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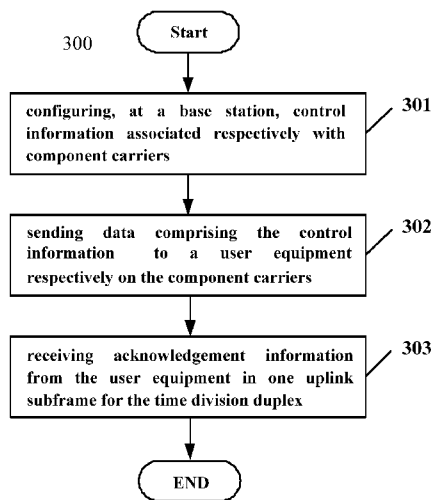


Figure 3

(57) Abstract: Embodiments of the present invention provide a method and apparatus for transmitting control information. The method comprises: configuring control information associated respectively with a plurality of component carriers at a base station; sending data to a user equipment respectively on the plurality of component carriers, the data at least comprising the control information associated with a respective component carrier; and receiving acknowledgement information for the data from the user equipment in one uplink subframe for time division duplex, wherein the control information is configured for indicating to the user equipment timing of sending the acknowledgement information for the data received on the respective component carrier for the frequency division duplex, said timing being consistent with the timing of sending the acknowledgement information for the data received on the respective component carrier for the time division duplex.

METHOD AND APPARATUS FOR TRANSMITTING CONTROL INFORMATION

TECHNICAL FIELD

5 The present invention relates to a wireless communications system and more particularly to a method and apparatus for transmitting control information in Long Term Evolution Time Division Duplex-Frequency Division Duplex (LTE TDD-FDD) joint system.

BACKGROUND

10 In the latest RAN#60 meeting of the third generation partnership project (3GPP), a work item related to LTE TDD-FDD joint operation was approved. Its objective is to enhance LTE TDD-FDD joint operation with the LTE TDD-FDD carrier aggregation (CA) feature and potentially also with other TDD-FDD joint operation solutions depending on the outcome of the initial scenario evaluation phase of the work item. The CA of FDD and TDD carriers may provide more system flexibility and performance benefits for operators
15 which own both FDD and TDD spectrums. However, due to differences between LTE FDD and LTE TDD specifications, especially in control signaling and subframe timing, some problems arise in the TDD-FDD carrier aggregation.

For example, as shown in Fig. 1(a), in an LTE FDD system, the round-trip time (RTT) for both uplink (UL) and downlink (DL) transmission is fixed as 8 ms and the maximum
20 Hybrid Automatic Repeat Request (HARQ) process number (HPN) is fixed as 8. Furthermore, in the FDD mode, the position for positive acknowledgement (ACK)/negative acknowledgement (NACK) feedback is fixed, i.e., it is transmitted after processing time of 3ms following DL transmission. Thus, in the FDD mode, a 3-bit HPN field is provided in downlink control information (DL DCI), which is sufficient to indicate the number of
25 HARQ processes for DL transmission.

However, for the TDD mode, due to the fact that UL transmission opportunities are depending on UL/DL configurations of the system, they are discontinuous. Therefore, a user equipment (UE) cannot always find an UL subframe for the ACK/NACK feedback of a physical downlink shared channel (PDSCH), for example. The UE needs to wait and
30 cannot perform the ACK/NACK feedback until the UL subframe arrives. As shown in Fig.

1(b), in the case that TDD UL/DL configuration 2 is adopted, the RRT is 11 ms and positions of ACK/NACK feedback are discontinuous. For example, Table 7-1 of 3GPP TS 36.213 illustrates maximum numbers of DL HARQ processes in different TDD UL/DL configurations. Table 1 represents the content of Table 7-1 of 3GPP TS 36.213.

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Table 1 Maximum Number of DL HARQ Processes

TDD UL/DL Configuration	Maximum Number of HARQ Processes
0	4
1	7
2	10
3	9
4	12
5	15
6	6

According to the TDD UL/DL configurations, the interval between PDSCH transmission and ACK/NACK feedback ranges from 4 to 13 subframes in length, and normally between 4 ms and 13 ms. Thus, in the TDD mode, the HPN field in the DL DCI is set as 4 bits.

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The current 3GPP Specification sets an important constraint on HARQ transmission in the case of carrier aggregation, that is, a physical uplink control channel (PUCCH) that carries HARQ is only transmitted on a primary component carrier (PCC). In a TDD-FDD joint system with carrier aggregation, when a TDD component carrier (CC) and a FDD CC are aggregated and the TDD CC is configured as the PCC, the ACK/NACK will be carried by the TDD PCC either on the PUCCH or PUSCH. Herein, for example, as shown in Fig. 2, for the FDD DL CC, after the PDSCH is transmitted by an eNB in a first DL subframe, ACK/NACK feedback will be sent in a UL subframe numbered as 7 in the TDD PCC, and afterwards, after a processing delay of 3 ms, the eNB may send the next PDSCH, and in this case, the RTT for this FDD DL CC is extended beyond 8ms and to 11 ms. At this time, if the HPN field is still configured as 3 bits in length in the FDD DL DCI, it is insufficient to indicate the actually required HPN.

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In addition, in 3GPP TS 36.213, it is specified that for a UE configured with more than one serving cell, the ACK/NACK of all CCs should be transmitted on the PCC via the PUCCH or PUSCH except for the following situation.

25

If a UE is configured with more than one serving cell but not configured as performing PUSCH and PUCCH transmission simultaneously, then in subframe n, if uplink control information (UCI) consists of a periodical CSI and/or HARQ-ACK and the UE does

not transmit the PUSCH on a primary cell but transmits the PUSCH on at least one secondary cell, then the UCI should be transmitted on the PUSCH of a secondary cell with the smallest ScellIndex (i.e. serving cell index).

5 In the case of carrier aggregation, the above situation occurs only when PUCCH and PUSCH resources of the PCC are used up. Thus, for a certain UE, the possibility that this situation occurs is very low. As for TDD-FDD CA, in the case that the SCC with the smallest ScellIndex is a TDD CC, the RTT for DL transmission on an FDD CC is still possible to exceed 8 ms. Therefore, in such a situation, the HPN with 3 bits is also insufficient to indicate the actually required HPN. There is still a problem of HPN
10 extension.

