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(54) **Title:** METHODS AND APPARATUS OF RELIABLE MULTICAST TRANSMISSION WITH UPLINK FEEDBACK

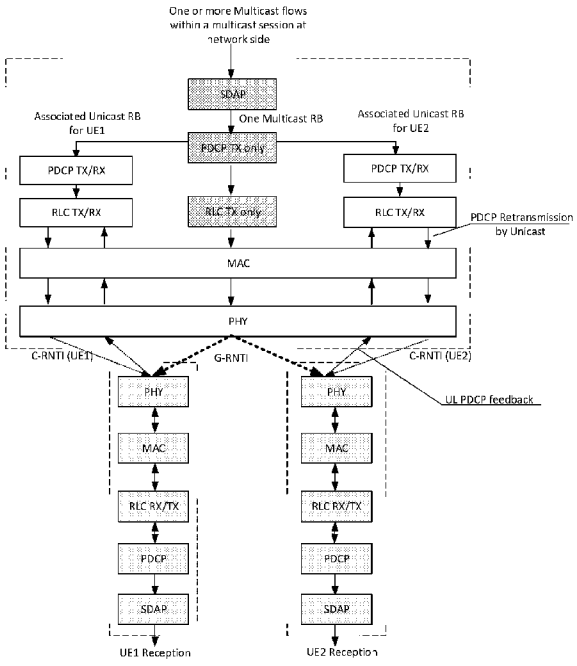


*FIG.7*

(57) **Abstract:** This disclosure describes methods and apparatus of supporting reliable multicast transmission in PTM mode. A new multicast radio bearer structure with associated PTP RB is proposed to enable reliable multicast transmission. The associated PTP RB is used for both uplink feedback and downlink retransmission. At UE side, a single protocol stack is proposed for the reception of both PTM RB and PTP RB.

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# Methods and apparatus of Reliable Multicast Transmission with Uplink Feedback

## Field

**[0001]** The present disclosure relates generally to communication systems, and more particularly, the method of enabling reliable multicast transmission with UE uplink feedback to support multicast service delivery from the wireless network to the UEs.

## BACKGROUND

**[0002]** Various cellular systems, including both 4G/LTE and 5G/NR systems, may provide a multicast functionality, which allows user equipment (UEs) in the system to receive multicast services transported by the cellular system. A variety of applications may rely on communication over multicast transmission, such as live stream, video distribution, vehicle-to-everything (V2X) communication, public safety (PS) communication, file download, and so on. In some cases, there may be a need for the cellular system to enable reliable multicast transmission in order to ensure the reception quality at the UE side. In these cases, it may be beneficial for the receiving UE to provide the feedback on its reception of the multicast transmission, which helps the network to perform necessary retransmission of the content to the UE.

## SUMMARY

**[0003]** The following presents a simplified summary of one or more aspects in order to provide a basic understanding of such aspects. This summary is not an extensive overview of all contemplated aspects, and is intended to neither identify key or critical elements of all aspects nor delineate the scope of any or all aspects. Its sole purpose is to present some concepts of one or more aspects in a simplified form as a prelude to the more detailed description that is presented later.

**[0004]** In an aspect of the disclosure, a method, a computer-readable medium, and an apparatus are provided. The apparatus may be a Base Station. The Base Station establishes a PTP RB to assist the reliable multicast transmission via PTM RB. The PTP RB can an associated unicast channel or uncast RB. The PTP RB is used to send polling request from the network to the UE.

**[0005]** In another aspect of the disclosure, the UE establishes a single Radio Bearer to receive the multicast transmission in PTM mode and the uncast transmission in PTP mode. The UE establishes a single RLC/PDCP entity and RLC/PDCP entity assembles the data coming from both PTM RB and PTP RB. The UE sends the Uplink feedback to indicate the reception statues about the downlink data.

**[0006]** To the accomplishment of the foregoing and related ends, the one or more aspects comprise the features hereinafter fully described and particularly pointed out in the claims. The following description and the annexed drawings set forth in detail certain illustrative features of the one or more aspects. These features are indicative, however, of but a few of the various ways in which the principles

of various aspects may be employed, and this description is intended to include all such aspects and their equivalents.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0007]** FIG. 1(a) is a schematic system diagram illustrating an exemplary Base Station (i.e. BS), in accordance with certain aspects of the present disclosure.

**[0008]** FIG. 1(b) is a schematic system diagram illustrating an exemplary UE, in accordance with certain aspects of the present disclosure.

**[0009]** FIG. 2 illustrates an exemplary NR wireless communication system, in accordance with certain aspects of the present disclosure.

**[0010]** FIG. 3 illustrates an exemplary multicast transmission RB structure to enable reliable multicast transmission, in accordance with certain aspects of the present disclosure.

**[0011]** FIG. 4 illustrates an exemplary PTM RB to PTP RB switch for multicast RB transmission based on Figure 3, in accordance with certain aspects of the present disclosure.

**[0012]** FIG. 5 illustrates another exemplary multicast transmission RB structure to enable reliable multicast transmission, in accordance with certain aspects of the present disclosure.

**[0013]** FIG. 6 illustrates an exemplary PTM RB to PTP RB switch for multicast RB transmission based on Figure 5, in accordance with certain aspects of the present disclosure.

**[0014]** FIG. 7 illustrates a further exemplary multicast transmission RB structure to enable reliable multicast transmission, in accordance with certain aspects of the present disclosure.

**[0015]** FIG. 8 illustrates an exemplary PTM RB to PTP RB switch for multicast RB transmission based on Figure 7, in accordance with certain aspects of the present disclosure.

## DETAILED DESCRIPTION

**[0016]** The detailed description set forth below in connection with the appended drawings is intended as a description of various configurations and is not intended to represent the only configurations in which the concepts described herein may be practiced. The detailed description includes specific details for the purpose of providing a thorough understanding of various concepts. However, it will be apparent to those skilled in the art that these concepts may be practiced without these specific details. In some instances, well known structures and components are shown in block diagram form in order to avoid obscuring such concepts.

