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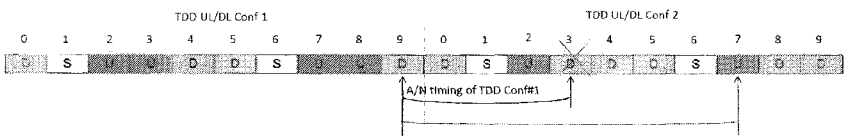

Fig. 7

(57) Abstract: A method including associating at least one bundle windowindex with at least one respective subframe of an uplink-downlink (UL-DL) configuration; and transmitting, for each respective at least one subframe, an ACK/NACK (A/N) indication and an indication of the at least one respective bundle window index.

FLEXIBLE HARQ TIMING

BACKGROUND

Technical Field

[0001] The exemplary and non-limiting embodiments relate generally to wireless communication and, more particularly, to interface management and traffic adaptation.

Brief Description of Prior Developments

[0002] The following is a list of some of the abbreviations which may be used herein:

3GPP	3rd Generation Partnership Project
A/N	ACK/NACK Indication
ACK	Positive Acknowledgment
AP	Access point
CA	Carrier aggregation
CCE	Control Channel Element
CSI	Channel State Information
DCI	Downlink Control Information
DL	Downlink
eIMTA	Enhanced Interference Mitigation & Traffic Adaptation
eNB	evolved Node B
HARQ	Hybrid automatic repeat request
LTE	Long term evolution
LAN	Local area network
NACK	Negative Acknowledgment
PCell	Primary cell
PDCCH	Physical downlink control channel
PDSCH	Physical downlink shared channel
PUCCH	Physical uplink control channel
PUSCH	Physical uplink shared channel
QAM	Quadrature Amplitude Modulation

RRC	Radio resource control
SCell	Secondary cell
SPS	Semi-Persistent Scheduled
TDD	Time-Division Duplex
UE	User equipment
UL	Uplink

SUMMARY

[0003] The following summary is merely intended to be exemplary. The summary is not intended to limit the scope of the claims.

[0004] In accordance with one aspect, a method comprises associating at least one bundle window index with at least one respective subframe of an uplink-downlink (UL-DL) configuration; and transmitting, for each respective at least one subframe, an ACK/NACK (A/N) indication and an indication of the at least one respective bundle window index.

[0005] In accordance with another aspect, an apparatus comprises at least one processor; and at least one non-transitory memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to associate at least one bundle window index with at least one respective subframe of an uplink-downlink (UL-DL) configuration; and transmit, for each respective at least one subframe, an ACK/NACK (A/N) indication and an indication of the at least one respective bundle window index.

[0006] In accordance with another aspect, a non-transitory program storage device readable by a machine, tangibly embodying a program of instructions executable

by the machine for performing operations, the operations comprising associating at least one bundle window index with at least one respective subframe of an uplink-downlink (UL-DL) configuration; and transmitting, for each respective at least one subframe, a ACK/NACK (A/N) indication and an indication of the at least one respective bundle window index.

[0007] In accordance with another aspect, an apparatus comprises means for associating at least one bundle window index with at least one respective subframe of an uplink-downlink (UL-DL) configuration; and means for transmitting, for each respective at least one subframe, a ACK/NACK (A/N) indication and an indication of the at least one respective bundle window index.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The foregoing aspects and other features are explained in the following description, taken in connection with the accompanying drawings, wherein:

[0009] Fig. 1 is a diagram illustrating an example wireless communication system;

[0010] Fig. 2 is a schematic diagram illustrating some of the components of the system shown in Fig. 1;

[0011] Fig. 3 is a chart of downlink allocations for various UL-DL configurations of one example;

[0012] Fig. 4 is a chart of UL-DL configurations of one example;

[0013] Fig. 5 is a diagram illustrating a DL HARQ timing problem;

[0014] Fig. 6 is a diagram illustrating use of UL-DL configuration 5 as a DL reference configuration;

[0015] Fig. 7 is a diagram illustrating use of a flexible HARQ timing;

[0016] Fig. 8 is a chart illustrating bundle window indexes using two bits for an example UL-DL configuration;

[0017] Fig. 9A is a diagram illustrating an example method;

[0018] Fig. 9B is a diagram illustrating an example method;

[0019] Fig. 10 is a flow chart illustrating aspects of the example methods shown in Fig. 9A and 9B;

[0020] Fig. 11 is a flow chart illustrating aspects of the example method shown in Fig. 9A; and

[0021] Fig. 12 is a flow chart illustrating aspects of the example method shown in Fig. 9B.

DETAILED DESCRIPTION OF EMBODIMENTS

[0022] Referring to Fig. 1, there is shown a diagram of a communication system 2 incorporating features of an example embodiment. Although the features will be described with reference to the example embodiments shown in the drawings, it should be understood that features can be embodied in many alternate forms of embodiments.

[0023] Referring also to Fig. 2, the communication system 2 generally comprises a User Equipment (UE) 10 and a wireless network 1. The wireless network 1 comprises a base station 12, such as a E-UTRAN Node B, also known as

Evolved Node B, (abbreviated as eNodeB or eNB), for example. The eNB forms a cell 16. The UE 10 is able to communicate with the eNB 12 by a wireless link 11 with uplinks (UL) 11A and downlinks (DL) 11B.

[0024] The UE 10 includes a controller, such as a computer or a data processor (DP) 10A, a computer-readable memory medium embodied as a memory (MEM) 10B that stores a program of computer instructions (PROG) 10C, and a suitable radio frequency (RF) transmitter and receiver 10D for bidirectional wireless communications with the eNB 12 via one or more antennas. The eNB 12 also includes a controller, such as a computer or a data processor (DP) 12A, a computer-readable memory medium embodied as a memory (MEM) 12B that stores a program of computer instructions (PROG) 12C, and a suitable RF transmitter and receiver 12D for communication with the UE 10 via one or more antennas. The eNB 12 is coupled via a data/control path 13 to the Network Control Element (NCE) or gateway 14. The NCE 14 comprises a processor 14A, memory 14B and software 14C. The NCE 14 may be connected to other network(s) and/or the Internet as shown in Fig. 2. The path 13 may be implemented as the S1 interface in the case the network 1 is a LTE network. The eNB 12 may also be coupled to another eNB via data/control path 15, which may be implemented as the X2 interface in the case the network 1 is a LTE network.

[0025] At least one of the PROGs 10C and 12C is assumed to include program instructions that, when executed by the associated DP, enable the device to operate in accordance with the exemplary embodiments of this invention as was detailed by non-limiting example above with respect to Figs. 1 and 2. That is, the exemplary

embodiments of this invention may be implemented at least in part by computer software executable by the DP 10A of the UE 10 and/or by the DP 12A of the eNB 12, or by hardware, or by a combination of software and hardware (and firmware).