In another aspect, if the SCC with the smallest ScellIndex is an FDD CC, then although it is possible to transmit ACK/NACK for FDD DL transmission according to FDD HARQ timing, it is still difficult for a UE, to a certain extent, to switch between two types of HARQ timing depending on whether there is a PUCCH/PUSCH resource allocated on the
15 TDD PCC.

SUMMARY

In order to solve the above problems existing in the prior art, embodiments of the present invention propose a method and apparatus for dynamically adjusting the value of a binding size to effectively confirm information transmission in the case that the TDD
20 UL-DL configuration is changed based on traffic adaptation.

According to one aspect of the present invention, there is provided a method for transmitting control information used in a time division duplex (TDD) and frequency division duplex (FDD) carrier aggregation system, the system being configured with a plurality of component carriers used respectively for the time division duplex and frequency
25 division duplex. The method comprises: configuring control information associated respectively with the plurality of component carriers at a base station; sending data to a user equipment respectively on the plurality of component carriers, the data at least comprising the control information associated with a respective component carrier; and receiving acknowledgement information for the data from the user equipment in one uplink subframe
30 used for the time division duplex, wherein the control information is configured to indicate to the user equipment timing of sending the acknowledgement information for the data received on the respective component carrier used for the frequency division duplex, said

timing being consistent with the timing of sending the acknowledgement information for the data received on the respective component carrier used for the time division duplex. \ , \

According to another aspect of the present invention, there is provided a method for transmitting acknowledgement information used in a TDD and FDD carrier aggregation system. The system is configured with a plurality of component carriers used respectively for the time division duplex and frequency division duplex. The method comprises: receiving data from a base station on the plurality of component carriers respectively, the data at least comprising control information associated a respective component carrier; extracting the control information from the received data; and sending acknowledgement information for the data in one uplink subframe used for the time division duplex based on the control information, wherein a user equipment obtains, based on the control information, timing of sending to the base station the acknowledgement information for the data received on the respective component carrier used for the frequency division duplex, said timing being consistent with the timing of sending the acknowledgement information for the data received on the respective component carrier used for the time division duplex.

According to another aspect of the present invention, there is provided a communications apparatus used in a TDD and FDD carrier aggregation system. The system is configured with a plurality of component carriers used respectively for the time division duplex and the frequency division duplex. The communications apparatus comprises: a processor configured for configuring control information associated respectively with the plurality of component carriers; an transmitter configured for sending data to a UE on the plurality of component carriers respectively, the data at least comprising the control information associated with a respective component carrier; and a receiver configured for receiving the acknowledgement information for the data from the UE in one uplink subframe used for the time division duplex, wherein the control information is configured to indicate to the UE timing of sending the acknowledgement information for the data received on the respective component carrier used for the frequency division duplex, said timing being consistent with the timing of sending the acknowledgement information for the data received on the corresponding component carrier used for the time division duplex.

According to another aspect of the present invention, there is provided a communications apparatus used in a TDD and FDD carrier aggregation system. The system is configured with a plurality of component carriers used respectively for the time division duplex and the frequency division duplex. The communications apparatus comprises: a receiver configured for receiving data from a base station on the plurality of

component carriers respectively, the data at least comprising control information associated with a respective component carrier; a processor configured for extracting the control information from the received data; and an transmitter configured for sending, based on the control information, acknowledgement information for the data in one uplink subframe used
5 for the time division duplex, wherein a user equipment obtains, based on the control information, timing of sending the acknowledgement information for the data received on the respective component carrier used for the frequency division duplex, said timing being consistent with the timing of sending the acknowledgement information for the data received on the respective component carrier used for the time division duplex.

10 According to yet another aspect of the present invention, there is provided a communications apparatus used in a time division duplex and frequency division duplex carrier aggregation system. The system is configured with a plurality of component carriers used respectively for the time division duplex and the frequency division duplex, wherein the components carriers used for the frequency division duplex include uplink
15 component carriers and downlink component carriers. The communications apparatus comprises: a device for receiving data from a base station, the data at least comprising control information associated with a respective component carrier; a device for extracting the control information from the data; and a device for sending, based on the respective control information, acknowledgement information for the data received on the component
20 carrier used for the time division duplex in one uplink subframe used for the time division duplex, and sending acknowledgement information for the data received on the respective downlink component carrier used for the frequency division duplex on one uplink component carrier used for the frequency division duplex, respectively.

BRIEF DESCRIPTION OF THE DRAWINGS

25 In conjunction with accompanying figures and referring to the following detailed description, features, advantages and other aspects of embodiments of the present invention will become more apparent. Here, several embodiments of the present invention are illustrated in an exemplary instead of limiting way, in which:

Fig. 1 shows a round trip time for uplink and downlink transmission in an LTE TDD
30 and LTE FDD system in the prior art;

Fig. 2 shows a potential problem in the case of FDD and TDD carrier aggregation;

Fig. 3 shows a flowchart for a method 300 used in an LTE FDD-TDD CA system for indicating HPN information to a UE according to an embodiment of the present invention;

Fig. 4 shows a flowchart of a method 400 used in an LTE FDD-TDD CA system for transmitting acknowledgement information to a base station according to an embodiment of the present invention; and

Fig. 5 illustrates a communications apparatus 500 on the base station side and a communications apparatus 510 on the user equipment side for implementing embodiments of the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS

10 Various exemplary embodiments of the present invention are described with reference to the accompanying figures hereafter.

It should be appreciated that these exemplary embodiments are provided merely for one skilled in the art to better understand and further implement the present invention, rather than limiting the scope of the present invention in any way.

15 As for UL transmission in the TDD mode, since synchronous HARQ is adopted and no HPN field exists in the UL DCI, there is no HPN extension problem caused by HPN difference between FDD and TDD modes as mentioned in the Background section. Thus, the embodiments of the present invention only involve the HPN extension problem in DL transmission.

20 According to the embodiments of the present invention, there is provided a solution in which the HPN extension problem presented in the prior art as mentioned above may be overcome by modifying the existing control signaling.