**[0017]** Several aspects of telecommunication systems will now be presented with reference to various apparatus and methods. These apparatus and methods will be described in the following detailed description and illustrated in the accompanying drawings by various blocks, components, circuits, processes, algorithms, etc. (collectively referred to as "elements"). These elements may be implemented using electronic hardware, computer software, or any combination thereof. Whether such elements are implemented as hardware or software depends upon the particular application and design constraints

imposed on the overall system.

**[0018]** Aspects of the present disclosure provide methods, apparatus, processing systems, and computer readable mediums for NR (new radio access technology, or 5G technology) or other radio access technology. NR may support various wireless communication services. These services may have different quality of service (QoS) requirements e.g. latency and reliability requirements. Figure 1(a) is a schematic system diagram illustrating an exemplary Base Station (i.e. BS). The BS may also be referred to as an access point, an access terminal, a base station, a Node-B, an eNode-B, a gNB, or by other terminology used in the art. As an example, base stations serve a number of mobile stations within a serving area, for example, a cell, or within a cell sector. The Base Station has an antenna, which transmits and receives radio signals. A RF transceiver, coupled with the antenna, receives RF signals from antenna, converts them to baseband signals, and sends them to processor. RF transceiver also converts received baseband signals from processor, converts them to RF signals, and sends out to antenna. Processor processes the received baseband signals and invokes different functions. Memory stores program instructions and data to control the operations of Base Station. Figure 1(b) is a schematic system diagram illustrating an exemplary UE. The UE may also be referred to as a mobile station, a mobile terminal, a mobile phone, smart phone, wearable, an IoT device, a table let, a laptop, or other terminology used in the art. UE has an antenna, which transmits and receives radio signals. A RF transceiver, coupled with the antenna, receives RF signals from antenna, converts them to baseband signal, and sends them to processor. RF transceiver also converts received baseband signals from processor, converts them to RF signals, and sends out to antenna. Processor processes the received baseband signals and invokes different functional modules to perform features in UE. Memory stores program instructions and data to control the operations of mobile station. Figure 2 illustrates an exemplary NR wireless communication system. Different protocol split options between Central Unit and Distributed Unit of gNB nodes may be possible. In one embodiment, SDAP and PDCP layer are located in the central unit, while RLC, MAC and PHY layers are located in the distributed unit.

**[0019]** The described invention operates in the context of multicast transmission in a cellular system. In certain systems, such as NR systems, NR multicast/broadcast is transmitted in the coverage of a cell. From logical channel perspective, MCCH provides the information of a list of NR multicast/broadcast services with ongoing sessions transmitted on MTCH(s). At physical layer, MTCH is scheduled by gNB in the search space of PDCCH with G-RNTI scrambled. UE decodes the MTCH data for a multicast session in the multicast PDSCH.

**[0020]** In legacy system supporting MBMS/eMBMS, the radio bearer structure for multicast and broadcast transmission is modelled in an independent way from unicast transmission. Because of the unidirectional transmission for legacy MBMS/eMBMS service, RLC UM node is used for the transmission of multicast/broadcast session. In this case there is no need to make the interaction between multicast and unicast for a particular UE which is in RRC Connected state.

**[0021]** There is a clear requirement on the reliable transmission for NR multicast services. But the

characteristics of multicast transmission does not allow the network to ensure all the UEs to make successful reception for the services. Otherwise, the network should apply very conservative link adaptation, which may impact the radio resource utilization efficiency.

**[0022]** In order to support the reliable transmission for NR multicast service, a feedback channel in the uplink is needed for each UE receiving the service, which can be used by the receiving UE to feedback its reception status about the service to the network. Based on the feedback, the network may perform necessary retransmission to improve the transmission reliability. From uplink feedback perspective, the feedback channel may be used for L2 feedback (e.g. RLC Status Report and/or PDCP Status Report). In addition, the feedback channel may be used for HARQ feedback. Furthermore, the feedback should be a bidirectional channel between the UE and the network, with the assumption that the network may take that channel to perform needed packet retransmission. The said packet retransmission is L2 retransmission (e.g. RLC retransmission and/or PDCP retransmission). In addition, the feedback channel may be used for HARQ retransmission.

**[0023]** The network needs to establish one or multiple Radio Bearers corresponding to the multicast flows of a particular multicast session in order to support the multicast transmission in the downlink over the air. The multiple Radio Bearer can be subject to Point-to-Multiple (i.e. PTM) or Point-to-Point (i.e. PTP) transmission within a cell. In case of Point-to-Multiple transmission, the multiple Radio Bearer is a PTM RB. In case of Point-to- Point transmission, the multiple Radio Bearer is a PTP RB.

**[0024]** The general principle of reliable multicast transmission is that, in network side, there is a separate unicast RLC channel or unicast Radio Bearer (in RLC AM mode) established to assist the reliable multicast transmission. Both unicast RLC channel and unicast Radio Bearer can be seen as an associated PTP RB for the corresponding PTM RB. The L2 entity (RLC and/or PDCP) for unicast channel or unicast Radio Bearer (i.e. RB) is separated from PTM RB (in RLC UM mode). Initial transmission of the multicast data is carried by PTM RB and is multicast to multiple UEs using G-RNTI. Any retransmissions if needed is carried by the associated PTP RB (the associated RLC channel or unicast Radio Bearer) and is unicast to the UE using C-RNTI. Alternatively, the network may perform multicast retransmission (e.g. blindly or based on the feedback from the UEs) over PTM RB, and the additional retransmissions if needed is unicast over the associated RLC channel (or unicast RB) to the UE using C-RNTI. In downlink, the associated RLC channel (or unicast RB) can be also used for Polling Request to trigger a specific UE to feedback its reception status of the L2 packets. In downlink, the PTM RB can be used for Polling Request if the Base Station intends to trigger all of the concerned UEs to feedback its reception status of the L2 packets.

**[0025]** In UE side, there is single or combined protocol stack established for the reception of the multicast data (carried by PTM Radio Bearer) and the unicast data (carried over the unicast channel or unicast Radio Bearer). The RLC entity of the protocol stack in UE side for the reception of the reliable multicast transmission is in RLC AM mode. This protocol stack in UE side represents a protocol stack for

air interface based transmission of a dedicated data RB (i.e. DRB).

