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(71) Applicant *(for all designated States except US)*: **RENESAS MOBILE CORPORATION** [JP/JP]; 6-2, Otemachi 2-chome, Chiyoda-ku, Tokyo 100-0004 (JP).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **BAI, Wei** [CN/CN]; Room 1201, Building 14, Xi Ba He Zhong Li, Chaoyang District, Beijing 100028 (CN). **ZENG, Erlin** [CN/CN]; Room 1605, Building A-12, Xi San Qi Jian Cai Cheng Fu Li Tao Yuan, Haidian District, Beijing 100096 (CN). **HAN, Jing** [CN/CN]; Room 1606, Building 3, Xi Ba He Xi Li Residential Area, Chaoyang District, Beijing 100028 (CN). **GAO, Chunyan** [CN/CN]; Room 271, #6 Building, Ru Yi Li, Bei Cao Chang Hu Tong, Xi Zhi Men Nei Da Jie, Xicheng District, Beijing 100035 (CN). **WANG, Haiming** [CN/CN]; Room 1403, Unit 5, Building 101, Jiang Fu Jia Yuan, Jiang Tai Road, Chaoyang District, Beijing 100015 (CN).

(74) Agent: **KING & WOOD MALLESONS**; 20th Floor, East Tower, World Financial Centre, No.1 Dongsanhuan Zhonglu, Chaoyang District, Beijing 100020 (CN).

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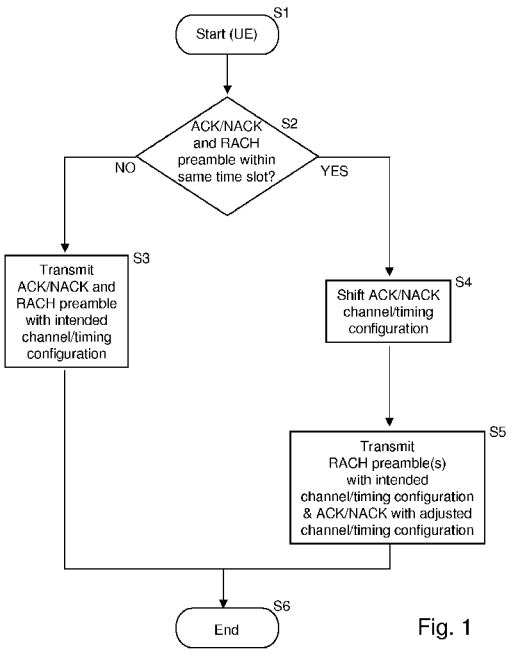

Fig. 1

(57) Abstract: The present invention proposes methods, devices and computer program products in relation to a communication module configured for communication, based on time slots, in a carrier aggregation mode aggregating a primary and at least one secondary carrier. A transmission of acknowledgement data using one of the carriers and a transmission of timing information using one of the carriers are controlled. It is determined whether transmission of acknowledgement information and transmission of timing information are scheduled to take place within the same time slot. Transmission of said first and second channel is controlled to take place on different carriers, if it is determined that transmissions of acknowledgement information and timing information are not scheduled to take place within the same time slot. The transmission of acknowledgement data is shifted, if it is determined that transmissions of acknowledgement information and timing information are scheduled to take place within the same time slot.

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EFFECTIVE DEALING WITH RESTRICTED TRANSMISSION POWER IN CARRIER AGGREGATION SCENARIOS

Field of the invention

The present invention relates to dealing with restricted transmission power in carrier aggregation scenarios. More specifically, the present invention relates to methods and devices configured to adapt scheduled transmissions in order to decrease transmission power peaks in restricted transmission power situations.

Background

Mobile data transmission and data services are constantly making progress. With the increasing penetration of such services, a need for increased bandwidth for conveying the data is emerging. One currently favored technical solution to achieve those increased bandwidth is known as carrier aggregation (CA). Carrier aggregation affords increased bandwidth providable to a terminal like a User Equipment (UE). To achieve this effect, multiple carriers known as component carriers (CC) are aggregated.

Generally, one CC serves as a primary carrier. The primary carrier represents the frequency block, on which the primary cell operates. The primary cell is the cell, in which the UE performs the initial connection establishment procedure and in which essential control information are communicated. Once such initial connection is established, the UE may connect to further cells, known as secondary cells. The secondary cells operate on secondary carriers which represent further frequency blocks. In a CA, one primary carrier and at least one secondary carrier are aggregated to form coexistent primary and secondary cells.

CA includes contiguous aggregation of adjacent carriers and non-contiguous aggregation, wherein the respective carriers are not adjacent to each other.

Such non-contiguous aggregation can be realized with component carriers of one frequency band (Intra-band non-contiguous aggregation) or with component carriers of two or more frequency bands (Inter-band non-contiguous aggregation).

On the field of mobile data transmission, currently, a system known as Long Term Evolution (LTE) is being further developed. The following explanation is performed on the basis of LTE only as an example. In this system, a terminal as a user equipment, i.e. a UE communicates with a base station like a evolved Node B, i.e. an eNodeB.

In LTE Rel-10, only intra-band carrier aggregation is included for uplink direction and only one timing advance (TA) is necessary. However, for LTE Rel-11 inter-band carrier aggregation and further features like radio remote head (RRH) and the provision of repeaters are planned. RRHs are radio units remote from the controlling, actual base station, where a base station may control more than one RRHs. When a UE communicates with two RRHs at different locations, the distances between the UE and the RRHs respectively may be different and different propagation delays may occur. Further, signals transmitted on two different component carriers of bands far apart from each other may be liable to different propagation delays. This introduces the necessity of multiple timing advance for LTE Rel-11.

The timing of uplink transmissions is to be controlled so that those transmissions can be received from the eNodeB within a scheduled time slot. If a transmission arrives beyond the scheduled time slot, interference with transmissions of further UEs may appear. Since a distance between an UE and an eNodeB and other conditions affect signal propagation delays, the timing of said uplink transmissions have to be adjusted.

In order to compensate the propagation delay, a mechanism known as timing advance by which the uplink transmission timing at the UE is set earlier than the expected timing at the eNodeB, is deployed. The timing advance procedure in LTE is divided into initial timing advance and timing advance updates. The initial TA is used after the UE synchronizes its

receiver to the downlink transmissions of the eNodeB and is set by means of the random access procedure: the eNodeB can estimate the uplink timing from the random access preamble and sends timing advance command including the time offset by which the UE should advance its transmission within a random access response (RAR) message. Since the UE is a mobile device, the propagation delay of transmissions may change from time to time. Thus, timing advance updates are needed to update the uplink transmission timing to counteract changes in the arrival time at the eNodeB. It is performed by a closed-loop mechanism whereby the eNodeB measures the received up-link timing and issues timing advance update commands to the UE by means of medium access control (MAC) elements.

For LTE Rel-11, it is planned to implement the multiple timing advance mechanism according to the originally timing advance mechanism by using the Random Access Channel (RACH). To achieve the necessary information for the one or more secondary carriers, a RACH preamble is to be transmitted using the Physical Random Access Channel PRACH of the secondary carrier.

One problem occurs when a RACH preamble is to be transmitted on a secondary carrier. It may be possible that an UE with a restricted power state is requested to transmit such RACH preamble using a secondary carrier in parallel with another transmission using the primary channel, e.g. on a Physical Uplink Control Channel (PUCCH), on a Physical Uplink Shared Channel (PUSCH) or a Sounding Reference Symbol (SRS).

A transmission using the PUCCH on primary carrier is considered as example. In current LTE systems, the power of a PUCCH transmission is calculated using the following formula:

$$P_{PUCCH}(i) = \min\left\{ \begin{array}{c} P_{CMAX,c}(i), \\ P_{0\_PUCCH} + PL_c + h(n_{CQI}, n_{HARQ}, n_{SR}) + \Delta_{F\_PUCCH}(F) + \Delta_{TxD}(F') + g(i) \end{array} \right\} [dBm]$$

The power of a RACH preamble transmission is calculated using the following formula:

$$P_{PRACH} = \min\left\{ \begin{matrix} P_{CMAX,c}(i), \\ PREAMBLE\_RECEIVED\_TARGET\_POWER + PL_c \end{matrix} \right\} [dBm]$$

With the following Symbols:

$P_{CMAX,c}$ configured maximum UE output power in subframe i for serving cell c

P_{0_PUCCH} parameter composed of the sum of a parameter $P_{O\_NOMINAL\_PUCCH}$ provided by higher layers and a parameter $P_{O\_UE\_PUCCH}$ provided by higher layers

PL_c downlink pathloss estimate calculated in the UE for serving cell c

$h(n_{CQI}, n_{HARQ}, n_{SR})$ PUCCH format dependent value, with CQI as channel quality information dependent parameter, HARQ as hybrid automatic repeat request dependent value and SR as scheduling request dependent parameter

$\Delta_{F\_PUCCH}(F)$ value corresponding to PUCCH format F relative to PUCCH format 1a

$\Delta_{TxD}(F')$ transmit diversity value dependent on PUCCH format F'

g(i) current PUCCH power control adjustment state.