According to an embodiment of the present invention, by means of explicitly adding one additional bit into the HPN field of the existing FDD DL DCI, the HPN field is enabled
25 to indicate up to 16 HARQ processes. If an UE is configured with TDD-FDD CA and a TDD CC is configured as the PCC, then it is needed to modify the current radio resource control (RRC) signaling for the CA, so as to notify the TDD-FDD CA configuration of this type. In this embodiment, once the UE is scheduled, then the eNB uses the HPN of 4 bits to code the DL DCI (or DL grant) that schedules the FDD DL CC resource; then at the UE
30 side, the UE blindly decodes the DL DCI of the FDD CC based on the new DCI size with

one additional bit. This method has been used in the decoding of the DCI with a CIF (carrier indicator field) for scheduling across CCs, which is not described redundantly. When the UE is aware of the CA configuration, in order to decode the DL DCI of this type, the UE will use the new DCI size with additional 3 bits to carry out blind decoding.

5 This explicit signaling approach can effectively communicate to the UE the HPN information associated with FDD CCs, while not increasing complexity of the blind decoding.

According to another embodiment of the present invention, there is provided a solution of communicating HNP information to a UE by using implicit signaling.

10 In an example, the HPN may be implicitly notified by position information of the DL DCI in an (e) PDCCH frame. For example, if the DL DCI is located in odd downlink subframes, then it implicitly indicates to the UE that one bit 0 is added to the HPN; and if the DL DCI is located in even downlink subframes, then it implicitly indicates to the UE that one bit 1 is added to the HPN, and vice versa. One skilled in the art should understand
15 that other different approaches may be used to provide the DL DCI or the (e) PDCCH including the DL DCI at different downlink subframes. As long as these approaches can implicitly communicate to the UE the HPN information associated with different DL CCs, they all can achieve the objective of the present invention and fall into the protection scope of the present invention.

20 In another example, the HPN may be implicitly notified to the UE by means of the position of the DL DCI or the (e) PDCCH including the DL DCI in a common search space monitored by the UE or in a search space specific to the UE. For example, the (e) PDCCH common search space where the DL DCI may be located or the search space specific to the UE may be divided into two sets according to the applied control channel element (CCE)
25 aggregation, e.g., a previous half of the search space may be classified as a first set and a last half of the search space as a second set; or the division may be depending on odd/even indices. In particular, for example, if the desired DCI is Format 2 and the CCE aggregation level is 2, namely $L=2$, then the number of PDCCH candidates in the UE search space is $M^{(L)}=6$, as shown in Table 9.1.1-1 in 3GPP TS 36.213. Table 2
30 represents the content of Table 9.1.1-1.

Table 2: PDCCH candidates monitored by a UE

Search Space $S_k^{(L)}$			Number of PDCCH candidates $M^{(L)}$
Type	Aggregation Level L	Size [in CCEs]	
UE-specific	1	6	6
	2	12	6
	4	8	2
	8	16	2
Common	4	16	4
	8	16	2

Afterwards, the PDCCH may further be divided into two sets, e.g., the first set may be divided as {1,2,3} and the second set may be divided as {4,5,6}, by means of which the UE is implicitly informed of the additional bit of the HPN being 0 or 1. For example, the DCI in the PDCCH of the first set implicitly contains one additional bit 0 while the DCI in the PDCCH of the second set implicitly contains one additional bit 1. However, one skilled in the art should understand that the division for the sets and their correspondence to the additional bit value are not limited to this, and any division manners and correspondence capable of achieving the objective of the present invention all fall into the protection scope of the present invention.

According to yet another embodiment of the present invention, there is provided a method for implicitly informing the additional bit on the (e) PDCCH.

In the existing UEs, each UE may support one antenna port, or a plurality of antenna ports, for example, a dual antenna port including antenna port 0 and antenna port 1. The UE supporting multiple antenna ports may adopt the UE transmit antenna selecting technology to select an antenna port to transmit uplink signals. The UE transmitting antenna selection is configured in a higher layer. In the current system, when a closed-loop antenna selection is enabled, i.e. a base station, e.g. an eNodeB, indicates which antenna should be used for the PUSCH by coding the information for indicating which antenna should be used for the PUSCH in the uplink scheduling grant (DCI 0). As for a UE with two transmit antennas, at the base station side, the base station scramble 16 CRC parity bits (for example, by modulo-2 addition), with one of two antenna selection masks as shown in Table 3. The antenna selection masks listed in Table 3 represent the content of Table 5.3.3.2-1 in 3GPP TS 36.212.

Table 3: UE transmit antenna selection mask

UE transmit antenna selection	Antenna selection mask $\langle x_{AS,0}, x_{AS,1}, \dots, x_{AS,15} \rangle$
UE port 0	$\langle 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0 \rangle$
UE port 1	$\langle 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1 \rangle$

In particular, as for a UE configured with two available transmit antennas, at the base station side, after adding the CRC, the base station uses one antenna mask and a corresponding UE identification (for example, RNTI) mask to scramble the CRC parity bits of the PDCCH with DCI format 0, wherein the UE identification mask is used for indicating the UE to which the scheduling grant is directed. At the UE side, the UE will use two masks to try decoding, wherein depending on which decoding is successful, the UE will know whether “1” or “0” is corresponding to the mask used by the base station. With this implicit coding, it is avoided to use the explicit antenna section bit. The explicit antenna section may result in an increased overhead for UEs not supporting (or not configured) for the transmit antenna selection.

According to one embodiment of the present invention, based on the principle similar to the transmit antenna section mask, for example, using an HPN mask including two bit strings (e.g., two 16-bit strings shown in Table 3), it is also possible to implicitly inform a UE of the value of one bit added to the HPN. For example, at the eNB side, the eNB may apply a UE identifier ID and one HPN mask, for example, $\langle 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0 \rangle$ to the CRC. Then, at the UE side, before the CRC check, the UE uses the UE ID and two HPN masks, i.e., $\langle 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0 \rangle$ and $\langle 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1 \rangle$ to perform decoding, for example, perform the bit exclusive-or (XOR) operation with the received data. In this example, the decoding by using $\langle 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0 \rangle$ mask is successful, thus the UE may be aware that the value of the added HPN bit is 0. Then, in combination of the value of the received HPN field, the UE may know the HPN information indicated by the base station.

