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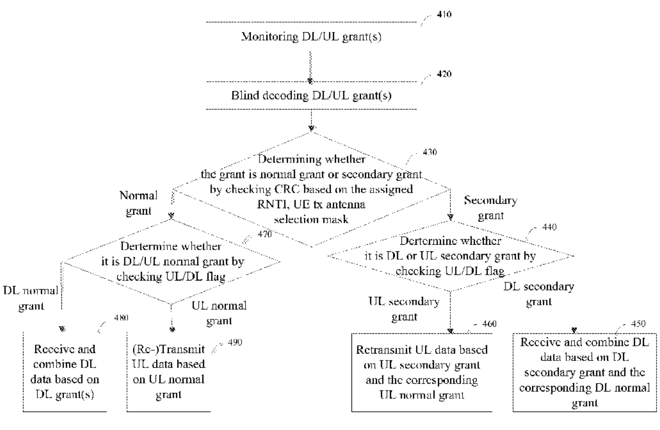

FIG. 4

(57) Abstract: These disclosed embodiments describe a method for a device, particularly a low-complexity MTC device, to enhance coverage by optimizing HARQ operation with repetitions. For downlink data transmission, a device receives the DL (normal or primary) grant from BS to determine reception of the initial data transmission or full-adaptive retransmission. A device may receive a secondary DL grant for receiving the data with partial-adaptive retransmission. For uplink data transmission, a device receives the UL normal (or primary) grant to perform initial data transmission or full-adaptive retransmission. The device may receive a secondary UL grant for retransmission according to the combined information from the secondary UL grant and the latest UL normal grant. The secondary grant can be a truncated normal grant for partial-adaptive HARQ retransmission with less control information and resource consumption, whereas the UL/DL normal (or primary) grant is mainly applied to support initial HARQ transmission and full-adaptive HARQ retransmission.

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ENHANCHEMENT FOR HARQ WITH CHANNEL REPETITIONS

TECHNICAL FIELD

[0001] This disclosure relates generally to wireless communications and, more particularly, to Enhancements for HARQ with channel repetitions under coverage enhancement mode.

BACKGROUND

[0002] In 3GPP LTE Rel-13 machine type communication (MTC) working item description (WID), there are three requirements which are respectively low complexity, coverage enhancement and power consumption. For coverage enhancement, a target maximum coupling loss (MCL) of 155.7dBm is proposed for both Rel-13 low complexity MTC UE and other non-MTC UE operating delay tolerant MTC applications. For PUSCH with the bottle-neck of MCL among all physical channels, i.e. 140.7dBm MCL, the target MCL of 155.7dBm means maximum 15dB coverage enhancement. Considering compensation of some coverage loss caused by low complexity, e.g. 3dB transmission power reduction for uplink, it is required to achieve maximum 18dB coverage enhancement. In order to achieve the target of coverage enhancement, repetition is necessary for most physical channels/signals. And many technologies can be used to improve the efficiency of repetition, i.e. reduce the number of repetitions as far as possible, such as cross-subframe channel estimation, increasing DMRS density, uplink PSD boosting, frequency-hopping and so on.

[0003] In CE mode for Rel13 MTC, channel repetition has been considered to improve data reception at low working SINR operation point by combining the repeated data. In the current LTE system, HARQ operation with one transmission per HARQ attempt has been used to exploit the frequency/time diversity of the channel for the combining gain. Besides, HARQ operation is also coupled with link adaptation, e.g., link adaptation may target10% BLER after 1st HARQ transmission. Essentially, LTE HARQ transmission is a Stop-And-Wait (SAW) retransmission whereas channel repetition is a non-stop or blind retransmission without feedback. So it seems necessary to support channel repetition as well as HARQ retransmission due to slightly different purposes. In this case, channel repetition can be applied for each HARQ transmission attempt while HARQ (re)transmission with feedback can be still kept. So HARQ mechanism should be supported with channel repetition for each HARQ transmission attempt.

[0004] Regarding to HARQ transmission for UE in CE mode, it seems not necessary to support full-adaptive HARQ, which may cause the large control overhead due to the data retransmission associated control channel carrying full control information and high power consumption for UE receiving the repeated control channel. Typically, the larger DCI the longer time for UE processing. However, the adaptation on the repetition number for retransmission is meaningful.

[0005] From the performance perspective, the adaptation on MCS may not improve performance of UE in CE mode due to the extreme low working SINR. Instead, it may make sense to only adjust some settings, e.g., the repetition number which provides the fine granularity on link adaptation.

[0006] So it makes sense to have a new design to support HARQ retransmission for UE in CE mode. In light of such motivation, a compact DCI with truncated format carrying partial control information for HARQ retransmission are proposed to carry the necessary and limited information for support the partial-adaptive HARQ for UEs in CE mode.