[0026] In general, the various embodiments of the UE 10 can include, but are not limited to, cellular telephones, personal digital assistants (PDAs) having wireless communication capabilities, portable computers having wireless communication capabilities, image capture devices such as digital cameras having wireless communication capabilities, gaming devices having wireless communication capabilities, music storage and playback appliances having wireless communication capabilities, Internet appliances permitting wireless Internet access and browsing, as well as portable units or terminals that incorporate combinations of such functions.

[0027] The computer readable MEMs 10B and 12B may be of any type suitable to the local technical environment and may be implemented using any suitable data storage technology, such as semiconductor based memory devices, flash memory, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory. The DPs 10A and 12A may be of any type suitable to the local technical environment, and may include one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs) and processors based on a multicore processor architecture, as non-limiting examples.

[0028] Note that the various DPs 10A, 12A may be

implemented as one or more processors/chips, either or both of the UE 10 and the eNB 12 may include more than one transmitter and/or receiver 10D, 12D, and particularly the eNB 12 may have its antennas mounted remotely from the other components of the eNB 12, such as for example tower-mounted antennas.

[0029] Features as described herein may be used with 3GPP LTE-Advanced technology Rel-12 and beyond. More specifically, features as described herein may be used on LTE TDD enhancement for DL-UL Interference Management and Traffic Adaptation (TDD_eIMTA) and its continuation.

[0030] During RAN #58 meeting, a new work item "Further Enhancements to LTE TDD for DL-UL Interference Management and Traffic Adaptation (LTE_TDD_eIMTA)" was approved. In this work item, dynamic TDD UL/DL reconfiguration is a feature for LTE Rel-12 or beyond, whose motivation is to realize the flexibility to have dynamic TDD UL/DL configuration in a TDD system to match the uplink and downlink traffic variation.

[0031] Regarding the HARQ timing, the agreement in RAN1 #74 meeting was:

- Downlink HARQ timing follow a higher layer RRC configured TDD configuration
- At least configurations 2 and 5 can be selected
- For further study (FFS) other configurations

The agreement in RAN1 #74bis meeting was:

- DL HARQ reference configuration can choose from Rel-8 TDD UL-DL configurations {2, 4, 5}

[0032] Currently, the concrete HARQ timing and A/N generation are specified in LTE TS 36.213 and listed in Fig. 3; Downlink association set index K: $\{k_0, k_1, \cdots k_{M-1}\}$ for TDD. For TDD, the UE shall, upon detection of a PDSCH transmission or a PDCCH indicating downlink SPS release within subframe(s) $n-k$, where $k \in K$ and K as defined in Fig. 3 intended for the UE and for which ACK/NACK response shall be provided, transmit the ACK/NACK response in UL subframe n.

[0033] For TDD UL-DL configuration 5, only ACK/NACK bundling is supported. TDD ACK/NACK bundling is performed per codeword across M multiple DL subframes associated with a single UL subframe n, where M is the number of elements in the set K defined in Fig. 3, by a logical "AND" operation of all the individual PDSCH transmission (with and without corresponding PDCCH) ACK/NACKs and ACK in response to PDCCH indicating downlink SPS release. The bundled 1 or 2 ACK/NACK bits are transmitted using PUCCH format 1a or PUCCH format 1b, respectively.

[0034] For TDD ACK/NACK multiplexing and a subframe n with $M>1$, where M is the number of elements in the set K defined in Fig. 3, spatial ACK/NACK bundling across multiple codewords within a DL subframe is performed by a logical "AND" operation of all the corresponding individual ACK/NACKs and PUCCH format 1b with channel selection is used. For TDD ACK/NACK multiplexing and a subframe n with $M=1$, spatial ACK/NACK bundling across multiple codewords within a DL subframe is not performed, 1 or 2 ACK/NACK bits are transmitted using PUCCH format 1a or PUCCH format 1b, respectively.

[0035] Regarding the TDD UL/DL configuration indication, three bits contained in a new explicit DCI have been used to indicate the TDD UL/DL configuration corresponding to each serving cell. After detected this signaling, the UE can clearly know the current practical UL/DL configuration.

[0036] Currently, LTE TDD allows for asymmetric UL-DL allocations by providing seven different semi-statically configured TDD UL-DL configurations shown in Fig. 4. These allocations can provide between 40% and 90% DL subframes. Current mechanism for adapting UL-DL allocation is based on the system information change procedure with a 640 ms period. The concrete TDD UL/DL configuration is semi-statically informed by SIB-1 signaling. SIB-1 (SystemInformationBlockType1) contents assist the UE when it is evaluating cell access and also defines the scheduling of other system information.

[0037] However, if this feature of dynamic TDD UL/DL reconfiguration is directly adopted, it shall create a HARQ timing problem. For example, as shown in Fig. 5, in the case of TDD eIMTA UL/DL configuration 1, if the UE receives PDSCH in DL subframe 9, it shall transmit corresponding A/N on PUCCH in UL subframe 3 in next radio frame according to currently specified LTE HARQ timing rules. However, if the current TDD UL/DL configuration is switched to TDD UL/DL configuration 2 to respond the traffic fluctuation, then subframe 3 in the next radio frame will be a DL subframe; not an UL subframe. Thus, the UE cannot feed back the A/N in subframe 3, and needs to find another UL subframe to transmit A/N. The resulting HARQ timing is changed. A similar problem would occur with UL scheduling/HARQ timing.

[0038] In order to solve this HARQ timing problem, the reference configuration approach is considered in TDD eIMTA with RRC configurable reference configuration. According to one example reference configuration, in the dynamic UL/DL reconfiguration set, the UL-DL configuration with the most DL subframes is selected as the DL reference configuration for DL HARQ timing no matter which UL-DL configuration is actually used. As shown in Fig. 6, in the case of TDD UL/DL configuration 5 being used as the DL reference configuration, if the UE receives PDSCH in the subframe set from subframe 9 of previous radio frame to subframe 8 of current radio frame, then it shall transmit corresponding A/N on PUCCH in UL subframe 2 in next radio frame according to currently specified LTE HARQ timing rules, which is plotted by the circle as shown in Fig. 6.

[0039] However, it is noted that in the example case of UL-DL configuration #5 being selected as DL reference configuration, the maximum number of aggregated carriers is limited to two (2) in the current specification. So, the DL peak data rate is limited greatly. Moreover, UL-DL configuration #5 will force HARQ-ACK bits corresponding to all DL transmissions to be transmitted on a single UL subframe, which will create an unbalanced PUCCH overhead. Additionally, only HARQ-ACK bundling and PUCCH format 3 can be supported for UL/DL configuration 5. HARQ-ACK bundling will lead to unnecessary DL throughput loss while PUCCH format 3 may limit the coverage and not all UEs can support PUCCH format 3.