In Addition, since the UE antenna selection mask is merely used for the UL grant (the PDCCH having DCI Format 0) while the HPN extension problem concerned by the embodiments of the present invention only happens in the DL grant (i.e., PDCCHs having DCI Format 1/1A/1B/1C/2/2A/2B/2D/3/3A), according to embodiments of the present invention, it is possible to reuse the UE antenna section mask for the HPN extension with 1 bit, such that the complexity in computation and design would not be introduced. Table 4 illustrates an example of the HPN mask of one embodiment of the present invention.

Table 4: HPN masks

Additional HPN Bit	HPN Mask $\langle x_{AS,0}, x_{AS,1}, \dots, x_{AS,15} \rangle$
0	$\langle 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0 \rangle$
1	$\langle 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1 \rangle$

This approach of implicitly informing the HPN keeps the reliability of PDCCHs without adding new bits, thus it does not increase the signaling overhead.

Fig. 3 shows a flowchart for a method 300 used in an LTE FDD-TDD CA system for indicating HPN information to a UE according to an embodiment of the present invention. As shown in Fig. 3, in Block 301, a base station (e.g., an eNodeB or eNB) configures control information associated respectively with a plurality of downlink component carriers (e.g. FDD CC and TDD CC). According to one embodiment of the present invention, the control information is the value of an HPN field. Then, in Block 302, the base station sends data to the UE respectively on the plurality of downlink component carriers (e.g., FDD DL CC and TDD DL CC), the data at least comprising control information associated with a respective downlink component carrier. Afterwards, in Block 303, it receives from the UE acknowledgement information for the data on one component carrier (e.g. TDD PCC) for the time division duplex. In method 300, the control information is configured to indicate to the UE that: timing of sending the acknowledgement information for the data received on the respective downlink component carrier for the frequency division duplex is consistent with the timing of sending the acknowledgement information for the data received on the downlink component carrier for the time division duplex.

According to one embodiment of the present invention, it is possible to directly set the HPN field in the DL DCI of an (e) PDCCH as 4 bits, so as to indicate to the UE the HPN information associated with a FDD CC. According to another embodiment of the present invention, it is possible to configure the position of the (e) PDCCH in different downlink subframes, so as to implicitly indicate to the UE the value of a bit which may be, as the additional bit, added into the HPN field included in the DL DCI of the (e) PDCCH, such that it may indicate to the UE the HPN information associated with the FDD CC. According to another embodiment of the present invention, the value of a bit which may be, as the additional bit, added into the HPN field included in the DL DCI of the (e) PDCCH, may be implicitly indicated to the UE by setting the position of the (e) PDCCH in the common search space monitored by the UE or in the search space specific to the UE, so as to indicate to the UE the HPN information associated with the FDD CC. According to another embodiment of the present invention, it is possible to reuse the UE antenna section mask for the HPN mask, so as to implicitly indicate to the UE the value of a bit which may

be, as the additional bit, added into the HPN field included in the DL DCI of the (e) PDCCH, to indicate to the UE the HPN information associated with the FDD CC.

Fig. 4 shows a flowchart of method 400 used in an LTE FDD-TDD CA system for transmitting acknowledgement information to a base station according to an embodiment of the present invention. In Block 401, a UE receives data from the base station respectively on a plurality of downlink component carriers, the data at least comprising control information associated with a respective downlink component carrier. Then, in Block 402, the UE extracts from the received data the control information associated with individual downlink component carriers. Then, in Block 403, the UE, based on the extracted control information, sends the acknowledgement information for the received data on one uplink component carrier for the time division duplex. In this method, the UE obtains, based on the extracted control information, timing of sending the acknowledgement information to the base station for the data received on the respective downlink component carrier for the frequency division duplex, said timing being consistent with the timing of sending the acknowledgement information for the data received on the downlink component carrier for the time division duplex.

Fig. 5 illustrates a communications apparatus 500 at the base station side for implementing method 300 in an LTE FDD-TDD CA system and a communications apparatus 510 at the equipment side for implementing method 400 according to an embodiment of the present invention. As shown in Fig. 5, the communications apparatus 500 at least comprises: a transmitter/receiver 501, configured for sending data to a UE, the data at least comprising control information associated with a respective downlink component carrier, and for receiving from the UE acknowledgement information for the data on one uplink component carrier for the time division duplex; and a processor 502, configured for configuring control information associated with downlink component carriers so as to indicate to the UE timing of sending the acknowledgement information, wherein the control information may indicate to the UE that: the timing of sending the acknowledgement information for the data received on the respective downlink component carrier for the frequency division duplex is consistent with the timing of sending the acknowledgement information for the data received on the downlink component carrier for the time division duplex. The communications apparatus 500 may also comprise a memory 504, used for storing program codes and data used in steps of method 300.

The communications apparatus 510 at the UE side comprises: a transmitter/receiver 511, configured for receiving data from the base station respectively on a plurality of downlink component carriers, the data at least comprising control information associated

with a respective downlink component carrier, and for sending, based on the control information, the acknowledgement information for the received data on one uplink component carrier for the time division duplex; and a processor 512, configured for extracting from the received data the control information associated with individual
5 downlink component carriers. The communications apparatus 510 may also comprise a memory 514, used for storing program codes and data used in steps of method 400.

