiguring or releasing the group-specific semi-persistent scheduling configuration, and

signaling the reconfigured group-specific semi-persistent scheduling configuration or the release thereof to the terminal.

31. The apparatus according to any one claims 21 to 30, wherein

the apparatus is operable as or at an access node, base station or modem of the cellular communication system, and/or

the apparatus is operable in at least one of a LTE and a LTE-A cellular system, and/or

the component carriers correspond to primary and/or secondary component carriers for carrier aggregation, and/or

the component carriers comprise component carriers operable on an unlicensed frequency band.

32. An apparatus comprising

at least one processor,

at least one memory including computer program code, and at least one interface configured for communication with at least another apparatus,

the at least one processor, with the at least one memory and the computer program code, being configured to cause the apparatus to perform:

receiving a group-specific semi-persistent scheduling configuration for a group of component carriers for carrier aggregation for a terminal of a cellular communication system from an access point of the cellular communication system, said group-specific semi-persistent scheduling configuration comprising a carrier-specific semi-persistent scheduling configuration for each component carrier of the group, and

setting up the group-specific semi-persistent scheduling configuration at the terminal of a cellular communication system.

33. The apparatus according to claim 32, wherein the group-specific semi-persistent scheduling configuration comprises at least one of downlink and uplink semi-persistent scheduling assignment of physical resource blocks on the component carriers.

34. The apparatus according to claim 32 or 33, further configured to perform:

determining a break of a component carrier of the terminal, and

deactivating a semi-persistent scheduling assignment of physical resource blocks on the broken component carrier, and activating a semi-persistent scheduling assignment of physical resource blocks on another active component carrier among the component carriers of the group-specific semi-persistent scheduling configuration.

35. The apparatus according to claim 34, further configured to perform:

suspending, from a time of the deactivation of the semi-persistent scheduling assignment of physical resource blocks on the broken component carrier, reception in physical resource blocks of a downlink semi-persistent scheduling assignment on the other active component carrier for a downlink suspension period and transmission in physical resource blocks of an uplink semi-persistent scheduling assignment on the other active component carrier for an uplink suspension period.

36. The apparatus according to claim 35, wherein

the uplink suspension period is longer than the downlink suspension period, and/or

the uplink suspension period and the downlink suspension period represent a fixed or terminal-specific value of a number of physical resource blocks or a time for semi-persistent scheduling suspension.

37. The apparatus according to any one of claims 34 to 36, further configured to perform:

discovering a time of the break of the component carrier,

recovering automatic repeat request processes of unacknowledged semi-persistent scheduling packets being transmitted or retransmitted on the broken component carrier.

38. The apparatus according to claim 37, further configured to perform in the break time discovering:

discovering the break time of a downlink component carrier by detecting a time of failure of control channel detection at the terminal, and/or

discovering the break time of an uplink component carrier by acquiring an indication of a time of failure of higher layer transmission detection at the access point from the access point on a downlink component carrier.

39. The apparatus according to claim 37 or 38, further configured to perform, in the recovering, recovering automatic repeat request processes of unacknowledged semi-persistent scheduling packets on a broken uplink component carrier by

transmitting the unacknowledged semi-persistent scheduling uplink packets being transmitted or retransmitted on the broken uplink component carrier before the uplink component carrier being determined as broken as new transmissions on the other uplink component carrier after the discovered time of the break of the uplink component carrier, or

including, in an activation confirmation of the other component carrier being signaled to the access point, an indication of positive and negative acknowledgments for unacknowledged semi-persistent scheduling downlink packets being transmitted or retransmitted on a downlink component carrier after the uplink component carrier being determined as broken.

40. The apparatus according to any one claims 32 to 39, wherein

the apparatus is operable as or at a terminal or user equipment or modem of the cellular communication system, and/or

the apparatus is operable in at least one of a LTE and a LTE-A cellular system, and/or

the component carriers correspond to primary and/or secondary component carriers for carrier aggregation, and/or

the component carriers comprise component carriers operable on an unlicensed frequency band.

41. A computer program product comprising computer-executable computer program code which, when the program is run on a computer, is configured to cause the computer to carry out the method according to any one of claims 1 to 11 or any one of claims 12 to 20.