[0040] One may question why not use UL/DL configuration 2 or 4 as the DL reference configuration. It has been proven in 3GPP RAN1 that using UL/DL

configuration 5 as the DL reference configuration can avoid at least 10% performance loss since UL/DL configuration 5 can be selected for traffic adaptation. That is to say, using UL/DL configuration 5 as DL reference configuration can maximize the performance gain of dynamic TDD UL/DL reconfiguration. However, it causes the above four problems, e.g., limited peak data rate, unbalanced PUCCH overhead, unnecessary DL retransmission due to A/N bundling and less coverage. Therefore, how to maximize this performance gain and guarantee HARQ timing need is solved as described herein.

[0041] Features as described herein illustrate a flexible HARQ timing for dynamic TDD UL/DL reconfiguration, such as in a small cell 16 (e.g., Pico or Femto) for example. Upon detection of a PDSCH transmission or a PDCCH indicating downlink SPS release within subframe(s) $n-k$, where $k \in K$ and K is defined in Fig. 3 intended for the UE and for which ACK/NACK response shall be provided, the UE is proposed to transmit the A/N bits with the information of corresponding bundle window in the first UL subframe with the subframe number equal or larger than n+4.

[0042] In order to distinguish the A/N feedback for different bundling windows, the concept of bundle window index (BWI) is introduced for the eNB to know the transmitted A/N bits corresponding to a bundle window. The bundle window index (BWI) may identify bundling windows which have A/N feedback. Two bits may be used to indicate the corresponding BWI which are processed and transmitted together with the uplink A/N bits. The method may comprise four BWI bit representations comprising 00, 01, 10, 11 as shown in Fig. 8 for example.

In the example described below in regard to UL-DL configuration 1, all four BWI representations (00, 01, 10, 11) are used. However, for other UL-DL configurations, such as UL-DL configurations 2, 3, 4 and 5 shown in Fig. 4 for example, less than all four BWI representations may be used. In the example below, the BWI representation is not used with UL-DL configuration 6 because UL-DL configuration 6 has more than four bundling windows.

[0043] The new methods listed below are based on this flexible HARQ feedback timing:

- For A/N bundling or A/N multiplexing with M=1, two generated A/N bits are concatenated (arranged in series) with the corresponding two-bit BWI, and then modulated to one 16QAM symbol (4 bits per symbol). This symbol may be transmitted on the PUCCH resource mapped by the lowest CCE index (nCCE) of the last received PDCCH used for transmission of the corresponding DCI assignment.

- For A/N multiplexing with M>1, firstly, four generated A/N bits are modulated to one 16QAM symbol. Then the corresponding two-bit BWI is used to map to one of four PUCCH resources derived by the lowest CCE index (nCCE) of each received PDCCH used for transmission of the corresponding DCI assignment. Then the modulated symbol may be transmitted on the PUCCH resource mapped by channel selection.

[0044] Hence, the corresponding A/N feedback can be transmitted timely after the detected PDSCH or PDCCH indicating the DL SPS release and avoid the introduction of larger RTT (round trip time) delay. In that sense,

the benefit of dynamic TDD UL/DL reconfiguration is further improved.

[0045] With the help of explicit UE-common DCI for reconfiguration indication, the UE may explicitly indicate the change of TDD UL/DL configuration by physical layer signalling. So, the transmission direction of each subframe may be clearly known to the UE after detecting the reconfiguration DCI. Fig. 7 illustrates the flexible HARQ timing for TDD. After detection of a PDSCH transmission or a PDCCH indicating downlink SPS release within subframe(s) $n-k$, where $k \in K$ and K is defined in Fig. 3 from TS36.213 intended for the UE and for which the ACK/NACK response shall be provided, the UE may transmit A/N bits with the information of corresponding bundle window in the nearest available UL subframe after 4ms. In order to distinguish the A/N feedback for different bundling windows, the concept of bundle window index (BWI) is introduced for the eNB to know the transmitted A/N bits corresponding to which bundle window. Considering the currently specified A/N mapping table, two bits are enough to indicate the corresponding BWI from 0 to 3 which are processed together with uplink A/N bits. Although five bundle windows are included in TDD UL/DL configuration 6, it may be not an issue since Configuration 6 is not a typical configuration, and Configuration 0 or 1 provide similar UL/DL resource to Configuration 6. Meanwhile, the eNB can restrict one bundle window so as to work properly. One example illustrating a bundle window index using 2 bits is shown in Fig. 8 for TDD UL/DL configuration 1. Configuration 1 has four bundle windows (subframes 2, 3, 7 and 8) as shown in Fig. 3. As shown in Fig. 8, these

four bundle windows are indexed with a BWI from 00 to 11. In that sense, the eNB and the UE can know the A/N bits corresponding to each respective bundle window.

[0046] Detailed example procedures are described below and in Figs. 9A and 9B; illustrating A/N and BWI bit processing. M is the bundle window size. Fig. 8 shows subframes 2 and 7 in UL-DL Configuration 1 associated with a bundle size M=2, and subframes 3 and 8 associated with a bundle size M=1 for example. UL-DL Configuration 1 is merely being used to illustrate an example. Features as described herein may also be used with any of UL-DL Configurations 0-5.

[0047] For the first example case shown in Fig. 9A, for A/N bundling or A/N multiplexing with M=1, such as subframe 3 and 8 shown in Fig. 8 for example. Two generated A/N bits 40 are generated by logical AND operation per code-word across two DL subframes then concatenated with the corresponding two-bit BWI 42. This may then be modulated 44 to one 16QAM symbol 46. This symbol 46 may then be transmitted on the PUCCH resource. This may be mapped 48 by the lowest CCE index (nCCE) of the last received PDCCH used for transmission of the corresponding DCI assignment. The transmission may be transmitted by the antenna(s) 50 of the UE 10. In the case of LTE transmission modes TM 1, 2, 5, 6, 7, the A/N to second code-word (CW) may be mapped to NACK.

[0048] For the second example case shown in Fig. 9B, for A/N multiplexing with M greater than 1 (M>1), such as subframe 2 and 7 shown in Fig. 8 for example. Four generated A/N bits 52 may be modulated 54 to one 16QAM symbol 56. The corresponding two-bit BWI 42 may be used

to map 58 to one of four PUCCH resources 60; which may be derived by the lowest CCE index (nCCE) of each received PDCCH used for transmission of the corresponding DCI assignment. Then the modulated symbol 56 may be transmitted on the PUCCH resource mapped by channel selection. Each respect one of the four BWI may be respectively associated to one of the four PUCCH resources 60. Thus, the two-bit BWI 42 may be used to channel selection (one of the four PUCCH resources 60), and the channel selection may be used to identify the two-bit BWI 42 at the eNB 12.