A limited power state of an UE may occur for various reasons. It means that the required transmission power for all transmissions at a time exceeds the available transmission power of the UE. The required transmission power may be relatively high because the distance between the UE and the eNodeB is high and a high pathloss between the UE and the eNodeB occurs. Hence, to achieve a needed minimum power at the eNodeB, the UE has to perform the transmission with a high transmission power. Further, the UE may transmit on more than one component carriers, so that the required entire transmission power consists of the transmission power for each used component carrier.

In LTE, a downlink retransmission protocol known as Hybrid Automatic Repeat Request (HARQ) is used. For each received data packet, UE transmits acknowledgement information. If the packet is received correctly,

UE transmits acknowledgement (ACK) information, whereby on receiving of incorrectly received packets negative acknowledgement (NACK) information is transmitted. Such ACK/NACK information is transmitted on a Physical Uplink Control Channel (PUCCH) of a primary carrier. When the UE has transmitted a NACK information, the eNodeB retransmits the related data packet.

Thus, when the UE has to transmit a RACH preamble on a secondary carrier as a reaction to a timing advance control request and at the same time ACK/NACK information on PUCCH on the primary carrier, high transmission power is needed, which may exceed the maximum transmission power of a UE in a power limited state.

However, a HARQ transmission including the ACK/NACK information on PUCCH has to be performed in order to prevent an unnecessary retransmission of correctly received data packets and therefore in order to ensure downlink performance.

For this reason, for parallel transmissions in PUCCH and in a Physical Uplink Shared Channel (PUSCH), in LTE Rel-10 it is implemented, that when UE is in power limited state, at first the demanded transmission power of PUCCH transmission is to be fulfilled by the UE and the remaining transmission power is to be used for the PUSCH transmission. The specification appreciates the importance of the HARQ transmissions on PUCCH.

A possible solution may be to firstly ensure the transmission power of the PUCCH transmission and using the remaining transmission power for the RACH preamble, controlled on the UE side. However, if the needed minimum power at the eNodeB can not be achieved, the RACH preamble may be not detected or detected with errors.

A further solution may be controlled on the eNodeB side. In order to implement such control, it would be necessary to implement and to allow transmissions by the UE on RACH only triggered by the eNodeB. As a result, on the first hand, the eNodeB side has information on when RACH

preambles are to be transmitted, since they are triggered. On the other hand, eNodeB side is able to trigger only one of both transmissions at a time and thus to decide, which of both transmissions is to be performed by the UE. If eNodeB decides RACH preamble to be transmitted, it triggers RACH preamble and suspends downlink data transmissions on all configured carriers in order to prevent ACK/NACK information to be transmitted by the UE. If eNodeB decides PUCCH transmission to be transmitted, it maintains downlink data transmissions and avoids transmission of RACH preamble by not triggering RACH preamble.

The introduced eNodeB side solution may be implemented always unconditioned. Disadvantages are, since one of both transmissions is always prohibited, some downlink performance loss or some delay of RACH transmission on secondary channels.

The introduced eNodeB side solution may be also implemented based on power information of UE side. In particular, a decision is made whether UE is in power limited state or not, and a non-simultaneous transmission of RACH preamble and ACK/NACK on PUCCH is only initiated in case of a power limited state of the UE. ENodeB can achieve power status information by use of power headroom reports (PHR) transmitted by the UE and, in case of activated secondary carrier, by considering the maximum power reduction (MPR) and the pathloss. Power Headroom Reports are triggered after secondary carrier is activated. In a time system based on time slots such as LTE, the eNodeB sends the uplink grant for a secondary carrier for example 8 subframes after secondary carrier is activated (n+8). PHR is then successfully decoded based on the first transmission of the UE and the power limited information is then available for the eNodeB for example 12 subframes after secodary carrier activation (n+12). A RACH trigger can be transmitted after that and the corresponding RACH preamble can be transmitted by the UE 6 subframes later (n+12+6). With a timebase of 1ms per subframe, a RACH preamble can be transmitted 18ms after secondary carrier is activated, which presents a very big delay for the necessary timing advance information.

The above stated disadvantages point out that an eNodeB side implementation may not solve the problem of parallel transmission on PRACH and PUCCH.

Thus, there is still a need to further improve such systems in terms of transmission of both, RACH preamble on secondary carrier(s) and PUCCH transmission on primary carrier in case of a power limited state of a UE.

Summary

Various aspects of examples of the invention are set out in the claims.

According to a first aspect of the present invention, there is provided a device, comprising communication means configured for communication, based on time slots, in a carrier aggregation mode aggregating a primary and at least one secondary carrier, control means configured to control transmission of acknowledgement information confirming receipt of payload data at the device and being transmitted in a first control channel using one of the carriers, and to control transmission of timing information indicating a transmission timing of the device in a second control channel using one of the carriers, and determination means configured to determine whether transmission of acknowledgement information and transmission of timing information are scheduled to take place within the same time slot, wherein said control means is configured to control transmission of said first channel and of said second channel to take place on different carriers, if it is determined by said determination means that transmission of acknowledgement information and transmission of timing information are not scheduled to take place within the same time slot, and to shift said transmission of acknowledgement information, if it is determined by said determination means that transmission of acknowledgement information and transmission of timing information are scheduled to take place within the same time slot.

According to a second aspect of the present invention, there is provided a method, comprising communicating, based on time slots, in a carrier aggregation mode aggregating a primary and at least one secondary carrier, controlling transmission of acknowledgement information confirming receipt of payload data at the device and being transmitted in a first control channel using one of the carriers, controlling transmission of timing information indicating a transmission timing of the device in a second control channel using one of the carriers, determining whether transmission of acknowledgement information and transmission of timing information are scheduled to take place within the same time slot, controlling transmission of said first channel and of said second channel to take place on different carriers, if it is determined in said determining step that transmission of acknowledgement information and transmission of timing information are not scheduled to take place within the same time slot, and shifting said transmission of acknowledgement information, if it is determined in said determining step that transmission of acknowledgement information and transmission of timing information are scheduled to take place within the same time slot.

According to a third aspect of the present invention, there is provided a computer program product comprising computer-executable components which, when executed on a computer, are configured to communicate, based on time slots, in a carrier aggregation mode aggregating a primary and at least one secondary carrier, and to control transmission of acknowledgement information confirming receipt of payload data at the device and being transmitted in a first control channel using one of the carriers, to control transmission of timing information indicating a transmission timing of the device in a second control channel using one of the carriers, to determine whether transmission of acknowledgement information and transmission of timing information are scheduled to take place within the same time slot, to control transmission of said first channel and of said second channel to take place on different carriers, if it is determined by said determination means that transmission of

acknowledgement information and transmission of timing information are not scheduled to take place within the same time slot, and to shift said transmission of acknowledgement information, when it is determined by said determination means that transmission of acknowledgement information and transmission of timing information are scheduled to take place within the same time slot.

Further, according to a fourth aspect there is provided a device, comprising communication means configured for communication, based on time slots, in a carrier aggregation mode aggregating a primary and at least one secondary carrier, control means configured to control receiving of acknowledgement information indicating success of transmission of payload data transmitted by the device and being received in a first control channel using one of the carriers, and to control receiving of timing information indicating a propagation delay in a second control channel using one of the carriers, and estimation means configured to estimate whether receiving of acknowledgement information and receiving of timing information are scheduled to take place within the same time slot, wherein said control means is configured to control receiving of said first channel and of said second channel to take place on different carriers, if it is estimated by said estimation means that receiving of acknowledgement information and receiving of timing information are not scheduled to take place within the same time slot, and to receive shifted acknowledgement information, if it is estimated by said estimation means that receiving of acknowledgement information and receiving of timing information are scheduled to take place within the same time slot.