42. The computer program product according to claim 41, embodied as a computer-readable storage medium.

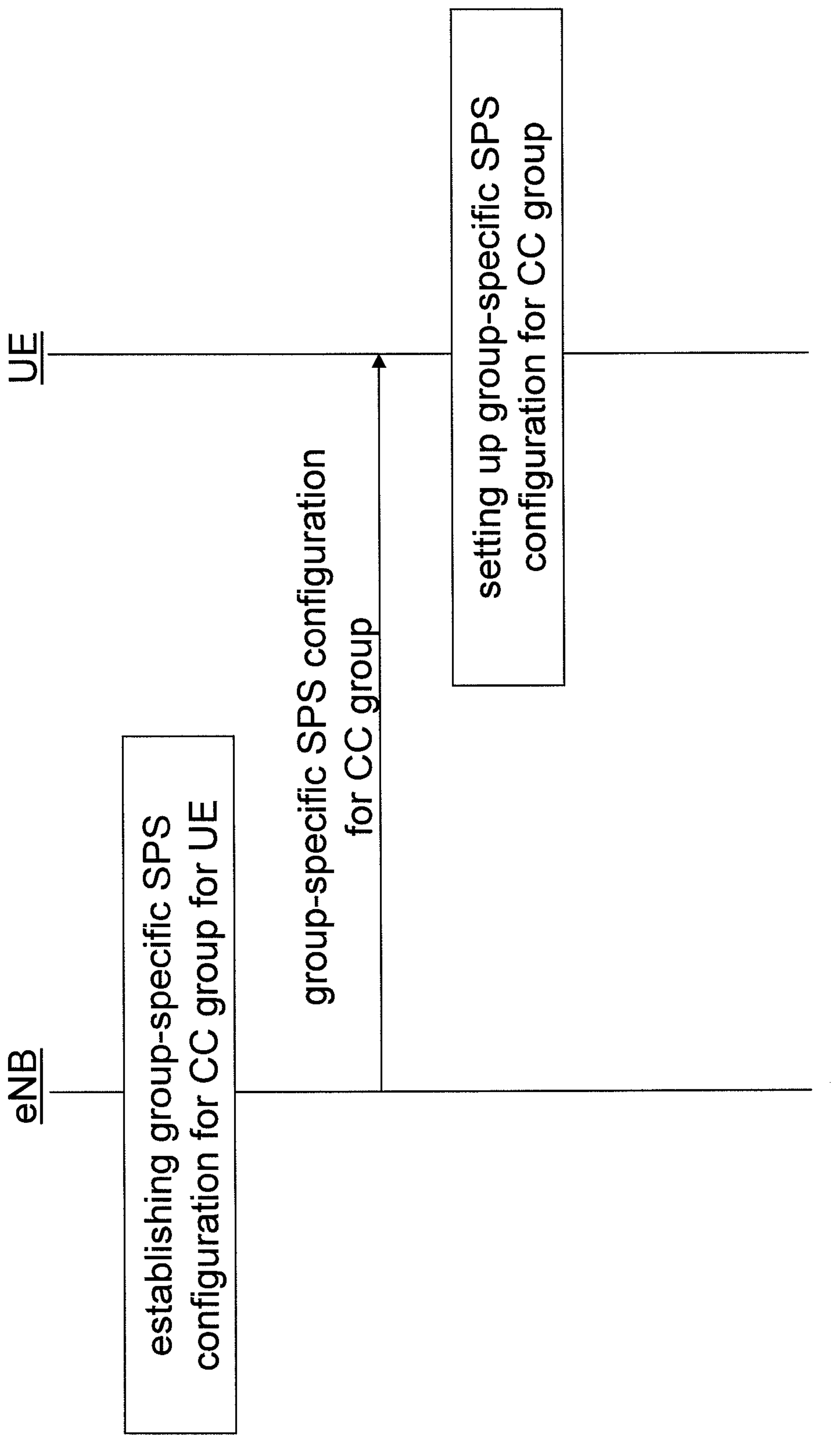
eNB
UE
establishing group-specific SPS configuration for CC group for UE
group-specific SPS configuration for CC group
setting up group-specific SPS configuration for CC group