[0049] With features as described above, upon detection of an explicit UE-common DCI for reconfiguration indication, the UE can clearly know the transmission direction of each subframe and then transmit the A/N bits corresponding to each bundle window to the eNB together with the information of bundle window index.

[0050] At the eNB side, after receiving the A/N bits and BWI information, the eNB can know which DL subframe is correctly detected by the UE and which is not. The eNB may then transmit new data or retransmit the previous data according to the concrete A/N feedback.

[0051] This method can transmit the A/N feedback in the nearest available UL subframe from the UE. Always using UL/DL configuration 5 as the DL reference configuration is not longer needed. In that sense, the RTT (round trip time) delay can be greatly reduced compared with always using UL/DL configuration 5 as the DL reference configuration.

[0052] Features as described herein allow the performance gain of dynamic TDD UL/DL reconfiguration to

be obtained. Features as described herein allow the large RTT delay caused by UL/DL configuration 5 as DL reference to be reduced. Features as described herein further improve the DL performance gain.

[0053] Referring also to Fig. 10, an example method may comprise associating at least one bundle window index with at least one respective subframe of an uplink-downlink (UL-DL) configuration as indicated by block 20; and transmitting, for each respective at least one subframe, an ACK/NACK (A/N) indication and an indication of the at least one respective bundle window index as indicated by block 22.

[0054] The method may comprise generating each of the at least one bundle window index as a two bit indication based upon the at least one subframe of the UL-DL configuration being uplink (UL) subframe(s). The method may comprise concatenating bits of one of the A/N indications with bits of one of the bundle window index. The method may comprise modulating the bits to one 16QAM symbol. The method may comprise mapping the symbol by a lowest CCE index (nCCE) of a last received Physical downlink control channel (PDCCH) used for transmission of a corresponding Downlink Control Information (DCI) assignment. The method may comprise modulating bits of the A/N indication for each respective subframe to one Quadrature Amplitude Modulation (QAM) symbol. The method may comprise mapping bits of the at least one bundle window index for each respective subframe to one of four Physical uplink control channel (PUCCH) resources. The method may comprise transmitting comprises the modulated symbol being transmitted on the PUCCH resource mapped by channel selection. The method may comprise transmitting

occurs in a first subsequent uplink (UL) configuration subframe having a subframe number equal to greater than n+4, where n is a subframe number of the last downlink subframe in the corresponding bundle window.

[0055] An example embodiment may be provided in an apparatus comprising at least one processor; and at least one non-transitory memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to associate at least one bundle window index with at least one respective subframe of an uplink-downlink (UL-DL) configuration; and transmit, for each respective at least one subframe, an ACK/NACK (A/N) indication and an indication of the at least one respective bundle window index.

[0056] The at least one memory and the computer program code may be configured to, with the at least one processor, generate each of the at least one bundle window index as a two bit indication based upon the at least one subframe of the UL-DL configuration being uplink (UL) subframe(s). The at least one memory and the computer program code may be configured to, with the at least one processor, concatenate bits of one of the A/N indications with bits of one of the bundle window index. The at least one memory and the computer program code may be configured to, with the at least one processor, modulate the bits to one 16QAM symbol. The at least one memory and the computer program code may be configured to, with the at least one processor, map the symbol by a lowest CCE index (nCCE) of a last received Physical downlink control channel (PDCCH) used for transmission of a corresponding Downlink Control Information (DCI)

assignment. The at least one memory and the computer program code may be configured to, with the at least one processor, modulate bits of the A/N indication for each respective subframe to one Quadrature Amplitude Modulation (QAM) symbol. The at least one memory and the computer program code may be configured to, with the at least one processor, map bits of the at least one bundle window index for each respective subframe to one of four Physical uplink control channel (PUCCH) resources. Transmitting may comprise the modulated symbol being transmitted on the PUCCH resource mapped by channel selection. Transmitting may occur in a first subsequent uplink (UL) configuration subframe having a subframe number equal to greater than n+4, where n is a subframe number of the last downlink subframe in the corresponding bundle window.

[0057] In another example embodiment, an apparatus is disclosed comprising means to perform any of the described methods.

[0058] An example embodiment may be provided in non-transitory program storage device, such as 10B for example, readable by a machine, tangibly embodying a program of instructions executable by the machine for performing operations, the operations comprising associating at least one bundle window index with at least one respective subframe of an uplink-downlink (UL-DL) configuration; and transmitting, for each respective at least one subframe, a ACK/NACK (A/N) indication and an indication of the at least one respective bundle window index.

[0059] Referring also to Figs. 11 and 12, the operations may comprise at least one of

- concatenating bits of one of the A/N indications with bits of one of the bundle window index as indicated by block 24, modulating the bits to one 16QAM symbol as indicated by block 26, and mapping the symbol by a lowest CCE index (nCCE) of a last received Physical downlink control channel (PDCCH) used for transmission of a corresponding Downlink Control Information (DCI) assignment as indicated by block 28; and

- modulating bits of the A/N indication for each respective subframe to one Quadrature Amplitude Modulation (QAM) symbol as indicated by block 30, mapping bits of the at least one bundle window index for each respective subframe to one of four Physical uplink control channel (PUCCH) resources as indicated by block 32, and transmitting comprises the modulated symbol being transmitted on the PUCCH resource mapped by channel selection as indicated by block 34.

[0060] Any combination of one or more computer readable medium(s) may be utilized as the memory. The computer readable medium may be a computer readable signal medium or a non-transitory computer readable storage medium. A non-transitory computer readable storage medium does not include propagating signals and may be, for example, but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device, or any suitable combination of the

foregoing. More specific examples (a non-exhaustive list) of the computer readable storage medium would include the following: an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an optical fiber, a portable compact disc read-only memory (CD-ROM), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing.

[0061] It should be understood that the foregoing description is only illustrative. Various alternatives and modifications can be devised by those skilled in the art. For example, features recited in the various dependent claims could be combined with each other in any suitable combination(s). In addition, features from different embodiments described above could be selectively combined into a new embodiment. Accordingly, the description is intended to embrace all such alternatives, modifications and variances which fall within the scope of the appended claims.

WHAT IS CLAIMED IS:

1. A method comprising:

associating at least one bundle window index with at least one respective subframe of an uplink-downlink (UL-DL) configuration; and

transmitting, for each respective at least one subframe, an ACK/NACK (A/N) indication and an indication of the at least one respective bundle window index.