SUMMARY

[0007] These disclosed embodiments describe a method for a device, particularly a low-complexity MTC device, to enhance uplink and/or downlink coverage by HARQ transmission with data repetitions per HARQ (re)transmission attempt. In case of downlink data transmission, the device receives the (first) DL grant from a base station to determine a reception of the initial HARQ transmission comprising a certain number of data repetitions. If the device fails to decode the data, it will at least provide the feedback information about the expected number of data repetitions per HARQ retransmission attempt as well as the NACK information. Accordingly, the UE

may receive the secondary DL grant from the base station to determine the means of receiving HARQ retransmissions according to the control information obtained from both the secondary grant and the latest DL grant. The secondary DL grant can be a truncated DL grant with the limited control information fields to reduce the overhead while keeping the performance. Alternatively, a new MTC HARQ physical control channel (a.k.a mPHCH) can be used to indicate the repetition number for retransmission in case of packet decoding failure.

[0008] Similarly, in case of uplink data transmission, a device receives the UL grant, e.g. the first UL grant from a base station to determine transmission of the initial HARQ transmission. The device may receive the secondary UL grant if the base station fails to decode the data and perform the HARQ retransmission(s). The device will determine the means of uplink HARQ retransmission according to the control information obtained from both the secondary grant and the latest UL grant. The secondary UL grant can be a truncated UL grant with the limited control information fields, comprising at least the information about the number of repetitions per HARQ retransmission attempt, in order to reduce the overhead while keeping the performance. In general, the secondary UL/DL grant can be used to support the non-adaptive HARQ retransmission with the smaller overhead and resource consumption, whereas the first UL/DL grant can be applied to support initial HARQ transmission and adaptive HARQ retransmission. Alternatively, the mPHCH can be used to indicate the number of repetitions for UL retransmission.

[0009] Secondary DL grant and secondary UL grant can share the same DCI and differentiated by an additional bit (e.g., UL/DL flag) to indicate whether it is for UL or DL within the DCI. In this case, UE can reduce the complexity for blind detection of DCI.

[00010] The mPHCH for UL/DL retransmission can be differentiated by different resources or additional bit (e.g., UL/DL flag).

BRIEF DESCRIPTION OF DRAWINGS

[00011] The invention can be more fully understood by reading the subsequent detailed description and examples with references made to the accompanying drawings, wherein:

[00012] FIG. 1 is a block diagram illustrating a schematic diagram of a wireless communications system according to one embodiment of the present invention.

[00013] FIG. 2 shows an example of secondary UL grant for support HARQ uplink retransmission according to one embodiment of the present invention.

[00014] FIG. 3 shows an example of secondary DL grant for support HARQ downlink retransmission according to one embodiment of the present invention.

[00015] FIG. 4 shows the flow chart of UE operation for grant reception according to one embodiment of the present invention.

DETAILED DESCRIPTION

[00016] Several exemplary embodiments of the present disclosure are described with reference to FIGs. 1 through 4. It is to be understood that the following disclosure provides various embodiments as examples for implementing different features of the present disclosure. Specific examples of components and arrangements are described in the following to simplify the present disclosure. These are, of course, merely examples and are not intended to be limiting. In addition, the present disclosure may repeat reference numerals and/or letters in the various examples. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various described embodiments and/or configurations.

[00017] The following description is of the best-contemplated mode of carrying out the invention. This description is made for the purpose of illustrating the general principles of the invention and should not be taken in a limiting sense. Note that the 3GPP specifications described herein are used to teach the spirit of the invention, and the invention is not limited thereto.

[00018] FIG. 1 is a block diagram illustrating a schematic diagram of a wireless communications system according to one embodiment of the present invention. The wireless communications system 100 includes one or more fixed base infrastructure units 110 and 111, forming one or more access networks 130 and 131 distributed over a geographical region. The access network 130 and 131 may be a Universal Terrestrial Radio Access Network (UTRAN) in the WCDMA technology or an E-UTRAN in the Long Term Evolution (LTE)/LTE-A technology. The base unit may also be referred to an access point, base station, Node-B, eNode-B (eNB), or other

terminologies used in the art. In some systems, one or more base stations are communicably coupled to a controller forming an access network that is communicably coupled to one or more core networks.

[00019] In FIG.1, one or more mobile stations 120 and 121 are connected wirelessly to base stations 110 and 111 for wireless service within a serving area, for example, a cell or within a cell sector. The mobile station may also be called user equipment (UE), a wireless communication device, terminal or some other terminologies. Mobile station 120 and 121 send uplink data to base stations 110 and 111 via uplink channel 140 and 141 in the time and/or frequency domain. The serving base station 110 and 111 transmit downlink signals via a downlink channel 150 and 151.

