(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
27 January 2022 (27.01.2022)

WIPO | PCT

(10) International Publication Number
WO 2022/016552 A1

(51) International Patent Classification:
H04W 4/00 (2018.01)

(21) International Application Number:
PCT/CN2020/104603

(22) International Filing Date:
24 July 2020 (24.07.2020)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant: **NEC CORPORATION** [JP/JP]; 7-1, Shiba 5-chome, Minato-ku, Tokyo 108-8001 (JP).

(72) Inventor; and

(71) Applicant *(for SC only)*: **WANG, Gang** [CN/CN]; 6F, Building D2, Liangmaqiao Diplomatic Office Building, No. 19 Dongfangdonglu, Chaoyang District, Beijing 100600 (CN).

(72) Inventor: **GAO, Yukai**; 6F, Building D2, Liangmaqiao Diplomatic Office Building, No. 19 Dongfangdonglu, Chaoyang District, Beijing 100600 (CN).

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

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, IT, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) **Title:** METHODS, DEVICES, AND COMPUTER READABLE MEDIUM FOR COMMUNICATION

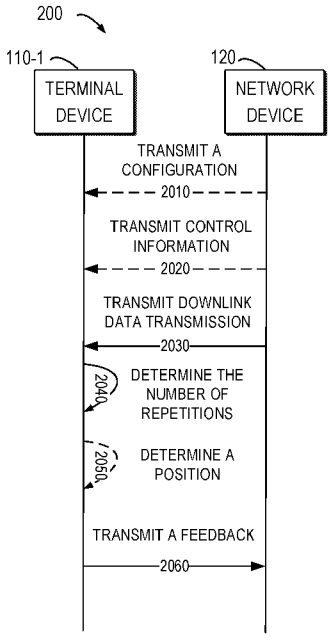

Fig. 2

(57) **Abstract:** Embodiments of the present disclosure relate to communication. According to embodiments of the present disclosure, enhancement on SPS PDSCH has been achieved. The terminal device receives downlink data transmission which is semi-persistent configured, the downlink data transmission having a plurality of repetitions. The terminal device determines the number of repetitions for the downlink data transmission. The network device transmits a feedback for the repetitions for the downlink data transmission based on the number of the repetitions. In this way, a position for transmitting a feedback is properly determined by the terminal device.

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METHODS, DEVICES, AND COMPUTER READABLE MEDIUM FOR COMMUNICATION

TECHNICAL FIELD

[0001] Embodiments of the present disclosure generally relate to the field of telecommunication, and in particular, to methods, devices, and computer readable medium for communication.

BACKGROUND

[0002] Scheduling is a process of allocation resources for transmission. There may be different types of scheduling, for example, dynamic scheduling, semi-persistent scheduling (SPS) and the like. SPS can be configured only in the uplink, or in the downlink (sps-ConfigDL) or in both directions. Configuration of SPS doesn't mean that the terminal device can start using SPS grants/assignments. The network device has to explicitly activate SPS as explained in order for the UE to use SPS grants/assignments. Further, the terminal device can transmit a feedback for the downlink data transmission. A position for transmitting the feedback is a key aspect for the SPS scheduling.

SUMMARY

[0003] In general, example embodiments of the present disclosure provide a solution for communication.

[0004] In a first aspect, there is provided a method for communication. The communication method comprises: receiving, at a terminal device and from a network device, downlink data transmission which is semi-persistent configured, the downlink data transmission having a plurality of repetitions; determining the number of repetitions for the downlink data transmission; and transmitting, to the network device, a feedback for the repetitions for the downlink data transmission based on the number of the repetitions.

[0005] In a second aspect, there is provided a method for communication. The communication method comprises transmitting, at a network device and to a terminal device, downlink data transmission which is semi-persistent configured, the downlink data transmission having a plurality of repetitions; and receiving, from the terminal device, a feedback for the repetitions for the downlink data transmission based on the number of

repetitions.

[0006] In a third aspect, there is provided a terminal device. The terminal device comprises a processing unit; and a memory coupled to the processing unit and storing instructions thereon, the instructions, when executed by the processing unit, causing the terminal device to perform acts comprising: receiving, from a network device, downlink data transmission which is semi-persistent configured, the downlink data transmission having a plurality of repetitions; determining the number of repetitions for the downlink data transmission; and transmitting, to the network device, a feedback for the repetitions for the downlink data transmission based on the number of the repetitions.

[0007] In a fourth aspect, there is provided a network device. The network device comprises a processing unit; and a memory coupled to the processing unit and storing instructions thereon, the instructions, when executed by the processing unit, causing the network device to perform acts comprising: transmitting, to a terminal device, downlink data transmission which is semi-persistent configured, the downlink data transmission having a plurality of repetitions; and receiving, from the terminal device, a feedback for the repetitions for the downlink data transmission based on the number of repetitions.

[0008] In a fifth aspect, there is provided a computer readable medium having instructions stored thereon, the instructions, when executed on at least one processor, causing the at least one processor to carry out the method according to any one of the first aspect or second aspect.

[0009] Other features of the present disclosure will become easily comprehensible through the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Through the more detailed description of some example embodiments of the present disclosure in the accompanying drawings, the above and other objects, features and advantages of the present disclosure will become more apparent, wherein:

[0011] Fig. 1 is a schematic diagram of a communication environment in which embodiments of the present disclosure can be implemented;

[0012] Fig. 2 illustrates a signaling flow for preventing frequent handover and/or cell re-selection according to some embodiments of the present disclosure;

[0013] Fig. 3 illustrates a simplified block diagram of position determination according to some embodiments of the present disclosure;

[0014] Figs. 4A-4D illustrate simplified block diagrams of position determination according to some embodiments of the present disclosure;

[0015] Figs. 5A-5B illustrate simplified block diagrams of TCI determination according to some embodiments of the present disclosure;

[0016] Fig. 6 is a flowchart of an example method in accordance with an embodiment of the present disclosure;

[0017] Fig. 7 is a flowchart of an example method in accordance with an embodiment of the present disclosure; and

[0018] Fig. 8 is a simplified block diagram of a device that is suitable for implementing embodiments of the present disclosure.

[0019] Throughout the drawings, the same or similar reference numerals represent the same or similar element.

DETAILED DESCRIPTION

[0020] Principle of the present disclosure will now be described with reference to some example embodiments. It is to be understood that these embodiments are described only for the purpose of illustration and help those skilled in the art to understand and implement the present disclosure, without suggesting any limitations as to the scope of the disclosure. The disclosure described herein can be implemented in various manners other than the ones described below.

[0021] In the following description and claims, unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skills in the art to which this disclosure belongs.

[0022] As used herein, the term "network device" refers to a device which is capable of providing or hosting a cell or coverage where terminal devices can communicate. Examples of a network device include, but not limited to, a Node B (NodeB or NB), an Evolved NodeB (eNodeB or eNB), a NodeB in new radio access (gNB) a Remote Radio Unit (RRU), a radio head (RH), a remote radio head (RRH), a low power node such as a femto node, a pico node, a satellite network device, an aircraft network device, and the like.

For the purpose of discussion, in the following, some example embodiments will be described with reference to eNB as examples of the network device.

[0023] As used herein, the term "terminal device" refers to any device having wireless or wired communication capabilities. Examples of the terminal device include, but not limited to, user equipment (UE), personal computers, desktops, mobile phones, cellular phones, smart phones, personal digital assistants (PDAs), portable computers, tablets, wearable devices, internet of things (IoT) devices, Internet of Everything (IoE) devices, machine type communication (MTC) devices, device on vehicle for V2X communication where X means pedestrian, vehicle, or infrastructure/network, or image capture devices such as digital cameras, gaming devices, music storage and playback appliances, or Internet appliances enabling wireless or wired Internet access and browsing and the like. In the following description, the terms "terminal device", "communication device", "terminal", "user equipment" and "UE" may be used interchangeably.

[0024] Communications discussed herein may use conform to any suitable standards including, but not limited to, New Radio Access (NR), Long Term Evolution (LTE), LTE-Evolution, LTE-Advanced (LTE-A), Wideband Code Division Multiple Access (WCDMA), Code Division Multiple Access (CDMA), cdma2000, and Global System for Mobile Communications (GSM) and the like. Furthermore, the communications may be performed according to any generation communication protocols either currently known or to be developed in the future. Examples of the communication protocols include, but not limited to, the first generation (1G), the second generation (2G), 2.5G, 2.85G, the third generation (3G), the fourth generation (4G), 4.5G, the fifth generation (5G) communication protocols. The techniques described herein may be used for the wireless networks and radio technologies mentioned above as well as other wireless networks and radio technologies.

[0025] As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. The term "includes" and its variants are to be read as open terms that mean "includes, but is not limited to." The term "based on" is to be read as "based at least in part on." The term "one embodiment" and "an embodiment" are to be read as "at least one embodiment." The term "another embodiment" is to be read as "at least one other embodiment." The terms "first," "second," and the like may refer to different or same objects. Other definitions, explicit and implicit, may be included below.

[0026] In some examples, values, procedures, or apparatus are referred to as "best," "lowest," "highest," "minimum," "maximum," or the like. It will be appreciated that such descriptions are intended to indicate that a selection among many used functional alternatives can be made, and such selections need not be better, smaller, higher, or otherwise preferable to other selections.

[0027] According to conventional technologies, for example, in release 15, only one SPS configuration is allowed per bandwidth part (BWP) per serving cell. The minimum period for SPS is 10ms. Further, in order to reduce latency and satisfy different requirements for different services, multiple SPS configurations are allowed per BWP per serving cell. The minimum period for SPS is 1 slot. According to some conventional technologies, only slot-based hybrid automatic repeat request acknowledgment (HARQ-ACK) feedback is allowed. Both slot-based Type-1 HARQ-ACK codebook construction and slot-based Type-2 HARQ-ACK codebook construction are supported. Further, sub-slot based HARQ-ACK feedback is supported to reduce the feedback latency. For example, the sub-slot length may be configured as 2-symbol or 7-symbol by radio resource control signaling. For HARQ-ACK codebook construction, only sub-slot based Type-2 HARQ-ACK codebook is supported.

[0028] In release 15, only inter-slot physical downlink shared channel (PDSCH) repetition is allowed. The repetition number is semi-statically configured in RRC by pdsch-AggregationFactor in PDSCH-Config/SPS-config. In Rel-16 multi-input-multi-output (MIMO) scenario, single-downlink control information based multi transmission point (M-TRP) ultra-reliable low-latency communication (URLLC) scheme 3 and scheme 4 are supported to improve reliability performance for PDSCH transmission. Scheme 3 repetition for PDSCH based on multi-TRP is supported, which allows two PDSCH repetitions are transmitted within a slot. Whether scheme 3 repetition based on multi-TRP is applied is indicated by scheduling DCI. Scheme 4 repetition for PDSCH based on multi-TRP is supported, which allows N PDSCH repetitions are transmitted in N consecutive slots. The repetition number of N is configured in a time domain resource allocation (TDRA) table and indicated by scheduling DCI.

