

- (51) International Patent Classification:
H04W 74/08 (2009.01)

(21) International Application Number:
PCT/CN2023/087066

(22) International Filing Date:
07 April 2023 (07.04.2023)

(25) Filing Language:
English

(26) Publication Language:
English

(71) Applicant: SHENZHEN TCL NEW TECHNOLOGY CO., LTD. [CN/CN]; Building D4, TCL International E City No. 1001, Zhongshan Park Road, Xili Street, Nanshan District, Shenzhen, Guangdong 518052 (CN).

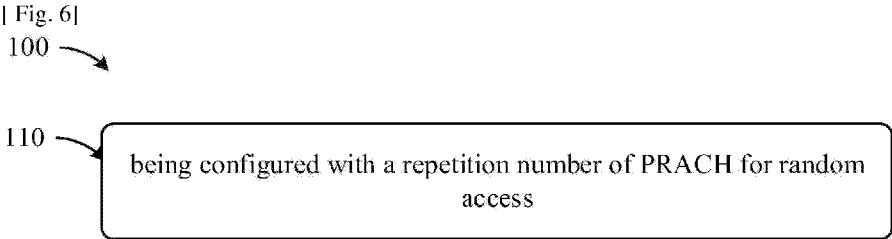
(72) Inventor: DENG, Yiwei; Building D4, TCL International E City No. 1001, Zhongshan Park Road, Xili Street, Nanshan District, Shenzhen, Guangdong 518052 (CN).

(74) Agent: PURPLEVINE INTELLECTUAL PROPERTY (SHENZHEN) CO., LTD.; 2901, Block C, China Resources Land Building, Dachong Community, Yuehai Street, Nanshan District, Shenzhen, Guangdong 518052 (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, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, 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, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, 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, ME, 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: WIRELESS COMMUNICATION METHOD AND RELATED DEVICES



(57) Abstract: A wireless communication method and related devices such as a user equipment (UE) and a base station (BS) (e.g., a gNB) are provided. The wireless communication method, performed by a UE, including being configured with a repetition number of physical random access channel (PRACH) for random access. With this method, cell coverage enhancement is realized.

Description

Title of Invention: WIRELESS COMMUNICATION METHOD AND RELATED DEVICES

TECHNICAL FIELD

[0001] The present application relates to wireless communication technologies, and more particularly, to a wireless communication method, and related devices such as a user equipment (UE) and a base station (BS) (e.g., a gNB) .

BACKGROUND ART

[0002] Wireless communication systems, such as the third-generation (3G) of mobile telephone standards and technology are well known. Such 3G standards and technology have been developed by the Third Generation Partnership Project (3GPP) . The 3rd generation of wireless communications has generally been developed to support macro-cell mobile phone communications. Communication systems and networks have developed towards being a broadband and mobile system. In cellular wireless communication systems, user equipment (UE) is connected by a wireless link to a radio access network (RAN) . The RAN includes a set of base stations (BSs) which provide wireless links to the UEs located in cells covered by the base stations, and an interface to a core network (CN) which provides overall network control. The RAN and CN each conducts respective functions in relation to the overall network.

[0003] The 3GPP has developed the so-called Long-Term Evolution (LTE) system, namely, an Evolved Universal Mobile Telecommunication System Terrestrial Radio Access Network (E-UTRAN) , for a mobile access network where one or more macro-cells are supported by base station known as an eNodeB or eNB (evolved NodeB) . LTE is evolving further towards the so-called 5G or NR (new radio) systems where one or more cells are supported by base stations known as a next generation Node B called gNodeB (gNB) .

[0004] The 5G New Radio (NR) standard will support a multitude of different services each with very different requirements. These services include Enhanced Mobile Broadband (eMBB) for high data rate transmission, Ultra-Reliable Low Latency Communication (URLLC) for devices requiring low latency and high link reliability and Massive Machine-Type Communication (mMTC) to support a large number of low-power devices for a long life-time requiring highly energy efficient communication.

[0005] In RAN #94 meeting, a new Rel-18 work item on NR coverage enhancements was approved. The objective of this work item is to study potential coverage e

enhancement solutions for PRACH and waveform for both FR1 and FR2. The detailed objectives are as follows.

- [0006] ● Specify following PRACH coverage enhancements (RAN1, RAN2)
- [0007] ○ Multiple PRACH transmissions with same beams for 4-step RACH procedure
- [0008] ○ Study, and if justified, specify PRACH transmissions with different beams for 4-step RACH procedure
- [0009] ○ Note 1: The enhancements of PRACH are targeting for FR2, and can also apply to FR1 when applicable.
- [0010] ○ Note 2: The enhancements of PRACH are targeting short PRACH formats, and can also apply to other formats when applicable.
- [0011] ● Study and if necessary specify following power domain enhancements
- [0012] ○ Enhancements to realize increasing UE power high limit for CA and DC based on Rel-17 RAN4 work on “Increasing UE power high limit for CA and DC”, in compliance with relevant regulations
- [0013] ■ Note 1: The study starts after RAN4 work on “Increasing UE power high limit for CA and DC” is done depending on conclusions from RAN4.
- [0014] ■ Note 2: The objective will be revisited and further clarified in RAN plenary after RAN4 work on “Increasing UE power high limit for CA and DC” is done, and the discussion in WGs will not start before the objective is revised with a clearer scope.
- [0015] ■ Note 3: Both RAN1 and RAN4 are expected to be involved; to decide the order of either (RAN4, RAN1) or (RAN1, RAN4) later.
- [0016] ○ Enhancements to reduce MPR/PAR, including frequency domain spectrum shaping with and without spectrum extension for DFT-S-OFDM and tone reservation
- [0017] ● Specify enhancements to support dynamic switching between DFT-S-OFDM and CP-OFDM
- [0018] Coverage is one of the key factors that an operator considers when commercializing cellular communication networks due to its direct impact on service quality as well as capital expenditure (CAPEX) and operational expenditure (OPEX). Despite the importance of coverage on the success of NR commercialization, a thorough coverage evaluation and a comparison with legacy radio access technologies (RATs) considering all NR specification details have not been done up to now.
- [0019] Compared to LTE, New Radio (NR) is designed to operate at much higher frequencies such as 28GHz or 39GHz in FR2. Furthermore, many countries are making available more spectrums on FR1, such as 3.5GHz, which is typically in higher frequencies than that for LTE or 3G. Due to the higher frequencies, it is in