Figure 1

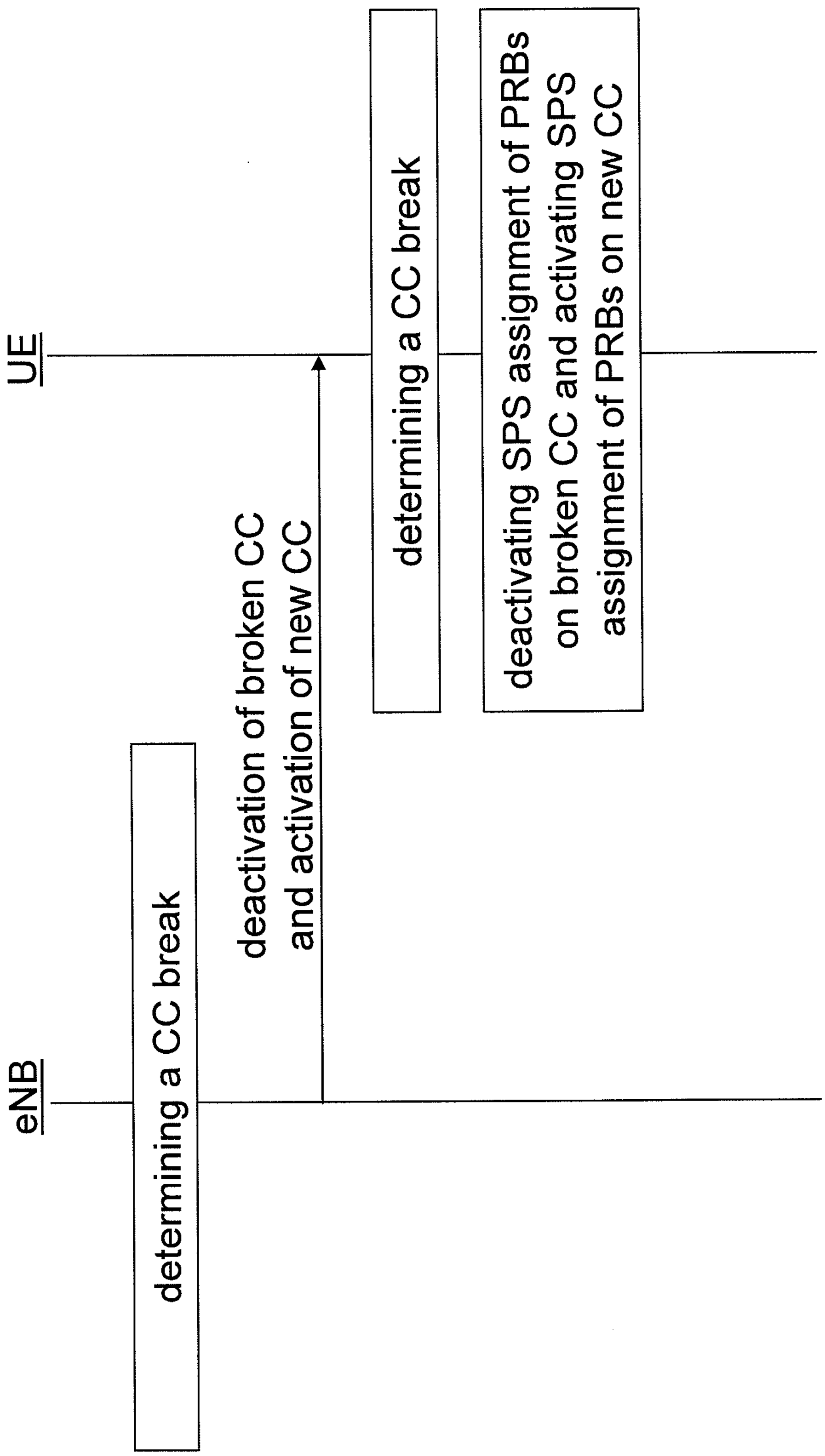
eNB
UE
determining a CC break
deactivation of broken CC
and activation of new CC
determining a CC break
deactivating SPS assignment of PRBs
on broken CC and activating SPS
assignment of PRBs on new CC