[0029] However, scheme 3/4 repetitions based on multi-TRP for SPS configuration is supported or not is less discussed and not clear. If not supported, it is not clear whether scheme 3/4 repetition based on multi-TRP for the first SPS PDSCH with activation DCI and SPS PDSCH retransmission scheduled by DCI is supported or not. If supported, for

SPS configuration with short periodicity, for example, 2 slots, the collision between SPS PDSCH reception occasion and uplink (UL) symbols configured by time divisional duplex (TDD) configuration is hard to avoid by gNB implementation. If the collision happens, the HARQ-ACK feedback for SPS PDSCH scheme 3 repetition should be studied.

[0030] For scheme 3 repetition (intra-slot repetition) in new radio (NR): when a UE is configured by the higher layer parameter RepSchemeEnabler set to 'TDMSchemeA' and indicated demodulation reference signal (DM-RS) port(s) within one cloud data management (CDM) group in the DCI field "Antenna Port(s)", the number of PDSCH transmission occasions is derived by the number of transmission configuration indicator (TCI) states indicated by the DCI field 'Transmission Configuration Indication' of the scheduling DCI.

- If two TCI states are indicated by the DCI field 'Transmission Configuration Indication', the UE is expected to receive two PDSCH transmission occasions, where the first TCI state is applied to the first PDSCH transmission occasion. The second TCI state is applied to the second PDSCH transmission occasion, and the second PDSCH transmission occasion shall have the same number of symbols as the first PDSCH transmission occasion. If the UE is configured by the higher layers with a value $\overline{K}$ in *StartingSymbolOffsetK*, it shall determine that the first symbol of the second PDSCH transmission occasion starts after $\overline{K}$ symbols from the last symbol of the first PDSCH transmission occasion. If the value $\overline{K}$ is not configured via the higher layer parameter StartingSymbolOffsetK, $\overline{K} = 0$ shall be assumed by the UE. The UE is not expected to receive more than two PDSCH transmission layers for each PDSCH transmission occasion.

- Otherwise, the UE is expected to receive a single PDSCH transmission occasion.

[0031] For scheme 4 repetition (inter-slot repetition) in NR: when a UE configured by the higher layer parameter PDSCH-config that indicates at least one entry in pdsch-TimeDomainAllocationList contain RepNumR16 in PDSCH-TimeDomainResourceAllocation.

- If two TCI states are indicated by the DCI field 'Transmission Configuration Indication' together with the DCI field "Time domain resource assignment' indicating an entry in pdsch-TimeDomainAllocationList which contain RepNumR16 in PDSCH-TimeDomainResourceAllocation and DM-RS port(s) within one CDM group in the DCI field "Antenna Port(s)", the same a start and length indicator value (SLIV) is

applied for all PDSCH transmission occasions, the first TCI state is applied to the first PDSCH transmission occasion.

[0032] When the value indicated by RepNumR16 in PDSCH-TimeDomainResourceAllocation equals to two, the second TCI state is applied to the second PDSCH transmission occasion. When the value indicated by RepNumR16 in PDSCH-TimeDomainResourceAllocation is larger than two, the UE may be further configured to enable CycMapping or SeqMapping in RepTCIMapping.

- When CycMapping is enabled, the first and second TCI states are applied to the first and second PDSCH transmission occasions, respectively, and the same TCI mapping pattern continues to the remaining PDSCH transmission occasions.

- When SeqMapping is enabled, the first TCI state is applied to the first and second PDSCH transmissions, and the second TCI state is applied to the third and fourth PDSCH transmissions, and the same TCI mapping pattern continues to the remaining PDSCH transmission occasions.

[0033] The UE may expect that each PDSCH transmission occasion is limited to two transmission layers. For all PDSCH transmission occasions associated with the first TCI state, the redundancy version to be applied is derived according to a predetermined table (for example, to Table 5.1.2.1-2). The redundancy version for PDSCH transmission occasions associated with the second TCI state is derived a further predetermined table (for example, Table 5.1.2.1-3), where additional shifting operation for each redundancy version rv_s is configured by higher layer parameter RVSeqOffset and n is counted only considering PDSCH transmission occasions associated with the second TCI state.

[0034] According to conventional technologies, the Type-1 HARQ-ACK codebook is determined based on the following factors: (1) PDSCH-to-HARQ_feedback timing values K1; (2) PDSCH time domain resource allocation (TDRA) table; (3) The ratio $2^{(\mu DL-\mu UL)}$ between the downlink SCS configuration μ_{DL} and the uplink SCS configuration μ_{UL} if different numerology between DL and UL is configured; (4) TDD configuration by TDD-UL-DL-ConfigurationCommon and TDD-UL-DL-ConfigDedicated.

[0035] In some conventional technologies, a UE reports HARQ-ACK information for a corresponding PDSCH reception or SPS PDSCH release only in a HARQ-ACK codebook that the UE transmits in a slot indicated by a value of a PDSCH-to-HARQ_feedback timing indicator field in a corresponding DCI format 1_0 or DCI format 1_1. The UE reports

NACK value(s) for HARQ-ACK information bit(s) in a HARQ-ACK codebook that the UE transmits in a slot not indicated by a value of a PDSCH-to-HARQ_feedback timing indicator field in a corresponding DCI format 1_0 or DCI format 1_1.

[0036] If the UE is provided *pdsch-AggregationFactor* and no entry in *pdsch-TimeDomainAllocationList* includes *RepNumR16* in *PDSCH-TimeDomainResourceAllocation*, $N_{\mathrm{PDSCH}}^{\mathrm{repeat}}$ is a value of *pdsch-AggregationFactor*; otherwise $N_{\mathrm{PDSCH}}^{\mathrm{repeat}} = 1$. The UE reports HARQ-ACK information for a PDSCH reception

- from slot $n - N_{\mathrm{PDSCH}}^{\mathrm{repeat}} + 1$ to slot n, if $N_{\mathrm{PDSCH}}^{\mathrm{repeat}} > 1$, or
- from slot $n - RepNumR16 + 1$ to slot n, if the Time domain resource assignment field in the DCI format scheduling the PDSCH reception indicates an entry in *pdsch-TimeDomainAllocationList* containing *RepNumR16,* or
- in slot n, otherwise.

only in a HARQ-ACK codebook that the UE includes in a PUCCH or PUSCH transmission in slot $n + k$, where k is a number of slots indicated by the PDSCH-to-HARQ_feedback timing indicator field in a corresponding DCI format or provided by *dl-DataToUL-ACK* if the PDSCH-to-HARQ_feedback timing indicator field is not present in the DCI format. If the UE reports HARQ-ACK information for the PDSCH reception in a slot other than slot $n + k$, the UE sets a value for each corresponding HARQ-ACK information bit to NACK.

[0037] According to embodiments of the present disclosure, enhancement on SPS PDSCH has been achieved. The terminal device receives downlink data transmission which is semi-persistent configured, the downlink data transmission having a plurality of repetitions. The terminal device determines the number of repetitions for the downlink data transmission. The network device transmits a feedback for the repetitions for the downlink data transmission based on the number of the repetitions. In this way, a position for transmitting a feedback is properly determined by the terminal device.

[0038] Fig. 1 illustrates a schematic diagram of a communication system in which embodiments of the present disclosure can be implemented. The communication system 100, which is a part of a communication network, comprises a terminal device 110-1, a terminal device 110-2, . . . , a terminal device 110-N, which can be collectively referred to as "terminal device(s) 110." The number N can be any suitable integer number.

[0039] The communication system 100 further comprises network terminal device 120-1,

a network device 120-2, . . . , a network device 120-M, which can be collectively referred to as "network device(s) 120." In some embodiments, the network device may be gNB. Alternatively, the network device may be IAB. The number M can be any suitable integer number. In the communication system 100, the network devices 120 and the terminal devices 110 can communicate data and control information to each other. Only for the purpose of illustrations, the network device 120-1 can be regarded as a source network device and the network device 120-2 can be regarded as a target network device. The numbers of terminal devices and network devices shown in Fig. 1 are given for the purpose of illustration without suggesting any limitations.

[0040] Communications in the communication system 100 may be implemented according to any proper communication protocol(s), comprising, but not limited to, cellular communication protocols of the first generation (1G), the second generation (2G), the third generation (3G), the fourth generation (4G) and the fifth generation (5G) and on the like, wireless local network communication protocols such as Institute for Electrical and Electronics Engineers (IEEE) 802.11 and the like, and/or any other protocols currently known or to be developed in the future. Moreover, the communication may utilize any proper wireless communication technology, comprising but not limited to: Code Divided Multiple Address (CDMA), Frequency Divided Multiple Address (FDMA), Time Divided Multiple Address (TDMA), Frequency Divided Duplexer (FDD), Time Divided Duplexer (TDD), Multiple-Input Multiple-Output (MIMO), Orthogonal Frequency Divided Multiple Access (OFDMA) and/or any other technologies currently known or to be developed in the future.

[0041] Embodiments of the present disclosure can be applied to any suitable scenarios. For example, embodiments of the present disclosure can be implemented at reduced capability NR devices. Alternatively, embodiments of the present disclosure can be implemented in one of the followings: NR multiple-input and multiple-output (MIMO), NR sidelink enhancements, NR systems with frequency above 52.6GHz, an extending NR operation up to 71GHz, narrow band-Internet of Thing (NB-IOT)/ enhanced Machine Type Communication (eMTC) over non-terrestrial networks (NTN), NTN, UE power saving enhancements, NR coverage enhancement, NB-IoT and LTE-MTC, Integrated Access and Backhaul (IAB), NR Multicast and Broadcast Services, or enhancements on Multi-Radio Dual-Connectivity.

[0042] The term "downlink (DL) sub-slot" may refer to a virtual sub-slot constructed

based on uplink (UL) sub-slot. The DL sub-slot may comprise fewer symbols than one DL slot.

[0043] Embodiments of the present disclosure will be described in detail below. Reference is first made to Fig. 2, which shows a signaling chart illustrating process 200 among network devices according to some example embodiments of the present disclosure. Only for the purpose of discussion, the process 200 will be described with reference to Fig. 1. The process 200 may involve the terminal device 110-1 and the network device 120 in Fig. 1.

[0044] In some embodiments, the network device 120 may transmit 2010 a configuration associated with the plurality of repetitions for downlink data transmission. In some embodiments, the configuration may indicate that the repetitions are intra-slot repetitions. For example, the configuration may indicate that a plurality of repetitions are transmitted in one slot. By way of example, if scheme 3 is configured, the configuration may indicate that two repetitions are transmitted in one slot.