evitable that the wireless channel will be subject to higher path-loss, making it more challenging to maintain an adequate quality of service that is at least equal to that of legacy RATs. One key mobile application of particular importance is voice service for which a typical subscriber will always expect a ubiquitous coverage wherever s/he is.

[0020] For FR1, NR can be deployed either in newly allocated spectrums, such as 3.5GHz, or in a spectrum re-farmed from a legacy network, e.g., 3G and 4G. In either case, coverage will be a critical issue considering the fact that these spectrums will most likely handle key mobile services such as voice and low-rate data services. For FR2, coverage was not thoroughly evaluated during the self-evaluation campaign towards IMT-2020 submission and not considered in 3GPP Rel-16 enhancements. In these regards, a thorough understanding of NR coverage performance is needed while taking into account the support of latest NR specification.

[0021] In RAN #94 meeting, a new 3GPP Rel-18 work item on NR coverage enhancements was approved. The objective of this study item is to study potential coverage enhancement solutions for specific scenarios for both FR1 and FR2. Some potential methods for coverage enhancement have been discussed in the previous RAN1 meetings; however, there are still some issues that need to be enhanced.

[0022] Other Related Arts

[0023] For CFRA, in current 3GPP specification, DCI format 1_0 with FDRA fields that are all set to "1" can be used to trigger the access procedure of PRACH, as shown below:

[0024] If the CRC of the DCI format 1_0 is scrambled by C-RNTI and the "Frequency domain resource assignment" field are of all ones, the DCI format 1_0 is for random access procedure initiated by a PDCCH order, with all remaining fields set as follows:

[0025] - Random Access Preamble index –6 bits according to ra-PreambleIndex in Clause 5.1.2 of [8, TS38.321]

[0026] - UL/SUL indicator –1 bit. If the value of the "Random Access Preamble index" is not all zeros and if the UE is configured with supplementaryUplink in ServingCellConfig in the cell, this field indicates which UL carrier in the cell to transmit the PRACH according to Table 7.3.1.1.1-1; otherwise, this field is reserved.

[0027] - SS/PBCH index –6 bits. If the value of the "Random Access Preamble index" is not all zeros, this field indicates the SS/PBCH that shall be used to determine the RACH occasion for the PRACH transmission; otherwise, this field is reserved.

[0028] - PRACH Mask index –4 bits. If the value of the "Random Access Preamble index" is not all zeros, this field indicates the RACH occasion associated with the SS/PBCH indicated by "SS/PBCH index" for the PRACH transmission, according to Clause 5.1.1 of [8, TS38.321] ; otherwise, this field is reserved

[0029] The PRACH mask index values are defined in Table 1 and this value is just used for decrease the collision probability between different UEs.

[0030] Table 1: PRACH Mask Index values

PRACH Mask Index/ <i>msgA-SSB-SharedRO-MaskIndex</i>	Allowed PRACH occasion(s) of SSB
0	All
1	PRACH occasion index 1
2	PRACH occasion index 2
3	PRACH occasion index 3
4	PRACH occasion index 4
5	PRACH occasion index 5
6	PRACH occasion index 6
7	PRACH occasion index 7
8	PRACH occasion index 8
9	Every even PRACH occasion
10	Every odd PRACH occasion
11	Reserved
12	Reserved
13	Reserved
14	Reserved
15	Reserved

[0031] - Reserved bits –12 bits for operation in a cell with shared spectrum channel access in frequency range 1 or when the DCI format is monitored in common search space for operation in a cell in frequency range 2-2; otherwise 10 bits

[0032] For 2-step RACH, a PUSCH occasion for PUSCH transmission is defined by a frequency resource and a time resource, and is associated with a DMRS resource. The DMRS resources are provided by msgA-DMRS-Config.

[0033] Each consecutive number of $\backslash_{\text{preamble}}$ preamble indexes from valid PRACH occasions in a PRACH slot

[0034] - first, in increasing order of preamble indexes within a single PRACH occasion

- [0035] - second, in increasing order of frequency resource indexes for frequency multiplexed PRACH occasions
- [0036] - third, in increasing order of time resource indexes for time multiplexed PRACH occasions within a PRACH slot
- [0037] are mapped to a valid PUSCH occasion and the associated DMRS resource
- [0038] - first, in increasing order of frequency resource indexes f_{id} for frequency multiplexed PUSCH occasions
- [0039] - second, in increasing order of DMRS resource indexes within a PUSCH occasion, where a DMRS resource index $DMRS_{id}$ is determined first in an ascending order of a DMRS port index and second in an ascending order of a DMRS sequence index in TS 38.211
- [0040] - third, in increasing order of time resource indexes t_{id} for time multiplexed PUSCH occasions within a PUSCH slot
- [0041] - fourth, in increasing order of indexes for N_s PUSCH slots
- [0042] SUMMARY
- [0043] The objective of the present application is to provide a wireless communication method and related devices, for realizing cell coverage enhancement.
- [0044] In a first aspect, an embodiment of the present application provides a wireless communication method, performed by a user equipment (UE), the method including: being configured with a repetition number of physical random access channel (PRACH) for random access.
- [0045] In a second aspect, an embodiment of the present application provides a wireless communication method, performed by a user equipment (UE), the method including: detecting random access response (RAR) of MSGA in an RAR window based on MSGB-radio network temporary identifier (RNTI).
- [0046] In a third aspect, an embodiment of the present application provides a wireless communication method, performed by a user equipment (UE), the method including: transmitting MSGA on physical random access channel (PRACH) and physical uplink shared channel (PUSCH), wherein a set of random access channel (RACH) occasions (ROs) for multiple PRACH are associated to a PUSCH.
- [0047] In a fourth aspect, an embodiment of the present application provides a wireless communication method, performed by a base station (BS), the method including: configuring a user equipment (UE) with a repetition number of physical random access channel (PRACH) for random access.