[00020] In one embodiment, the communication system utilizes Orthogonal Frequency Division Multiplexing Access (OFDMA) or a multi-carrier based architecture including Adaptive Modulation and Coding (AMC) on the downlink and next generation single-carrier (SC) based FDMA architecture for uplink transmissions. SC based FDMA architectures include Interleaved FDMA (IFDMA), Localized FDMA (LFDMA), DFT-spread OFDM (DFT-SOFDM) with IFDMA or LFDMA. In OFDMA based systems, remote units are served by assigning downlink or uplink radio resources that typically comprises a set of sub-carriers over one or more OFDM symbols. Exemplary OFDMA based protocols include the developing LTE/LTE-A of the 3GPP standard and IEEE 802.16 standard. The architecture may also include the use of spreading techniques such as multi-carrier CDMA (MC-CDMA), multi-carrier direct sequence CDMA (MC-DS-CDMA), Orthogonal Frequency and Code Division Multiplexing (OFCDM) with one or two dimensional spreading, or may be based on simpler time and/or frequency division multiplexing/multiple access techniques, or a combination of these various techniques.

[00021] In alternative embodiments, communication system may utilize other cellular communication system protocols including, but not limited to, TDMA or direct sequence CDMA. The disclosure however is not intended to be limited to any particular wireless communication system.

[00022] In FIG. 1, the mobile communication network 100 is an OFDM/ OFDMA system comprising a base station eNB 110 and eNB 111, and a plurality of mobile station 120 and mobile station 121. When there is a downlink data block to be sent from base station to mobile station, each mobile station gets a downlink resource assignment, e.g., a set of downlink radio resources indicated in downlink control information (DCI) which is transmitted with a physical downlink control channel (PDCCH). Thus, mobile stations receive corresponding physical downlink shared channel (PDSCH) in the set of downlink radio resources. When a UE needs to send an uplink data block to base station, the mobile station gets a grant from the base station that assigns a set of uplink radio resources, i.e. an uplink grant convey by a DCI. Thus, the UE transmits corresponding physical uplink shared channel (PUSCH) in the set of uplink radio resources.

[00023] FIG. 2 shows an example of a secondary UL grant usage for HARQ retransmission in uplink according to one embodiment of current invention. In one embodiment, a P-UG (Primary UL grant or normal UL grant) carries the full control information for the first transmission, which may include the parameters such as MCS, frequency hopping pattern index, the number of repetitions for first transmission and the resource allocation. The P-UG could be based on ePDCCH, and the number of repetitions could also be configured by RRC signaling. A S-UG (secondary UL grant) carries the partial and/or additional control information for the retransmission, which may include the number of repetitions for retransmission and/or RV sequences for repetition. Also, the S-UG could be based on ePDCCH/ePHICH, and the number of repetitions could be configured by RRC signaling.

[00024] Upon receiving the P-UG, UE performs the new data transmission according to the parameter settings carried in the P-UG. For the 1^{st} transmission of data, the redundancy version (RV) sequence could be 0231, or 0021. And for the repetitions of the 1^{st} transmission, the RV sequences could be variable or fixed. Upon receiving the S-UG, UE performs the data retransmission, e.g. 2^{nd} transmission, according to the parameter settings carried in the S-UG and the remaining parameters carried in the P-UG corresponding to the initial transmission or the latest transmission for full-adaptive retransmission. For the 2nd transmission of data, the RV sequence could be different than the initial transmission, e.g., 0000. And for the repetitions of the 2nd transmission, the RV sequences could be variable or fixed. eNB can combine the data from the initial transmission and retransmission for data decoding. The UE determines the new data transmission or data retransmission based on whether the received UL grant is a primary UG or a secondary UG. It also means that there is no need of Physical HARQ Indication Channel (PHICH) to indicate ACK/NACK information. In this case, ACK/NACK is implicitly indicated by transmission of P-UG or S-UG.

[00025] FIG. 3 shows an example of a secondary DL grant usage for HARQ retransmission in downlink according to one embodiment of current invention. In one embodiment, a P-DG (Primary DL grant or normal UL grant) carries the full control information for the new data transmission (i.e., 1st data transmission), which may include the parameters such as MCS, frequency hopping pattern index, the number of repetitions for first transmission and the resource allocation. A S-DG (secondary DL grant) carries the partial or additional control information for the retransmission, which may include the number of repetitions for retransmission and/or RV sequences for repetitions. In one novel aspect, S-DG could be based on ePDCCH/ePHICH, and it could comprise truncated DCI (or named as secondary DCI), except for the indication of repetition level for data retransmission, it could also comprise implicit indication of PDSCH timing for asynchronous retransmission. The settings of remaining parameters for decoding data can be obtained from the information carried in the P-DG. S-DG could also carry the additional information which is not included in the P-DG.