[0045] Alternatively or in addition, the configuration may indicate that the repetitions are inter-slot repetitions. For example, the configuration may indicate that the plurality of repetitions are transmitted in a plurality of slots. By way of example, if scheme 4 is configured, the configuration may indicate that there are N repetitions are transmitted in N consecutive slots.

[0046] The network device 120 may transmit 2020 control information to the terminal device 110-1. The control information may comprise an indication for activating the configuration. In other embodiments, the configuration may also comprise a TDRA table. In some embodiments, at least one entry in the TDRA table may comprise an indication of the number of repetitions. Examples of the TDRA tables will be described later. Moreover, in some example embodiments, the control information may also indicate a set of HARQ-ACK timing values, for example, 1, 2, and 4. It should be noted that the HARQ-ACK timing values can be any proper values. Alternatively or in addition, the control information may also indicate a time domain position of an uplink control channel.

[0047] The network device 120 transmits 2030 downlink data transmission to the terminal device 110-1. The downlink data transmission is semi-persistent configured. The downlink data transmission has the plurality of repetitions. As mentioned above, the plurality of repetitions may be transmitted in the same slot. Alternatively, the plurality of

repetitions may be transmitted in different slots.

[0048] The terminal device 110-1 determines 2040 the number of repetitions for the downlink data transmission. For example, if the number of repetitions is 2, the terminal device 110-1 may determine that scheme 3 is configured. Alternatively, if the terminal device 110-1 determines the number of repetitions based on the TDRA table, the terminal device 110-1 may understand that scheme 4 is configured.

[0049] In some embodiments, the terminal device 110-1 may determine the number of repetitions which are received. For example, as shown in Fig. 3, in this scenario where scheme 3 is configured, there are two downlink data transmission repetitions, 3010-1 and 3010-2. The first repetition 3010-1 may colloid with the uplink transmission. In some embodiments, when the scheme 3 repetition is configured for SPS configuration, at least one SPS repetition colloids with UL symbol within one slot, the terminal device 110-1 may not transmit the feedback for the two SPS PDSCH transmission occasions for a transport block (TB). Alternatively, when scheme 3 repetition is configured for SPS configuration, at least one repetition within one slot is received (i.e., available), the terminal device 110-1 may transmit the feedback for the SPS PDSCH transmission occasion(s) for a transport block (TB).

[0050] The terminal device 110-1 may determine 2050 a position for transmitting a feedback. In some embodiments, if the first repetition 3010-1 is received, the terminal device 110-1 may determine a position in a codebook for HARQ-ACK corresponding to the first repetition. For example, for slot based Type-1 HARQ-ACK codebook, the terminal device 110-1 may only report a valid HARQ-ACK value for the two transmission occasions for a TB with OR operation in the HARQ-ACK position, which is determined based on the configured SLIV for the first SPS PDSCH transmission 3010-1.

[0051] Alternatively or in addition, if the first repetition in the plurality of repetitions is not received, the terminal device 110-1 may determine a set of SLIVs which are overlapping with at least one of the plurality of repetitions but non-overlapping with uplink symbols within the slot. The terminal device 110-1 may determine a target SLIV from the set of SLIVs. The target SLIV may have the earliest ending symbol in the TDRA table associated with the slot. The terminal device 110-1 may determine the position for HARQ-ACK in the Type-1 codebook based on the target SLIV. As shown in Fig. 4A , in slot 410, the RI 3 overlaps with the first repetition 4010-1 but also overlaps with uplink

symbols, and the RI 1 overlaps with the second repetition 4010-2 and does not overlap with the uplink symbols. The terminal device 110-1 may determine the position based on the SLIV associated with the RI 1. As shown in Fig. 4B, in slot 420, the RI0 overlaps with the first repetition 4020-1 and does not overlap with the uplink symbols. The RI 3 overlaps with the first repetition 4020-1 but also overlaps with uplink symbols. The RI 1 overlaps with the second repetition 4020-2 and does not overlap with the uplink symbols. Since the SLIV associated with the RI 0 has the earliest ending symbol in the slot 420, the position can be determined based on the SLIV associated with the RI 0.

[0052] In some embodiments, if the first repetition in the plurality of repetitions is not received, the terminal device 110-1 may determine a set of SLIVs which are overlapping with the second repetition but non-overlapping with uplink symbols within the slot. The terminal device 110-1 may determine a position in a codebook for HARQ-ACK based on the set of SLIVs. As shown in Fig. 4C, in slot 430, the RI0 overlaps with the first repetition 4030-1 and does not overlap with the uplink symbols. The RI 3 overlaps with the first repetition 4030-1 but also overlaps with uplink symbols. The RI 1 overlaps with the second repetition 4030-2 and does not overlap with the uplink symbols. Since the SLIV associated with the RI 1 overlaps with the second repetition 4030-2, the position can be determined based on the SLIV associated with the RI 1.

[0053] Alternatively, if the first repetition in the plurality of repetitions is not received, the terminal device 110-1 may determine a first SLIV of the first repetition based on the configuration. The terminal device 110-1 may determine an offset between the first repetition and the second repetition based on the configuration. A second SLIV of the second repetition may be determined based on the first SLIV and the offset. The terminal device 110-1 may update a time domain resource allocation table with adding the second SLIV into the time domain resource allocation table. The position in a codebook for HARQ-ACK may be determined based on the second SLIV in the updated time domain resource allocation table. If the terminal device 110-1 is configured with scheme 3 repetition, there is one “virtual” SLIV added in the TDRA table for Type-1 HARQ-ACK codebook generation. For example, as shown in Fig. 4D, in slot 440, the SLIV configuration for the first repetition 4040-1 is starting symbol index S, symbol length L, and the offset between the first repetition 4040-1and the second repetition 4040-2 is X. The starting symbol index for the second SLIV 4140 of the second repetition 4040-2 is S+L+X, and length of the second SLIV 4140 is L. The terminal device 110-1 may

determine the position based on the second SLIV 4140.

[0054] According to embodiments, if the first repetition with defined SLIV collides with UL symbol, the second repetition without defined SLIV is received by UE, the terminal device 110-1 can determine the position properly and still can report valid HARQ-ACK value for the SPS PDSCH transmission occasion(s) for the TB.

[0055] In some embodiments, the terminal device 110-1 may obtain from the control information, a TDRA table, a set of HARQ-ACK timing values, and a time domain position of an uplink control channel. At least one entry in the time domain resource allocation table may comprise a repetition number indication. The terminal device 110-1 may determine the number of repetitions and a SLIV of each entry based on the TDRA table. The terminal device 110-1 may determine a set of positions based on the number of repetitions and the SLIV of each entry in the TDRA table, the set of HARQ-ACK timing values, and the time domain position of the uplink control channel. The HARQ-ACK timing values may be any suitable number, for example, 1, 3, or 4. For example, when the terminal device 110-1 is configured by the higher layer parameter PDSCH-config that indicates at least one entry in pdsch-TimeDomainAllocationList contain RepNumR16 in PDSCH-TimeDomainResourceAllocation, for each SLIV, the terminal device 110-1 may use the maximum value of RepNumR16 configured in the pdsch-TimeDomainAllocationList to construct the HARQ-ACK codebook. Table 1 below shows an example TDRA table.

Table 1

Row Index (RI)	K0	Start	Length	Repetition Number
0	0	#0	2	2
1	0	#2	6	NA
2	0	#2	6	4
3	0	#8	4	NA

[0056] For example, for Table 1 above, maximum Repetition Number R16 for the SLIV of RI #1 and RI #2 is 4, maximum Repetition Number R16 for the SLIV of RI #0 is 2. Table 2 shows specifications of Type-1 HARQ-ACK codebook determination. Table 3

shows pseudo codes for Type-1 HARQ-ACK codebook determination.

Table 2

If the UE is provided *pdsch-AggregationFactor* and no entry in *pdsch-TimeDomainAllocationList* includes *RepNumR16* in *PDSCH-TimeDomainResourceAllocation*, $N_{\mathrm{PDSCH}}^{\mathrm{repeat}}$ is a value of *pdsch-AggregationFactor*; otherwise $N_{\mathrm{PDSCH}}^{\mathrm{repeat}} = 1$. The UE reports HARQ-ACK information for a PDSCH reception

- from slot $n - N_{\mathrm{PDSCH}}^{\mathrm{repeat}} + 1$ to slot n, if $N_{\mathrm{PDSCH}}^{\mathrm{repeat}} > 1$, or
- from slot $n - RepNumR16 + 1$ to slot n, if the Time domain resource assignment field in the DCI format scheduling the PDSCH reception indicates an entry in *pdsch-TimeDomainAllocationList* containing *RepNumR16,* or
- in slot n, otherwise

only in a HARQ-ACK codebook that the UE includes in a PUCCH or PUSCH transmission in slot $n + k$, where k is a number of slots indicated by the PDSCH-to-HARQ_feedback timing indicator field in a corresponding DCI format or provided by *dl-DataToUL-ACK* if the PDSCH-to-HARQ_feedback timing indicator field is not present in the DCI format. If the UE reports HARQ-ACK information for the PDSCH reception in a slot other than slot $n + k$, the UE sets a value for each corresponding HARQ-ACK information bit to NACK.

Table 3

while $r < \mathcal{C}(R)$

if the UE is provided *tdd-UL-DL-ConfigurationCommon*, or *tdd-UL-DL-ConfigurationDedicated* and, if the Time domain resource assignment field in the DCI format scheduling the PDSCH reception indicates an entry in *pdsch-TimeDomainAllocationList* containing *RepNumR16*, for each slot from slot $\left\lfloor (n_U - K_{1,k}) \cdot 2^{\mu_{DL} - \mu_{UL}} \right\rfloor + n_D - RepNumR16_r + 1$

to slot $\left\lfloor (n_U - K_{1,k}) \cdot 2^{\mu_{DL} - \mu_{UL}} \right\rfloor + n_D$

, at least one symbol of the PDSCH time resource derived by row r is configured as

UL where $K_{1,k}$ is the k-th slot timing value in set K_1 ,

$R = R \backslash r$;

else

$r = r + 1$;

end if

end while

[0057] In some embodiments, the terminal device 110-1 may obtain from the control information, a TDRA table, a set of HARQ-ACK timing values, and a time domain position of an uplink control channel. The terminal device 110-1 may determine a SLIV of one entry based on the TDAR table. The terminal device 110-1 may determine a maximum number of repetitions based on the TDAR table. The terminal device 110-1 may determine a set of positions based on the maximum number of repetitions, the SLIV of each entry in the TDRA table, the set of HARQ-ACK timing values, and the time domain position of the uplink control channel. For example, when the terminal device 110-1 is configured by the higher layer parameter PDSCH-config that indicates at least one entry in pdsch-TimeDomainAllocationList containing RepNumR16 in PDSCH-TimeDomainResourceAllocation, for all SLIVs in the pdsch-TimeDomainAllocationList, the terminal device 110-1 may use the maximum value of RepNumR16 configured in the pdsch-TimeDomainAllocationList to construct the HARQ-ACK codebook. Table 4 below shows an example TDRA table. As shown in Table 4, the maximum repetition number is 4.