- [0048] In a fifth aspect, an embodiment of the present application provides a wireless communication method, performed by a base station (BS) , the method including: calculating MSGB-radio network temporary identifier (RNTI) for a user equipment (UE) to detect random access response (RAR) of MSGA in an RAR window based on the MSGB-RNTI.
- [0049] In a sixth aspect, an embodiment of the present application provides a wireless communication method, performed by a base station (BS) , the method including: receiving MSGA on physical random access channel (PRACH) and physical uplink shared channel (PUSCH) , wherein a set of random access channel (RACH) occasions (ROs) for multiple PRACH are associated to a PUSCH.
- [0050] In a seventh aspect, an embodiment of the present application provides a user equipment (UE) , including a processor, configured to call and run program instructions stored in a memory, to execute any of the methods of the first aspect to the third aspect.
- [0051] In an eighth aspect, an embodiment of the present application provides a base station (BS) , including a processor, configured to call and run program instructions stored in a memory, to execute any of the methods of the fourth aspect to the sixth aspect.
- [0052] In a ninth aspect, an embodiment of the present application provides a computer readable storage medium provided for storing a computer program, which enables a computer to execute the method of any of the first aspect to the sixth aspect.
- [0053] In a tenth aspect, an embodiment of the present application provides a computer program product, which includes computer program instructions enabling a computer to execute the method of any of the first aspect to the sixth aspect.
- [0054] In an eleventh aspect, an embodiment of the present application provides a computer program, when running on a computer, enabling the computer to execute the method of any of the first aspect to the sixth aspect.

DESCRIPTION OF DRAWINGS

- [0055] In order to more clearly illustrate the embodiments of the present application or related art, the following figures that will be described in the embodiments are briefly introduced. It is obvious that the drawings are merely some embodiments of the present application, a person having ordinary skill in this field can obtain other figures according to these figures without paying the premise.
- [0056] FIG. 1 is a schematic diagram illustrating more than one CG configurations for a UE.
- [0057] FIG. 2 is a schematic diagram illustrating jitter for XR traffic arrival.

- [0058] FIG. 3 is a block diagram of a user equipment and a base station of wireless communication in a communication controlling system according to an embodiment of the present application.
- [0059] FIG. 4 is a schematic diagram illustrating radio protocol architecture within gNB and UE.
- [0060] FIG. 5 is a schematic diagram illustrating a gNB further including a centralized unit (CU) and a plurality of distributed unit (DUs) .
- [0061] FIG. 6 is a flowchart of a wireless communication method according to an embodiment of the present application.
- [0062] FIG. 7 is a flowchart of a wireless communication method according to another embodiment of the present application.
- [0063] FIG. 8 is a schematic diagram illustrating RAR window of MSGB based on last PUSCH within MSGA.
- [0064] FIG. 9 is a schematic diagram illustrating multiple RAR windows of MSGB based on each PO.
- [0065] FIG. 10 is a flowchart of a wireless communication method according to still another embodiment of the present application.
- [0066] FIG. 11 is a schematic diagram illustrating multiple PRACH occasions for multiple PRACH transmission mapping to one PUSCH.
- [0067] FIG. 12 is a schematic diagram illustrating a set of ROs within multiple PRACH of ROs that are mapped to one PO.
- [0068] FIG. 13 is a schematic diagram illustrating one RO mapped to one PUSCH.
- [0069] FIG. 14 is a flowchart of a wireless communication method according to yet another embodiment of the present application.
- [0070] FIG. 15 is a schematic diagram illustrating a UCI associated to more than one CG configurations.
- [0071] FIG. 16 is a schematic diagram illustrating a UCI associated to more than one CG configurations.
- [0072] FIG. 17 is a flowchart of a wireless communication method according to yet another embodiment of the present application.
- [0073] FIG. 18 is a schematic diagram illustrating relationship between TOs and virtual index.
- [0074] FIG. 19 is a flowchart of a wireless communication method according to yet another embodiment of the present application.

DETAILED DESCRIPTION OF EMBODIMENTS

- [0075] Embodiments of the application are described in detail with the technical matters, structural features, achieved objects, and effects with reference to the accompanying d

rawings as follows. Specifically, the terminologies in the embodiments of the present application are merely for describing the purpose of the certain embodiment, but not to limit the application.

[0076] In this document, the term "/" should be interpreted to indicate "and/or." A combination 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," or "A, B, and/or C" 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 combination may contain one or more members of A, B, or C.

[0077] Multiple PRACH transmission with same beams for 4-step RACH was approved in RAN #94 meeting, and multiple PRACH transmission with different beams for 4-step RACH procedure may also be enabled. For UE with contention-free random access (CFRA) mechanism, it is reasonable to support multiple PRACH transmission for CFRA for UE at the cell edge. When UE is located at the cell edge, the coverage capacity for initial access is bad and then potential mechanism will be needed. One potential way is to enable CFRA with multiple PRACH transmission.

[0078] Therefore, if multiple PRACH transmission for CFRA is supported, how to indicate PRACH repetition needs to be studied.