[00026] Upon receiving the P-DG, the UE receives the new data transmission according to the parameter settings carried in the P-DG. And during this procedure, UE's feedback behaviors upon decoding comprise: if the P-DG is correct and the data is failed, and the UE transmits NACK. If the P-DG is incorrect and the data is failed, the DTX could be used. And if the data is correct, the UE could transmit ACK. Upon receiving the S-DG, the UE receives the retransmitted data (2nd transmission) according to the parameter settings carried in the S-DG and the remaining parameters carried in the P-DG corresponding to the initial or the latest data transmission. And during this procedure, eNB's feedback behaviors upon receiving feedback comprise: upon receiving NACK, eNB could transmit S-DG for partial-adaptive retransmission, or transmits P-DG for full-adaptive retransmission or new data transmission. And if eNB received ACK or DTX from UE, and eNB could transmit P-DG for new data transmission or full-adaptive retransmission. UE can combine the data from initial transmission and retransmission for decoding. The UE determines the new data transmission or data retransmission from eNB based on whether the received DL grant is a primary DG or a secondary DG. In one novel aspect, the NACK could be derived based on PUCCH, and in NACK, there is recommendation of repetition level for data transmission.

[00027] In another embodiment, if semi-persistent scheduling is applied, a P-UG/DG is scrambled with SPS-RNTI to indicate the configuration for the new data transmission.

In this case, a S-UG/DG is required to control data retransmission for partial-HARQ operation. Additionally, a P-UG/DG can also be applied to control data retransmission for full-adaptive HARQ retransmission. The settings of remaining parameters for retransmitted data reception can be based on the P-UG/DG scrambled with SPS-RNTI for the initial transmission in addition to the information carried in the S-UG/DG and/or the information carried in the P-UG/DG scrambled with C-RNTI for retransmission.

[00028] In another embodiment, instead of semi-persistent scheduling the most parameters can be configured by the higher at least for the initial transmission. These parameters can be updated by the higher layer signaling (e.g., RRC signaling) or P-UG/DG. For example, P-UG/DG with new data indicator to indicate the new data transmission can be used to carry the updated parameter settings for the initial transmission. Such configuration change can be valid until reception of the next P-UG/DG with the new data indicator to indicate the new data transmission. Alternatively, P-UG/DG for change of the parameters in a period can be scrambled with a new RNTI (a.k.a, U-RNTI, i.e., RNTI for parameter updating) to differentiate with the normal grant for one time transmission. For the retransmission, S-UG/DG can be used to control the retransmission associated with the parameter settings by the higher layer and the updated parameter settings carried by P-UG/DG with a new data indicator and/or a new RNTI.

[00029] A S-DG/UG can be carried by a MTC (Machine Type Communication) physical channel (a.k.a mPDCCH) with eREG/eCCE based resource allocation if the large control information bits are needed. The number of repetitions for mPDCCH (MTC Physical Data Control Channel) transmission can be (re-)configured by RRC layer based on UE report on the level of coverage enhancement. The UE report indicates the repetition number or level with the hypothesis of 1% BLER target for S-DG/UG reception.

[00030] For S-DG/UG transmission, a new RNTI (a.k.a, Secondary RNTI, or S-RNTI) can be assigned and scrambled with CRC. UE can decode mPDCCH with CRC scrambled with S-RNTI to identify if it is a secondary grant. The assigned S-RNTI can be signaled to UE via the higher layer signaling (e.g., RRC signaling). Alternatively, the same RNTI for the P-DG/UG can be used for S-DG/UG transmission. In this case, UE can identify whether it is a normal grant or a secondary grant based on DCI (Downlink Control Information) payload size assuming the different payload sizes are used for the normal and secondary grants.

[00031] FIG. 4 shows a exemplary flow chart of the UE processing the received grant(s) from eNB. UE will monitor the mPDCCH for grant(s) in step 410. Based on blind decoding of the grants in step 420, UE can check CRC scrambled with S-RNTI or C-RNTI to determine whether the decoded DCI is for a normal grant or a secondary grant in step 430. Afterwards, UE can check the UL/DL flag in the grant to check whether it is for UL grant or DL grant. If the grant is a normal grant, UE determines if the normal grant is DL or UL normal grant by checking the UL/DL flag in step 470, if the flag indicates that the grant is an UL normal grant , and the UE (re)transmits UL data based on the UL normal grant in step 490, or else receives and combine DL data based on the DL normal grant. If the grant is secondary grant in step 430, and then UE further determines if the secondary grant is DL or UL secondary grant by checking UL/DL flag in step 440, if the flag indicates that the secondary grant is a UL secondary grant, and then UE retransmits UL data based on UL secondary grant and the corresponding UL normal grant in step 460, or receives and combines Dl data based on DL secondary grant and the corresponding DL normal grant in step 450.

[00032] While the present disclosure and the best modes thereof have been described in a manner establishing possession and enabling those of ordinary skill to make and use the same, it will be understood and appreciated that there are equivalents to the exemplary embodiments disclosed herein and that modifications and variations may be made thereto without departing from the scope and spirit of the inventions, which are to be limited not by the exemplary embodiments but by the appended claims.