Figure 2

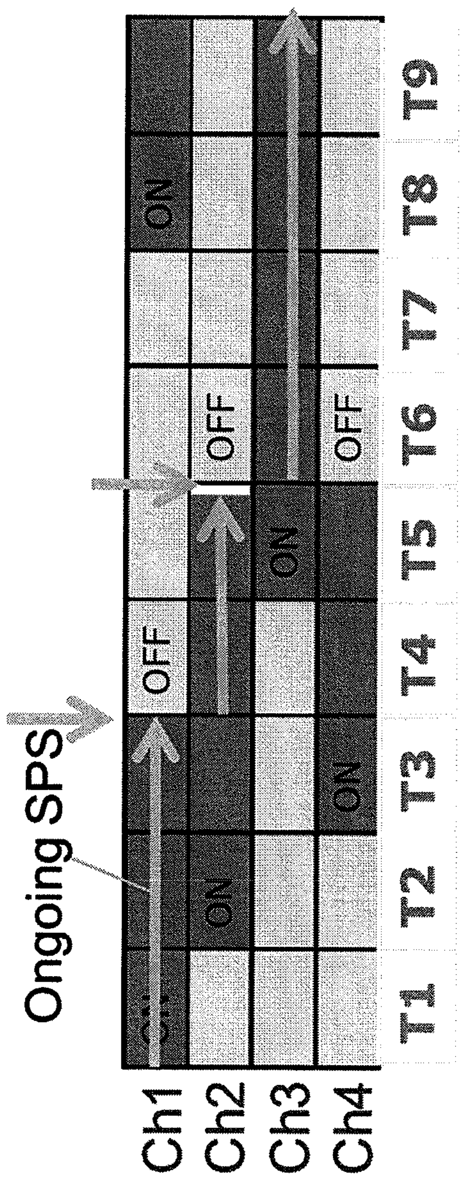
Ongoing SPS
Ch1
Ch2
Ch3
Ch4
T1
T2
T3
T4
T5
T6
T7
T8
T9
ON
ON
OFF
ON
OFF
OFF
ON

Figure 3

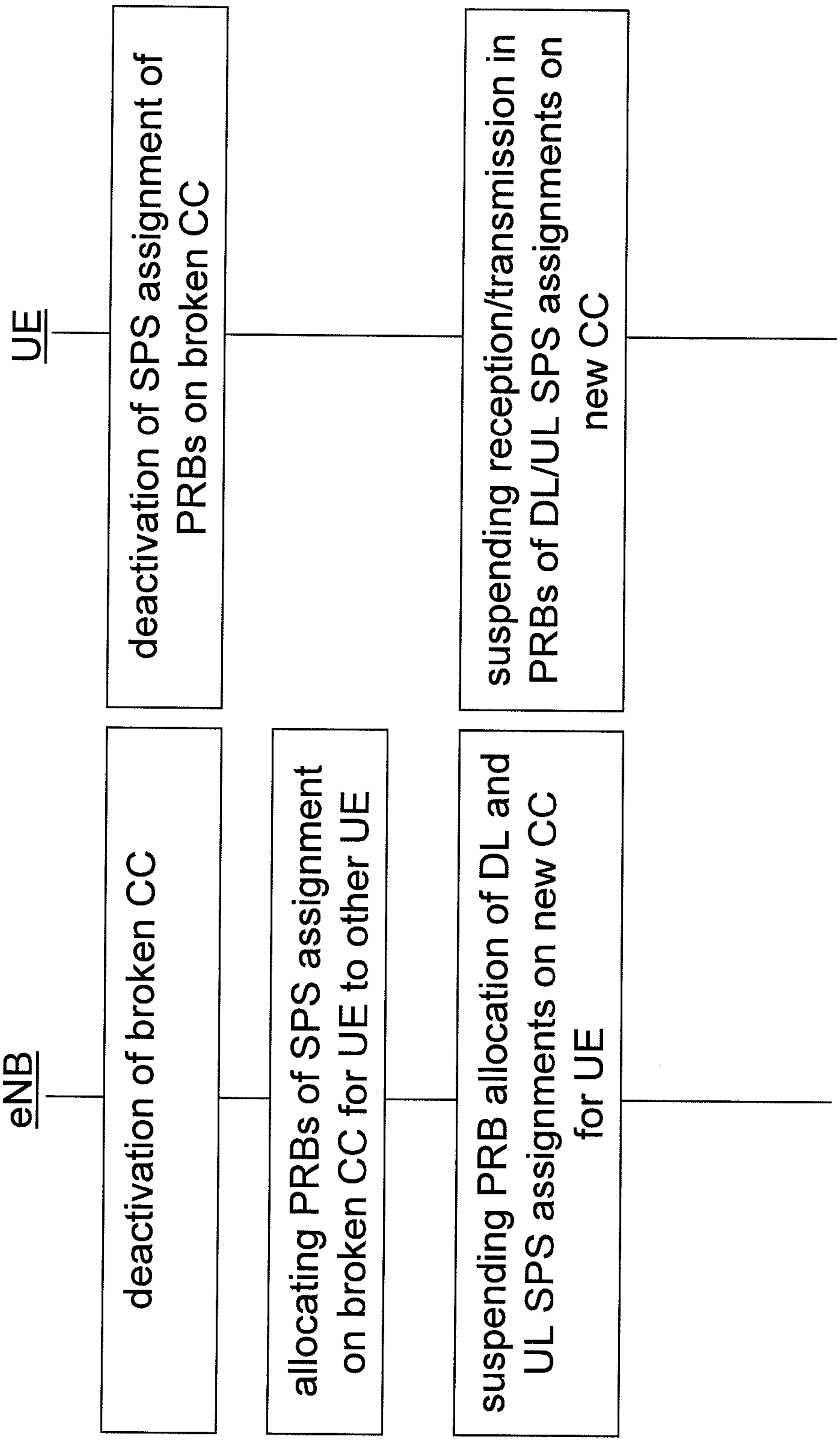
eNB
deactivation of broken CC
allocating PRBs of SPS assignment on broken CC for UE to other UE
suspending PRB allocation of DL and UL SPS assignments on new CC for UE
UE
deactivation of SPS assignment of PRBs on broken CC
suspending reception/transmission in PRBs of DL/UL SPS assignments on new CC