[0079] Multiple PRACH transmission with same beams for 4-step RACH was approved in RAN #94 meeting, and multiple PRACH transmission with different beams for 4-step RACH procedure may also be enabled. Similarly, for 2-step RACH, it's also a uplink (UL) bottleneck channel. Enabling multiple PRACH transmission for 2-step RACH is needed; however, some issues may be caused when multiple PRACH transmission is enabled for 2-step RACH:

[0080] For 2-step RACH, both RACH resources and PUSCH resources are configured, as shown below:

```

MsgA-ConfigCommon-r16 ::= SEQUENCE {
    rach-ConfigCommonTwoStepRA-r16    RACH-ConfigCommonTwoStepRA-r16,
    msgA-PUSCH-Config-r16              MsgA-PUSCH-Config-r16
    OPTIONAL --Cond InitialBWPCConfig
}

```

[0081] In current 3GPP specification, a PUSCH occasion for PUSCH transmission is defined by a frequency resource and a time resource and is associated with a demodulation reference signal (DMRS) resource. The DMRS resources are provided by msgA-DMRS-Config. Each consecutive number of N_{preamble} preamble indexes from valid PRACH occasions in a PRACH slot

[0082] - first, in increasing order of preamble indexes within a single PRACH occasion

- [0083] - second, in increasing order of frequency resource indexes for frequency multiplexed PRACH occasions
- [0084] - third, in increasing order of time resource indexes for time multiplexed PRACH occasions within a PRACH slot
- [0085] are mapped to a valid PUSCH occasion and the associated DMRS resource
- [0086] - first, in increasing order of frequency resource indexes f_{id} for frequency multiplexed PUSCH occasions
- [0087] - second, in increasing order of DMRS resource indexes within a PUSCH occasion, where a DMRS resource index $DMRS_{id}$ is determined first in an ascending order of a DMRS port index and second in an ascending order of a DMRS sequence index in TS 38.211
- [0088] - third, in increasing order of time resource indexes t_{id} for time multiplexed PUSCH occasions within a PUSCH slot
- [0089] - fourth, in increasing order of indexes for N_s PUSCH slots
- [0090] Based on above analysis, the order of RACH is preamble-frequency-time basis and the corresponding PUSCH's order is frequency-DMRS-time-slot basis. However, when multiple PRACH repetition is enabled for 2-step RACH, multiple RACH preamble or PRACH transmission will be associated to one PO with different DMRS sequence or port. This will make UE confused. Thus, the relationship between RACH and corresponding PUSCH should be re-defined. In addition, whether PUSCH within MSG A needs to repeat or not will also be studied. Furthermore, when multiple PRACH within MSG A is enabled, how to determine the RNTI should be studied. In current 3GPP spec, the MSGB-RNTI is calculated based on time and/or frequency resources of a valid PRACH occasion, as shown in the following :
$$MSGB-RNTI = 1 + s_{id} + 14 \times t_{id} + 14 \times 80 \times f_{id} + 14 \times 80 \times 8 \times ul_carrier_id + 14 \times 80 \times 8 \times 2$$
- [0091] where s_{id} is the index of the first OFDM symbol of the valid PRACH occasion within the multiple PRACH occasions for multiple PRACH transmission of MSG A ($0 \leq s_{id} < 14$), t_{id} is the index of the first slot of the PRACH occasion in a system frame ($0 \leq t_{id} < 80$), where the sub-carrier spacing to determine t_{id} is based on the value of μ specified in clause 5.3.2 in TS 38.211 [8] for $\mu = \{0, 1, 2, 3\}$, and for $\mu = \{5, 6\}$, t_{id} is the index of the 120 kHz slot i in a system frame that contains the PRACH occasion ($0 \leq t_{id} < 80$), f_{id} is the index of the PRACH occasion in the frequency domain ($0 \leq f_{id} < 8$), and $ul_carrier_id$ is the UL carrier used for Random Access Preamble transmission (0 for N UL carrier, and 1 for SUL carrier).

- [0092] Thus, which one PRACH occasion or whether more than one PRACH occasion within the multiple PRACH occasions for multiple PRACH transmission of MSG A needs to be determined.
- [0093] Furthermore, in current 3GPP spec, the RAR window for 2-step RACH is based on the corresponding PUSCH with MSG A. However, when multiple MSG A transmission is enabled, which one or which set of PUSCHs within the MSG A can be used to determine the RAR window needs to be studied.
- [0094] In short, when multiple MSG A transmission is enabled, then following issues should be considered:
- [0095] - How to determine the relationship between PRACH and corresponding PUSCH within MSG A;
 - [0096] - How to determine the MSGB-RNTI;
 - [0097] - How to determine the RAR window of MSGB;
- [0098] In Rel-16, as shown in FIG. 1, more than one configured grant (CG) configuration is configured to UE to reduce the alignment delay of URLLC traffic since the traffic arrival of URLLC is randomly. This is similar to XR traffic with jitter. For jitter of XR, it's unknown to gNB and UE. To address this issue, multiple CG configurations with different start points can be used, and then UE can choose one of the most suitable CG configuration for transmission.
- [0099] For XR, due to large packet size of XR, more time and frequency resources will be needed for a CG to transmit all of the packet of XR. When jitter is happened, the traffic arrival location will be not at the start of first transmission occasion (TO) within a CG configuration, as shown in FIG. 2. In some cases, the latency of traffic will be caused, and the TOs within a CG configuration may not be enough to transmit whole of the packet. One potential way is to introduce multiple CG configurations and activate the CG configurations simultaneously. Similar to the multiple CG configurations in Rel-16 URLLC, a time offset for a CG configuration is configured. When multiple CG configurations for XR are enabled, a slot of time and frequency resources will be reserved for a UE, and many TOs may not be used. In addition, in last RAN1 meeting, it has been agreed that the uplink control information (UCI) which is used for indicating un-used TOs needs to be carried by CG-PUSCH. In this mechanism, there will be no signalling used to indicate the un-used TOs within a CG configuration when the CG configuration is not chosen by UE. Thus, a UCI used for indicating the un-used TOs needs to be extended from one CG to multiple CG configurations.
- [0100] In short, how to indicate the un-used TOs in the case of more than one CG configuration needs to be studied.