[00033] Those with skill in the art will understand that information and signals may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the above description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[00034] Those with skill in the art will further appreciate that the various illustrative logical blocks, modules, processors, means, circuits, and algorithm steps described in connection with the aspects disclosed herein may be implemented as electronic hardware (e.g., a digital implementation, an analog implementation, or a combination of the two, which may be designed using source coding or some other technique), various forms of program or design code incorporating instructions (which may be

referred to herein, for convenience, as “software” or a “software module”), or combinations of both. To clearly illustrate this interchangeability of hardware and software, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but such implementation decisions should not be interpreted as causing a departure from the scope of the present disclosure.

[00035] In addition, the various illustrative logical blocks, modules, and circuits described in connection with the aspects disclosed herein may be implemented within or performed by an integrated circuit (“IC”), an access terminal, or an access point. The IC may comprise a general purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, electrical components, optical components, mechanical components, or any combination thereof designed to perform the functions described herein, and may execute codes or instructions that reside within the IC, outside of the IC, or both. A general purpose processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

[00036] It is understood that any specific order or hierarchy of steps in any disclosed process is an example of a sample approach. Based upon design preferences, it is understood that the specific order or hierarchy of steps in the processes may be rearranged while remaining within the scope of the present disclosure. The accompanying method claims present elements of the various steps in a sample order, and are not meant to be limited to the specific order or hierarchy presented.

[00037] The steps of a method or algorithm described in connection with the aspects disclosed herein may be embodied directly in hardware, in a software module executed by a processor, or in a combination of the two. A software module (e.g., including executable instructions and related data) and other data may reside in a data

memory such as RAM memory, flash memory, ROM memory, EPROM memory, EEPROM memory, registers, a hard disk, a removable disk, a CD-ROM, or any other form of computer-readable storage medium known in the art. A sample storage medium may be coupled to a machine such as, for example, a computer/processor (which may be referred to herein, for convenience, as a “processor”) such that the processor can read information (e.g., code) from and write information to the storage medium. A sample storage medium may be integral to the processor. The processor and the storage medium may reside in an ASIC. The ASIC may reside in user equipment. In the alternative, the processor and the storage medium may reside as discrete components in user equipment. Moreover, in some aspects any suitable computer-program product may comprise a computer-readable medium comprising codes relating to one or more of the aspects of the disclosure. In some aspects a computer program product may comprise packaging materials.

[00038] While the invention has been described in connection with various aspects, it will be understood that the invention is capable of further modifications. This application is intended to cover any variations, uses or adaptation of the invention following, in general, the principles of the invention, and including such departures from the present disclosure as come within the known and customary practice within the art to which the invention pertains.

CLAIMS

1. A method to perform HARQ operation for a user equipment (UE), comprising:

receiving a grant;

determining whether the grant is a normal grant or a secondary grant;

determining whether the normal grant or the secondary grant is an UL or DL grant; and

transmitting or receiving the data based on the normal grant or the secondary grant associated with the normal grant.

2. The method of claim 1, wherein receiving a grant comprises receiving a grant with a RNTI scrambled in CRC.

3. The method of claim 1, wherein determining whether it is a normal grant or a secondary grant comprises:

a grant with a C-RNTI scrambled in CRC is identified as the normal grant;

a grant with a S-RNTI scrambled in CRC is identified as the secondary grant.

4. The method of claim 1, wherein determining whether it is a normal grant or a secondary grant comprises:

a grant with a C-RNTI scrambled in CRC for payload size M is identified as the normal grant; and

a grant with a C-RNTI scrambled in CRC for payload size N is identified as the secondary grant.

5. The method of claim 4, wherein a grant with the same RNTI scrambled in CRC but subject to different payload sizes to identify whether it is the normal grant or secondary grant further comprises:

a normal grant with payload size M carrying full control information whereas a secondary grant with payload size N (N<M) carrying partial or additional control information.

6. The method of claim 5, wherein the full control information comprise at least one of the following parameters: a frequency hopping pattern index, a number of repetition for transmission, a RV sequence number, an UL/DL flag, an ACK/NACK flag and a new data indicator.

7. The method of claim 5, wherein the partial or additional control information

comprise at least one of the following parameters: a frequency hopping pattern index, a number of repetition for transmission, a RV sequence number, an ACK/NACK flag and an UL/DL flag.

8. The method of claim 1, wherein determining whether it is UL or DL grant comprises:

if UL flag is set, the grant is a UL grant; and

if DL flag is set, the grant is a DL grant.

9. The method of claim 1, wherein transmitting or receiving the data based on the normal grant or the secondary grant associated with the normal grant receiving a grant comprises:

receiving DL data for initial data transmission according to the parameter settings in the early received DL normal grant corresponding to the initial data transmission.

10. The method of claim 1, wherein transmitting or receiving the data based on the normal grant or the secondary grant associated with the normal grant receiving a grant comprises:

receiving DL data for data retransmission according to the parameter settings in the received DL secondary grant and the remaining parameter settings in the early received DL normal grant corresponding to initial data transmission.