Furthermore, according to a fifth aspect, there is provided a method, comprising communicating, based on time slots, in a carrier aggregation mode aggregating a primary and at least one secondary carrier, controlling receiving of acknowledgement information indicating success of transmission of payload data transmitted by the device and being received in a first control channel using one of the carriers, controlling receiving of

timing information indicating a propagation delay in a second control channel using one of the carriers, estimating whether receiving of acknowledgement information and receiving of timing information are scheduled to take place within the same time slot, controlling receiving of said first channel and of said second channel to take place on different carriers, if it is estimated by said estimation means that receiving of acknowledgement information and receiving of timing information are not scheduled to take place within the same time slot, and receiving shifted acknowledgement information, if it is estimated by said estimation means that receiving of acknowledgement information and receiving of timing information are scheduled to take place within the same time slot.

Likewise, according to a sixth aspect, there is provided a computer program product, comprising computer-executable components which, when executed on a computer, are configured to communicate, based on time slots, in a carrier aggregation mode aggregating a primary and at least one secondary carrier, and to control receiving of acknowledgement information indicating success of transmission of payload data transmitted by the device and being received in a first control channel using one of the carriers, to control receiving of timing information indicating a propagation delay in a second control channel using one of the carriers, to estimate whether receiving of acknowledgement information and receiving of timing information are scheduled to take place within the same time slot, to control receiving of said first channel and of said second channel to take place on different carriers, if it is estimated by said estimation means that receiving of acknowledgement information and receiving of timing information are not scheduled to take place within the same time slot, and to receive shifted acknowledgement information, if it is estimated by said estimation means that receiving of acknowledgement information and receiving of timing information are scheduled to take place within the same time slot.

Respective advantageous further developments of the method and/or device are as set out in the corresponding dependent claims.

The above computer program products may be embodied as a (volatile or non-volatile) computer-readable storage medium.

The methods, devices and computer program products described in this document, at least in exemplary embodiments, are able to detect or to estimate whether two transmissions are scheduled to take place within a same time slot and using different carriers, which increases a requested transmission power to be performed by a user equipment UE. In case of restricted transmission power on the UE side, the requested transmission power may not be performable by the UE. To overcome such situation, one of the concurrently scheduled transmissions is shifted to another time slot or another carrier.

By virtue thereof, a successful transmission of both scheduled transmissions can be assured. A restricted power situation can thus be handled effectively.

Brief descriptions of drawings

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

FIGURE 1 illustrates exemplary method steps carried out by and implemented at the User Equipment side, UE side;

FIGURE 2 illustrates exemplary method steps carried out by and implemented at the User Equipment side, UE side, according to a first embodiment;

FIGURE 3 illustrates exemplary method steps carried out by and implemented at the User Equipment side, UE side, according to a second embodiment;

FIGURE 4 illustrates exemplary method steps carried out by and implemented at the evolved Node B side, eNodeB side, according to a first embodiment;

FIGURE 5 illustrates a timing sequence according to a second embodiment.

Description of exemplary embodiments

Exemplary aspects of the invention will be described herein below.

It is to be noted that the following exemplary description refers to an environment of the LTE system (long term evolution) in which carrier aggregation is deployed. However, it is to be understood that this serves for explanatory purposes only. Other systems differing from the LTE system can be adopted as long as they deploy carrier aggregation.

In such carrier aggregation, one carrier is a primary carrier and at least one carrier aggregated with a primary component carrier is referred to as secondary carrier. Thus, in a communication configured in carrier aggregation mode, a primary and at least one secondary carrier are present.

The communication is performed based on time slots and in channels. Those channels are divided in payload channels and control channels. Examples for payload channels are the physical downlink shared channel PDSCH for transmission of payload data in downlink direction and physical uplink shared channel PUSCH for transmission of payload data in uplink direction. Examples for control channels are the physical downlink control channel PDCCH for transmission of control information in downlink direction and physical uplink control channel PUCCH for transmission of control information in uplink transmission.

A further example for a control channel is the physical random access channel PRACH, a normally contention-based channel used for initial access of a UE to the network.

The transmissions on PRACH are also used for determination of the timing advance values for synchronized communication between UE and eNodeB. In LTE Rel-11, PRACH is intended to be used for determination of multiple timing advance values on the at least one secondary carrier.

The PUCCH on primary carrier is mainly used to transmit the hybrid automatic repeat request HARQ feedback for downlink transmissions. Further control information without the high priority of HARQ feedback, like CQI, PMI and RI are transmitted using PUCCH.

In case of power limited state of the UE in combination with PUCCH and PRACH transmissions in parallel, following solution is proposed.

A transmission of the lower priority content of PUCCH can be waived, when successful transmission of PRACH timing information (preamble) to be used for estimation of propagation delay and PUCCH acknowledgement information can be ensured.

In a first aspect of the invention the problem is therefore solved by dropping the lower priority content of a PUCCH transmission and shifting the ACK/NACK information into the concurrent PRACH preamble transmission. In this way a concurrent transmission in both, primary and secondary carrier, can be avoided and the necessary transmission power to be expended by the UE can be decreased without loss of the necessary information of both intended transmissions. To achieve this effect, the ACK/NACK information is merged with the PRACH preamble via PRACH resource selection as described later.

In a second aspect of the invention, the problem is solved by shifting the PUCCH transmission into a time slot subsequent to the intended time slot. Also in this way a concurrent transmission in both, primary and secondary carrier, can be avoided, since at first the PRACH preamble is transmitted on secondary carrier without transmission on primary carrier and in a subsequent time slot the PUCCH transmission including the ACK/NACK information is performed on primary carrier without transmission on

secondary carrier. Thus, a necessary transmission power to be expended by the UE can be decreased.

Now, it is more specifically referred to the drawings and exemplary embodiments illustrated therein.

Figure 1 illustrates exemplary method steps carried out by and implemented at the User Equipment side, i.e. at the UE side. The process starts in an initial step 1 at the UE. Acknowledgement data ACK/NACK is to be transmitted with an intended channel and timing configuration and a RACH preamble is to be transmitted with an intended channel and timing configuration. In a subsequent step S2 it is determined whether acknowledgement data ACK/NACK and RACH preamble are intended to be transmitted within the same time slot. In case acknowledgement data and RACH preamble are not intended to be transmitted within the same time slot (NO in step S2), the procedure advances to step S3. In step S3, acknowledgement data ACK/NACK is transmitted with said intended channel and timing configuration and said RACH preamble is also transmitted with the intended channel and timing configuration and the process ends in step S6.

In case acknowledgement data and RACH preamble are intended to be transmitted within the same time slot (YES in step S2), the procedure advances to step S4. In step S4, the channel and timing configuration of acknowledgement data ACK/NACK is adjusted, i.e. is shifted.

After said adjustment, the procedure advances to step S5. In step S5 the RACH preamble is transmitted with the intended channel and timing configuration, whereas the acknowledgement data ACK/NACK is transmitted with the adjusted channel and timing configuration and the process ends in step S6.

Figure 2 illustrates exemplary sub method steps of the above mentioned shifting step S4 carried out by and implemented at an embodiment of the User Equipment, i.e. of the UE. In this embodiment, the shifting is

implemented by shifting the acknowledgement data ACK/NACK into the concurrent PRACH preamble transmission and by encoding said acknowledgement data ACK/NACK with said preamble transmission. The process starts in step 11 and advances to a receiving step S12. In step S12 the UE receives information regarding a RACH preamble ID receiving modus and one or more RACH preamble IDs. The number of received RACH preamble IDs depends on the number of acknowledgement data (ACK/NACK) elements and to the RACH preamble ID receiving modus.

The RACH preamble receiving modus may be a semi-statically configuration to use multiple preambles, whereby when configured, the UE has to receive a RACH preamble trigger including one RACH preamble ID, and then UE assumes that said included one RACH preamble ID and further *x* preamble IDs are reserved for said UE.

The RACH preamble receiving modus may further be receiving information on using multiple preambles via dedicated signaling, e.g. via downlink control information DCI received on physical downlink control channel PDCCH. UE may receive one RACH preamble ID via DCI on PDCCH and following *x* RACH preamble IDs via consecutive random access preamble identifiers RAPID.