- [0101] In Rel-17, PRACH coverage enhancement has not been addressed, despite being identified as one of the bottleneck channels in corresponding studies. PRACH transmission is very important for many procedures, e.g., initial access and beam failure recovery. To achieve better coverage performance, some enhancement methods will be needed. This disclosure proposes some coverage enhanced methods for PRACH channel. With these methods, better coverage will be achieved for uplink channel.
- [0102] FIG. 3 illustrates that, in some embodiments, one or more user equipments (UEs) 10 and a base station (e.g., gNB or eNB) 20 for wireless communication in a communication network system 30 according to an embodiment of the present application are provided. The communication network system 30 includes the one or more UEs 10 and the base station 20. The one or more UEs 10 may include a memory 12, a transceiver 13, and a processor 11 coupled to the memory 12 and the transceiver 13. The base station 20 may include a memory 22, a transceiver 23, and a processor 21 coupled to the memory 22 and the transceiver 23. The processor 11 or 21 may be configured to implement proposed functions, procedures and/or methods described in this description. Layers of radio interface protocol may be implemented in the processor 11 or 21. The memory 12 or 22 is operatively coupled with the processor 11 or 21 and stores a variety of information to operate the processor 11 or 21. The transceiver 13 or 23 is operatively coupled with the processor 11 or 21, and the transceiver 13 or 23 transmits and/or receives a radio signal. The base station 20 and a next generation core network (5GCN) may also communicate with each other either wirelessly or in a wired way. When the communication network system 30 complies with the New Radio (NR) standard of the 3rd Generation Partnership Project (3GPP), the next generation core network is a backend serving network system and may include an Access and Mobility Management Function (AMF), User Plane Function (UPF), and a Session Management Function (SMF). In one aspect, the user equipment 10 can include almost any consumer electronic device or appliance that can connect to a radio access network and a core network for the releases of 3GPP and further, such as, but not limited to NR networks.
- [0103] The processor 11 or 21 may include application-specific integrated circuit (ASIC), other chipset, logic circuit and/or data processing device. The memory 12 or 22 may include read-only memory (ROM), random access memory (RAM), flash memory, memory card, storage medium and/or other storage device. The transceiver 13 or 23 may include baseband circuitry to process radio frequency signals. When the embodiments are implemented in software, the techni

ques described herein can be implemented with modules (e.g., procedures, functions, and so on) that perform the functions described herein. The modules can be stored in the memory 12 or 22 and executed by the processor 11 or 21. The memory 12 or 22 can be implemented within the processor 11 or 21 or external to the processor 11 or 21 in which case those can be communicatively coupled to the processor 11 or 21 via various means as is known in the art. The user plane radio protocol architecture within the gNB and UE is shown in FIG. 4, which includes optional Service Data Adaptation Protocol (SDAP), Packet Data Convergence Protocol (PDCP), Radio Link Control (RLC), Medium Access Control (MAC). In RAN functional split, a gNB further includes a centralized unit (CU) and a plurality of distributed unit (DUs) as shown in FIG. 5. The protocol stack of CU includes an RRC layer, an optional SDAP layer, and a PDCP layer, while the protocol stack of DU includes an RLC layer, a MAC layer, and a PHY layer. The F1 interface between the CU and DU is established between the PDCP layer and the RLC layer.

[0104] FIG. 6 illustrates a wireless communication method according to an embodiment of the present application. Referring to FIG. 6 in conjunction with FIG. 3, the method 100 includes the following. In Step 110, the UE is configured by the base station with a repetition number of physical random access channel (PRACH) for random access. With this method, cell coverage enhancement is realized.

[0105] In an embodiment, the repetition number of PRACH may be configured by radio resource control (RRC) signaling. In another embodiment, the repetition number of PRACH may be indicated by downlink control information (DCI). In an example, the repetition number of PRACH may be indicated by a table of PRACH Mask Index. In another example, the repetition number of PRACH may be indicated by a field in DCI. In some embodiments, candidate values of PRACH repetition may be configured by RRC, and one of the candidate values may be indicated by DCI. In still another embodiment, each state of frequency domain resource assignment (FDRA) in DCI may be used to indicate one of candidate values of PRACH repetition.

[0106] Further details on how to indicate PRACH repetition are described as follows.

[0107] This disclosure proposes method (s) to determine the repetition number of PRACH for CFRA. The UE in CFRA mechanism may also be located in cell edge. To improve the capacity of coverage, the most straightforward way is to enable repetition of CFRA. Based on current 3GPP spec, the parameters of CFRA are configured by RACH-ConfigDedicated and/or triggered by PDCCH format 1-0 with FDRA fields set all "1". The following mechanism can be used to indicate the repetition number of CFRA.

[0108] In a first possible solution of the present application, the repetition value of CFRA can be configured in RRC (as shown in Table 2 and Table 3 below) , e.g. RACH-ConfigDedicated, CFRA.