11. The method of claim 1, wherein transmitting or receiving the data based on the normal grant or the secondary grant associated with the normal grant receiving a grant comprises:

transmitting UL data according to the parameter settings in the received UL normal grant.

12. The method of claim 1, wherein transmitting or receiving the data based on the normal grant or the secondary grant associated with the normal grant receiving a grant comprises:

retransmitting UL data according to the parameter settings in the received UL secondary grant and the remaining parameter settings in the early received corresponding UL normal grant.

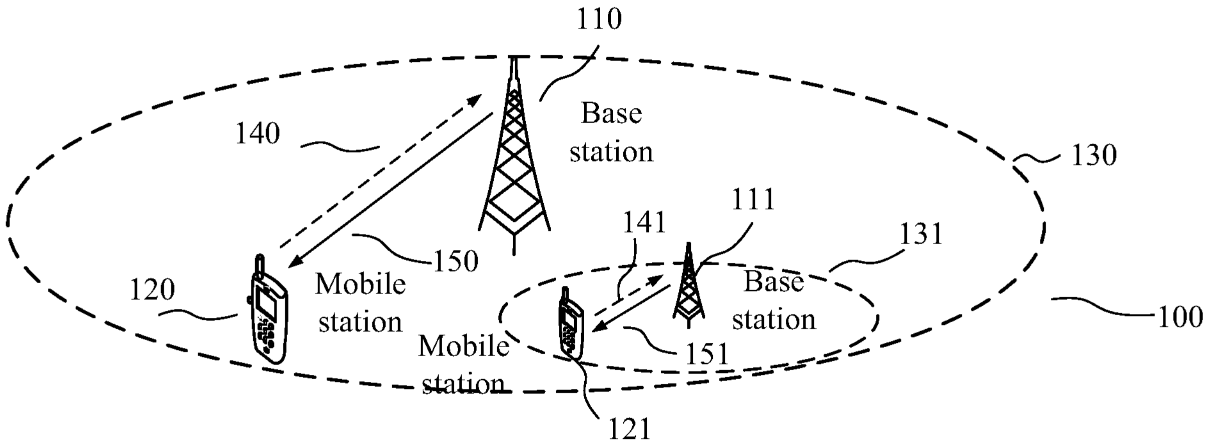
110
Base station
140
130
111
141
131
Base station
120
Mobile station
150
100
Mobile station
151
121

FIG. 1

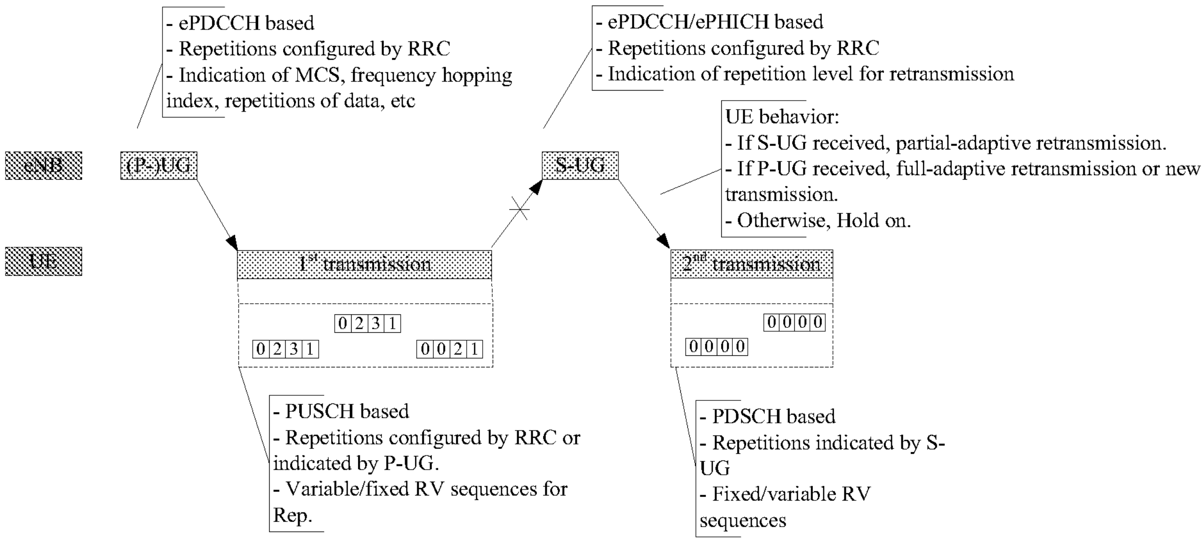
- ePDCCH based
- Repetitions configured by RRC
- Indication of MCS, frequency hopping index, repetitions of data, etc
- ePDCCH/ePHICH based
- Repetitions configured by RRC
- Indication of repetition level for retransmission
UE behavior:
- If S-UG received, partial-adaptive retransmission.
- If P-UG received, full-adaptive retransmission or new transmission.
- Otherwise, Hold on.
eNB
(P-)UG
S-UG
UE
1st transmission
2nd transmission
0 2 3 1
0 2 3 1
0 0 2 1
0 0 0 0
0 0 0 0
- PUSCH based
- Repetitions configured by RRC or indicated by P-UG.
- Variable/fixed RV sequences for Rep.
- PDSCH based
- Repetitions indicated by S-UG
- Fixed/variable RV sequences