As for the problems existing in the prior art, according to another embodiment of the present invention, there is provided a more direct solution, that is, the PUCCH is enabled at a UE to be transmitted on the FDD SCC, such that ACK/NACK for the FDD DL CC and the
10 ACK/NACK for TDD DL are transmitted on different component carriers. In particular, in this embodiment, the resource allocation for the ACK/NACK of the PDSCH on all TDD CCs is depending on the existing specification for the TDD CA system, however, as for the ACK/NACK of the PDSCH on all FDD CCs, if the PCC is a TDD CC, then one UL CC is selected in the FDD, and another set of PUCCHs are provided on this CC, and the
15 ACK/NACK for the FDD PDSCH is arranged on the configured PUCCHs. Alternatively, it is possible to configure a plurality of FDD UL CCs, one of which carries the PUCCH. If the resource of the PUCCH is appropriate for the ACK/NACK of all PDSCHs, then all ACK/NACKs may be arranged on the PUCCH; and if not, then the ACK/NACKs may be arranged on the PUSCH of all FDD UL CCs. In other words, the DL HARQs for
20 individual FDD CCs will be transmitted on respective FDD UL CCs. In this case, the ACK/NACK for the FDD PDSCH may be carried on the FDD PUCCH/PUSCH according to the timing of FDD HARQ, so as to avoid the problem due to the previous HPN difference between the FDD and the TDD.

Although the description is made in the above with the LTE TDD-FDD CA system as
25 an example, one skilled in the art should understand that the present invention is not limited thereto. Any system supporting the HPN may use the method and apparatus according to the embodiments of the present invention.

The above description in conjunction with the accompanying figures is provided exemplarily just for illustrating the present invention. One skilled in the art can understand
30 that it is possible to propose different structures based on the principle of the present invention as mentioned above. Although these different structures are not described or illustrated herein, they all reflect the principle of the present invention and are covered by the spirit and scope of the present invention. Additionally, all examples mentioned herein are explicitly mainly used for the purpose of teaching, for helping readers understand the
35 principle of the present invention and concepts the inventor contributed to the art, and they

should not be interpreted as limiting the present invention. Moreover, the description of the principle, aspects and embodiments of the present invention mentioned herein and specific examples thereof are all contain equivalents thereof.

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CLAIMS

1. A method for communicating control information used in a time division duplex (TDD) and frequency division duplex (FDD) carrier aggregation system, which is
5 configured with a plurality of component carriers used respectively for the time division duplex and the frequency division duplex, the method comprising:
- configuring, at a base station, control information associated respectively with the plurality of component carriers;
 - 10 sending data to a user equipment respectively on the plurality of component carriers, the data at least comprising the control information associated with a respective component carrier; and
 - receiving acknowledgement information for the data from the user equipment in one uplink subframe for the time division duplex,
 - 15 wherein the control information is configured to indicate to the user equipment timing of sending the acknowledgement information for the data received on the respective component carrier for the frequency division duplex, said timing being consistent with the timing of sending the acknowledgement information for the data received on the respective component carrier for the time division duplex.
2. The method according to Claim 1, further comprising: configuring the control
20 information by setting a hybrid automatic repeat request process number (HPN) field included in a physical downlink control channel (PDCCH).
3. The method according to Claim 2, further comprising: configuring the control information at least by setting the hybrid automatic repeat request process number (HPN) field as having a predetermined number of bits.
- 25 4. The method according to Claim 2, further comprising: configuring the control information at least by setting a position of the physical downlink control channel in a subframe for downlink transmission.
5. The method according to Claim 2, further comprising: configuring the control information at least by setting a position of the physical downlink control channel in a
30 search space monitored by the user equipment.
6. The method according to Claim 2, further comprising: configuring the control information at least by applying a hybrid automatic repeat request process number mask to a parity check bit included in the downlink control channel, wherein the hybrid automatic repeat request process number mask at least comprises a bit string.

7. The method according to Claim 3, wherein the predetermined number of bits is 4.

8. The method according to any of Claims 4-6, wherein the hybrid automatic repeat request process number field comprises 3 bits.

5 9. A method for transmitting acknowledgement information used in a time division duplex (TDD) and frequency division duplex (FDD) carrier aggregation system, which is configured with a plurality of component carriers used respectively for the time division duplex and frequency division duplex, the method comprising:

10 receiving data from a base station on the plurality of component carriers respectively, the data at least comprising control information associated with a respective component carrier;

extracting the control information from the received data; and

sending acknowledgement information for the data in one uplink subframe for the time division duplex based on the control information,

15 wherein the user equipment obtains based on the control information timing of sending to the base station the acknowledgement information for the data received on the respective component carrier for the frequency division duplex, the timing being consistent with the timing of sending the acknowledgement information for the data received on the respective component carrier for the time division duplex.

20 10. The method according to Claim 9, wherein the user equipment obtains the control information by decoding a hybrid automatic repeat request process number field included in a physical downlink control channel (PDCCH).

11. The method according to Claim 10, wherein the user equipment obtains the control information based at least on a value of a predetermined number of the hybrid automatic repeat request process number field.

25 12. The method according to Claim 10, wherein the user equipment obtains the control information based at least on a position of the physical downlink control channel in a subframe for downlink transmission and the hybrid automatic repeat request process number field.

30 13. The method according to Claim 10, wherein the user equipment obtains the control information based at least on a position of the physical downlink control channel in a search space monitored by the user equipment and the hybrid automatic repeat request process number field.

14. The method according to Claim 10, wherein the user equipment obtains the control information at least by applying a hybrid automatic repeat request process number mask to

decode a parity check bit included in the downlink control channel and the hybrid automatic repeat request process number field, wherein the hybrid automatic repeat request process number mask at least comprises two different bit strings.

5 15. The method according to Claim 11, wherein the hybrid automatic repeat request process number field comprises 4 bits.

16. The method according to any of Claims 12-14, wherein the hybrid automatic repeat request process number field comprises 3 bits.

10 17. A method for transmitting acknowledgement information used in a time division duplex (TDD) and frequency division duplex (FDD) carrier aggregation system, which is configured with a plurality of component carriers used respectively for the time division duplex and frequency division duplex, wherein the component carriers used for the frequency division duplex comprises uplink component carriers and downlink component carriers, the method comprising:

15 receiving data from a base station on the plurality of component carriers respectively, the data at least comprising control information associated with a respective component carrier;

extracting the control information from the data; and

20 based on the respective control information, sending acknowledgement information for the data received on the component carrier for the time division duplex in one uplink subframe for the time division duplex and acknowledgement information for the data received on the respective downlink component carrier for the frequency division duplex on one uplink component carrier for the frequency division duplex, respectively.