Table 4

Row Index (RI)	K0	Start	Length	Repetition Number
0	0	#0	2	2

1	0	#2	6	NA
2	0	#2	6	4
3	0	#8	4	NA

[0058] Table 5 shows specifications of Type-1 HARQ-ACK codebook determination. Table 6 shows pseudo codes for Type-1 HARQ-ACK codebook determination.

Table 5

If the UE is provided *pdsch-AggregationFactor* and no entry in *pdsch-TimeDomainAllocationList* includes *RepNumR16* in *PDSCH-TimeDomainResourceAllocation*, $N_{\mathrm{PDSCH}}^{\mathrm{repeat}}$ is a value of *pdsch-AggregationFactor*; otherwise $N_{\mathrm{PDSCH}}^{\mathrm{repeat}} = 1$. The UE reports HARQ-ACK information for a PDSCH reception

- from slot $n - N_{\mathrm{PDSCH}}^{\mathrm{repeat}} + 1$ to slot n, if $N_{\mathrm{PDSCH}}^{\mathrm{repeat}} > 1$, or

if the Time domain resource assignment field in the DCI format scheduling the PDSCH reception indicates an entry in *pdsch-TimeDomainAllocationList* containing *RepNumR16,* $N_{\mathrm{PDSCH}}^{\mathrm{repeat}}$ is a value of maximum *RepNumR16* in the *TimeDomainAllocationList.* The UE reports HARQ-ACK information for a PDSCH reception

- from slot $n - RepNumR16 + 1$ to slot n, or
- in slot n, otherwise

only in a HARQ-ACK codebook that the UE includes in a PUCCH or PUSCH transmission in slot $n + k$, where k is a number of slots indicated by the PDSCH-to-HARQ_feedback timing indicator field in a corresponding DCI format or provided by *dl-DataToUL-ACK* if the PDSCH-to-HARQ_feedback timing indicator field is not present in the DCI format. If the UE reports HARQ-ACK information for the PDSCH reception in a slot other than slot $n + k$, the UE sets a value for each corresponding HARQ-ACK information bit to NACK.

Table 6

while $r < C(R)$

if the UE is provided *tdd-UL-DL-ConfigurationCommon*, or *tdd-UL-DL-ConfigurationDedicated* and, for each slot from slot $\left\lfloor (n_U - K_{1,k}) \cdot 2^{\mu_{DL}-\mu_{UL}} \right\rfloor + n_D - N_{PDSCH}^{repeat} + 1$ to slot $\left\lfloor (n_U - K_{1,k}) \cdot 2^{\mu_{DL}-\mu_{UL}} \right\rfloor + n_D$, at least one symbol of the PDSCH time resource derived by row r is configured as UL where $K_{1,k}$ is the k-th slot timing value in set K_1,

$R = R \backslash r$;

else

$r = r + 1$;

end if

end while

[0059] Referring back to Fig. 2, the terminal device 110-1 transmits 2060 the feedback to the network device 120 on the determined position. In some embodiments, the terminal device 110-1 may receive from the network device 120 further control information which indicates a plurality of TCI states. The terminal device 110-1 may receive from the network device 120 a further configuration indicating a predetermined TCI state used for further downlink data transmission without repetitions. In some embodiments, the predetermined TCI state may be the first TCI in the further control information. Alternatively or in addition, the predetermined TCI state may be the last TCI in the further control information. It should be noted that the predetermined TCI state may be any suitable TCI selected by the network device 120. The terminal device 110-1 may receive, based on the predetermined TCI sates, the further downlink data transmission without repetitions from the network device.

[0060] For example, the terminal device may determine the beam direction based on the TCI states. In some embodiments, scheme 3/4 repetition based on multi-TRP is configured for the terminal device 110-1, the scheme 3/4 repetition will not be applied for the SPS PDSCH scheduled by a DCI format with CRC scrambled by CS-RNTI with NDI=0 and SPS PDSCH retransmission scheduled by a DCI format with CRC scrambled by CS-RNTI with NDI=1. For scheme 3, when a terminal device is configured by the higher layer parameter RepSchemeEnabler set to 'TDMSchemeA' and indicated DM-RS port(s) within one CDM group in the DCI field "Antenna Port(s)", the number of PDSCH transmission occasions is derived by the number of TCI states indicated by the DCI field 'Transmission Configuration Indication' of the scheduling DCI. The terminal device doesn't expect to be indicated more than one TCI states by the DCI field 'Transmission Configuration Indication' of the scheduling DCI scrambled with a CS-RNTI. For scheme

4 , when a UE configured by the higher layer parameter PDSCH-config that indicates at least one entry in pdsch-TimeDomainAllocationList contain RepNumR16 in PDSCH-TimeDomainResourceAllocation, the terminal device doesn't expect one entry in pdsch-TimeDomainAllocationList contain RepNumR16 in PDSCH-TimeDomainResourceAllocation is indicated for SPS PDSCH by the scheduling DCI scrambled with a CS-RNTI. For example, as shown in Fig. 5A, the DCI 5110 may be used to activate the SPS PDSCH 5120 during the slot 510-1. The SPS PDSCH 5130 in the slot 510-2 and the SPS PDSCH 5140 in the slot 510-3 may not have repetitions. The DCI may only have one TCI state.

[0061] Alternatively, in some embodiments, scheme 3/4 repetition based on multi-TRP is configured for the terminal device 110-1, the scheme 3/4 repetition will be only applied for the first SPS PDSCH scheduled by a DCI format with CRC scrambled by CS-RNTI with NDI=0 and/or SPS PDSCH retransmission scheduled by a DCI format with CRC scrambled by CS-RNTI with NDI=1. If more than one TCI state is indicated by the activation DCI, the first/last TCI state is used for SPS PDSCH without corresponding PDCCH. For scheme 3, if two TCI states are indicated by the DCI field 'Transmission Configuration Indication',of the scheduling DCI scrambled with a CS-RNTI provided by cs-RNTI, the UE is not expected to receive two PDSCH transmission occasions for the SPS PDSCH without PDCCH. For scheme 4 , when a UE configured by the higher layer parameter PDSCH-config that indicates at least one entry in pdsch-TimeDomainAllocationList contain RepNumR16 in PDSCH-TimeDomainResourceAllocation, If one entry in pdsch-TimeDomainAllocationList contain RepNumR16 in PDSCH-TimeDomainResourceAllocation is indicated for SPS PDSCH for UE by the scheduling DCI scrambled with a CS-RNTI provided by cs-RNTI, the UE is not expected to receive more than two PDSCH transmission occasions for the SPS PDSCH without PDCCH. For example, as shown in Fig. 5B, the DCI 5210 may be used to activate the SPS PDSCH during the slot 520-1. There are two repetitions in the slot 520-1, for example, the first SPS PDSCH repetition 5220-1 and the second SPS PDSCH repetition 5220-2. The SPS PDSCH 5230 in the slot 520-2 and the SPS PDSCH 5240 in the slot 520-3 may not have repetitions. The DCI 5210 may have more than one TCI state. The first/last TCI state in the DCI 5210 may be used for SPS PDSCH without corresponding PDCCH.

[0062] In this way, it clarifies whether scheme 3/4 repetition can be used for the first SPS

PDSCH with activation DCI and SPS PDSCH retransmission scheduled by DCI. It is beneficial to improve the reliability for SPS PDSCH transmission with PDCCH if used.

[0063] Fig. 6 shows a flowchart of an example method 600 in accordance with an embodiment of the present disclosure. Only for the purpose of illustrations, the method 1400 can be implemented at a terminal device 110-1 as shown in Fig. 1.

[0064] In some embodiments, the terminal device 110-1 may receive a configuration associated with the plurality of repetitions for downlink data transmission. In some embodiments, the configuration may indicate that the repetitions are intra-slot repetitions. For example, the configuration may indicate that a plurality of repetitions are transmitted in one slot. By way of example, if scheme 3 is configured, the configuration may indicate that two repetitions are transmitted in one slot.

[0065] Alternatively or in addition, the configuration may indicate that the repetitions are inter-slot repetitions. For example, the configuration may indicate that the plurality of repetitions are transmitted in a plurality of slots. By way of example, if scheme 4 is configured, the configuration may indicate that there are N repetitions are transmitted in N consecutive slots.

[0066] The terminal device 110-1 may receive control information from the network device 120. The control information may comprise an indication for activating the configuration. In other embodiments, the configuration may also comprise a TDRA table. In some embodiments, at least one entry in the TDRA table may comprise an indication of the number of repetitions. Examples of the TDRA tables will be described later. Moreover, in some example embodiments, the control information may also indicate a set of HARQ-ACK timing values, for example, 1, 2, and 4. It should be noted that the HARQ-ACK timing values can be any proper values. Alternatively or in addition, the control information may also indicate a time domain position of an uplink control channel.

[0067] At block 610, the terminal device 110-1 receives downlink data transmission from the network device 120. The downlink data transmission is semi-persistent configured. The downlink data transmission has the plurality of repetitions. As mentioned above, the plurality of repetitions may be transmitted in the same slot. Alternatively, the plurality of repetitions may be transmitted in different slots.

[0068] At block 620, the terminal device 110-1 determines the number of repetitions for the downlink data transmission. For example, if the number of repetitions is 2, the

terminal device 110-1 may determine that scheme 3 is configured. Alternatively, if the terminal device 110-1 determines the number of repetitions based on the TDRA table, the terminal device 110-1 may understand that scheme 4 is configured.

[0069] In some embodiments, the terminal device 110-1 may the number of repetitions which are received. In some embodiments, when the scheme 3 repetition is configured for SPS configuration, at least one SPS repetition colloids with UL symbol within one slot, the terminal device 110-1 may not transmit the feedback for the two SPS PDSCH transmission occasions for a transport block (TB). Alternatively, when scheme 3 repetition is configured for SPS configuration, at least one repetition within one slot is received (i.e., available), the terminal device 110-1 may transmit the feedback for the SPS PDSCH transmission occasion(s) for a TB.

[0070] In some embodiments, the terminal device 110-1 may determine a position for transmitting a feedback. In some embodiments, if the first repetition 3010-1 is received, the terminal device 110-1 may determine a position in a codebook for HARQ-ACK corresponding to the first repetition. For example, for slot based Type-1 HARQ-ACK codebook, the terminal device 110-1 may only report a valid HARQ-ACK value for the two transmission occasions for a TB with OR operation in the HARQ-ACK position, which is determined based on the defined SLIV for the first repetition 3010-1.