2. A method as in claim 1 comprising generating each of the at least one bundle window index as a two bit indication based upon the at least one subframe of the UL-DL configuration being uplink (UL) subframe(s).

3. A method as in claim 1 comprising concatenating bits of the A/N indications with bits of one of the bundle window index.

4. A method as in claim 3 comprising modulating the bits to one 16QAM symbol.

5. A method as in claim 4 comprising mapping the symbol by a lowest CCE index (nCCE) of a last received Physical downlink control channel (PDCCH) used for transmission of a corresponding Downlink Control Information (DCI) assignment.

6. A method as in claim 1 comprising modulating bits of the A/N indication for each respective subframe to one Quadrature Amplitude Modulation (QAM) symbol.

7. A method as in claim 6 comprising mapping bits of the at least one bundle window index for each respective

subframe to one of four Physical uplink control channel (PUCCH) resources.

8. A method as in claim 7 where transmitting comprises the modulated symbol being transmitted on the PUCCH resource mapped by channel selection.

9. A method as in claim 1 where transmitting occurs in a first subsequent uplink (UL) configuration subframe having a subframe number equal to greater than n+4, where n is a subframe number of a last downlink subframe in the corresponding bundle window.

10. An apparatus comprising:

at least one processor; and

at least one non-transitory memory including computer program code,

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

associate at least one bundle window index with at least one respective subframe of an uplink-downlink (UL-DL) configuration; and

transmit, for each respective at least one subframe, an ACK/NACK (A/N) indication and an indication of the at least one respective bundle window index.

11. An apparatus as in claim 10 where the at least one memory and the computer program code are configured to, with the at least one processor, generate each of the at least one bundle window index as a two bit indication

based upon the at least one subframe of the UL-DL configuration being uplink (UL) subframe(s).

12. An apparatus as in claim 10 where the at least one memory and the computer program code are configured to, with the at least one processor, concatenate bits of the A/N indications with bits of one of the bundle window index.

13. An apparatus as in claim 12 where the at least one memory and the computer program code are configured to, with the at least one processor, modulate the bits to one 16QAM symbol.

14. An apparatus as in claim 13 where the at least one memory and the computer program code are configured to, with the at least one processor, map the symbol by a lowest CCE index (nCCE) of a last received Physical downlink control channel (PDCCH) used for transmission of a corresponding Downlink Control Information (DCI) assignment.

15. An apparatus as in claim 10 where the at least one memory and the computer program code are configured to, with the at least one processor, modulate bits of the A/N indication for each respective subframe to one Quadrature Amplitude Modulation (QAM) symbol.

16. An apparatus as in claim 15 where the at least one memory and the computer program code are configured to, with the at least one processor, map bits of the at least one bundle window index for each respective subframe to one of four Physical uplink control channel (PUCCH) resources.

17. An apparatus as in claim 10 where transmitting comprises the modulated symbol being transmitted on the PUCCH resource mapped by channel selection.

18. An apparatus as in claim 10 where transmitting occurs in a first subsequent uplink (UL) configuration subframe having a subframe number equal to greater than n+4, where n is a subframe number of a last downlink subframe in the corresponding bundle window.

19. A non-transitory program storage device readable by a machine, tangibly embodying a program of instructions executable by the machine for performing operations, the operations comprising:

associating at least one bundle window index with at least one respective subframe of an uplink-downlink (UL-DL) configuration; and

transmitting, for each respective at least one subframe, a ACK/NACK (A/N) indication and an indication of the at least one respective bundle window index.

20. A non-transitory program storage device as in claim 19 where the operations comprise at least one of:

concatenating bits of the A/N indications with bits of one of the bundle window index, modulating the bits to one 16QAM symbol, and mapping the symbol by a lowest CCE index (nCCE) of a last received Physical downlink control channel (PDCCH) used for transmission of a corresponding Downlink Control Information (DCI) assignment; and

modulating bits of the A/N indication for each respective subframe to one Quadrature Amplitude Modulation (QAM) symbol, mapping bits of the at least one bundle window index for each respective subframe to one of four Physical uplink control channel (PUCCH) resources, and transmitting comprises the modulated symbol being transmitted on the PUCCH resource mapped by channel selection.