25 18. A communications apparatus used in a time division duplex (TDD) and frequency division duplex (FDD) carrier aggregation system, which is configured with a plurality of component carriers used respectively for the time division duplex and the frequency division duplex, the communications apparatus comprising:

a processor configured for configuring control information associated respectively with the plurality of component carriers,

30 a transmitter configured for sending data to a user equipment on the plurality of component carriers respectively, the data at least comprising the control information associated with a respective component carrier; and

a receiver configured for receiving acknowledgement information for the data from the user equipment in one uplink subframe for the time division duplex,

wherein the control information is configured to indicate to the user equipment timing of sending the acknowledgement information for the data received on the respective component carrier for the frequency division duplex, said timing being consistent with the timing of sending the acknowledgement information for the data received on the respective component carrier for the time division duplex.

19. The communications apparatus according to Claim 18, wherein the processor is further configured to configure the control information by setting a hybrid automatic repeat request process number (HPN) field included in a physical downlink control channel (PDCCH).

20. The communications apparatus according to Claim 18, wherein the processor is further configured to configure the control information at least by setting the hybrid automatic repeat request process number (HPN) field as having a predetermined number of bits.

21. The communications apparatus according to Claim 18, wherein the processor is further configured to configure the control information at least by setting a position of the physical downlink control channel in a subframe for downlink transmission.

22. The communications apparatus according to Claim 18, wherein the processor is further configured to configure the control information at least by setting a position of the physical downlink control channel in a search space monitored by the user equipment.

23. The communications apparatus according to Claim 18, wherein the processor is further configured to configure the control information at least by applying a hybrid automatic repeat request process number mask to a parity check bit included in the downlink control channel, wherein the hybrid automatic repeat request process number mask at least comprises one bit string.

24. A communications apparatus used in a time division duplex (TDD) and frequency division duplex (FDD) carrier aggregation system, which is configured with a plurality of component carriers used respectively for the time division duplex and the frequency division duplex, the communications apparatus comprising:

a receiver configured for receiving data from a base station on the plurality of component carriers respectively, the data at least comprising control information associated with a respective component carrier;

a processor configured for extracting the control information from the received data;
and

a transmitter configured for sending, based on the control information, acknowledgement information for the data in one uplink subframe for the time division duplex,

5 wherein the user equipment obtains, based on the control information, timing of sending to the base station the acknowledgement information for the data received on the respective component carrier for the frequency division duplex, said timing being consistent with the timing of sending the acknowledgement information for the data received on the respective component carrier for the time division duplex.

10 25. The communications apparatus according to Claim 24, wherein the processor is further configured to obtain the control information by decoding the hybrid automatic repeat request process number (HPN) field included in a physical downlink control channel (PDCCH).

15 26. The communications apparatus according to Claim 24, wherein the processor is further configured to obtain the control information based at least on a value of a predetermined number of the hybrid automatic repeat request process number (HPN) field.

27. The communications apparatus according to Claim 24, wherein the processor is further configured to obtain the control information based at least on a position of the physical downlink control channel in a subframe for downlink transmission and the hybrid automatic repeat request process number field.

20 28. The communications apparatus according to Claim 24, wherein the processor is further configured to obtain the control information based at least on a position of the physical downlink control channel in a search space monitored by the user equipment and the hybrid automatic repeat request process number field.

25 29. The communications apparatus according to Claim 24, wherein the processor is further configured to obtain the control information at least by applying a hybrid automatic repeat request process number mask to decode a parity check bit included in the downlink control channel and the hybrid automatic repeat request process number field, wherein the hybrid automatic repeat request process number mask at least comprises two different bit strings.

30 30. A communications apparatus used in a time division duplex (TDD) and frequency division duplex (FDD) carrier aggregation system, which is configured with a plurality of component carriers used respectively for the time division duplex and the frequency division duplex, the communications apparatus comprising:

a device for receiving data from a base station respectively on the plurality of component carriers, the data at least comprising control information associated with a respective component carrier;

a device for extracting the control information from the data; and

- 5 a device for sending, based on the respective control information, acknowledgement information for the data received on the component carrier for the time division duplex in one uplink subframe for the time division duplex, and sending acknowledgement information for the data received on the downlink component carrier for the frequency division duplex in one uplink component carrier for the frequency division duplex,
10 respectively.