[0071] Alternatively or in addition, if the first repetition in the plurality of repetitions is not received, the terminal device 110-1 may determine a set of SLIVs which are overlapping with at least one of the plurality of repetitions but non-overlapping with uplink symbols within the slot. The terminal device 110-1 may determine a target SLIV from the set of SLIVs. The target SLIV may have the earliest ending symbol in the TDRA table associated with the slot. The terminal device 110-1 may determine the position for HARQ-ACK based on the target SLIV. The terminal device 110-1 may determine the position based on the SLIV associated with the RI 1.

[0072] In some embodiments, if the first repetition in the plurality of repetitions is not received, the terminal device 110-1 may determine a set of SLIVs which are overlapping with the second repetition but non-overlapping with uplink symbols within the slot. The terminal device 110-1 may determine a position in a codebook for HARQ-ACK based on the set of SLIVs.

[0073] Alternatively, if the first repetition in the plurality of repetitions is not received, the

terminal device 110-1 may determine a first SLIV of the first repetition based on the configuration. The terminal device 110-1 may determine an offset between the first repetition and the second repetition based on the configuration. A second SLIV of the second repetition may be determined based on the first SLIV and the offset. The terminal device 110-1 may update a time domain resource allocation table with adding the second SLIV into the time domain resource allocation table. The position in a codebook for HARQ-ACK may be determined based on the second SLIV in the updated time domain resource allocation table. If the terminal device 110-1 is configured with scheme 3 repetition, there is one "virtual" SLIV added in the TDRA table for type 1 HARQ-ACK codebook generation.

[0074] According to embodiments, if the first repetition with defined SLIV collides with UL symbol, the second repetition without defined SLIV is received by the terminal device 110-1, the terminal device 110-1 can determine the position properly and still can report valid HARQ-ACK value for the SPS PDSCH transmission occasion(s) for the TB.

[0075] In some embodiments, the terminal device 110-1 may obtain from the control information, a TDRA table, a set of HARQ-ACK timing values, and a time domain position of an uplink control channel. At least one entry in the time domain resource allocation table may comprise a repetition number indication. The terminal device 110-1 may determine the number of repetitions and a SLIV of one entry based on the TDRA table. The terminal device 110-1 may determine a set of positions based on the number of repetitions and the SLIV of each entry in the TDRA table, the set of HARQ-ACK timing values, and the time domain position of the uplink control channel. The HARQ-ACK timing values may be any suitable number, for example, 1, 3, or 4.

[0076] In some embodiments, the terminal device 110-1 may obtain from the control information, a TDRA table, a set of HARQ-ACK timing values, and a time domain position of an uplink control channel. The terminal device 110-1 may determine a SLIV of one entry based on the TDAR table. The terminal device 110-1 may determine a maximum number of repetitions based on the TDAR table. The terminal device 110-1 may determine a set of positions based on the maximum number of repetitions, the SLIV of each entry in the TDRA table, the set of HARQ-ACK timing values, and the time domain position of the uplink control channel.

[0077] At block 630, the terminal device 110-1 transmits the feedback to the network

device 120 on the determined position. In some embodiments, the terminal device 110-1 may receive from the network device 120 further control information which indicates a plurality of TCI states. The terminal device 110-1 may receive from the network device 120 a further configuration indicating a predetermined TCI states used for further downlink data transmission without repetitions. The terminal device 110-1 may receive, based on the predetermined TCI sates, the further downlink data transmission without repetitions from the network device. For example, the terminal device may determine the beam direction based on the TCI states.

[0078] Fig. 7 shows a flowchart of an example method 700 in accordance with an embodiment of the present disclosure. Only for the purpose of illustrations, the method 700 can be implemented at a first network device 120 as shown in Fig. 1.

[0079] In some embodiments, the network device 120 may transmit a configuration associated with the plurality of repetitions for downlink data transmission. In some embodiments, the configuration may indicate that the repetitions are intra-slot repetitions. For example, the configuration may indicate that a plurality of repetitions are transmitted in one slot. By way of example, if scheme 3 is configured, the configuration may indicate that two repetitions are transmitted in one slot.

[0080] Alternatively or in addition, the configuration may indicate that the repetitions are inter-slot repetitions. For example, the configuration may indicate that the plurality of repetitions are transmitted in a plurality of slots. By way of example, if scheme 4 is configured, the configuration may indicate that there are N repetitions are transmitted in N consecutive slots.

[0081] The network device 120 may transmit control information to the terminal device 110-1. The control information may comprise an indication for activating the configuration. In other embodiments, the configuration may also comprise a TDRA table. In some embodiments, at least one entry in the TDRA table may comprise an indication of the number of repetitions. Examples of the TDRA tables will be described later. Moreover, in some example embodiments, the control information may also indicate a set of HARQ-ACK timing values, for example, 1, 2, and 4. It should be noted that the HARQ-ACK timing values can be any proper values. Alternatively or in addition, the control information may also indicate a time domain position of an uplink control channel.

[0082] At block 710, the network device 120 transmits downlink data transmission to the

terminal device 110-1. The downlink data transmission is semi-persistent configured. The downlink data transmission has the plurality of repetitions. As mentioned above, the plurality of repetitions may be transmitted in the same slot. Alternatively, the plurality of repetitions may be transmitted in different slots.

[0083] At block 720, the network device 120 receives, from the terminal device 110-1, a feedback for the repetitions for the downlink data transmission based on the number of repetitions. In some embodiments, the network device 120 may transmit to the terminal device 110-1 further control information indicating a plurality of transmission configuration indicator (TCI) states. The network device 120 may transmit to the terminal device 110-1 a further configuration indicating a predetermined TCI states used for further downlink data transmission without repetitions. The network device 120 may transmit to the terminal device 110-1 based on the predetermined TCI sates the further downlink data transmission without repetitions to the terminal device.

[0084] Fig. 8 is a simplified block diagram of a device 800 that is suitable for implementing embodiments of the present disclosure. The device 800 can be considered as a further example implementation of the terminal device 110 and the network device 120 as shown in Fig. 1. Accordingly, the device 800 can be implemented at or as at least a part of the terminal device 110 or the network device 120.

[0085] As shown, the device 800 includes a processor 810, a memory 820 coupled to the processor 810, a suitable transmitter (TX) and receiver (RX) 840 coupled to the processor 810, and a communication interface coupled to the TX/RX 840. The memory 820 stores at least a part of a program 830. The TX/RX 840 is for bidirectional communications. The TX/RX 840 has at least one antenna to facilitate communication, though in practice an Access Node mentioned in this application may have several ones. The communication interface may represent any interface that is necessary for communication with other network elements, such as X2 interface for bidirectional communications between eNBs, S1 interface for communication between a Mobility Management Entity (MME)/Serving Gateway (S-GW) and the eNB, Un interface for communication between the eNB and a relay node (RN), or Uu interface for communication between the eNB and a terminal device.

[0086] The program 830 is assumed to include program instructions that, when executed by the associated processor 810, enable the device 800 to operate in accordance with the

embodiments of the present disclosure, as discussed herein with reference to Fig. 2 to 6. The embodiments herein may be implemented by computer software executable by the processor 810 of the device 800, or by hardware, or by a combination of software and hardware. The processor 810 may be configured to implement various embodiments of the present disclosure. Furthermore, a combination of the processor 810 and memory 820 may form processing means 850 adapted to implement various embodiments of the present disclosure.

[0087] The memory 820 may be of any type suitable to the local technical network and may be implemented using any suitable data storage technology, such as a non-transitory computer readable storage medium, semiconductor-based memory devices, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory, as non-limiting examples. While only one memory 820 is shown in the device 800, there may be several physically distinct memory modules in the device 800. The processor 810 may be of any type suitable to the local technical network, and may include one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs) and processors based on multicore processor architecture, as non-limiting examples. The device 800 may have multiple processors, such as an application specific integrated circuit chip that is slaved in time to a clock which synchronizes the main processor.

[0088] Generally, various embodiments of the present disclosure may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. Some aspects may be implemented in hardware, while other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other computing device. While various aspects of embodiments of the present disclosure are illustrated and described as block diagrams, flowcharts, or using some other pictorial representation, it will be appreciated that the blocks, apparatus, systems, techniques or methods described herein may be implemented in, as non-limiting examples, hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some combination thereof.

[0089] The present disclosure also provides at least one computer program product tangibly stored on a non-transitory computer readable storage medium. The computer program product includes computer-executable instructions, such as those included in program modules, being executed in a device on a target real or virtual processor, to carry

out the process or method as described above with reference to any of Figs. 4-10. Generally, program modules include routines, programs, libraries, objects, classes, components, data structures, or the like that perform particular tasks or implement particular abstract data types. The functionality of the program modules may be combined or split between program modules as desired in various embodiments. Machine-executable instructions for program modules may be executed within a local or distributed device. In a distributed device, program modules may be located in both local and remote storage media.

[0090] Program code for carrying out methods of the present disclosure may be written in any combination of one or more programming languages. These program codes may be provided to a processor or controller of a general purpose computer, special purpose computer, or other programmable data processing apparatus, such that the program codes, when executed by the processor or controller, cause the functions/operations specified in the flowcharts and/or block diagrams to be implemented. The program code may execute entirely on a machine, partly on the machine, as a stand-alone software package, partly on the machine and partly on a remote machine or entirely on the remote machine or server.

[0091] The above program code may be embodied on a machine readable medium, which may be any tangible medium that may contain, or store a program for use by or in connection with an instruction execution system, apparatus, or device. The machine readable medium may be a machine readable signal medium or a machine readable storage medium. A machine readable medium may include 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 of the machine readable storage medium would include 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.

[0092] Further, while operations are depicted in a particular order, this should not be understood as requiring that such operations be performed in the particular order shown or in sequential order, or that all illustrated operations be performed, to achieve desirable results. In certain circumstances, multitasking and parallel processing may be advantageous. Likewise, while several specific implementation details are contained in

the above discussions, these should not be construed as limitations on the scope of the present disclosure, but rather as descriptions of features that may be specific to particular embodiments. Certain features that are described in the context of separate embodiments may also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment may also be implemented in multiple embodiments separately or in any suitable sub-combination.

[0093] Although the present disclosure has been described in language specific to structural features and/or methodological acts, it is to be understood that the present disclosure defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims.

WHAT IS CLAIMED IS:

1. A communication method comprising:

receiving, at a terminal device and from a network device, downlink data transmission which is semi-persistent configured, the downlink data transmission having a plurality of repetitions;

determining the number of repetitions for the downlink data transmission; and

transmitting, to the network device, a feedback for the repetitions for the downlink data transmission based on the number of the repetitions.

2. The method of claim 1, further comprising:

receiving from the network device a configuration associated with the plurality of repetitions for the downlink data transmission; and

receiving from the network device control information comprising an indication for activating the configuration.

3. The method of claim 1, wherein transmitting the feedback for the repetitions for the downlink data transmission comprises:

in accordance with a determination that all of the repetitions are received, transmitting the feedback to the network device.