Figure 4

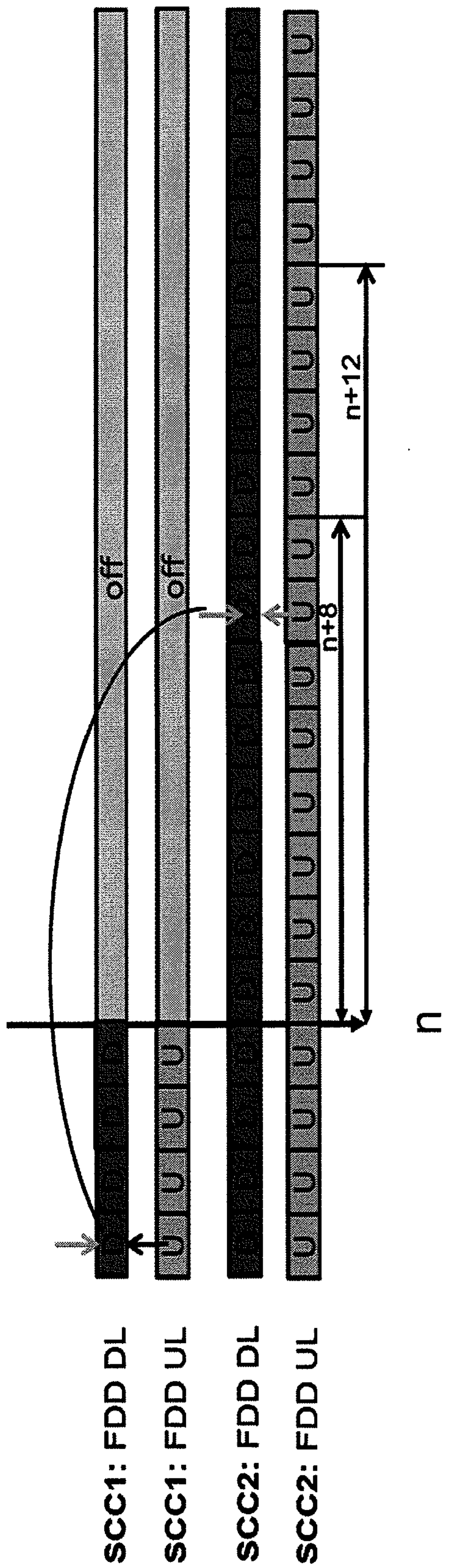

Figure 5

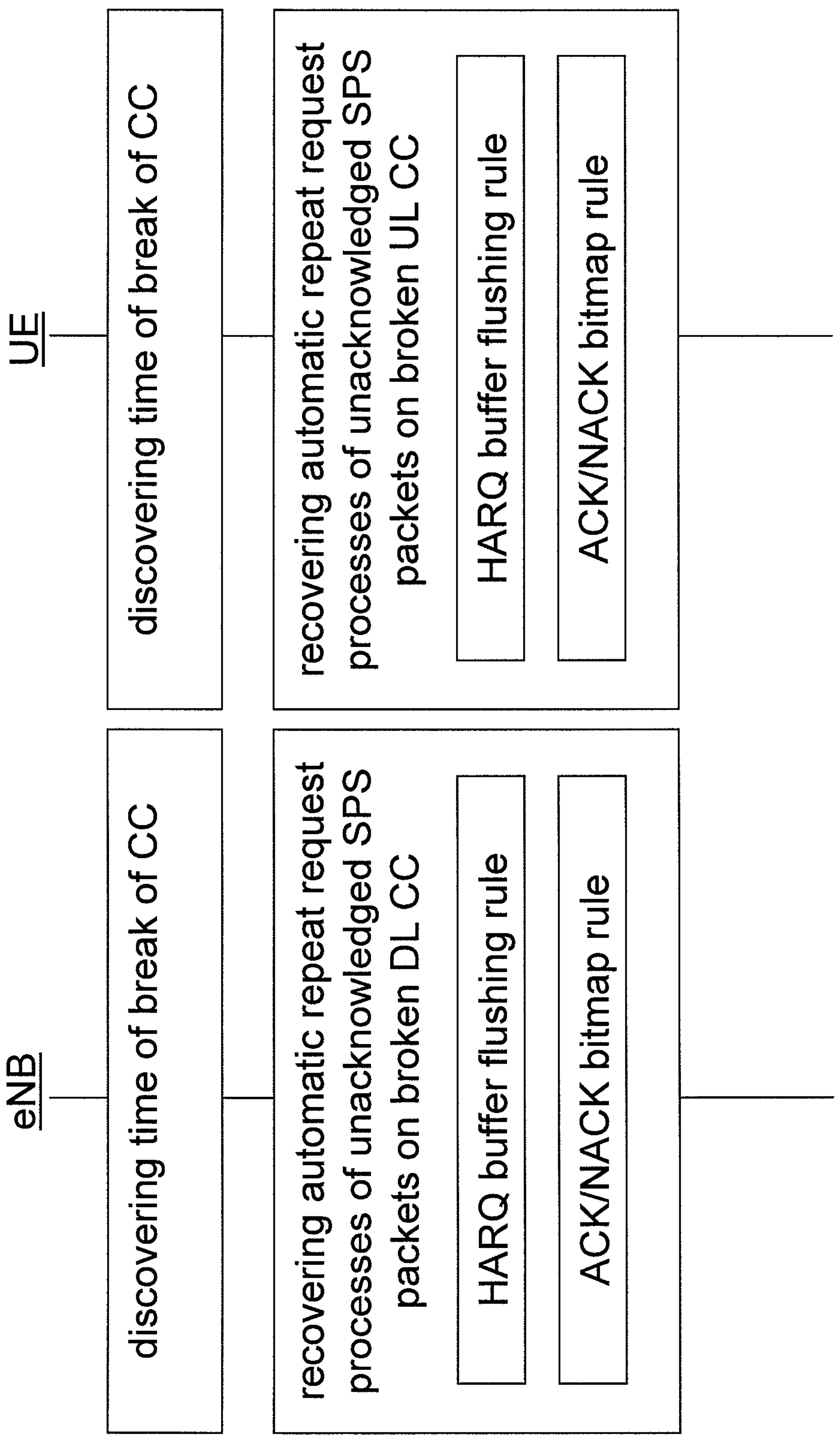
eNB
discovering time of break of CC
recovering automatic repeat request processes of unacknowledged SPS packets on broken DL CC
HARQ buffer flushing rule
ACK/NACK bitmap rule
UE
discovering time of break of CC
recovering automatic repeat request processes of unacknowledged SPS packets on broken UL CC
HARQ buffer flushing rule
ACK/NACK bitmap rule