Such DCI signaling received by the UE may be implemented as follows. The intended DCI format may be 1A, which is used for the compact scheduling of one PDSCH codeword in one cell and random access procedure initiated by a PDCCH order. A possible bit string may be defined as follows:

Format 1A is used for random access procedure initiated by a PDCCH order only if format 1A CRC is scrambled with C-RNTI and all the remaining fields are set as follows:

- Localized/Distributed VRB assignment flag – 1 bit is set to '0'
- Resource block assignment – $\lceil \log_2(N_{RB}^{DL}(N_{RB}^{DL}+1)/2) \rceil$ bits, which shall be set to [1, 1, 1,...,1, 0]
- Preamble Index – 6 bits
- PRACH Mask Index – 4 bits

- All the remaining bits in format 1A for compact scheduling assignment of one PDSCH codeword are set to zero.

By the one unused allocation state of such DCI signaling it is indicated that multiple preambles are allocated and the one RACH preamble ID is communicated with the included Preamble Index.

Alternatively, UE may receive a pre-configuration including at least one indexed multiple RACH preamble ID combination and may further receive an index indicating one of said at least one multiple RACH preamble combination.

Such DCI signaling received by the UE may be implemented like the above mentioned DCI signaling with the difference, that the

- Preamble Index – 6 bits

is replaced by an

- Index of the allocated preamble combination – 3 or more bits.

The index communicated with the proposed DCI signaling indicates the one of said at least one multiple RACH preamble combination.

Prior to the receiving step S12, a corresponding eNodeB estimates whether acknowledgement data ACK/NACK and RACH preamble are intended to be transmitted from the UE within the same time slot and determines an amount of acknowledgement data ACK/NACK bits to be transmitted by the UE, which is described more detailed later with reference to figure 4.

The eNodeB then allocates more than one RACH preamble IDs to the UE and communicates those RACH preamble IDs to the UE via the above described signaling, that is, by transmitting information regarding a RACH preamble ID receiving modus and one or more RACH preamble IDs to the UE.

At that, in the eNodeB, each allocated RACH preamble ID corresponds to each of the expected possible acknowledgement data (ACK/NACK) states, respectively.

The process then advances to step S13. In step S13, UE assigns RACH preamble IDs based on the RACH preamble receiving modus, the received RACH preamble ID(s) and the acknowledgement data ACK/NACK to be transmitted. In this way, each of the RACH preamble IDs reserved for the UE is assigned to each of the possible acknowledgement data (ACK/NACK) states, respectively.

In step S14 the UE determines which RACH preamble ID(s) of the reserved RACH preamble ID(s) is or are to be used for PRACH preamble transmission according to assignment of step 13 and to the actual acknowledgement data (ACK/NACK) states to be transmitted.

The following step S15 indicates the transition to step S5 of figure 1. In this case in step S5 only RACH preambles with the determined RACH preamble IDs are transmitted. The actual acknowledgement data ACK/NACK is therefore encoded with the preamble transmission on PRACH of the secondary carrier.

Since the corresponding eNodeB applies the same assignment of RACH preamble IDs to acknowledgement data (ACK/NACK) states, eNodeB is able to decode acknowledgement data ACK/NACK from the preamble transmission by the UE on PRACH of the secondary carrier by the information which RACH preamble IDs are used.

Figure 3 illustrates exemplary sub method steps of the above mentioned shifting step S4 carried out by and implemented at another embodiment of the User Equipment, i.e. of the UE. In this embodiment, the shifting is implemented by shifting the acknowledgement data ACK/NACK to a subsequent time slot. The process starts in step S21 and advances to step S22. In step S22 a subsequent time slot is scheduled for the acknowledgement data ACK/NACK to be transmitted. The difference between the intended time slot and the newly scheduled time slot should be a predetermined positive integer, so that there is no simultaneous acknowledgement data ACK/NACK transmission on PUCCH of the primary carrier and PRACH preamble transmission on secondary carrier.

The positive integer should be minimized in order to minimize affecting the downlink data transmission. In frequency division duplex FDD mode, a bidirectional communication mode in which transmission and reception takes place at the same time on different carrier frequencies, the positive integer may be 1. In time division duplex TDD mode, a bidirectional communication mode in which transmission and reception takes place in different time slots but on the same carrier frequencies, the positive integer may be determined based on the next available transmission (uplink) time slot.

The process then advances to step S23. In step S23 it is determined whether in the newly scheduled time slot a transmission of further acknowledgement data ACK/NACK is already intended.

In case a transmission of further acknowledgement data ACK/NACK is not intended for the newly scheduled time slot (NO in step S23), the process advances to step S24, wherein the acknowledgement data ACK/NACK is shifted to said newly scheduled time slot and then the process advances to step S28. The following step S28 indicates the transition to step S5 of figure 1 with the newly scheduled time slot as the adjusted timing configuration.

In case a transmission of further acknowledgement data ACK/NACK is already intended for the newly scheduled time slot (YES in step S23), the process advances to step S25. In step S25 the UE determines whether the acknowledgement data ACK/NACK (A/N seq1) to be transmitted appended to the further acknowledgement data ACK/NACK (A/N seq2) already intended for the newly scheduled time slot would exceed the payload size of the PUCCH transmission in the newly scheduled time slot. The determination depends on the total number of ACK/NACK bits of the ACK/NACK sequences (A/N seq1, A/N seq2) to be transmitted and the actually set format of the PUCCH transmission.

In case the acknowledgement data ACK/NACK (A/N seq1) to be transmitted appended to the further acknowledgement data ACK/NACK (A/N seq2)

already intended for the newly scheduled time slot would not exceed the payload size of the PUCCH transmission in the newly scheduled time slot (NO in step S25), the process advances to step S26.

In step S26 the acknowledgement data ACK/NACK (A/N seq1) to be transmitted is appended to the further acknowledgement data ACK/NACK (A/N seq2) already intended for the newly scheduled time slot and the process advances to step S28. The following step S28 indicates the transition to step S5 of figure 1 with the newly scheduled time slot as the adjusted timing configuration.

In case the acknowledgement data ACK/NACK (A/N seq1) to be transmitted appended to the further acknowledgement data ACK/NACK (A/N seq2) already intended for the newly scheduled time slot would exceed the payload size of the PUCCH transmission in the newly scheduled time slot (YES in step S25), the process advances to step S27.

In step S27 the acknowledgement data ACK/NACK (A/N seq1) to be transmitted is bundled with the further acknowledgement data ACK/NACK (A/N seq2) already intended for the newly scheduled time slot by using a predefined bundling scheme in order to lower the payload size and the process advances to step S28. The following step S28 indicates the transition to step S5 of figure 1 with the newly scheduled time slot of the bundled ACK/NACK sequences (A/N seq1, A/N seq2) as the adjusted timing configuration.

A corresponding eNodeB is able to receive the acknowledgement data ACK/NACK (A/N seq1) time-displaced from the expected time slot. In case of appending acknowledgement data ACK/NACK (A/N seq1) to the further acknowledgement data ACK/NACK (A/N seq2) or of bundling acknowledgement data ACK/NACK (A/N seq1) with the further acknowledgement data ACK/NACK (A/N seq2) by the UE, the corresponding eNodeB is able to separate both ACK/NACK sequences from each other.

Figure 4 illustrates exemplary method steps of a preparation of a RACH trigger carried out by and implemented at the evolved NodeB side, i.e. at the eNodeB side. The process starts in step S31 and advances to step S32. In step S32 it is estimated whether acknowledgement data ACK/NACK on PUCCH on primary carrier and a preamble on PRACH of the secondary carrier are to be transmitted within the same time slot by the UE.

The estimation is performed as follows. For example, a RACH trigger is transmitted at a subframe *n* by the eNodeB, the corresponding RACH preamble might be transmitted at subframe *n+6* by the UE. Further in this example, a downlink data packet is transmitted at subframe *n+2*, and in a FDD scenario, the corresponding ACK/NACK information is transmitted 4 subframes after the data packet is received by the UE, so also acknowledgement data ACK/NACK might be transmitted at subframe *n+6* and a collision of both transmissions may occur.

In case the acknowledgement data ACK/NACK on PUCCH on primary carrier and the preamble on PRACH of the secondary carrier are not to be transmitted within the same time slot by the UE (NO in step S32), the process advances to step S38, which represents the end of said process.

In case the acknowledgement data ACK/NACK on PUCCH on primary carrier and the preamble on PRACH of the secondary carrier are to be transmitted within the same time slot by the UE (YES in step S32), the process advances to step S33. In step S33, the number of the expected possible acknowledgement data (ACK/NACK) states, and thus the number of the expected possible ACK/NACK bits are determined based on the transmitted downlink data packets.