4. The method of claim 1, wherein transmitting the feedback for the repetitions for the downlink data transmission comprises:

in accordance with a determination that at least one repetition is received, transmitting the feedback to the network device.

5. The method of claim 4, wherein the plurality of repetitions for the downlink data transmission are transmitted within a slot, and the method further comprises:

in accordance with a determination that the first repetition in the plurality of repetitions is received, determining a position in a codebook for hybrid automatic repeat request acknowledgment (HARQ-ACK) corresponding to the first repetition, and

wherein transmitting the feedback for the repetitions for the downlink data transmission comprises:

transmitting the feedback on the determined position.

6. The method of claim 4, wherein the plurality of repetitions for the downlink data transmission are transmitted within a slot, and the method further comprises:

in accordance with a determination that the first repetition in the plurality of repetitions is not received, determining a set of start and length indicator values (SLIVs) which are overlapping with at least one of the plurality of repetitions but non-overlapping with uplink symbols within the slot;

determining from the set of SLIVs a target SLIV having the earliest ending symbol in a time domain resource allocation table associated with the slot; and

determining a position in a codebook for hybrid automatic repeat request acknowledgment (HARQ-ACK) based on the target SLIV, and wherein transmitting the feedback comprises:

transmitting the feedback on the determined position.

7. The method of claim 4, wherein the plurality of repetitions for the downlink data transmission are transmitted within a slot, and the method further comprises:

in accordance with a determination that the first repetition in the plurality of repetitions is not received, determining a set of start and length indicator values (SLIVs) which are overlapping with the second repetition but non-overlapping with uplink symbols within the slot; and

determining a position in a codebook for hybrid automatic repeat request acknowledgment (HARQ-ACK) based on the set of SLIVs, and wherein transmitting the feedback comprises:

transmitting the feedback on the determined position.

8. The method of claim 4, wherein the plurality of repetitions for the downlink data transmission are transmitted within a slot, and the method further comprises:

in accordance with a determination that the first repetition in the plurality of repetitions is not received, determining a first start and length indicator value (SLIV) of the first repetition based on the configuration;

determining an offset between the first repetition and the second repetition based on the configuration;

determining a second SLIV of the second repetition based on the first SLIV and the

offset;

updating a time domain resource allocation table with adding the second SLIV into the time domain resource allocation table; and

determining a position in a codebook for hybrid automatic repeat request acknowledgment (HARQ-ACK) based on the second SLIV in the updated time domain resource allocation table, and wherein transmitting the feedback comprises:

transmitting the feedback on the determined position.

9. The method of claim 4, wherein the plurality of repetitions for the downlink data transmission are transmitted in a plurality of slots, and wherein the method further comprises:

obtaining, from the control information, a time domain resource allocation table, a set of hybrid automatic repeat request acknowledgement (HARQ-ACK) timing values, and a time domain position of an uplink control channel, at least one entry in the time domain resource allocation table comprising an repetition number indication;

determining the number of repetitions and a start and length indicator value (SLIV) of one entry based on the time domain resource allocation table; and

determining a set of positions for transmitting the feedback based on the number of repetitions, the SLIV of each entry in the time domain resource allocation table , the set of HARQ-ACK timing values, and the time domain position of the uplink control channel.

10. The method of claim 4, wherein the plurality of repetitions for the downlink data transmission are transmitted in a plurality of slots, and wherein the method further comprises:

obtaining, from the control information, a time domain resource allocation table, a set of hybrid automatic repeat request acknowledgement (HARQ-ACK) timing values, and a time domain position of an uplink control channel;

determining a start and length indicator value (SLIV) of one entry based on the time domain resource allocation table;

determining a maximum number of repetitions based on the time domain resource allocation table; and

determining a set of positions for transmitting the feedback based on the maximum number of repetitions, the SLIV of each entry in the time domain resource allocation table, the set of HARQ-ACK timing values, and the time domain position of an uplink control

channel.

11. The method of claim 1, further comprising:

receiving from the network device further control information indicating a plurality of transmission configuration indicator (TCI) states;

receiving from the network device a further configuration indicating a predetermined TCI state used for further downlink data transmission without repetitions; and

receiving, based on the predetermined TCI sates, the further downlink data transmission without repetitions from the network device.

12. A communication method comprising:

transmitting, at a network device and to a terminal device, downlink data transmission which is semi-persistent configured, the downlink data transmission having a plurality of repetitions; and

receiving, from the terminal device, a feedback for the repetitions for the downlink data transmission based on the number of repetitions.

13. The method of claim 12, further comprising:

transmitting, to the terminal device, a configuration associated with the plurality of repetitions for the downlink data transmission ; and

transmitting, to the terminal device, control information comprising an indication for activating the configuration.

14. The method of claim 13, wherein the configuration indicates that the plurality of repetitions for the downlink data transmission are transmitted within a slot.

15. The method of claim 13, wherein the configuration indicates that the plurality of repetitions for the downlink data transmission are transmitted in a plurality of slots.

16. The method of claim 13, wherein the configuration indicates a time domain resource allocation table.

17. The method of claim 13, wherein the control information indicates a time

domain resource allocation table, a set of hybrid automatic repeat request acknowledgement (HARQ-ACK) timing values, and a time domain position of an uplink control channel.

18. The method of claim 12, further comprising:

transmitting to the terminal device further control information indicating a plurality of transmission configuration indicator (TCI) states;

transmitting to the terminal device a further configuration indicating a predetermined TCI states used for further downlink data transmission without repetitions; and

transmitting based on the predetermined TCI sates the further downlink data transmission without repetitions to the terminal device.

19. A terminal device, comprising:

a processing unit; and

a memory coupled to the processing unit and storing instructions thereon, the instructions, when executed by the processing unit, causing the terminal device to perform the method according to any one of claims 1-11.

20. A network device, comprising:

a processing unit; and

a memory coupled to the processing unit and storing instructions thereon, the instructions, when executed by the processing unit, causing the network device to perform the method according to any one of claims 12-18.

21 A computer readable medium having instructions stored thereon, the instructions, when executed on at least one processor, causing the at least one processor to carry out the method according to any one of claims 1-11.

22. A computer readable medium having instructions stored thereon, the instructions, when executed on at least one processor, causing the at least one processor to carry out the method according to any one of claims 12-18.

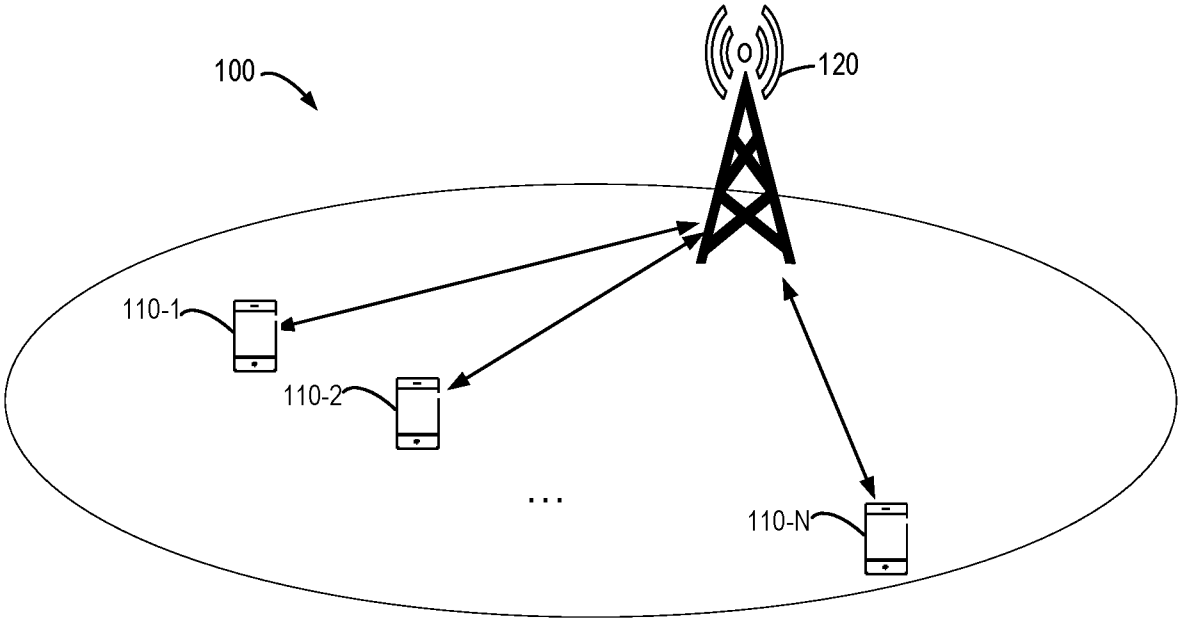


Fig. 1

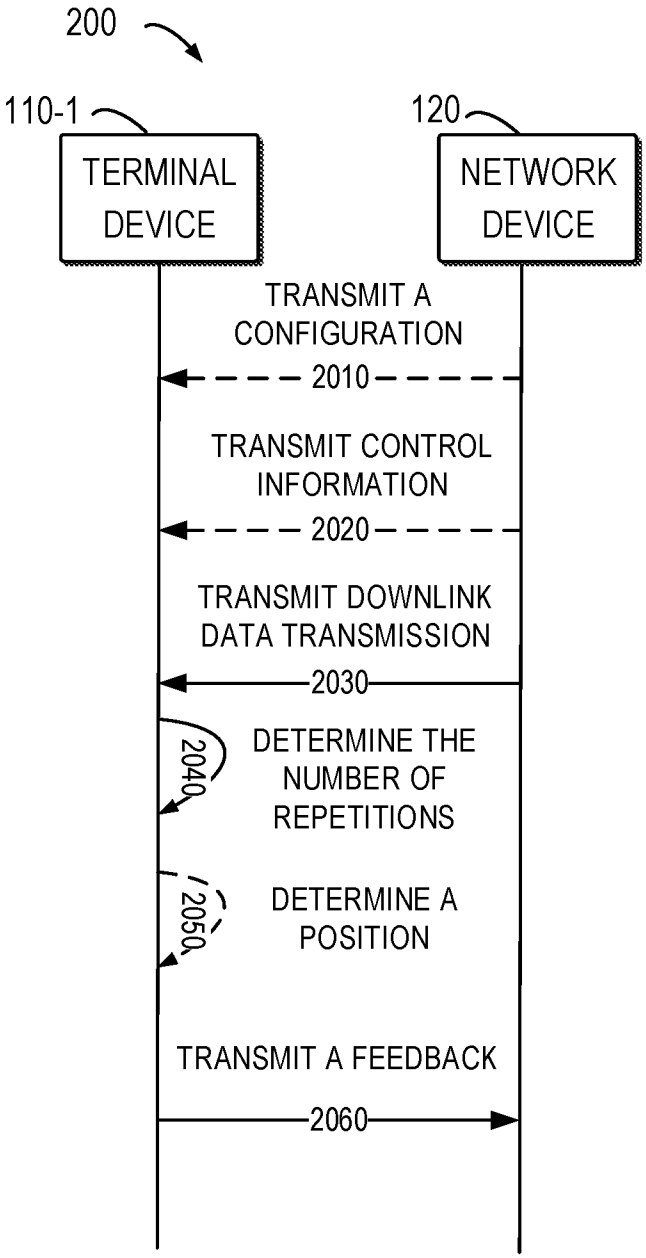

200
110-1
TERMINAL DEVICE
120
NETWORK DEVICE
TRANSMIT A CONFIGURATION
2010
TRANSMIT CONTROL INFORMATION
2020
TRANSMIT DOWNLINK DATA TRANSMISSION
2030
2040
DETERMINE THE NUMBER OF REPETITIONS
2050
DETERMINE A POSITION
TRANSMIT A FEEDBACK
2060