Figure 6

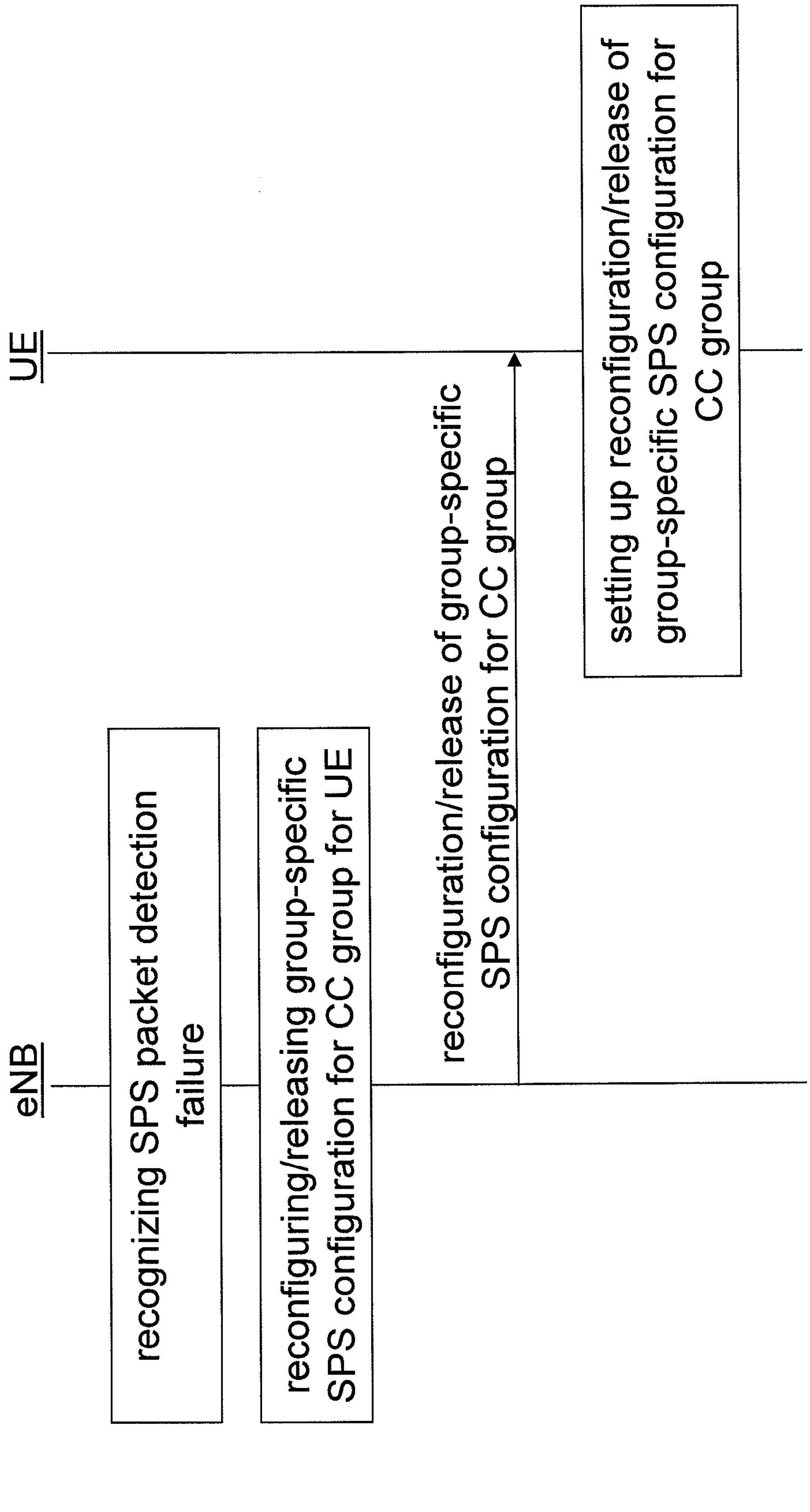
eNB
UE
recognizing SPS packet detection failure
reconfiguring/releasing group-specific SPS configuration for CC group for UE
reconfiguration/release of group-specific SPS configuration for CC group
setting up reconfiguration/release of group-specific SPS configuration for CC group