The determination is performed as follows. For example a downlink data packet transmitted by the eNodeB may cause two ACK/NACK bits, which have in total four states, which is also the number of RACH preamble IDs to be allocated to the UE.

The process then advances to step S34. In step S34 the eNodeB allocates the determined number of RACH preamble IDs corresponding to the number of possible ACK/NACK bit states to the UE.

In the following step S35, the eNodeB communicates those allocated preamble IDs to the UE by transmitting information regarding a RACH preamble ID receiving modus and one or more RACH preamble IDs to the UE.

In particular, the transmission of information regarding a RACH preamble ID receiving modus by the eNodeB may be a semi-statically configuration of the UE of using multiple preambles. In this case, the eNodeB transmits a RACH trigger including one RACH preamble ID.

Further, the transmission of information regarding a RACH preamble ID receiving modus may also be transmitting information on using multiple preambles via dedicated signaling, e.g. via downlink control information DCI transmitted on physical downlink control channel PDCCH. In this case, eNodeB may transmit one RACH preamble ID via DCI on PDCCH and following x RACH preamble IDs via consecutive random access preamble identifiers RAPID.

Alternatively, eNodeB may transmit a pre-configuration including at least one indexed multiple RACH preamble ID combination and further transmits an index indicating one of said at least one multiple RACH preamble combination.

The respective DCI signalings transmitted by the eNodeB may be implemented as already shown above.

At that, in the eNodeB, each allocated RACH preamble ID corresponds to each of the expected possible acknowledgement data (ACK/NACK) states, respectively.

In the following step S36, the eNodeB receives the RACH preamble(s) transmitted by the UE and proceeds to step S37.

In step S37, the eNodeB extracts the acknowledgement data ACK/NACK from the preamble(s) transmitted on PRACH of the secondary carrier by the UE by means of the information which RACH preamble IDs are used in the received preamble(s). The process then advances to the end step S38.

Figure 5 illustrates the principle of shifting the acknowledgement data ACK/NACK to a subsequent time slot. In the left section of figure 5 is shown that transmission of acknowledgement data ACK/NACK (A/N seq1) on PUCCH on primary carrier and transmission of PRACH preamble on secondary carrier collides with each other, when the respective transmissions are intended to be performed within the same time slot.

However, in the right section of figure 5 a possible result of shifting the acknowledgement data ACK/NACK (A/N seq1) to a subsequent time slot according to an embodiment of the present invention is shown. In this example, acknowledgement data ACK/NACK (A/N seq1) and PRACH preamble are to be transmitted in subframe *n* and the shifting operation shifts the acknowledgement data ACK/NACK (A/N seq1) to subframe *n+1* so that a collision of both intended transmissions can be avoided. It is further shown that in the time slot *n+1* a further acknowledgement data ACK/NACK (A/N seq2) is intended to be transmitted. It can be seen that the ACK/NACK sequences (A/N seq1, A/N seq2) are appended or bundled in time slot *n+1* according to the above described steps of appending or bundling said ACK/NACK sequences (A/N seq1, A/N seq2).

Generally, the invention is implemented in an environment such as LTE system adopting carrier aggregation. Exemplary embodiments of the invention are represented by methods and/or correspondingly configured devices such as eNodeBs and/or UEs. More specifically, the invention generally relates to modem modules of such devices. Other systems can benefit also from the principles presented herein as long as they have identical or similar properties like the carrier aggregation under LTE.

As described in this document, the invention enables handling transmissions of timing information and acknowledgement information in power limited situations. Said timing information are, e.g., RACH preambles, said acknowledgement information are, e.g., ACK/NACK information. However, these information are not limited to said examples. Especially timing information transmissions may comprise all uplink (from UE side) transmissions that are capable to be used for estimation of propagation delay on eNB side. In general, the invention may be applicable to solve situations where two transmissions of control information of any kind are scheduled to be performed within the same time slot in power limited situations.

Embodiments of the present invention may be implemented in software, hardware, application logic or a combination of software, hardware and application logic. The software, application logic and/or hardware generally, but not exclusively, may reside on the devices' modem module. In an example embodiment, the application logic, software or an instruction set is maintained on any one of various conventional computer-readable media. In the context of this document, a "computer-readable medium" may be any media or means that can contain, store, communicate, propagate or transport the instructions for use by or in connection with an instruction execution system, apparatus, or device, such as a computer or smart phone, or user equipment.

The present invention relates in particular but without limitation to mobile communications, for example to environments under LTE, WCDMA, WIMAX and WLAN and can advantageously be implemented in user equipments or smart phones, or personal computers connectable to such networks. That is, it can be implemented as/in chipsets to connected devices, and/or modems thereof.

If desired, the different functions discussed herein may be performed in a different order and/or concurrently with each other. Furthermore, if desired,

one or more of the above-described functions may be optional or may be combined.

Although various aspects of the invention are set out in the independent claims, other aspects of the invention comprise other combinations of features from the described embodiments and/or the dependent claims with the features of the independent claims, and not solely the combinations explicitly set out in the claims.

It is also noted herein that while the above describes example embodiments of the invention, these descriptions should not be viewed in a limiting sense. Rather, there are several variations and modifications which may be made without departing from the scope of the present invention as defined in the appended claims.

The present invention proposes methods, devices and computer program products in relation to a communication module configured for communication, based on time slots, in a carrier aggregation mode aggregating a primary and at least one secondary carrier. A transmission of acknowledgement data using one of the carriers and a transmission of timing information using one of the carriers are controlled. It is determined whether transmission of acknowledgement information and transmission of timing information are scheduled to take place within the same time slot. Transmission of said first and second channel is controlled to take place on different carriers, if it is determined that transmissions of acknowledgement information and timing information are not scheduled to take place within the same time slot. The transmission of acknowledgement data is shifted, if it is determined that transmissions of acknowledgement information and timing information are scheduled to take place within the same time slot.

List of acronyms, abbreviations and definitions

CA	Carrier Aggregation
CC	Component Carrier
CQI	Channel Quality Indicator
DCI	Downlink Control Information

eNB	eNodeB evolved Node B
FDD	Frequency Division Duplex
HARQ	Hybrid Automatic Repeat Request
LTE	Long Term Evolution
MAC	Medium Access Control
MPR	Maximum Power Reduction
PDCCH	Physical Downlink Control CHannel
PDSCH	Physical Downlink Shared CHannel
PHR	Power Headroom Report
PRACH	Physical Random Access CHannel
PUCCH	Physical Uplink Control CHannel
PUSCH	Physical Uplink Shared CHannel
RACH	Random Access CHannel
RAPID	Random Access Preamble IDentifier
RAR	Random Access Response
RRH	Radio Remote Head
SR	Scheduling Request
SRS	Sounding Reference Symbol
TA	Timing Advance
TDD	Time Division Duplex
UE	User Equipment

What is claimed is:

1. A device, comprising:

communication means configured for communication, based on time slots, in a carrier aggregation mode aggregating a primary and at least one secondary carrier,

control means configured to control transmission of acknowledgement information confirming receipt of payload data at the device and being transmitted in a first control channel using one of the carriers, and to control transmission of timing information indicating a transmission timing of the device in a second control channel using one of the carriers, and

determination means configured to determine whether transmission of acknowledgement information and transmission of timing information are scheduled to take place within the same time slot,

wherein said control means is configured to

control transmission of said first channel and of said second channel to take place on different carriers, if it is determined by said determination means that transmission of acknowledgement information and transmission of timing information are not scheduled to take place within the same time slot, and to

shift said transmission of acknowledgement information, if it is determined by said determination means that transmission of acknowledgement information and transmission of timing information are scheduled to take place within the same time slot.

2. A device according to claim 1,

wherein said control means is configured to shift said transmission of acknowledgement information from said first control channel using one of the carriers to said second control channel using one of the carriers.

3. A device according to claim 2, further comprising:

receiving means configured to receive encoding information prescribing how to merge said acknowledgement information with said timing information,

wherein said control means is configured to merge said acknowledgement information and said timing information to one transmission based on said received encoding information.

4. A device according to claim 1,

wherein said control means is configured to shift said transmission of acknowledgement information to a time slot which differs from the time slot in which said timing information is transmitted.

5. A device according to claim 4,

wherein said control means is configured to check whether transmission of further acknowledgement information is scheduled to take place within said time slot which differs from the time slot in which said timing information is transmitted, the device further comprising:

calculation means configured to calculate, if transmission of further acknowledgement information is scheduled to take place within said time slot which differs from the time slot in which said timing information is transmitted, whether said acknowledgement information appended to said further acknowledgement information would exceed a maximum payload size of said time slot which differs from the time slot in which said timing information is transmitted.