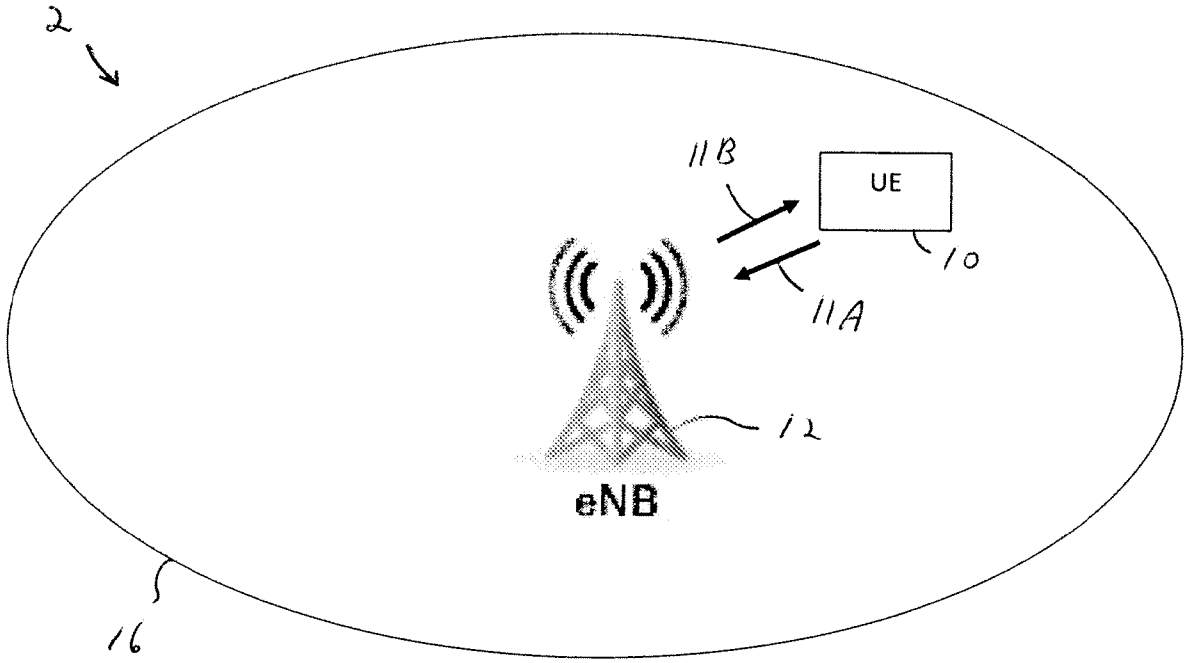

Fig. 1

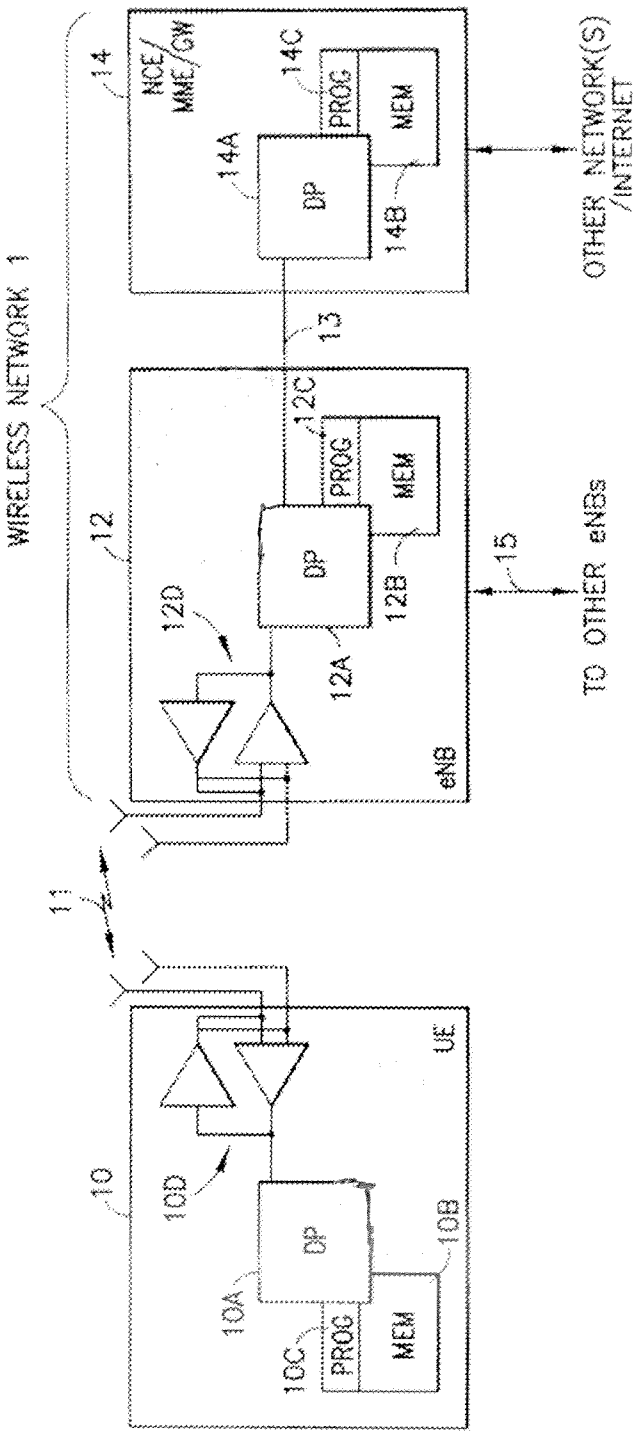
WIRELESS NETWORK 1
14
NCE/
MME/GW
14C
PROG
MEM
14A
DP
14B
OTHER NETWORK(S)
/INTERNET
13
12
12C
PROG
MEM
DP
12B
12D
12A
15
TO OTHER eNBs
eNB
11
10
10D
DP
10A
10C
PROG
MEM
10B
UE

Fig. 2

UL-DL Configuration	Subframe *n*									
	0	1	2	3	4	5	6	7	8	9
0	-	-	6	-	4	-	-	6	-	4
1	-	-	7, 6	4	-	-	-	7, 6	4	-
2	-	-	8, 7, 4, 6	-	-	-	-	8, 7, 4, 6	-	-
3	-	-	7, 6, 11	6, 5	5, 4	-	-	-	-	-
4	-	-	12, 8, 7, 11	6, 5, 4, 7	-	-	-	-	-	-
5	-	-	13, 12, 9, 8, 7, 5, 4, 11, 6	-	-	-	-	-	-	-
6	-	-	7	7	5	-	-	7	7	-

Fig. 3

UL/DL configuration	Switching-point periodicity	Subframe number									
		0	1	2	3	4	5	6	7	8	9
0	5 ms	D	S	U	U	U	D	S	U	U	U
1	5 ms	D	S	U	U	D	D	S	U	U	D
2	5 ms	D	S	U	D	D	D	S	U	D	D
3	10 ms	D	S	U	U	U	D	D	D	D	D
4	10 ms	D	S	U	U	D	D	D	D	D	D
5	10 ms	D	S	U	D	D	D	D	D	D	D
6	5 ms	D	S	U	U	U	D	S	U	U	D

Fig. 4

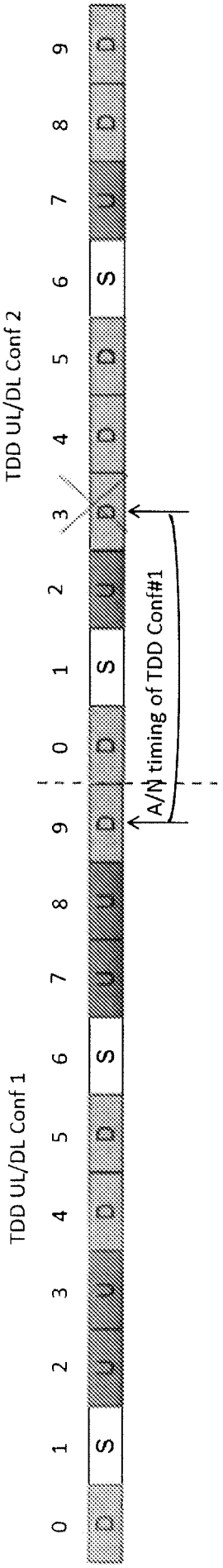
TDD UL/DL Conf 1
TDD UL/DL Conf 2
A/N timing of TDD Conf#1