Figure 7

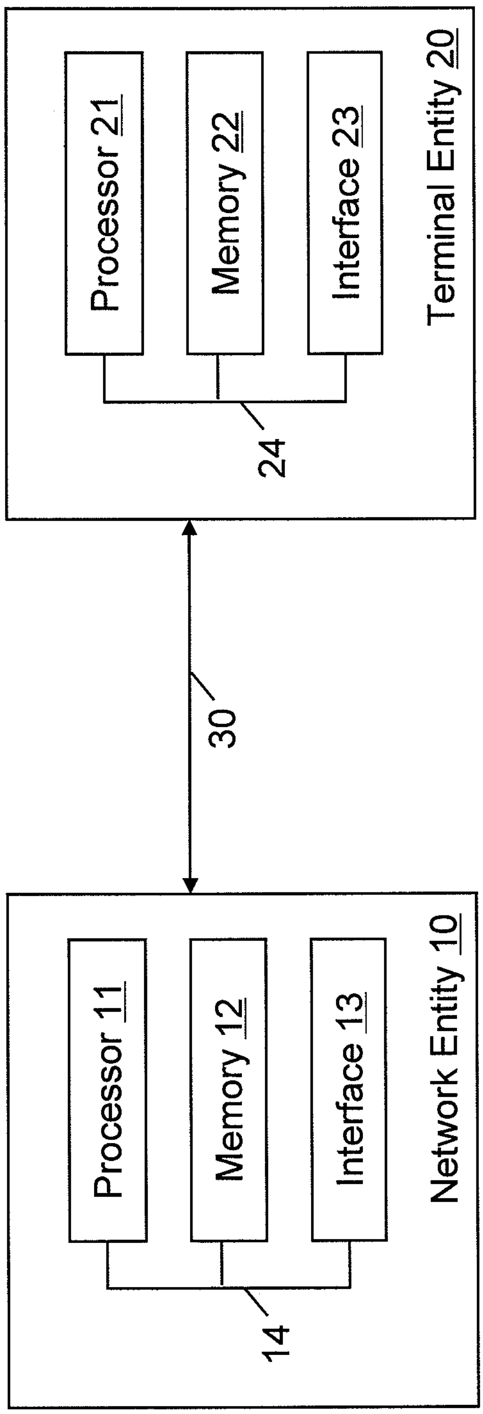
Processor 21
Memory 22
Interface 23
Terminal Entity 20
24
30
Processor 11
Memory 12
Interface 13
Network Entity 10
14

Figure 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2012/071132

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/12 (2009.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: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)

CNABS, CNTXT, VEN: GROUP, SEMI-PERSISTENT, CARRIER, AGGREGATION, FAILURE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN101998496A (ZTE CORP.) 30 Mar. 2011(30.03.2011) see the description paragraphs 75-78, 82, 88, 93	1-42
X	CN101998469A (ZTE CORP.) 30 Mar. 2011(30.03.2011) see the description paragraphs 34-41	1-42
X	WO2010129617A1 (QUALCOMM INC.) 11 Nov. 2010(11.11.2010) see the description paragraphs 70, 71, 84,	1, 2, 12, 13, 21, 22, 32, 33, 41-42
A		3-11, 14-20, 23-31, 34-40
A	CN101998643A (ZTE CORP.) 30 Mar. 2011(30.03.2011) see the whole document	1-42

☐ Further documents are listed in the continuation of Box C. ☒ 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
05 Nov. 2012 (05.11.2012)	**22 Nov. 2012 (22.11.2012)**

Name and mailing address of the ISA/CN
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100088
Facsimile No. 86-10-62019451

Authorized: officer
JIANG, Jingjing
Telephone No. (86-10)62411430

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2012/071132

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN101998496A	30.03.2011	NONE	
CN101998469A	30.03.2011	NONE	
WO2010129617A1	11.11.2010	CN102415195A	11.04.2012
		KR20120005547A	16.01.2012
		EP2428087A1	14.03.2012
		WO2010129617A9	15.09.2011
		US2011116454A1	19.05.2011
CN101994643A	30.03.2011	WO2011023036A1	03.03.2011