**[0026]** In uplink, the associated RLC channel (or unicast Radio Bearer) is used to provide the uplink feedback using C-RNTI e.g. L2 status report (RLC or PDCP). UE monitors two independent packet data flows (with one for PTM data and the other for PTP data) through different RNTIs. UE assembles the data packets from two data flows at RLC/PDCP. This operation is based on the corresponding handling at network side, where the Sequence Numbering of the packets (regardless of PTP or PTM) is aligned.

**[0027]** From the logical channel modeling perspective, there are different alternatives. In the first alternative, the network establish two logical channels (with one for PTM data flow and the other for PTP data flow) for reliable multicast transmission. In this case, UE monitors two independent logical channels (LCHs) for downlink data reception. UE is configured to establish two independent logical channels. UE delivers the data packets received from the two LCHs to the same RLC entity for succeeding handling.

**[0028]** In the second alternative, the network establishes two logical channels (with one for PTM data flow and the other for PTP data flow) for reliable multicast transmission. UE is configured to establish only one logical channel. UE monitors two independent logical channels (LCHs) for downlink data reception. This means there is a two-to-one mapping for the downlink logical channels. UE delivers the data packets received from the two LCHs to the same RLC entity for succeeding handling.

**[0029]** In the third alternative, the network establishes a single logical channel (for both PTM data flow and PTP data flow) for reliable multicast transmission. The network schedules the downlink transmission (from either PTM data flow or PTP data flow) at the same logical channel but use different RNTI to indicate. PTM transmission block is indicated by G-RNTI and PTP transmission block is indicated by C-RNTI. In this case, UE monitors single logical channel (LCH) for downlink data reception. UE delivers the data packets received from the LCH to the RLC entity for succeeding handling.

**[0030]** In Figure 3, an example of multicast transmission RB structure is illustrated. In the network side, PTM RB is used for Downlink multicast transmission and its RLC mode is UM mode. Specific to UE1 and UE2, an associated unicast RLC channel is established respectively for Downlink RLC packet retransmission and Uplink RLC Status Report. The network can also send the Polling Request to the UE to ask the UE to provide RLC Status Report on the reception of the PTM RB. In practice, the Downlink multicast transmission can be one or a plural of PTM RB, with each corresponding to an independent logical channel (e.g. Multicast Traffic Channel, MTCH). Each multicast channel is scheduled by a specific G-RNTI at PDCCH. The network can establish one associated unicast RLC channel for each PTM RB that the UE receives. Alternatively, the network can establish one associated unicast RLC channel for all PTM RBs that the UE receives.

**[0031]** In the network side, the RLC entity of PTM RB (i.e. the RLC TX only entity) is responsible for the Sequence Numbering (i.e. SN) allocation for the RLC packets. RLC TX only entity makes multicast delivery via PTM RB. RLC TX only entity delivers a copy of all the RLC packets (with RLC SN) to the RLC TX/RX entity of UE1 and UE2 in the network side. The RLC TX/RX entity of UE1

and UE2 (in the network side) buffer the RLC packets until positive packet status report received. RLC TX/RX entity of UE1 and UE2 (in the UE side) provide RLC status report to network when Polling request is received via the corresponding unicast leg. RLC TX/RX entity of UE1 and UE2 (in the network side) remove the RLC packets when positive packet status report received. RLC TX/RX entity of UE1 and UE2 (in the network side) discard the RLC packets based on a discard timer to avoid too long buffering for the packets. The discard timer can be per packet. Alternatively the discarding of the RLC packets can be performed according to a configured window that defines how many number of RLC SDUs can be buffered. For example, the new RLC packets coming may trigger the discarding of the previous RLC packets, which follows the principle of First In First Out (FIFO) if the window reaches the limitation.

**[0032]** In the UE side (UE1 or UE2), there is a single protocol stack for the reception of the PTM RB and the PTP RB. In uplink, the associated RLC channel sends RLC feedback (i.e. RLC Status Report) to PTP RB. The said RLC feedback acknowledges the reception status of both initial transmission and retransmission. UE monitors UE specific PDCCH using C-RNTI and read the potential scheduling information for PTP RB, and at the same time monitors multicast PDCCH using G-RNTI and read the potential scheduling information for PTM RB. As in legacy system, PTP RB is carried by dedicated traffic logical channel (i.e. DTCH). PTM RB is carried by Multicast traffic logical channel (i.e. MTCH). UE assembles the data packets from two independent data flows at RLC/PDCP. This operation is based on the corresponding handling at network side, where the Sequence Numbering of the packets (regardless of PTP or PTM) is aligned.

**[0033]** In Figure 4, a switch example from PTM RB to PTP RB for multicast RB transmission based on Figure 3 is illustrated. The PTM RB leg is deactivated when there is a need to switch the PTM to PTP (e.g. because there are not so many UEs receiving the multicast service). In UE side, after PTM to PTP switch, UE only monitors the unicast logical channel via C-RNTI. During PTM to PTP switch, the UE reception protocol stack is no change. From network side, the upper part of RLC functionality of RLC TX only entity is kept and this means RLC SN is still allocated by RLC TX only entity in order to ensure consistent RLC SN allocation after PTM to PTP. As an alternative, the RLC TX only entity is removed and the PDCP entity directly delivers the packets to RLC TX/RX of UE1/UE2. As a second alternative, the RLC TX only and PDCP entity (for multicast RB) is removed, a separate PDCP (for unicast) is established at network side to delivers the packets in unicast manner. In both of these alternatives, the SN numbering of RLC is restarted at network side, then the UE side RLC entity may need be reset. One method to avoid resetting the RLC entity at UE side is that in the network side, the RLC SN numbering of the PTM RLC entity needs to be inherited at the newly established unicast RLC entity at network side.

**[0034]** During the PTM->PTP transmission mode switch, from security configuration (i.e. ciphering/integrity protection) perspective, a common security configuration can be applied to both PTM RB and PTP RB for multicast transmission. This means the security setting can be inherited after transmission mode switch. Alternatively, the PTP RB can disable the ciphering/integrity protection, or

just use nia0 and/or nea0.