Fig. 5

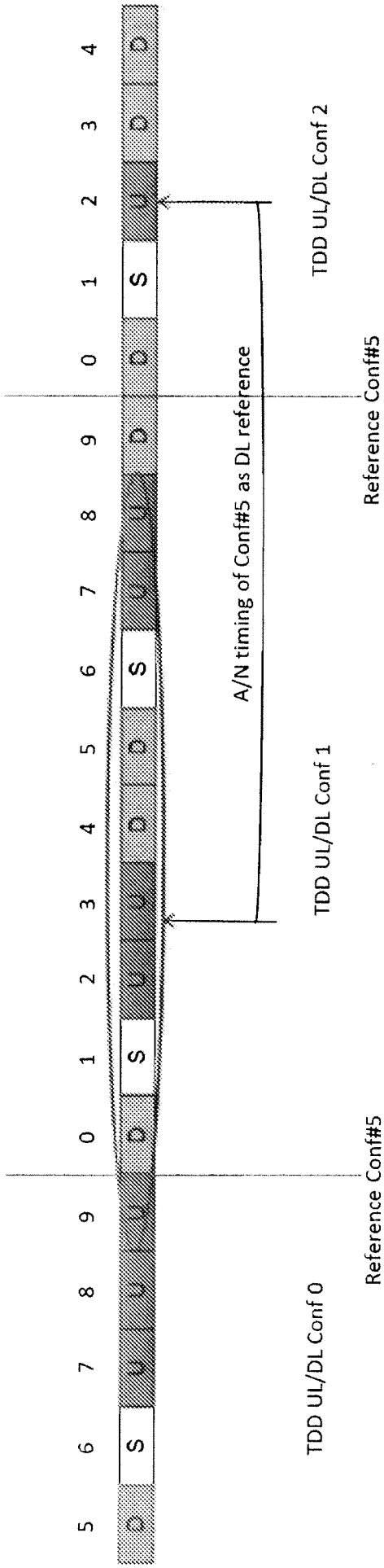
TDD UL/DL Conf 0
TDD UL/DL Conf 1
TDD UL/DL Conf 2
Reference Conf#5
Reference Conf#5
A/N timing of Conf#5 as DL reference

Fig. 6

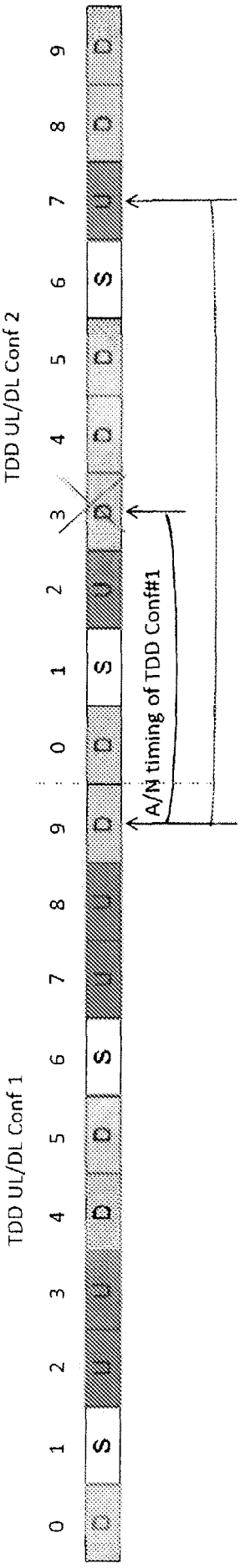

Fig. 7

UL-DL Configuration	Subframe n									
	0	1	2	3	4	5	6	7	8	9
1	-	-	7, 6	4	-	-	-	7, 6	4	-

Bundle window index: 00 01 10 11

Fig. 8

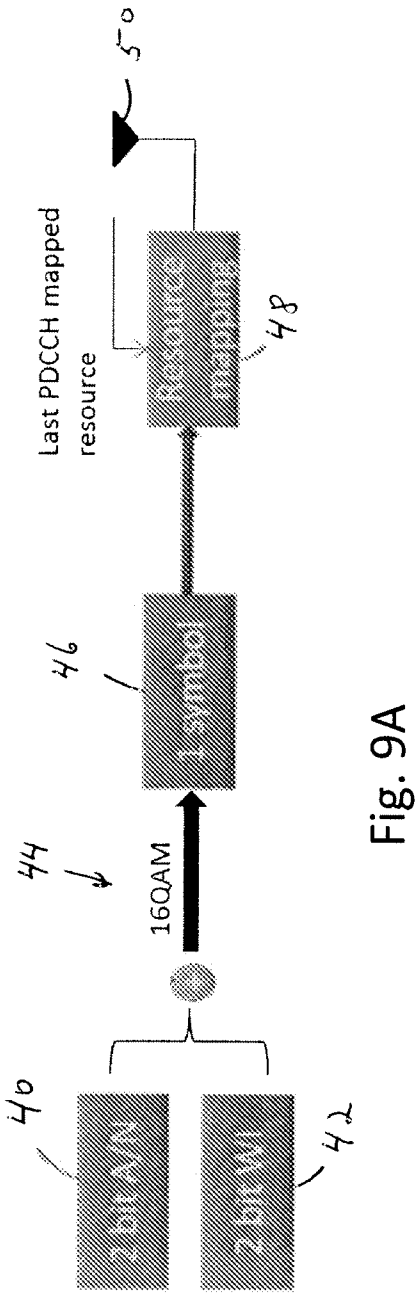
40
42
44
16QAM
1 symbol
46
Last PDCCH mapped resource
48
50

Fig. 9A

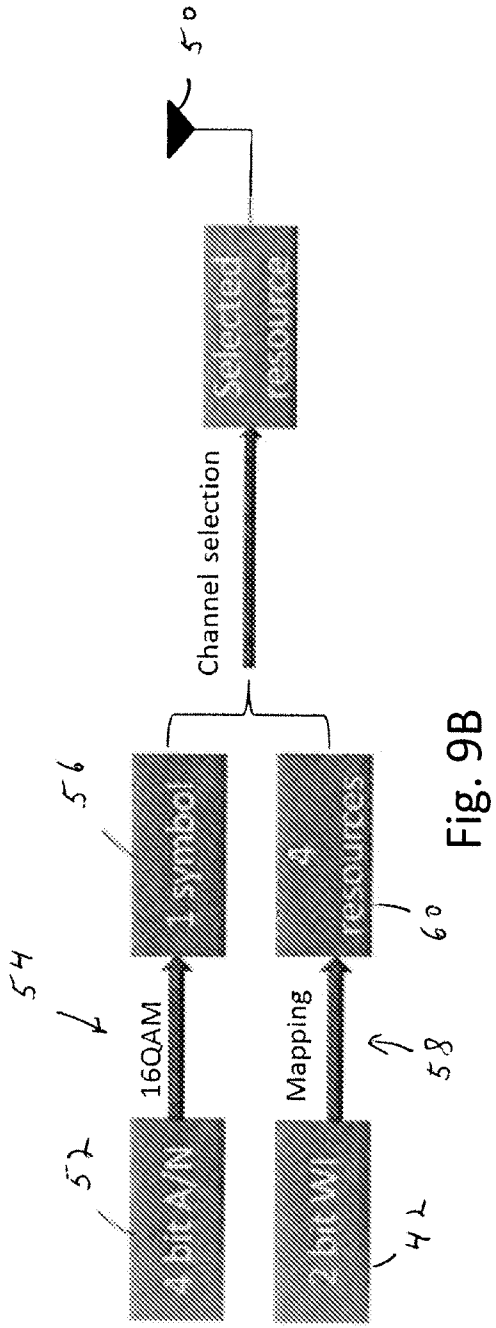
50
Channel selection
54
52
16QAM
1 symbol
56
Mapping
58
60
42