[0109] Table 2. The number of repetition configure for RA

Rule 26,
25.04.2023

RACH-ConfigDedicated ::=	SEQUENCE {	
cfra	CFRA	OPTIONAL, -- Need
S		
ra-Prioritization	RA-Prioritization	OPTIONAL, -- Need
N		
Repetition k	ENUMERATED {1,2,4,8} or {1,2,4,8,16,32} or {1,2,3,4,5,6,7,8} or {2,4,8,16} or {2,4,6,8}	
[[		
ra-PrioritizationTwoStep-r16	RA-Prioritization	OPTIONAL, -- Need
N		
cfra-TwoStep-r16	CFRA-TwoStep-r16	OPTIONAL
Need S		
]]		
}		

Table 3. The number of repetition configure for RA

CFRA ::=	SEQUENCE {	
occasions	SEQUENCE {	
rach-ConfigGeneric	RACH-ConfigGeneric,	
ssb-perRACH-Occasion	ENUMERATED {oneEighth, oneFourth, oneHalf, one, two, four, eight, sixteen}	
		OPTIONAL -- Cond
Mandatory		
}		OPTIONAL, -- Need S
Repetition k	ENUMERATED {1,2,4,8} or {1,2,4,8,16,32} or {1,2,3,4,5,6,7,8} or {2,4,8,16} or {2,4,6,8}	

```

resources CHOICE {
  ssb SEQUENCE {
    ssb-ResourceList SEQUENCE (SIZE(1..maxRA-SSB-Resources)) OF
CFRA-SSB-Resource,
    ra-ssb-OccasionMaskIndex INTEGER (0..15)
  },
  csirs SEQUENCE {
    csirs-ResourceList SEQUENCE (SIZE(1..maxRA-CSIRS-Resources)) OF
CFRA-CSIRS-Resource,
    rsrp-ThresholdCSI-RS RSRP-Range
  }
},
...,
[[
totalNumberOfRA-Preambles INTEGER (1..63) OPTIONAL --
Cond Occasions
]]
}

```

[0110] **【deleted】**

Rule 26,
25.04.2023

[0111] In a second possible solution of the present application, the repetition value of CFR A can be indicated by DCI, e.g. DCI format 1-0. The repetition of PRACH can be joint coding with the table of PRACH Mask Index values, which are defined in TS. 38.321. A new column can be added into the table, and one of repetition number of PRACH can be included in the column, where the number of P RACH is an integer and/or the candidate repetition number can be {1, 2, 4, 8} or {1, 2, 4, 8, 16, 32} or {1, 2, 3, 4, 5, 6, 7, 8} or {2, 4, 8, 16} or {2, 4, 6, 8} or is configurable. For instance, as shown in Table 4.

[0112] Table 4. PRACH Mask Index and number of repetition of PRACH values

PRACH Mask Index/ <i>msgA-SSB-SharedRO- MaskIndex</i>	Allowed PRACH occasion(s) of SSB	Number of repetition of PRACH
0	All	1
1	PRACH occasion index 1	2
2	PRACH occasion index 2	4
3	PRACH occasion index 3	8
4	PRACH occasion index 4	2
5	PRACH occasion index 5	4
6	PRACH occasion index 6	8
7	PRACH occasion index 7	8
8	PRACH occasion index 8	4
9	Every even PRACH occasion	2
10	Every odd PRACH occasion	4
11	Reserved	...
12	Reserved	...
13	Reserved	...
14	Reserved	...
15	Reserved	...

- [0113] In some embodiments, the candidate values of repetition can be configured by RRC, and then a column within Table 4 can be used to indicate one of the repetition values.
- [0114] In a third possible solution of the present application, an implicit way can be considered. Both frequency domain resource assignment (FDRA) fields within DCI 1_0 set all “1” and all “0” can be used to trigger the access procedure of PRACH, and each state of FDRA field can be used to indicate one of CFRA repetitions. For instance, FDRA fields set all “0” can indicate one candidate of PRACH repetitions. In some embodiments, a new fallback DCI format with specific FDRA fields with all “0” or all “1” can be used to trigger CFRA procedure, and then a corresponding value of a PRACH repetition for CFRA can be indicated, wherein the value can be pre-defined. The repetition value relationship between different specific FDRA field can also be pre-defined.
- [0115] In a fourth possible solution of the present application, reuse the reserved fields in DCI to indicate the number of repetition of PRACH. Several bits within a reserved field can be used. One way is to explicitly indicate a value of repetition. Another way is that RRC configures a set of candidate values of PRACH repetition, e.g. {1, 2, 4, 8}, and then a field in DCI is used to indicate one repetition value within the set. For instance, 2 bits are used to indicate the number of repetition of CFRA, for example, “00” indicates the PRACH repetition value of 1, “01” indicate

s the PRACH repetition value of 2, “10” indicates the PRACH repetition value of 4, and “11” indicates the PRACH repetition value of 8.

[0116] FIG. 7 illustrates a wireless communication method according to another embodiment of the present application. Referring to FIG. 7 in conjunction with FIG. 3, the method 200 includes the following. In Step 210, the UE detects random access response (RAR) of MSGA in an RAR window based on MSGB-radio network temporary identifier (RNTI). With this method, cell coverage enhancement is realized.

[0117] In an embodiment, the MSGB-RNTI may be based on a last valid or any one valid PRACH occasion within multiple PRACH occasions for multiple PRACH transmission of MSGA. In another embodiment, the MSGB-RNTI may be based on a set of valid PRACH occasions within multiple PRACH occasions for multiple PRACH transmission of MSGA. In still another embodiment, the MSGB-RNTI may be based on beam index of MSGA. In an embodiment, the RAR window may start from at least one symbol after a last symbol of last physical uplink shared channel (PUSCH) occasion corresponding to multiple PRACH transmission. In another embodiment, the RAR window may start from at least one symbol after a last symbol of last PUSCH occasion corresponding to each of multiple PRACH transmission. In still another embodiment, the RAR window may start from at least one symbol after each last symbol of last PUSCH occasion within a set of PUSCH occasions within MSGA.

[0118] Further details on how to determine the MSGB-RNTI are described as follows.