Fig. 2

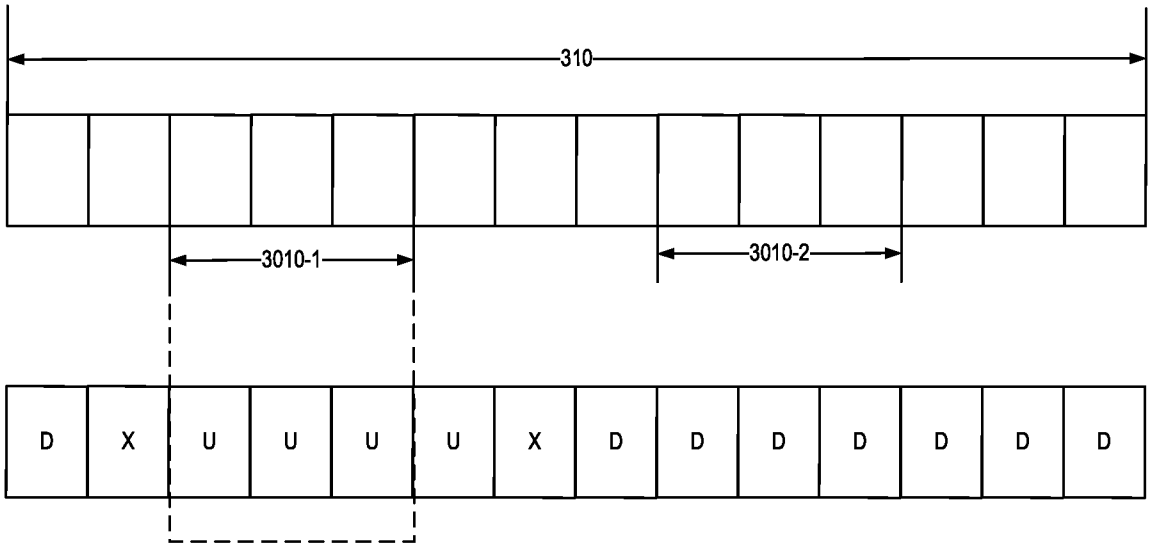


Fig. 3

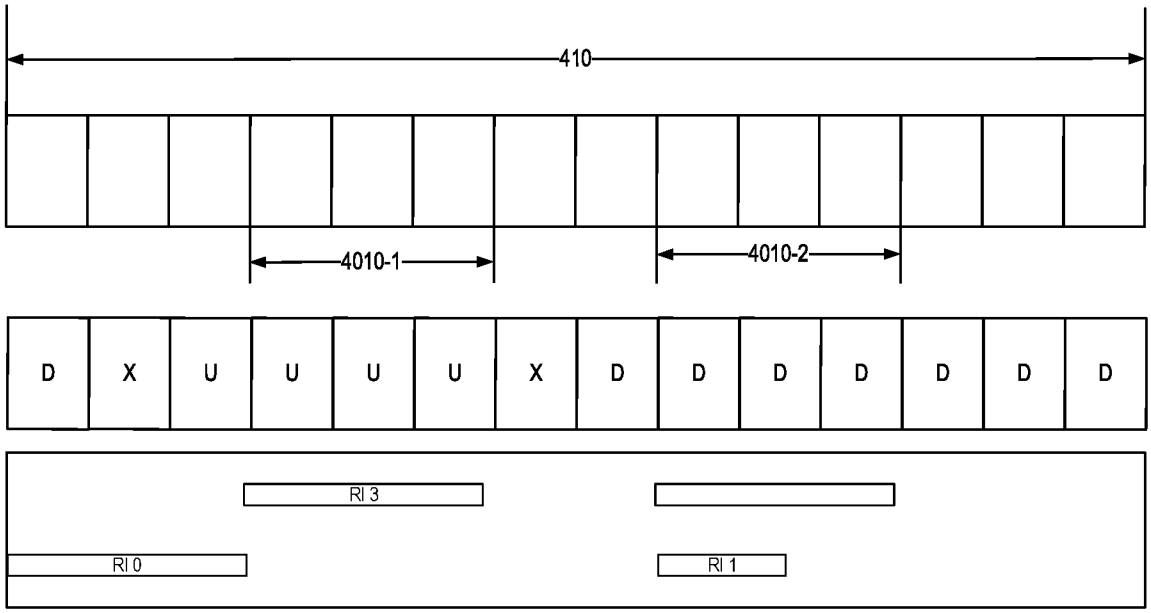


Fig. 4A

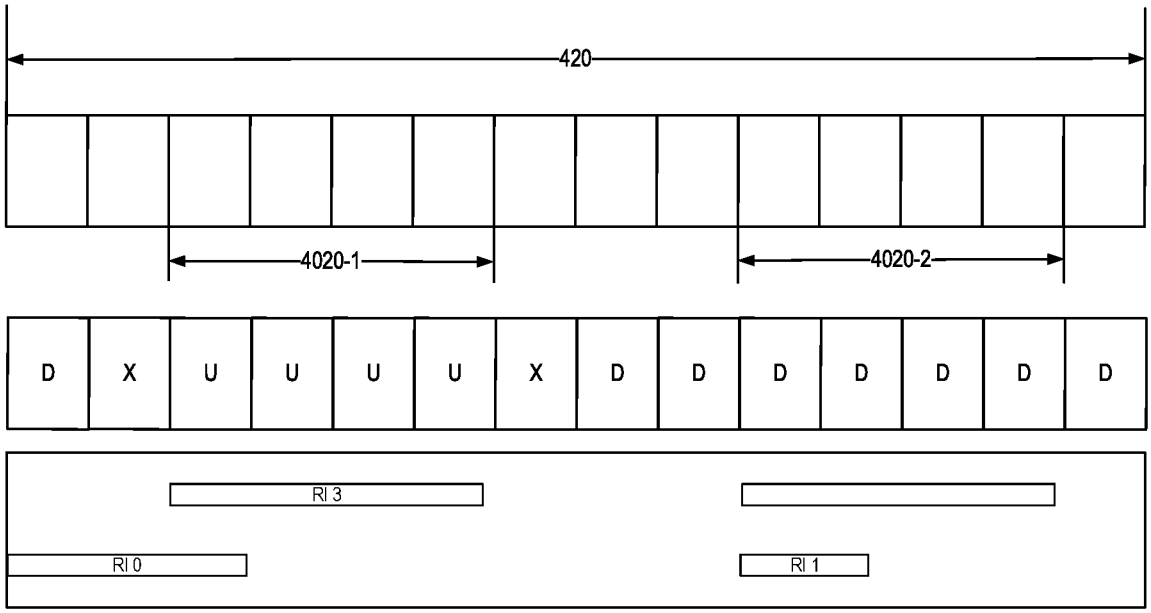


Fig. 4B

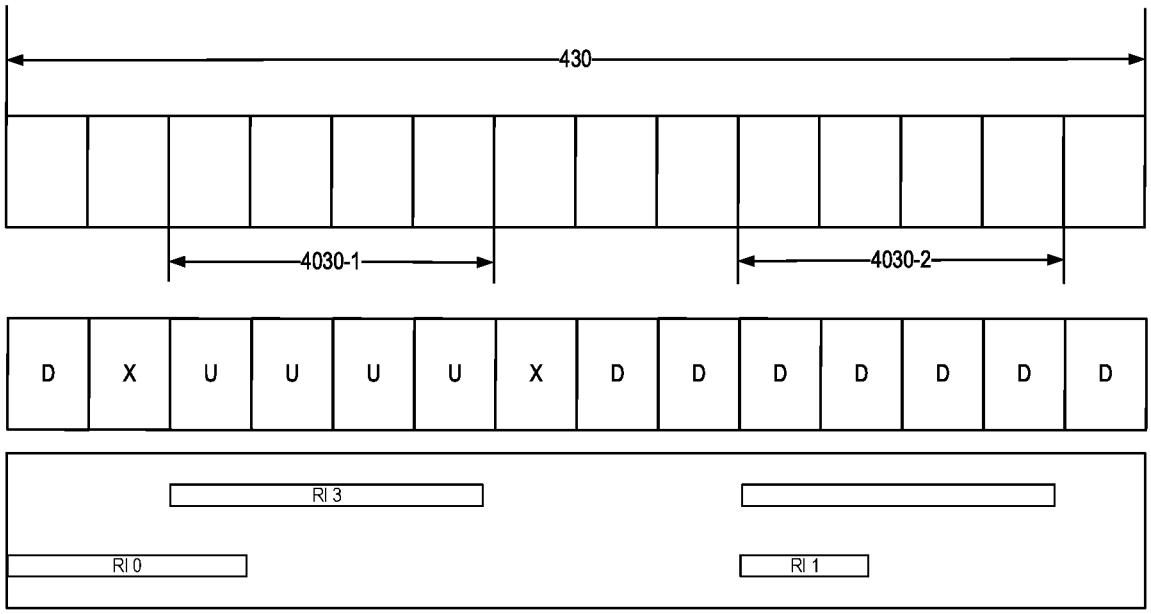


Fig. 4C

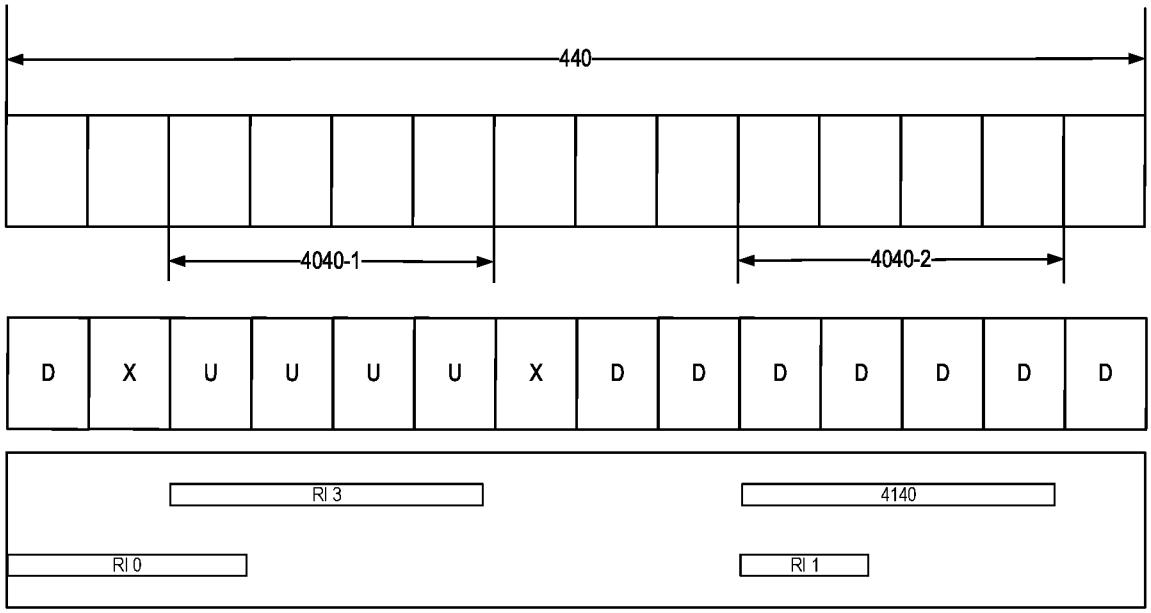


Fig. 4D

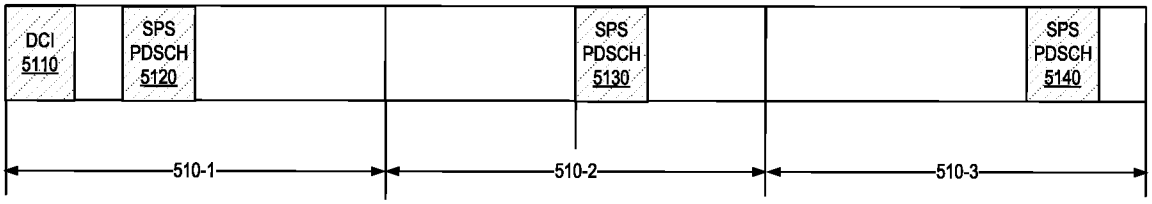
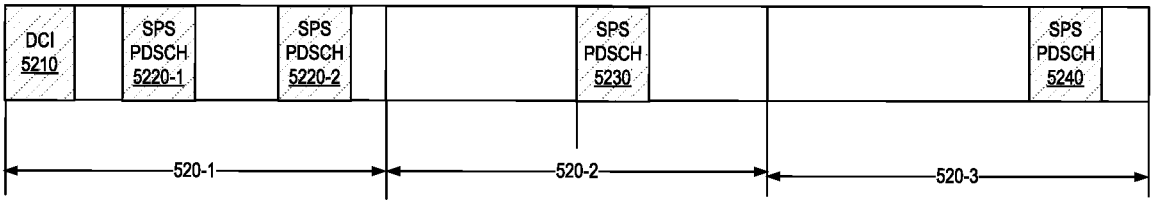

DCI
5110
SPS
PDSCH
5120
SPS
PDSCH
5130
SPS
PDSCH
5140
510-1
510-2
510-3

Fig. 5A


DCI
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PDSCH
5220-1
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SPS
PDSCH
5240
520-1
520-2
520-3

Fig. 5B

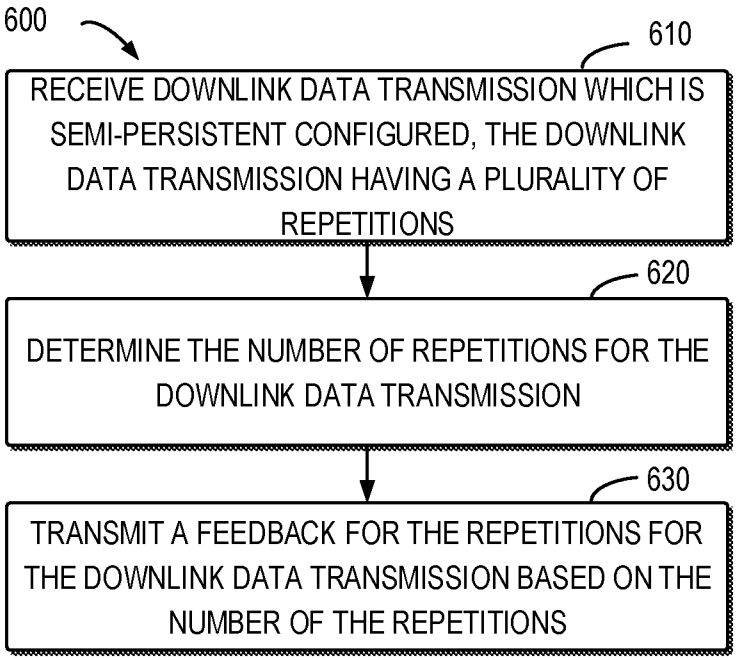
600
610
RECEIVE DOWNLINK DATA TRANSMISSION WHICH IS SEMI-PERSISTENT CONFIGURED, THE DOWNLINK DATA TRANSMISSION HAVING A PLURALITY OF REPETITIONS
620
DETERMINE THE NUMBER OF REPETITIONS FOR THE DOWNLINK DATA TRANSMISSION
630
TRANSMIT A FEEDBACK FOR THE REPETITIONS FOR THE DOWNLINK DATA TRANSMISSION BASED ON THE NUMBER OF THE REPETITIONS

Fig.6

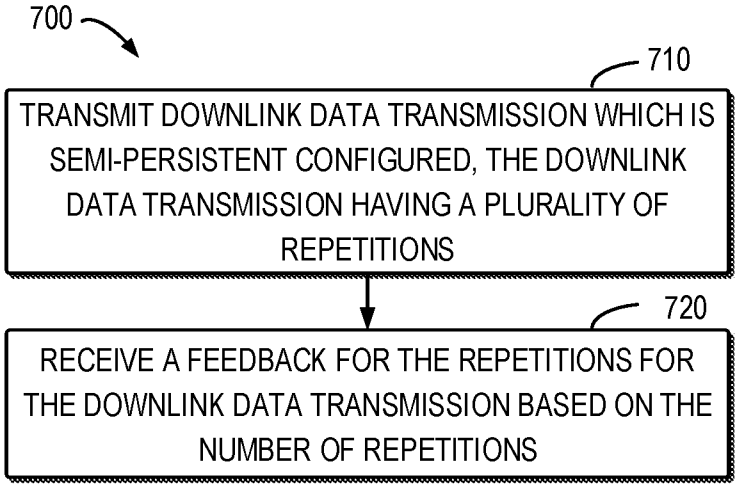
700
710
TRANSMIT DOWNLINK DATA TRANSMISSION WHICH IS SEMI-PERSISTENT CONFIGURED, THE DOWNLINK DATA TRANSMISSION HAVING A PLURALITY OF REPETITIONS
720
RECEIVE A FEEDBACK FOR THE REPETITIONS FOR THE DOWNLINK DATA TRANSMISSION BASED ON THE NUMBER OF REPETITIONS

Fig. 7

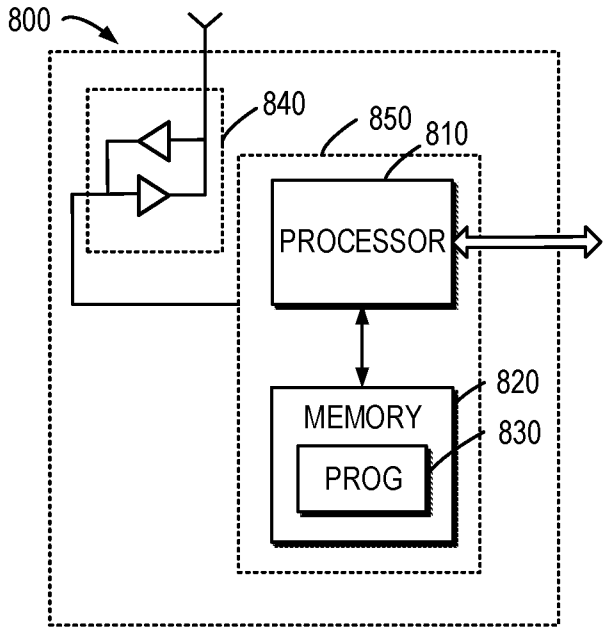

Fig. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2020/104603

A. CLASSIFICATION OF SUBJECT MATTER

H04W 4/00(2018.01)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; H04Q; H04L

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

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

CNPAT, WPI, EPODOC, CNKI, GOOGLE, 3GPP: SPS, semi-persistent, configure, configuration, schedule, downlink, DL, repetition, number, feedback, data, transmission, TDRA, table, position, codebook