Fig. 9B

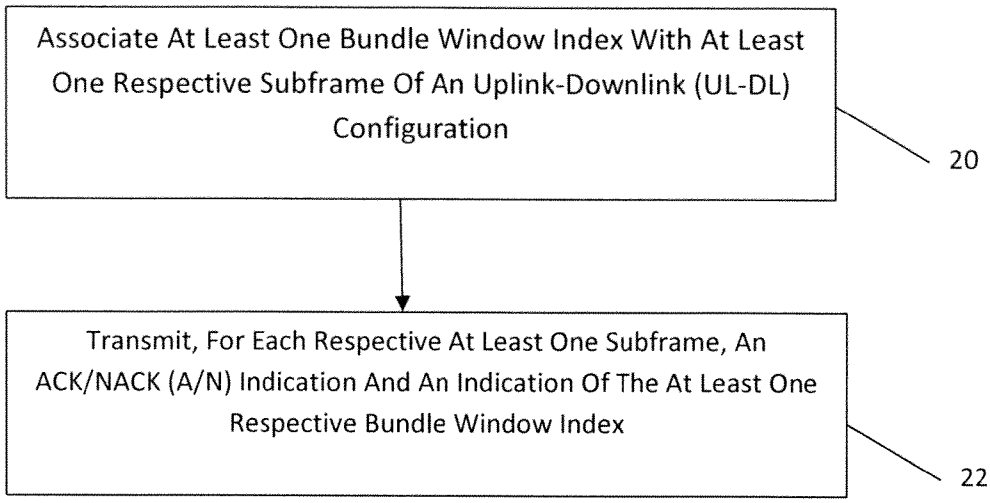

Fig. 10

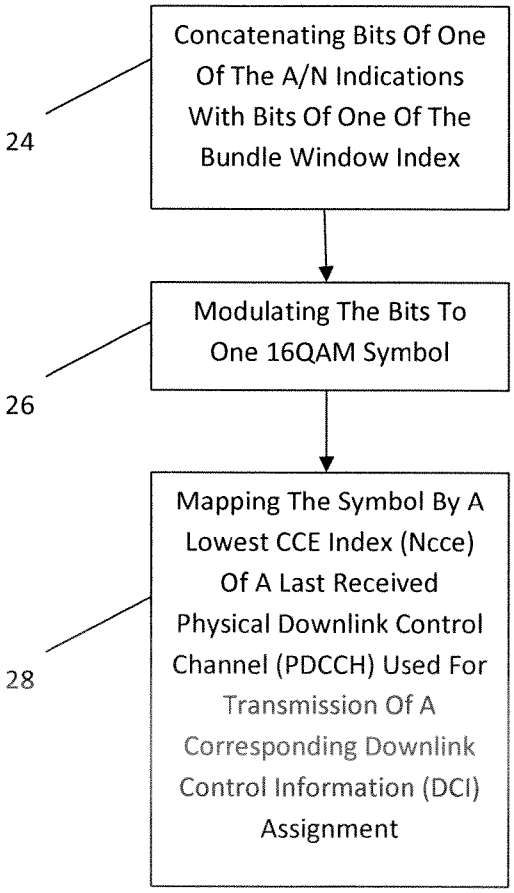

Fig. 11

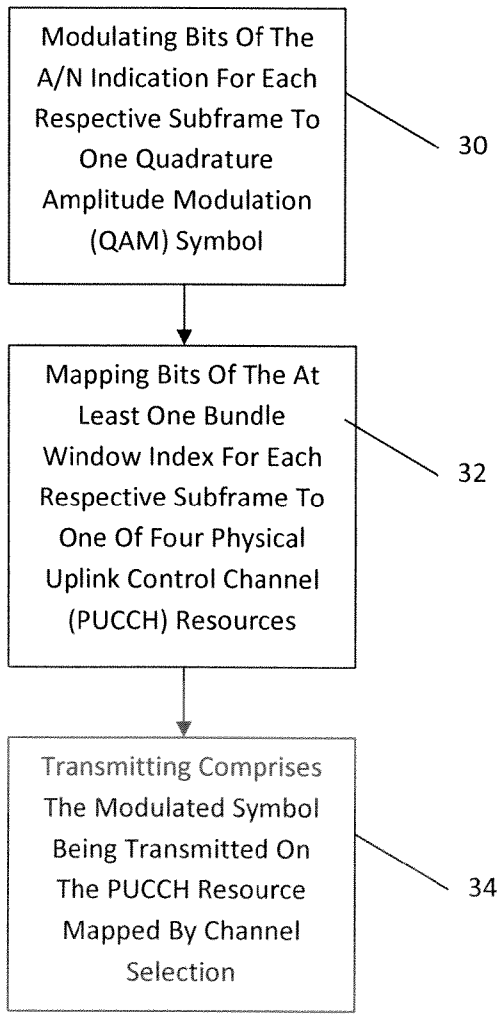

Fig. 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2013/088938

A. CLASSIFICATION OF SUBJECT MATTER

H04L 1/18(2006.01)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)

H04L; H04W

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS, VEN:window, bundle window, bundle, uplink, downlink, index

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2009134179 A1 (ERICSSON TELEFON AB L MET AL.) 05 November 2009 (2009-11-05) description, page 3, lines 12 to 14, lines 21 to 34 and figures 1a, 1b, 2, 3 and 4	1-20
A	US 2009323617 A1 (NOKIA SIEMENS NETWORKS) 31 December 2009 (2009-12-31) 全文	1-20

☐ 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 July 2014	**15 August 2014**
Name and mailing address of the ISA/ **STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA(ISA/CN)** **6,Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088 China** Facsimile No. **(86-10)62019451**	Authorized officer **SUN,Di** Telephone No. **(86-10)62411246**

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2013/088938

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
WO 2009134179 A1	05 November 2009	US 8477666 B2	02 July 2013
		CN 102017504 A	13 April 2011
		EP 2294744 A1	16 March 2011
		US 2011044278 A1	24 February 2011
US 2009323617 A1	31 December 2009	CN 102084618 A	01 June 2011
		WO 2010006903 A1	21 January 2010
		JP 2011526454 A	06 October 2011
		KR 101324143 B1	01 November 2013
		JP 5425901 B2	26 February 2014
		US 8488533 B2	16 July 2013
		KR 20110036073 A	06 April 2011
		EP 2297894 A1	23 March 2011