[0119] This disclosure proposes method (s) to determine the MSGB-RNTI. The last valid or any one valid PRACH occasion (RO) within MSG A and/or beam index of MSG A can be considered. In current 3GPP specification, the MSGB-RNTI is calculated based on the time and/or frequency resource of a valid PRACH occasion. When multiple MSG A transmission is enabled, which one of valid ROs is used for the calculation of the MSGB-RNTI should be studied. The MSGB-RNTI associated with the PRACH occasion in which the Random Access Preamble is transmitted, is computed as: $\text{MSGB-RNTI} = 1 + s_id + 14 \times t_id + 14 \times 80 \times f_id + 14 \times 80 \times 8 \times ul_carrier_id + 14 \times 80 \times 8 \times 2$

[0120] where s_id is the index of the first OFDM symbol of the last valid or any one valid PRACH occasion within the multiple PRACH occasions for multiple PRACH transmission of MSG A ($0 \leq s_id < 14$), t_id is the index of the first slot of the PRACH occasion in a system frame ($0 \leq t_id < 80$), where the sub-carrier spacing to determine t_id is based on the value of μ specified in clause 5.3.2 in TS 38.211 [8] for $\mu = \{0, 1, 2, 3\}$, and for $\mu = \{5, 6\}$, t_id is the index of the 120 kHz slot in a system frame that contains the PRACH occasion ($0 \leq t_id < 80$), f_id is the index of the PRACH occasion in the frequency domain ($0 \leq f_id < 8$), and $ul_carrier_id$ is

the UL carrier used for Random Access Preamble transmission (0 for N UL carrier, and 1 for SUL carrier) .

[0121] In some embodiments, more than one MSGB-RNTI can be used for UE to detect RAR of MSGA, each MSGB-RNTI is calculated based on a valid PRACH occasion within multiple PRACH occasions for multiple PRACH transmission of MSGA or a set of valid PRACH occasions within multiple PRACH occasions for multiple PRACH transmission of MSGA. In some embodiments, the MSGB-RNTI is determined based on the beam index of MSGA.

[0122] In some embodiments, the MSGB-RNTI can be determined based on the beam index of MSGA from UE side, as shown in following: MSGB-RNTI = $1 + s_id + 14 \times t_id + 14 \times 80 \times f_id + 14 \times 80 \times 8 \times ul_carrier_id + 14 \times 80 \times 8 \times 2 + beam_index$

[0123] where s_id is the index of the first OFDM symbol of the last valid or any one valid PRACH occasion within the multiple PRACH occasions for multiple PRACH transmission of MSG A ($0 \leq s_id < 14$) , t_id is the index of the first slot of the PRACH occasion in a system frame ($0 \leq t_id < 80$) , where the sub-carrier spacing to determine t_id is based on the value of μ specified in clause 5.3.2 in TS 38.211 [8] for $\mu = \{0, 1, 2, 3\}$, and for $\mu = \{5, 6\}$, t_id is the index of the 120 kHz slot in a system frame that contains the PRACH occasion ($0 \leq t_id < 80$) , f_id is the index of the PRACH occasion in the frequency domain ($0 \leq f_id < 8$) , and $ul_carrier_id$ is the UL carrier used for Random Access Preamble transmission (0 for N UL carrier, and 1 for SUL carrier) , $beam_index$ is the beam index from UE side.

[0124] Further details on how to determine the RAR window of MSGB are described as follows.

[0125] This disclosure proposes method (s) to determine the RAR of MSG A, the number of PRACH of an attempt of RACH procedure can be regarded as an entity for being associated to determination on the RAR of MSG A. In current 3GPP specification, the RAR window for 2-step RACH is based on the corresponding PUSCH within the MSG A. However, when the repetition of the PUSCH within MSG A is enabled, how to determine the RAR windows for 2-step RACH should be studied.

[0126] In a first possible solution of the present application, in response to a transmission of a PRACH and a PUSCH or to a transmission of multiple PRACHs if the PRACH preamble is mapped to a valid or a set of valid PUSCH occasions, a UE attempts to detect a DCI format 1_0 with CRC scrambled by a corresponding MSGB-RNTI during a window controlled by higher layers (e.g. TS 38.321) . The window starts at the first symbol of the earliest CORESET the UE is configured to receive PDCCH for Type1-PDCCH CSS set or the first symbol

of the PDCCH occasion, that is at least one symbol after the last symbol of the last or last actual PUSCH occasion or last PUSCH occasion detected by gNB corresponding to the multiple PRACH transmission, where the symbol duration corresponds to the SCS for Type1-PDCCH CSS set. For instance, as shown in FIG. 8, it is assumed that 4 PRACH repetition transmits over 4 ROs {RO1, RO3, RO5, RO7} and the corresponding PUSCH with 2 repetition transmits over 2 PUSCH occasions (POs) {PO1, PO2}, then the start of RAR window of MSGB is based on PO2.

[0127] In a second possible solution of the present application, in response to a transmission of a PRACH and a PUSCH, or to a transmission of only a PRACH if the PRACH preamble is mapped to a valid PUSCH occasion, a UE attempts to detect a DCI format 1_0 with CRC scrambled by a corresponding MsgB-RNTI during a window controlled by higher layers (e.g. TS 38.321). The window starts at the first symbol of the earliest CORESET the UE is configured to receive PDCCH for Type1-PDCCH CSS set or the first symbol of each the PDCCH occasion, that is at least one symbol after the last symbol of the last or last actual PUSCH occasion or last PUSCH occasion detected by gNB corresponding to the PRACH transmission, where the symbol duration corresponds to the SCS for Type1-PDCCH CSS set. For instance, as shown in FIG. 9, it is assumed that 4 PRACH repetition transmits over 4 ROs {RO1, RO3, RO5, RO7} and the corresponding PUSCH with 2 repetition transmits over 2 POs {PO1, PO2}, then the start of RAR window 1 of MSGB is based on PO1, the start of RAR window 2 of MSGB is based on PO2.