**[0035]** In Figure 5, an alternative example of multicast transmission RB structure is illustrated, as a variant of Figure 3. This example basically follows the same principle as Figure 3. As a difference from Figure 3, the PDCP in the network side allocates the SN of PDCP packets and make multicast delivery via PTM RB. The PDCP entity sends the copy of all of the PDCP packets with PDCP header to the RLC TX/RX entity of UE1 and UE2 in the network side. The RLC TX/RX entity of UE1 and UE2 (in the network side) buffer the RLC packets until positive packet status report received for the corresponding RLC packets. RLC TX/RX entity of UE1 and UE2 (in UE side) provide RLC status report to network when Polling request is received. The Polling request can be sent via either multicast leg or unicast leg. The RLC TX/RX entity of UE1 and UE2 (in UE side) needs to separate the packets coming from unicast PTP RB and multicast PTM RB after MAC demultiplexing operation, because of isolated RLC SN numbering for the RLC packets. The RLC TX/RX entity of UE1 and UE2 (in the network side) remove the RLC packets when positive packet status report received. RLC TX/RX entity of UE1 and UE2 (network side) follows the same discard mechanism as described for the example in Figure 3.

**[0036]** During the RLC status report from UE to the network, specific information (i.e. logical channel ID, Bearer ID, or other identity information) needs to be inserted into the RLC status report to indicate which leg (i.e. multicast PTM leg and/or unicast PTP leg) the RLC status report applies, since multicast PTM leg and unicast PTP leg have independent RLC entities and the packets coming from PDCP entity is subject to different RLC SN allocation. In addition, if a particular RLC status report is received by the Base Station on the PTM RB, the Base Station may need to ask the associated unicast RLC entity to perform retransmission based on negative acknowledgement. In practice, the RLC SDU buffered at the associated unicast RLC entity is based on the PDCP SN, instead of RLC SN. For example, if the PDCP packet (with PDCP SN #1000) is segmented into multiple RLC packets, the whole PDCP packet needs to be retransmitted in case of one missing RLC segments.

**[0037]** An alternative way to handle the SN allocation of the packets for the example of Figure 5 is that, the two RLC entities always uses the PDCP SN as allocated by the PDCP entity as his RLC SN, even though this may need to configure aligned SN length between RLC entity and PDCP entity. The benefit of this approach is to make the SN aligned between multicast leg and unicast leg. In this case, the RLC status report should report the PDCP SN and there is no need for RLC status report to carry transmission leg information.

**[0038]** In Figure 6, a switch example from PTM RB to PTP RB for multicast RB transmission based on Figure 5 is illustrated. The basic switch principle as described in Figure 4 applies to Figure 6 also. As a difference, The RLC TX only entity is no longer needed after the switch from PTM RB to PTP RB. From network side, the PDCP entity for multicast RB can be kept to make the PDCP SN consistent after switch. As an option, the PDCP entity for multicast RB is removed and a separate PDCP (for unicast) is established at network side to delivers the packets in unicast manner. In this option, the SN numbering is restarted at network side, then in UE side, the PDCP may need be reset. One method to avoid resetting the PDCP entity at UE side is that in the network side, the PDCP SN numbering of the PTM PDCP entity

needs to be inherited at the newly established unicast PDCP entity at network side.

**[0039]** In Figure 7, an alternative example of multicast transmission RB structure is illustrated, as a variant of Figure 3. This example basically follows the same principle as Figure 3. As a difference from Figure 3, the PDCP RLC retransmission functionality is enforced at PDCP layer. The PDCP entity in the network side allocates the SN of PDCP packets and make multicast delivery via PTM RB. The PDCP entity sends the copy of all of the PDCP packets with PDCP SN to the PDCP TX/RX entity of UE1 and UE2 (in the network side). PDCP TX/RX entity of UE1 and UE2 only implement the part of the PDCP functionality (i.e. SN allocation is not needed). PDCP TX/RX entity of UE1 and UE2 (network side) buffer the PDCP packets until positive packet status report received for the corresponding PDCP packets. PDCP TX/RX entity of UE1 and UE2 (UE side side) provide PDCP status report to network when Polling request is received via the corresponding unicast leg. RLC TX/RX entity of UE1 and UE2 (UE side) needs to separate the packets coming from unicast LCH and multicast LCH before delivers to PDCP. The PDCP TX/RX entity of UE1 and UE2 (network side) remove the PDCP packets (PDCP PDU) when positive packet status report received. PDCP TX/RX entity of UE1 and UE2 (network side) discard the PDCP packets based on the same discard mechanism as described for the example in Figure 3.

**[0040]** In Figure 8, a switch example from PTM RB to PTP RB for multicast RB transmission based on Figure 7 is illustrated. The basic switch principle as described in Figure 4 applies to Figure 8 also. As a difference, after the PTM RB to PTP RB switch, the upper part of PDCP functionality of PDCP TX only entity is kept at network side. As an option, the PDCP TX only entity is removed and the SDAP of multicast RB directly delivers the packets to PDCP TX/RX of UE1/UE2. In this option, the SN numbering is restarted at network side, then at UE side the PDCP entity may need be reset. One method to avoid resetting the PDCP entity at UE side is that in the network side, the PDCP SN numbering of the PTM PDCP entity needs to be inherited at the newly established unicast PDCP entity at network side.

**[0041]** The examples as described for reliable multicast transmission after PTM to PTP RB switch is identical to inter-UE duplicated RB transmission. The switch operation may be configured via RRC reconfiguration, MAC CE or L1 DCI. For example, if there are two UEs receiving separate PTP RB after PTM to PTP RB switch, the identical data is duplicated over the PTP RB transmission to the two UEs.

**[0042]** It is understood that the specific order or hierarchy of blocks in the processes / flowcharts disclosed is an illustration of exemplary approaches. Based upon design preferences, it is understood that the specific order or hierarchy of blocks in the processes / flowcharts may be rearranged. Further, some blocks may be combined or omitted. The accompanying method claims present elements of the various blocks in a sample order, and are not meant to be limited to the specific order or hierarchy presented.