6. A device according to claim 5,

wherein said control means is configured to append said acknowledgement information to said further acknowledgement information, if said acknowledgement information appended to said further acknowledgement information would not exceed a maximum payload size of said time slot which differs from the time slot in which said timing information is transmitted, and to

bundle said acknowledgement information and said further acknowledgement information to lower the payload size, if said acknowledgement information appended to said further acknowledgement information would exceed a maximum payload size of said time slot which differs from the time slot in which said timing information is transmitted.

7. A device, comprising:

communication means configured for communication, based on time slots, in a carrier aggregation mode aggregating a primary and at least one secondary carrier,

control means configured to control receiving of acknowledgement information indicating success of transmission of payload data transmitted by the device and being received in a first control channel using one of the carriers, and to control receiving of timing information indicating a propagation delay in a second control channel using one of the carriers, and

estimation means configured to estimate whether receiving of acknowledgement information and receiving of timing information are scheduled to take place within the same time slot,

wherein said control means is configured to

control receiving of said first channel and of said second channel to take place on different carriers, if it is estimated by said estimation means that receiving of acknowledgement information and receiving of timing information are not scheduled to take place within the same time slot, and to

receive shifted acknowledgement information, if it is estimated by said estimation means that receiving of acknowledgement information and receiving of timing information are scheduled to take place within the same time slot.

8. A device according to claim 7,

wherein said control means is configured to receive acknowledgement information shifted from said first control channel using one of the carriers to said second control channel using one of the carriers.

9. A device according to claim 8, further comprising:

transmission means configured to transmit encoding information prescribing how to merge said acknowledgement information with said timing information,

wherein said control means is configured to demerge said acknowledgement information and said timing information from one receipt based on said encoding information.

10. A device according to claim 7,

wherein said control means is configured to receive acknowledgement information shifted to a time slot which differs from the time slot in which said timing information is received.

11. A device according to claim 10,

wherein said control means is configured to receive said acknowledgement information appended to further acknowledgement information within said time slot which differs from the time slot in which said timing information is received.

12. A device according to claim 10,

wherein said control means is configured to receive said acknowledgement information bundled with said further acknowledgement information within said time slot which differs from the time slot in which said timing information is received, and

to extract said acknowledgement information and said further acknowledgement information bundled with each other.

13. A method, comprising:

communicating, based on time slots, in a carrier aggregation mode aggregating a primary and at least one secondary carrier,

controlling transmission of acknowledgement information confirming receipt of payload data at the device and being transmitted in a first control channel using one of the carriers,

controlling transmission of timing information indicating a transmission timing of the device in a second control channel using one of the carriers,

determining whether transmission of acknowledgement information and transmission of timing information are scheduled to take place within the same time slot,

controlling transmission of said first channel and of said second channel to take place on different carriers, if it is determined in said determining step that transmission of acknowledgement information and transmission of timing information are not scheduled to take place within the same time slot, and

shifting said transmission of acknowledgement information, if it is determined in said determining step that transmission of acknowledgement information and transmission of timing information are scheduled to take place within the same time slot.

14. A method according to claim 13,

wherein said shifting is performed by shifting said transmission of acknowledgement information from said first control channel using one of the carriers to said second control channel using one of the carriers.

15. A method according to claim 14, further comprising:

receiving encoding information prescribing how to merge said acknowledgement information with said timing information, and

merging said acknowledgement information and said timing information to one transmission based on said received encoding information.

16. A method according to claim 13,

wherein said shifting is performed by shifting said transmission of acknowledgement information to a time slot which differs from the time slot in which said timing information is transmitted.

17. A method according to claim 16, further comprising:

checking whether transmission of further acknowledgement information is scheduled to take place within said time slot which differs from the time slot in which said timing information is transmitted, and

calculating, if transmission of further acknowledgement information is scheduled to take place within said time slot which differs from the time slot in which said timing information is transmitted, whether said acknowledgement information appended to said further acknowledgement information would exceed a maximum payload size of said time slot which differs from the time slot in which said timing information is transmitted.

18. A method according to claim 17, further comprising:

appending said acknowledgement information to said further acknowledgement information, if said acknowledgement information appended to said further acknowledgement information would not exceed a maximum payload size of said time slot which differs from the time slot in which said timing information is transmitted, and

bundling said acknowledgement information and said further acknowledgement information to lower the payload size, if said acknowledgement information appended to said further acknowledgement information would exceed a maximum payload size of said time slot which differs from the time slot in which said timing information is transmitted.

19. A method, comprising:

communicating, based on time slots, in a carrier aggregation mode aggregating a primary and at least one secondary carrier,

controlling receiving of acknowledgement information indicating success of transmission of payload data transmitted by the device and being received in a first control channel using one of the carriers,

controlling receiving of timing information indicating a propagation delay in a second control channel using one of the carriers,

estimating whether receiving of acknowledgement information and receiving of timing information are scheduled to take place within the same time slot,

controlling receiving of said first channel and of said second channel to take place on different carriers, if it is estimated by said estimation means that receiving of acknowledgement information and receiving of timing information are not scheduled to take place within the same time slot, and

receiving shifted acknowledgement information, if it is estimated by said estimation means that receiving of acknowledgement information and receiving of timing information are scheduled to take place within the same time slot.

20. A method according to claim 19,

wherein said receiving shifted acknowledgement information is performed by receiving acknowledgement information shifted from said first control channel using one of the carriers to said second control channel using one of the carriers.

21. A method according to claim 20, further comprising:

transmitting encoding information prescribing how to merge said acknowledgement information with said timing information, and

demerging said acknowledgement information and said timing information from one receipt based on said encoding information.

22. A method according to claim 19,

wherein said receiving shifted acknowledgement information is performed by receiving acknowledgement information shifted to a time slot which differs from the time slot in which said timing information is received.

23. A method according to claim 22,

wherein said receiving shifted acknowledgement information is performed by receiving said acknowledgement information appended to further acknowledgement information within said time slot which differs from the time slot in which said timing information is received.

24. A method according to claim 22,

wherein said receiving shifted acknowledgement information is performed by receiving said acknowledgement information bundled with said further acknowledgement information within said time slot which differs from the time slot in which said timing information is received, further comprising:

extracting said acknowledgement information and said further acknowledgement information bundled with each other.

25. A computer program product comprising computer-executable components which, when executed on a computer, are configured to communicate, based on time slots, in a carrier aggregation mode aggregating a primary and at least one secondary carrier, and

to control transmission of acknowledgement information confirming receipt of payload data at the device and being transmitted in a first control channel using one of the carriers,

to control transmission of timing information indicating a transmission timing of the device in a second control channel using one of the carriers,

to determine whether transmission of acknowledgement information and transmission of timing information are scheduled to take place within the same time slot,

to control transmission of said first channel and of said second channel to take place on different carriers, if it is determined by said determination means that transmission of acknowledgement information and transmission of timing information are not scheduled to take place within the same time slot, and

to shift said transmission of acknowledgement information, when it is determined by said determination means that transmission of

acknowledgement information and transmission of timing information are scheduled to take place within the same time slot.

26. A computer program product, comprising computer-executable components which, when executed on a computer, are configured to communicate, based on time slots, in a carrier aggregation mode aggregating a primary and at least one secondary carrier, and

to control receiving of acknowledgement information indicating success of transmission of payload data transmitted by the device and being received in a first control channel using one of the carriers,

to control receiving of timing information indicating a propagation delay in a second control channel using one of the carriers,

to estimate whether receiving of acknowledgement information and receiving of timing information are scheduled to take place within the same time slot,

to control receiving of said first channel and of said second channel to take place on different carriers, if it is estimated by said estimation means that receiving of acknowledgement information and receiving of timing information are not scheduled to take place within the same time slot, and

to receive shifted acknowledgement information, if it is estimated by said estimation means that receiving of acknowledgement information and receiving of timing information are scheduled to take place within the same time slot.