DRAWINGS

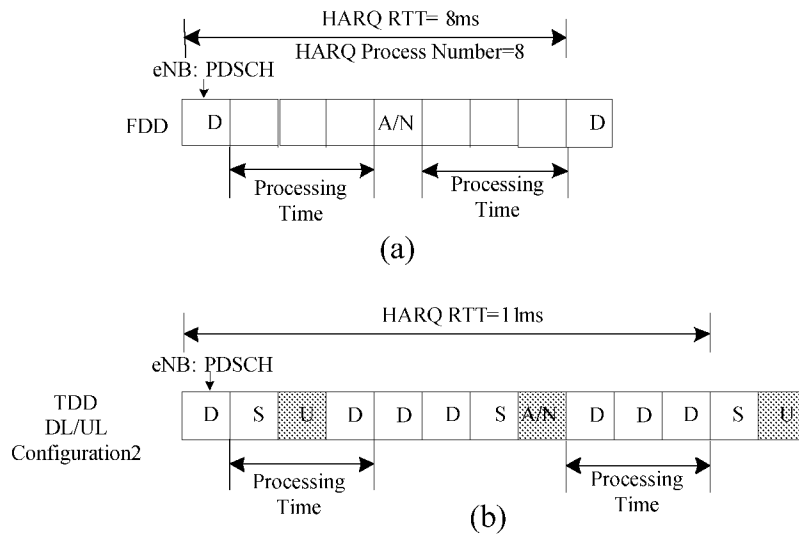


Figure 1

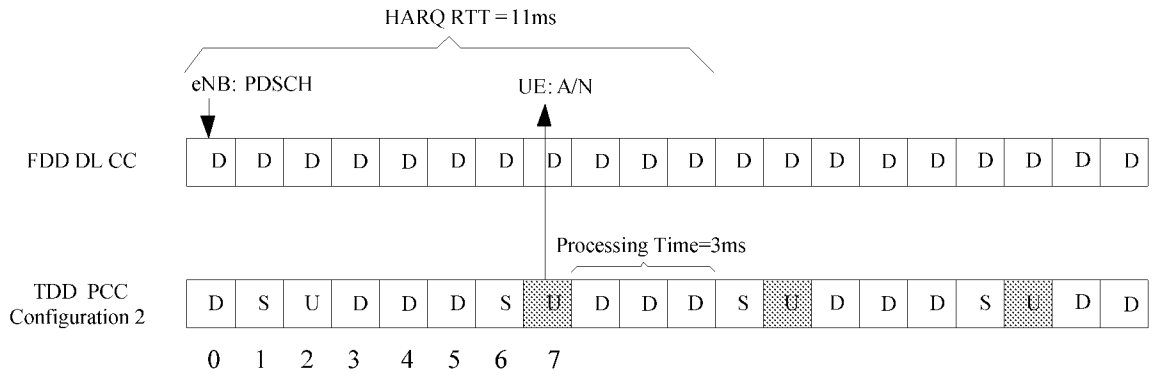


Figure 2

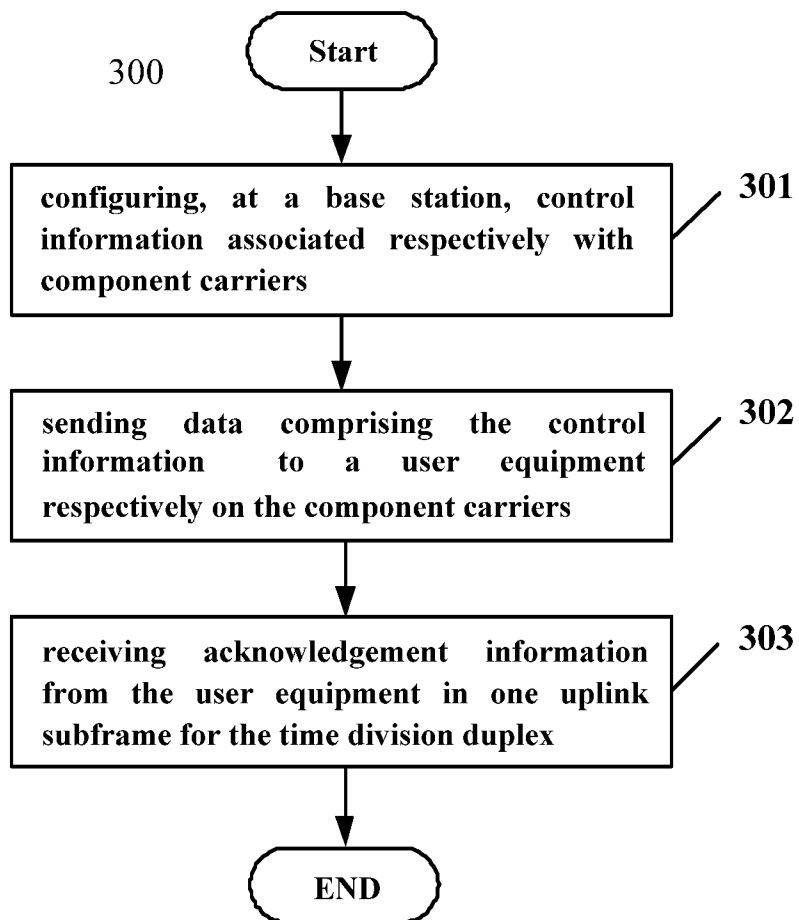


Figure 3

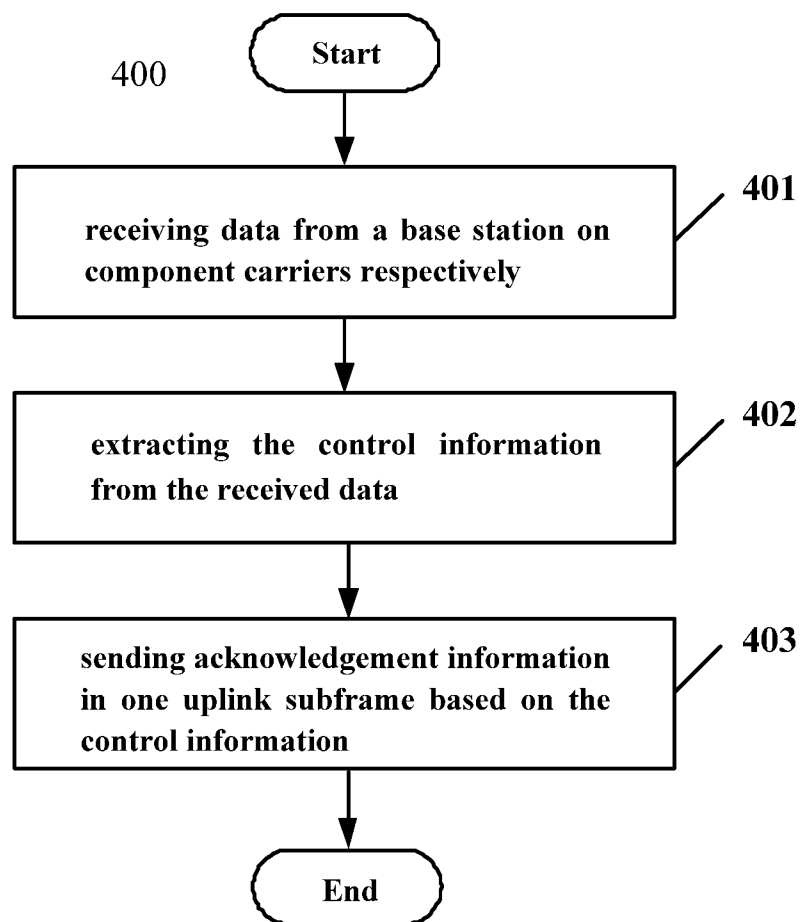


Figure 4

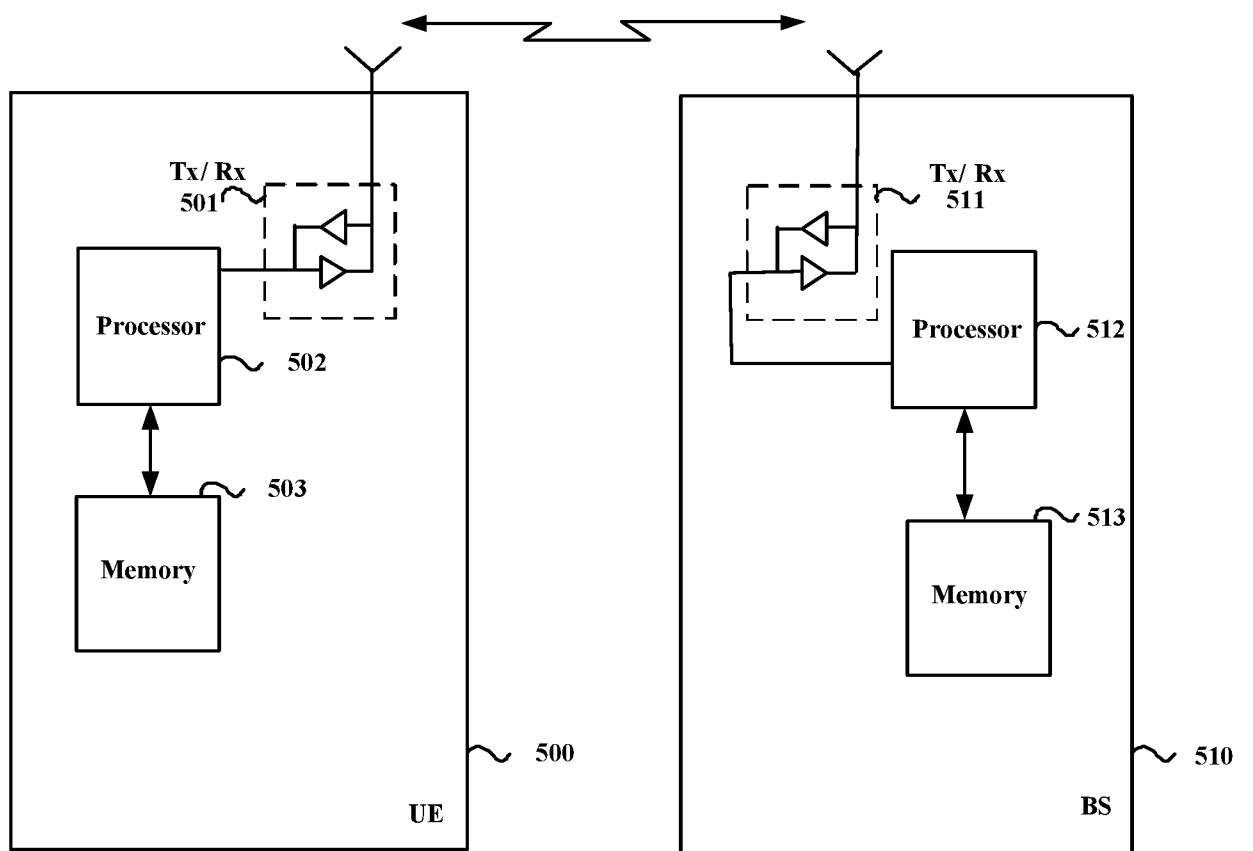


Figure 5

INTERNATIONAL SEARCH REPORT

International application No PCT/IB2014/001710
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A. CLASSIFICATION OF SUBJECT MATTER INV. H04L1/18 H04L5/00 ADD.				
According to International Patent Classification (IPC) or to both national classification and IPC				
B. FIELDS SEARCHED				
Minimum documentation searched (classification system followed by classification symbols) H04L				
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched				
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, COMPENDEX, INSPEC, WPI Data				
C. DOCUMENTS CONSIDERED TO BE RELEVANT				
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.		
X	YONG LI ET AL: "Control Channel Design for Carrier Aggregation between LTE FDD and LTE TDD Systems", VEHICULAR TECHNOLOGY CONFERENCE (VTC SPRING), 2012 IEEE 75TH, IEEE, 6 May 2012 (2012-05-06), pages 1-5, XP032202278, DOI: 10.1109/VETECS.2012.6239853 ISBN: 978-1-4673-0989-9 Sections I-III, IV.A	1-30		
X, P	----- WO 2013/192601 A2 (QUALCOMM INC [US]) 27 December 2013 (2013-12-27) paragraphs [0008], [0009], [0066] - [0069], [0082] - [0088], [0106] - [0118], [0160] - [0173]; figure 9A ----- -/--	1-30		
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.				