FIG. 2

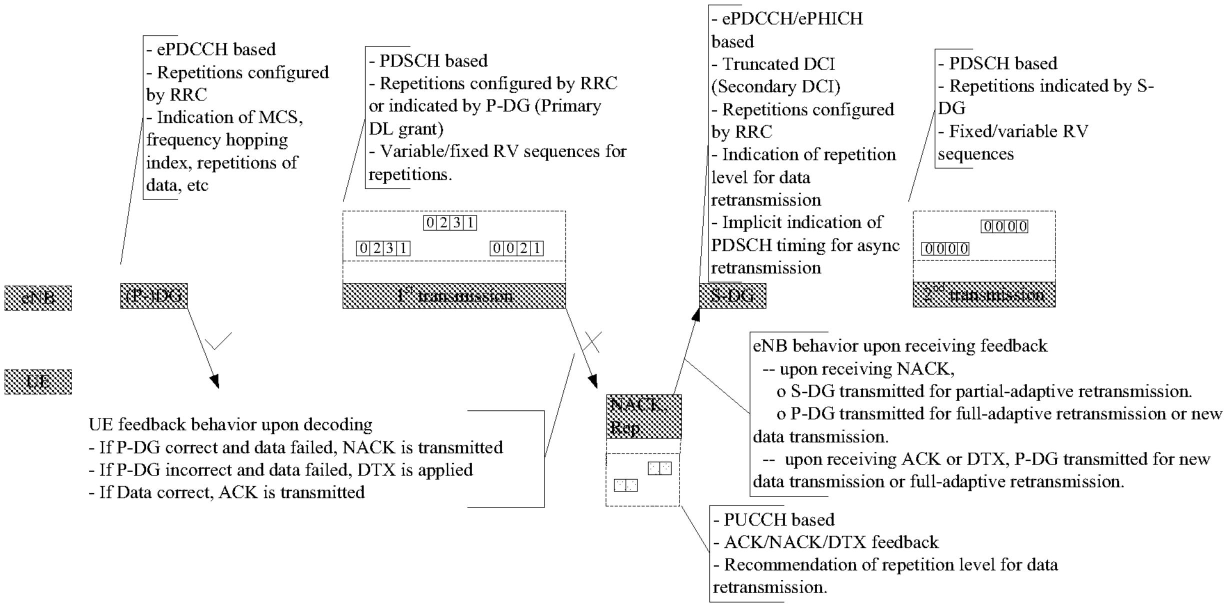
- ePDCCH based
- Repetitions configured by RRC
- Indication of MCS, frequency hopping index, repetitions of data, etc
- PDSCH based
- Repetitions configured by RRC or indicated by P-DG (Primary DL grant)
- Variable/fixed RV sequences for repetitions.
- ePDCCH/ePHICH based
- Truncated DCI (Secondary DCI)
- Repetitions configured by RRC
- Indication of repetition level for data retransmission
- Implicit indication of PDSCH timing for async retransmission
- PDSCH based
- Repetitions indicated by S-DG
- Fixed/variable RV sequences
0 2 3 1
0 2 3 1
0 0 2 1
0 0 0 0
0 0 0 0
eNB
UE
(P-)DG
1st transmission
S-DG
2nd transmission
NACK Rep
eNB behavior upon receiving feedback
-- upon receiving NACK,
o S-DG transmitted for partial-adaptive retransmission.
o P-DG transmitted for full-adaptive retransmission or new data transmission.
-- upon receiving ACK or DTX, P-DG transmitted for new data transmission or full-adaptive retransmission.
UE feedback behavior upon decoding
- If P-DG correct and data failed, NACK is transmitted
- If P-DG incorrect and data failed, DTX is applied
- If Data correct, ACK is transmitted
- PUCCH based
- ACK/NACK/DTX feedback
- Recommendation of repetition level for data retransmission.