**[0043]** The previous description is provided to enable any person skilled in the art to practice the various aspects described herein. Various modifications to these aspects will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other aspects. Thus, the claims are not intended to be limited to the aspects shown herein, but is to be accorded the full scope consistent with the language claims, wherein reference to an element in the singular is not intended to

mean "one and only one" unless specifically so stated, but rather "one or more." The word "exemplary" is used herein to mean "serving as an example, instance, or illustration." Any aspect described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other aspects. Unless specifically stated otherwise, the term "some" refers to one or more. Combinations such as "at least one of A, B, or C," "one or more of A, B, or C," "at least one of A, B, and C," "one or more of A, B, and C," and "A, B, C, or any combination thereof" include any combination of A, B, and/or C, and may include multiples of A, multiples of B, or multiples of C. Specifically, combinations such as "at least one of A, B, or C," "one or more of A, B, or C," "at least one of A, B, and C," "one or more of A, B, and C," and "A, B, C, or any combination thereof" may be A only, B only, C only, A and B, A and C, B and C, or A and B and C, where any such combinations may contain one or more member or members of A, B, or C. All structural and functional equivalents to the elements of the various aspects described throughout this disclosure that are known or later come to be known to those of ordinary skill in the art are expressly incorporated herein by reference and are intended to be encompassed by the claims. Moreover, nothing disclosed herein is intended to be dedicated to the public regardless of whether such disclosure is explicitly recited in the claims. The words "module," "mechanism," "element," "device," and the like may not be a substitute for the word "means." As such, no claim element is to be construed as a means plus function unless the element is expressly recited using the phrase "means for."

**[0044]** While aspects of the present disclosure have been described in conjunction with the specific embodiments thereof that are proposed as examples, alternatives, modifications, and variations to the examples may be made. Accordingly, embodiments as set forth herein are intended to be illustrative and not limiting. There are changes that may be made without departing from the scope of the claims set forth below.

# CLAIMS

1. A method of wireless communication comprising:

Reliable multicast transmission from the network to the UE with Uplink feedback from the receiving UE.

2. The method of claim 1, wherein the network establishes a PTP RB to assist the reliable multicast transmission via PTM RB.

3. The method of claim 2, wherein the PTP RB can an associated unicast channel or uncast RB.

4. The method of claim 3, wherein the PTP RB is used to send polling request from the network to the UE.

5. A method of wireless communication comprising:

Reception of the reliable multicast transmission from the network by the UE

6. The method of claim 5, wherein the UE sends the uplink feedback to the network to indicate the reception status of the multicast data.

7. The method of claim 5, wherein the UE establishes a single RB to receive both PTP RB and PTM RB.

8. The method of claim 5, wherein the UE assembles the data from PTP RB and PTM RB at a single RLC entity and PDCP entity.

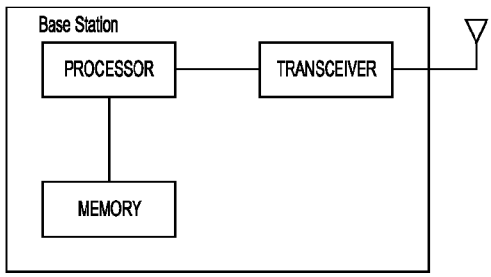


*FIG. 1 (a)*

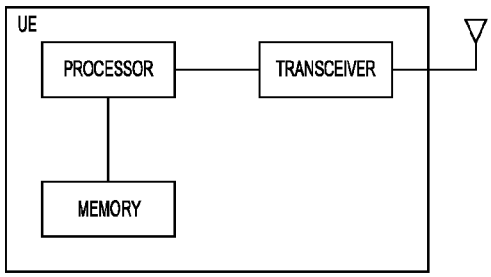


*FIG. 1 (b)*

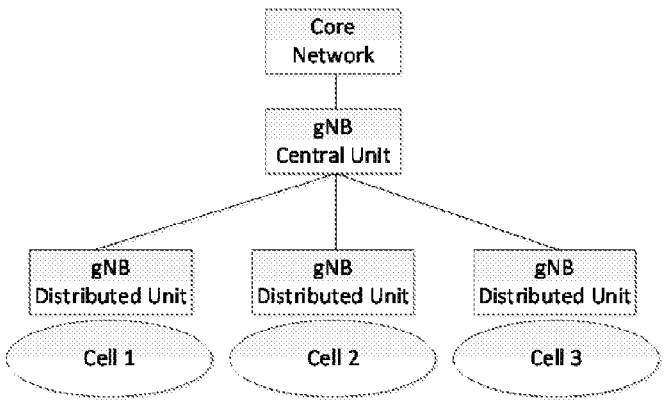


*FIG. 2*

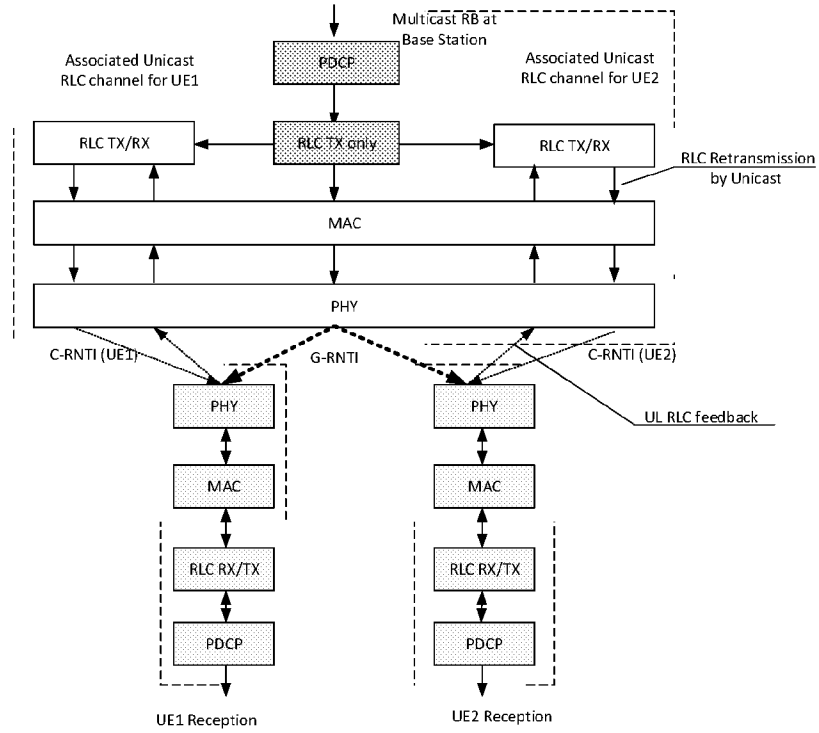
Multicast RB at Base Station
PDCP
Associated Unicast RLC channel for UE1
Associated Unicast RLC channel for UE2
RLC TX/RX
RLC TX only
RLC TX/RX
RLC Retransmission by Unicast
MAC
PHY
C-RNTI (UE1)
G-RNTI
C-RNTI (UE2)
UL RLC feedback
PHY
PHY
MAC
MAC
RLC RX/TX
RLC RX/TX
PDCP
PDCP
UE1 Reception
UE2 Reception