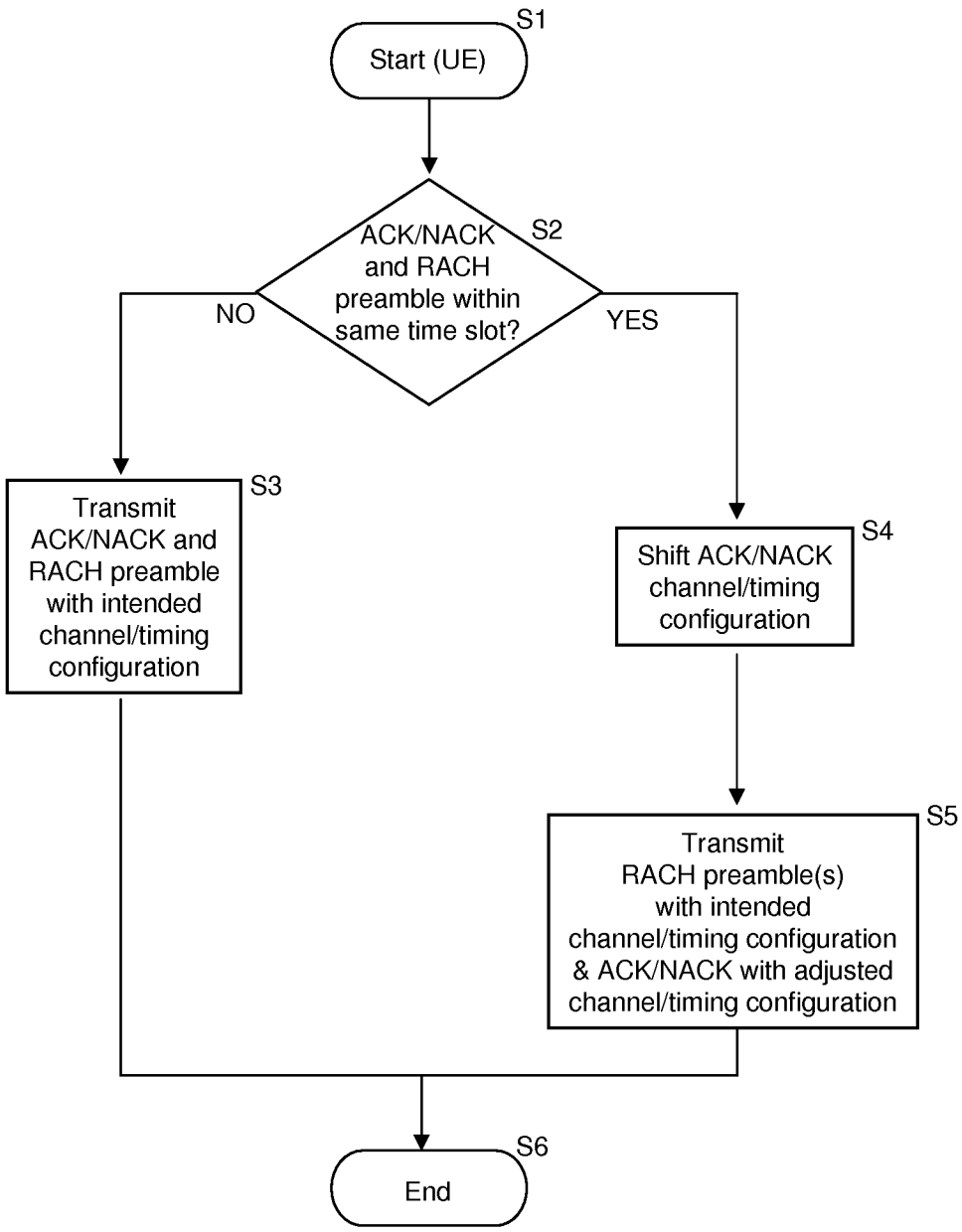
S1
Start (UE)
S2
ACK/NACK and RACH preamble within same time slot?
NO
YES
S3
Transmit ACK/NACK and RACH preamble with intended channel/timing configuration
S4
Shift ACK/NACK channel/timing configuration
S5
Transmit RACH preamble(s) with intended channel/timing configuration & ACK/NACK with adjusted channel/timing configuration
S6
End

Fig. 1

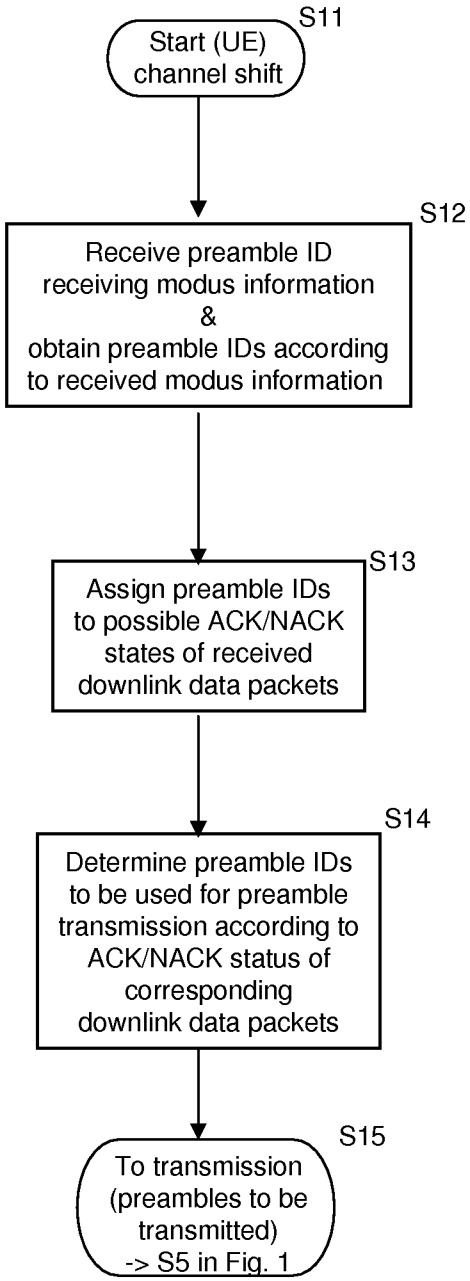
S11
Start (UE) channel shift
S12
Receive preamble ID receiving modus information & obtain preamble IDs according to received modus information
S13
Assign preamble IDs to possible ACK/NACK states of received downlink data packets
S14
Determine preamble IDs to be used for preamble transmission according to ACK/NACK status of corresponding downlink data packets
S15
To transmission (preambles to be transmitted) -> S5 in Fig. 1

Fig. 2

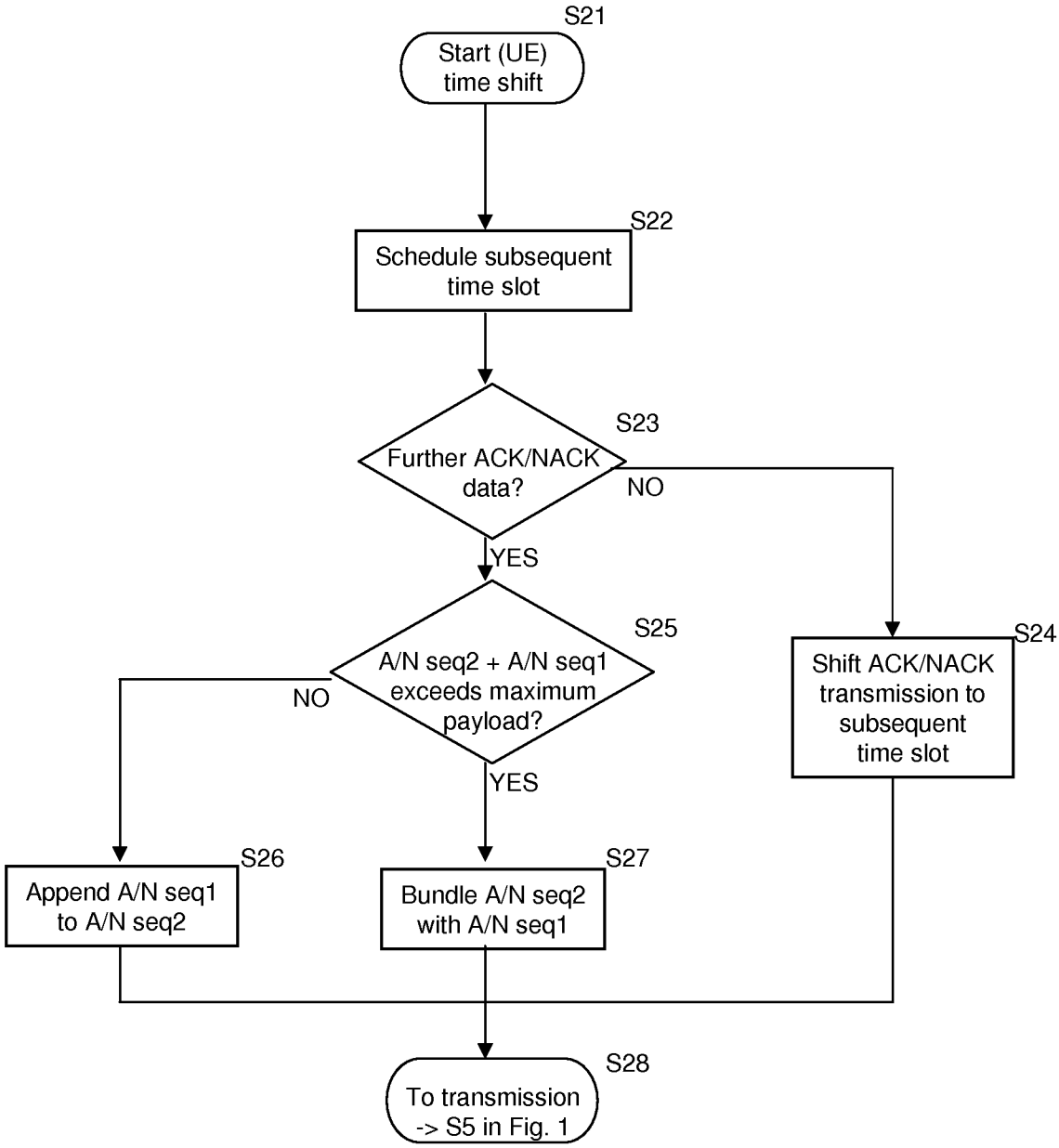
S21
Start (UE) time shift
S22
Schedule subsequent time slot
S23
Further ACK/NACK data?
NO
YES
S24
Shift ACK/NACK transmission to subsequent time slot
S25
A/N seq2 + A/N seq1 exceeds maximum payload?
NO
YES
S26
Append A/N seq1 to A/N seq2
S27
Bundle A/N seq2 with A/N seq1
S28
To transmission -> S5 in Fig. 1