FIG. 3

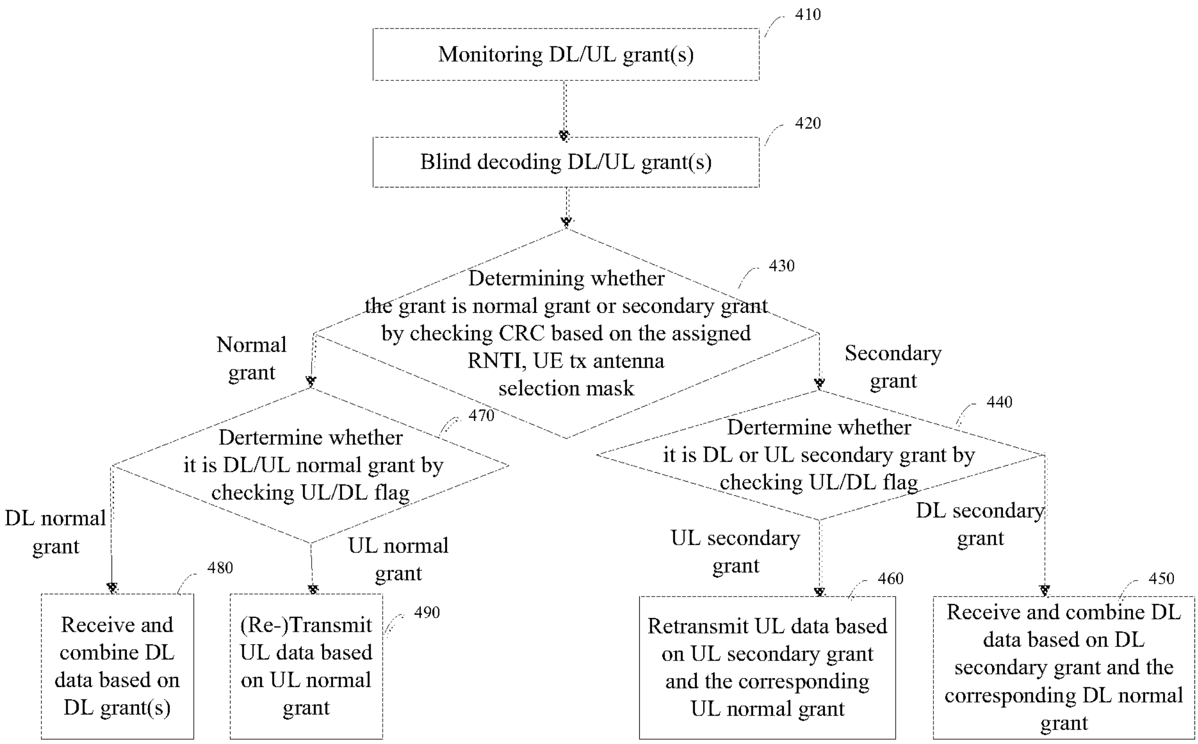
410
Monitoring DL/UL grant(s)
420
Blind decoding DL/UL grant(s)
430
Determining whether the grant is normal grant or secondary grant by checking CRC based on the assigned RNTI, UE tx antenna selection mask
Normal grant
Secondary grant
470
Dertermine whether it is DL/UL normal grant by checking UL/DL flag
440
Dertermine whether it is DL or UL secondary grant by checking UL/DL flag
DL normal grant
UL normal grant
UL secondary grant
DL secondary grant
480
Receive and combine DL data based on DL grant(s)
490
(Re-)Transmit UL data based on UL normal grant
460
Retransmit UL data based on UL secondary grant and the corresponding UL normal grant
450
Receive and combine DL data based on DL secondary grant and the corresponding DL normal grant

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2015/076866

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/04(2009.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W; H04L; H04B

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)

CNPAT, EPODOC, WPI, CNKI, 3GPP: grant, DCI, control w information, truncat+, partial, additional, HARQ, repetition, secondary, primary, normal, RNTI, CRC, uplink, downlink, MTC, machine to machine

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2013074722 A1 (QUALCOMM INC.) 23 May 2013 (2013-05-23) description, paragraphs [0033], [0044]-[0073], figures 4-7	1-12
A	CN 103220795 A (ZTE CORPORATION) 24 July 2013 (2013-07-24) the whole document	1-12
A	CN 103582098 A (CHINA MOBILE COMMUNICATIONS CORPORATION) 12 February 2014 (2014-02-12) the whole document	1-12
A	CN 103918211 A (LG ELECTRONICS INC.) 09 July 2014 (2014-07-09) the whole document	1-12
A	3rd Generation Partnership Project. "3GPP TS 36.321 V12.5.0" *Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification(Release 12),* 31 March 2015 (2015-03-31), the whole document	1-12

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
05 January 2016	**26 January 2016**

Name and mailing address of the ISA/CN	Authorized officer
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Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
WO 2013074722 A1	23 May 2013	CN 103931255 A	16 July 2014
		EP 2781133 A1	24 September 2014
		US 2013121274 A1	16 May 2013
		KR 20140090252 A	16 July 2014
		JP 2014533910 A	15 December 2014
CN 103220795 A	24 July 2013	WO 2013107250 A1	25 July 2013
CN 103582098 A	12 February 2014	WO 2014012502 A1	23 January 2014
CN 103918211 A	09 July 2014	WO 2013066086 A1	10 May 2013
		EP 2757725 A1	23 July 2014
		US 2014348091 A1	27 November 2014
		KR 20140093222 A	25 July 2014