FIG. 3

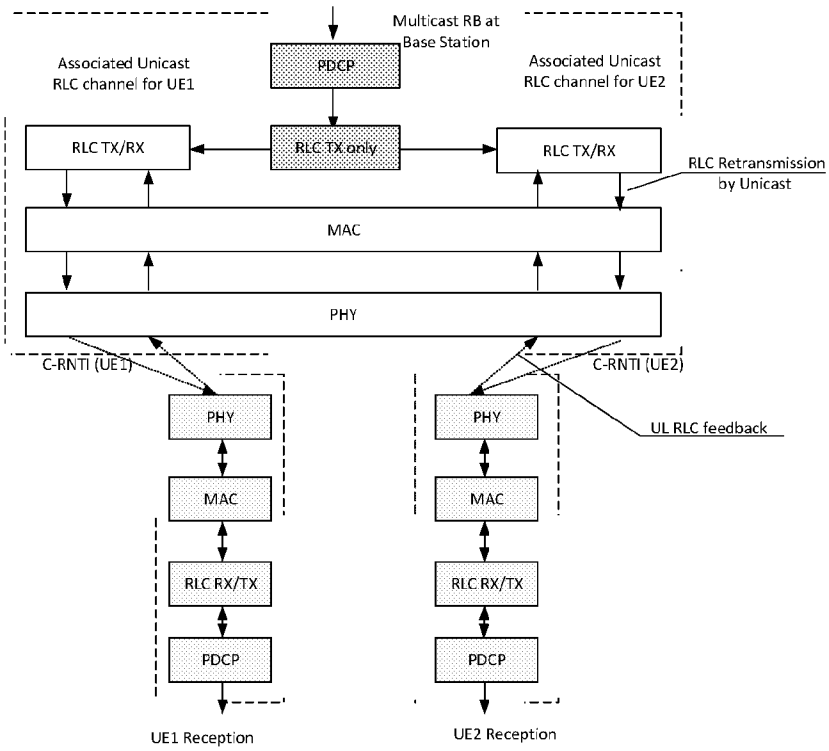
Multicast RB at Base Station
PDCP
Associated Unicast RLC channel for UE1
Associated Unicast RLC channel for UE2
RLC TX/RX
RLC TX only
RLC TX/RX
RLC Retransmission by Unicast
MAC
PHY
C-RNTI (UE1)
C-RNTI (UE2)
UL RLC feedback
PHY
PHY
MAC
MAC
RLC RX/TX
RLC RX/TX
PDCP
PDCP
UE1 Reception
UE2 Reception

FIG.4

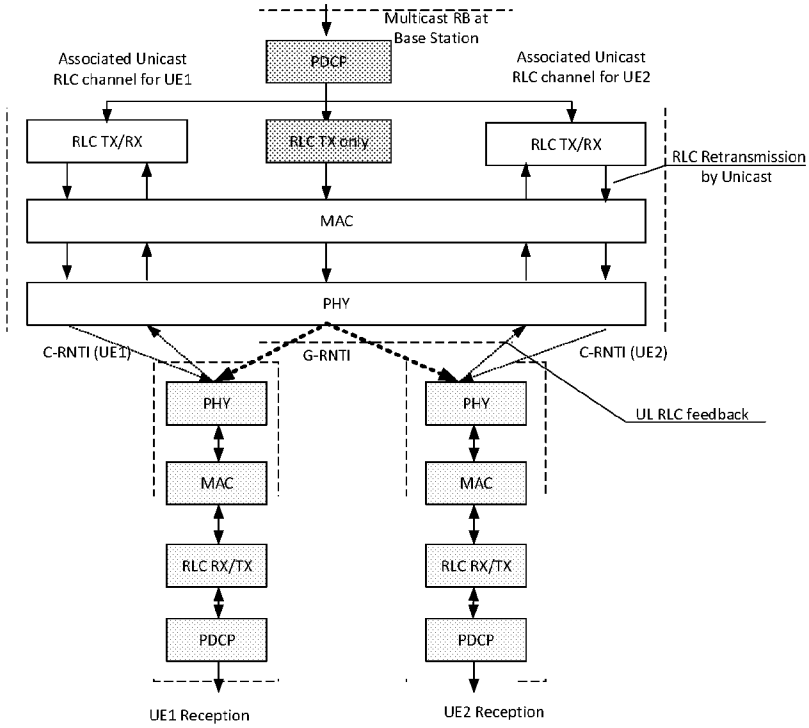
Multicast RB at Base Station
PDCP
Associated Unicast RLC channel for UE1
Associated Unicast RLC channel for UE2
RLC TX/RX
RLC TX only
RLC TX/RX
RLC Retransmission by Unicast
MAC
PHY
C-RNTI (UE1)
G-RNTI
C-RNTI (UE2)
UL RLC feedback
PHY
MAC
RLC RX/TX
PDCP
PHY
MAC
RLC RX/TX
PDCP
UE1 Reception
UE2 Reception