Fig. 3

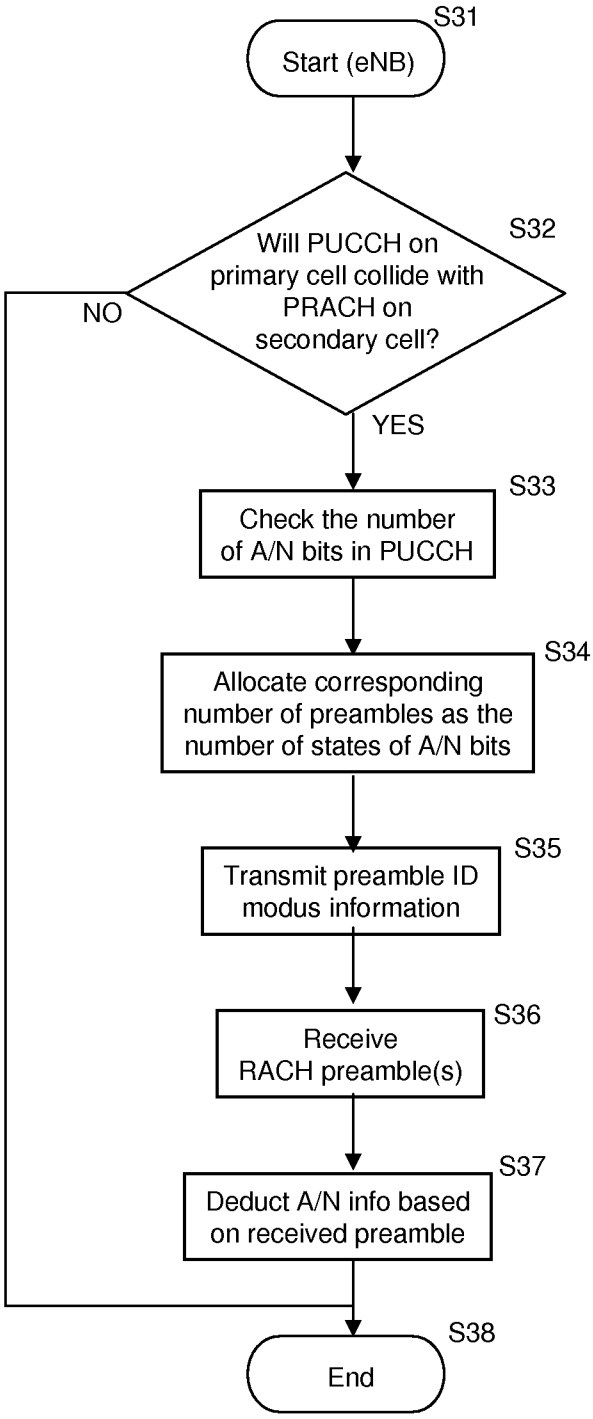
S31
Start (eNB)
S32
Will PUCCH on primary cell collide with PRACH on secondary cell?
NO
YES
S33
Check the number of A/N bits in PUCCH
S34
Allocate corresponding number of preambles as the number of states of A/N bits
S35
Transmit preamble ID modus information
S36
Receive RACH preamble(s)
S37
Deduct A/N info based on received preamble
S38
End

Fig. 4

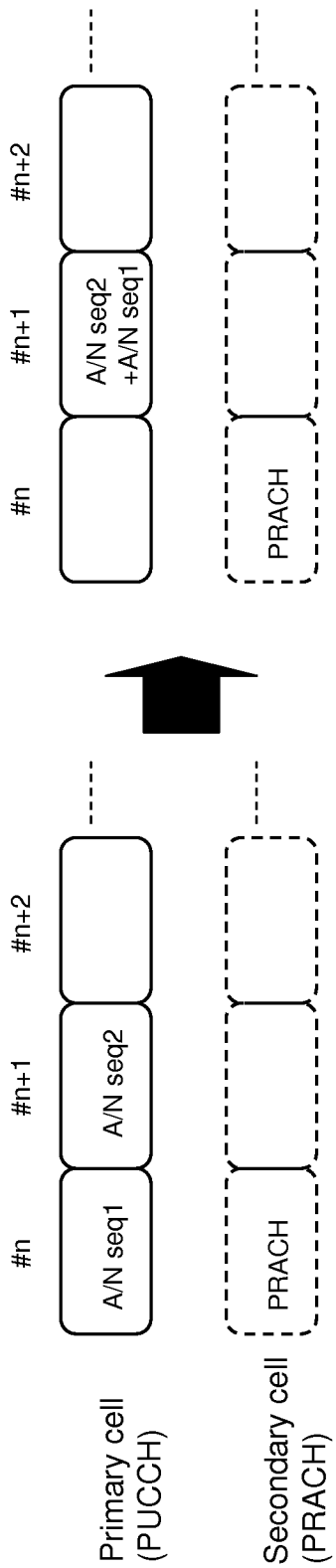
#n
#n+1
#n+2
A/N seq1
A/N seq2
PRACH
Primary cell
(PUCCH)
Secondary cell
(PRACH)
#n
#n+1
#n+2
A/N seq2
+A/N seq1
PRACH

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2011/081990

A. CLASSIFICATION OF SUBJECT MATTER

H04W72/04 (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, H04L1, H04L5, H04Q7

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)

VEN, CPRSABS, CNKI: carrier aggregat+, CA, component carrier?, CC, payload, time slot, same, different, estimat+, acknowledg+, power control+, tim+, transmit+, receiv+, shift, schedule+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO2011137177A1 (RES IN MOTION LTD) 03 Nov. 2011(03.11.2011) Page 18, line 13-page 21, line 4 of the description, fig.7-fig13	1-26
A	WO2010114252A2 (LG ELECTRONICS INC) 07 Oct. 2010(07.10.2010) Page 16, line 10-page 42, line 9 of the description	1-26
A	CN101835261A (NEW POST COMMUNICATION EQUIP CO LTD) 15 Sept. 2010 (15.09.2010) the whole document	1-26
A	WO2011019009A1 (NEC CORP) 17 Feb. 2011 (17.02.2011) the whole document	1-26
A	CN101489255A (ZTE CORP) 22 Jul. 2009 (22.07.2009) the whole document	1-26

☐ 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
31.7 月 2012 (31.07.2012)	**09 Aug. 2012 (09.08.2012)**
Name and mailing address of the ISA/CN The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451	Authorized officer WANG, Chunyan Telephone No. (86-10)62411355

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