* Special categories of cited documents : <table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none; vertical-align: top;"> "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 </td> <td style="width: 50%; border: none; vertical-align: top;"> "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 </td> </tr> </table>			"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
"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			
9 January 2015	19/01/2015			
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Miclea, Sorin			

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2014/001710

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	<p>FIBERHOME: "DL HARQ timing for TDD-FDD CA with self-carrier scheduling when TDD is PCell", 3GPP DRAFT; R1-141368 DL HARQ TIMING FOR TDD-FDD CA WITH SELF-CARRIER SCHEDULING WHEN TDD IS PCELL, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06</p> <p>, vol. RAN WG1, no. Shenzhen, China; 20140331 - 20140404 21 March 2014 (2014-03-21), XP050813548, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_76b/Docs/ [retrieved on 2014-03-21]</p>	1,9,17, 18,24,30
A,P	Section 2	2-8, 10-16, 19-23, 25-29
X,P	<p>-----</p> <p>CATT ET AL: "Way forward on FDD Scell PDSCH HARQ timing with TDD as Pcell", 3GPP DRAFT; R1-140977, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE</p> <p>, vol. RAN WG1, no. Prague, Czech Republic; 20140210 - 20140214 17 February 2014 (2014-02-17), XP050770809, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_76/Docs/ [retrieved on 2014-02-17]</p>	1,9,17, 18,24,30
A,P	Slide 2	2-8, 10-16, 19-23, 25-29

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2014/001710

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2013192601 A2	27-12-2013	US 2013343239 A1	26-12-2013
		WO 2013192601 A2	27-12-2013