*FIG. 5*

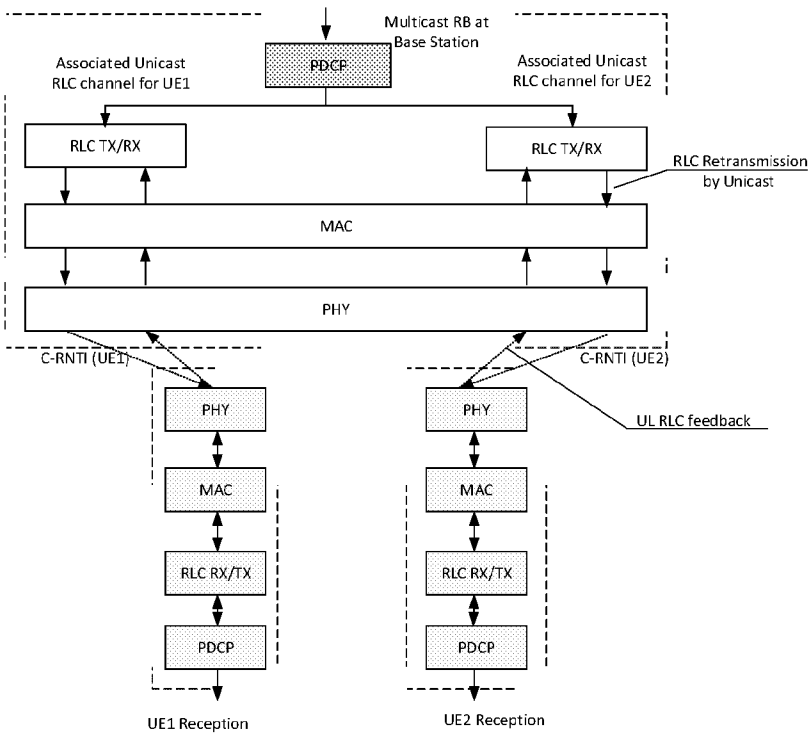
Multicast RB at Base Station
PDCP
Associated Unicast RLC channel for UE1
Associated Unicast RLC channel for UE2
RLC TX/RX
RLC TX/RX
RLC Retransmission by Unicast
MAC
PHY
C-RNTI (UE1)
C-RNTI (UE2)
UL RLC feedback
PHY
MAC
RLC RX/TX
PDCP
PHY
MAC
RLC RX/TX
PDCP
UE1 Reception
UE2 Reception

*FIG. 6*

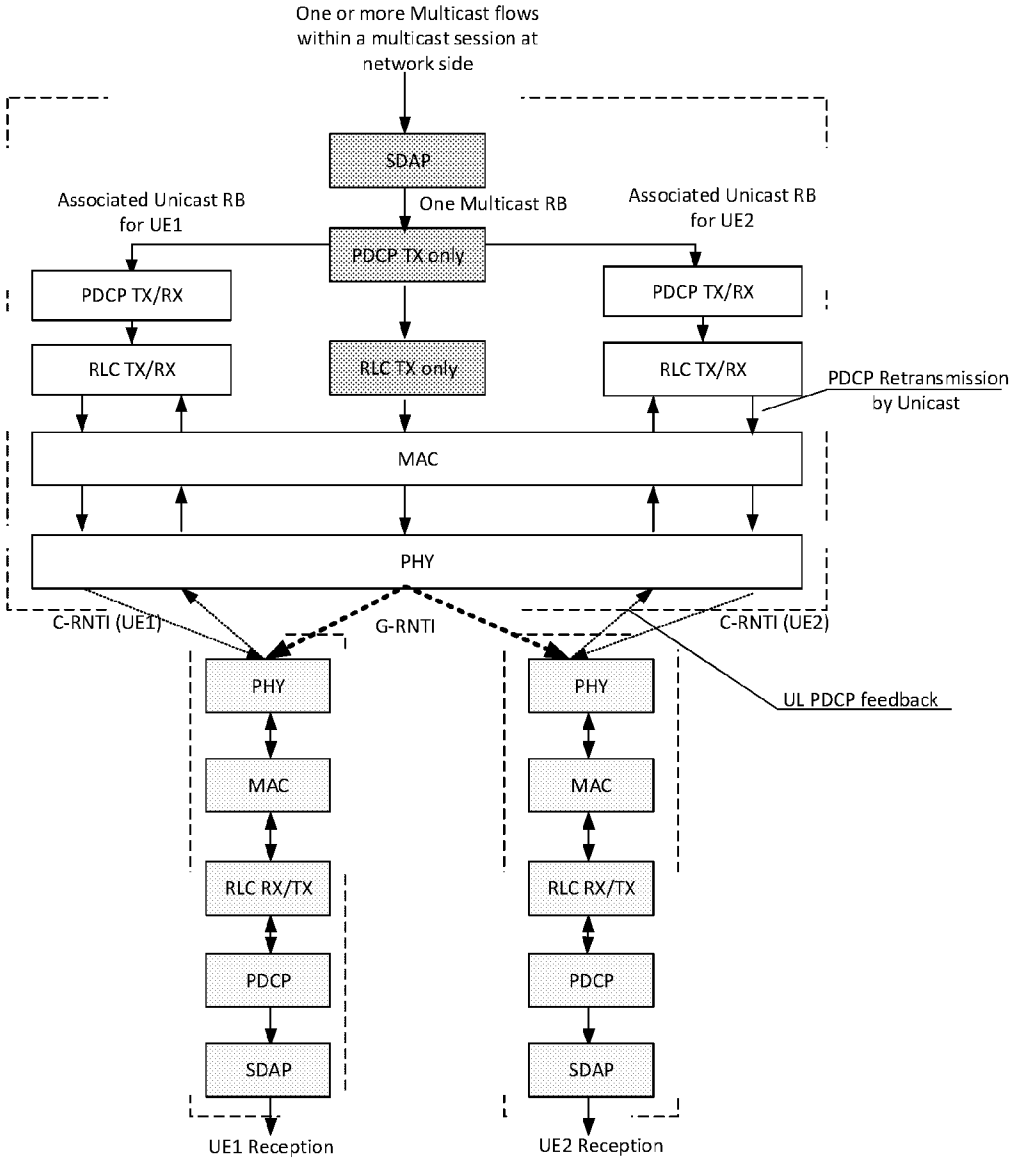
One or more Multicast flows within a multicast session at network side
SDAP
Associated Unicast RB for UE1
One Multicast RB
Associated Unicast RB for UE2
PDCP TX only
PDCP TX/RX
PDCP TX/RX
RLC TX/RX
RLC TX only
RLC TX/RX
PDCP Retransmission by Unicast
MAC
PHY
C-RNTI (UE1)
G-RNTI
C-RNTI (UE2)
PHY
PHY
UL PDCP feedback
MAC
MAC
RLC RX/TX
RLC RX/TX
PDCP
PDCP
SDAP
SDAP
UE1 Reception
UE2 Reception