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	ERICSSON. "Repetition enhancements for UL SPS operation" *3GPP TSG-RAN WG2 #102 R2-1807219,* 25 May 2018 (2018-05-25), part 2	1-4, 11-22
Y	HUAWEI et al. "Corrections on other aspects for URLLC/IIOT enhancements" *3GPP TSG RAN WG1 Meeting #101-e R1-2004611,* 05 June 2020 (2020-06-05), part 2.3	1-4, 11-22
A	HUAWEI et al. "Corrections on other aspects for URLLC/IIOT enhancements" *3GPP TSG RAN WG1 Meeting#100bis-e R1-2002584,* 30 April 2020 (2020-04-30), the whole document	1-22
A	CMCC. "Repetitions Transmission for SPS configurations" *3GPP TSG-RAN WG2 Meeting#108 R2-1915995,* 22 November 2019 (2019-11-22), the whole document	1-22
A	WO 2017078784 A1 (INTEL CORPORATION) 11 May 2017 (2017-05-11) the whole document	1-22
A	WO 2014110785 A1 (BROADCOM CORPORATION) 24 July 2014 (2014-07-24) the whole document	1-22

☑ 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
12 March 2021	**26 March 2021**
Name and mailing address of the ISA/CN **National Intellectual Property Administration, PRC** **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088** **China** Facsimile No. **(86-10)62019451**	Authorized officer **BAI,Xuehui** Telephone No. **86-(10)-53961635**

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2020/104603

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 111226408 A (MEDIATEK SINGAPORE PTE. LTD.) 02 June 2020 (2020-06-02) the whole document	1-22

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2020/104603

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
WO 2017078784 A1	11 May 2017	None	
WO 2014110785 A1	24 July 2014	None	
CN 111226408 A	02 June 2020	WO 2020063638 A1	02 April 2020
		TW 202014010 A	01 April 2020
		US 2020099477 A1	26 March 2020