FIG.7

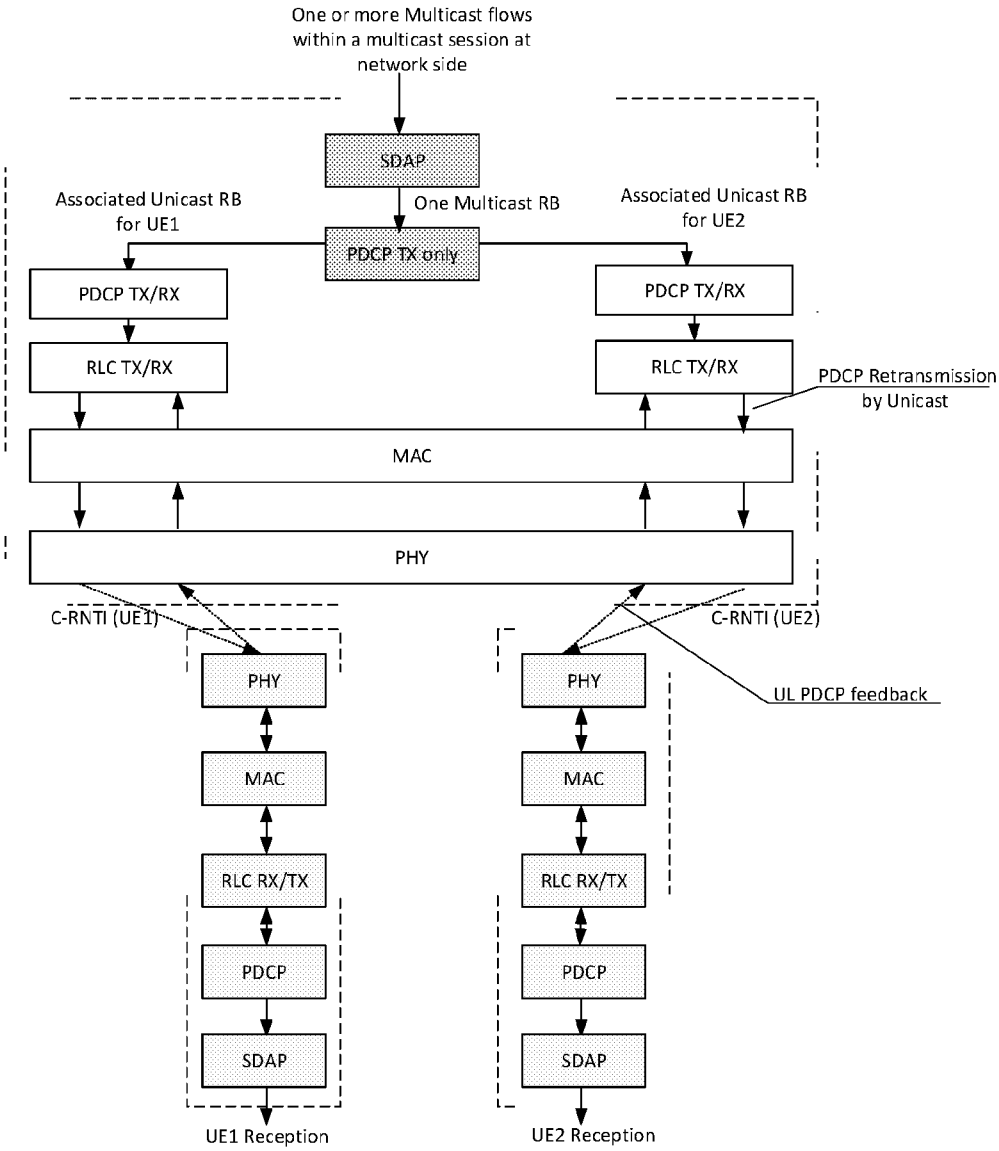
One or more Multicast flows within a multicast session at network side
SDAP
Associated Unicast RB for UE1
One Multicast RB
Associated Unicast RB for UE2
PDCP TX only
PDCP TX/RX
PDCP TX/RX
RLC TX/RX
RLC TX/RX
PDCP Retransmission by Unicast
MAC
PHY
C-RNTI (UE1)
C-RNTI (UE2)
PHY
PHY
UL PDCP feedback
MAC
MAC
RLC RX/TX
RLC RX/TX
PDCP
PDCP
SDAP
SDAP
UE1 Reception
UE2 Reception

FIG.8

# INTERNATIONAL SEARCH REPORT

International application No.
**PCT/CN2020/098904**

## A. CLASSIFICATION OF SUBJECT MATTER

H04L 12/18(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)

CNPAT,WPI,EPODOC,3GPP:reliable,UE,uplink,multicast,ptm,feedback,ack,nack,uplink,transmission,PTM

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | CN 107210865 A (INTEL IP CORPORATION) 26 September 2017 (2017-09-26)<br>description, paragraphs 0004-0006, 0073-0142 | 1-8 |
| X | CN 108540272 A (BEIJING XINWEI TELECOMMUNICATION TECHNOLOGY CO., LTD.) 14 September 2018 (2018-09-14)<br>description, paragraphs 0005-0018 | 1-8 |
| X | CN 103797745 A (SCA IPLA HOLDINGS INC.) 14 May 2014 (2014-05-14)<br>descripiton, paragraphs 0007-0023 | 1-8 |
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☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

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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 |
|---|---|
| **08 March 2021** | **25 March 2021** |
| Name and mailing address of the ISA/CN<br>**National Intellectual Property Administration, PRC**<br>**6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing**<br>**100088**<br>**China**<br>Facsimile No. **(86-10)62019451** | Authorized officer<br>**LIU,Juan**<br>Telephone No. **86-(10)-53961619** |

# INTERNATIONAL SEARCH REPORT

International application No.
**PCT/CN2020/098904**

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
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**INTERNATIONAL SEARCH REPORT**
**Information on patent family members**

International application No.
**PCT/CN2020/098904**

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| | | | | WO | 2013027019 | A1 | 28 February 2013 |
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