[0128] In a third possible solution of the present application, in response to a transmission of a PRACH and a PUSCH, or to a transmission of only a PRACH if the PRACH preamble is mapped to a valid PUSCH occasion, a UE attempts to detect a DCI format 1_0 with CRC scrambled by a corresponding MsgB-RNTI during a window controlled by higher layers (e.g. TS 38.321). The multiple windows start at the first symbol of the earliest CORESET the UE is configured to receive PDCCH for Type1-PDCCH CSS set or the first symbol of the PDCCH occasion, that is at least one symbol after each of the last symbol of the last PUSCH within a set of POs within MSGA or each of the last symbol of the actual PUSCH occasion within a set of POs within MSGA or each of the last symbol of the last PUSCH occasion within a set of POs within MSGA detected by gNB, where the symbol duration corresponds to the SCS for Type1-PDCCH CSS set.

[0129] FIG. 10 illustrates a wireless communication method according to still another embodiment of the present application. Referring to FIG. 10 in conjunction

with FIG. 3, the method 300 includes the following. In Step 310, the UE transmits to the base station MSGA on physical random access channel (PRACH) and physical uplink shared channel (PUSCH), wherein a set of random access channel (RACH) occasions (ROs) for multiple PRACH are associated to a PUSCH. With this method, cell coverage enhancement is realized.

[0130] In an embodiment, multiple ROs for an attempt of multiple PRACH transmission may be mapped to one PUSCH and/or demodulation reference signal (DMRS). In another embodiment, a set of ROs within multiple ROs for an attempt of multiple PRACH transmission may be mapped to one PUSCH and/or DMRS. In still another embodiment, each of ROs within multiple ROs for an attempt of multiple PRACH transmission may be mapped to one PUSCH and/or DMRS. In an embodiment, a time offset between PUSCH occasion (PO) and ROs may be based on a last RO within the multiple ROs for multiple PRACH transmission. In another embodiment, a time offset between PO and ROs may be based on a PRACH slot which includes a last RO within the multiple ROs used for multiple PRACH transmission. In still another embodiment, a time offset between the multiple ROs which are used for multiple PRACH transmission and PUSCHs for the multiple PUSCH transmission may be based on last ROs within the multiple ROs or a last slot which includes the last RO of the multiple PRACH transmission. In some embodiments, a pre-defined rule may be established between multiple PRACH and PUSCH.

[0131] Further details on how to determine the relationship between PRACH and corresponding PUSCH within MSG A are described as follows.

[0132] This disclosure proposes method (s) to determine the relationship between PRACH and PUSCH within MSG A. A set of ROs for multiple PRACH can be associated to a PUSCH. The conventional frequency-DMRS-time-slot mechanism used to map PRACH to PUSCH will cause misalignment between gNB and UE when multiple PRACH is enabled for 2-step RACH. In this case, the ROs of an attempt of PRACH can be regarded as an entity, and then this entity is mapped to a PUSCH (aPUSCH transmission occasion with same or different DMRS). The following methods can be considered.

[0133] In a first possible solution of the present application, multiple ROs for an attempt of multiple PRACH transmission (e.g. with same or different preambles) are mapped to one PUSCH and/or DMRS. In other words, when multiple PRACH transmission is enabled, the corresponding PUSCH is without repetition. In this case, multiple PRACH transmission of an attempt PRACH procedure can be associated to a PUSCH. For instance, as shown in FIG. 11, it is assumed that 2-step RACH procedure with 4 repetit

ion of PRACH over {RO1, RO3, RO5, RO7} is involved, then all of the ROs of the PRACH repetition should be mapped to one PO, e.g. PO1. RO means RACH occasion, and PO means a PUSCH occasion or a PUSCH transmission occasion. In some cases, an attempt of RACH procedure is with the indexes of ROs which are consecutive and increasing.

- [0134] In a second possible solution of the present application, a set of ROs within multiple ROs for an attempt of multiple PRACH transmission (e.g. with same or different preambles) are mapped to one PUSCH and/or DMRS. In other words, when multiple PRACH transmission is enabled, the corresponding PUSCH can also be with repetition. In this case, each set of PRACH transmission can be associated to a PUSCH. As shown in FIG. 12, it is assumed that 2-step RACH procedure with 4 repetition is involved and the repetition of PRACH can occupy 4 consecutive ROs in time domain, one attempt of multiple PRACH transmission is over {RO1, RO2, RO3, RO4}, another attempt of multiple PRACH transmission is over {RO2, RO4, RO6, RO8}, and then {RO1, RO3} are mapped to PO1, {RO5, RO7} are mapped to PO2, {RO2, RO4} are mapped to PO3, and {RO6, RO8} are mapped to PO4. RO means RACH occasion, and PO means a PUSCH occasion or a PUSCH transmission occasion. In some cases, the time offset between PO and ROs is based on the last RO or any one RO or any one fixed RO or any a set of ROs within the multiple ROs for multiple PRACH transmission. In some embodiments, the time offset between PO and ROs is based on the PRACH slot which includes the last RO or any one RO or any one fixed RO or any a set of ROs within the multiple ROs used for multiple PRACH transmission.
- [0135] In some embodiments, a ROG (RACH occasion group) is mapped to a PUSCH, and the number within a ROG can be determined as the following: Define $C = \text{mod}(M, N)$, $K1 = \text{ceil}(M/N)$, and $K2 = \text{floor}(M/N)$.
- [0136] M is the number of ROs for multiple PRACH transmission, N is the number of transmission occasion for PUSCH repetition for MSG A. Define $M1 = \text{mod}(P, M)$, $K1 = \text{ceil}(C/M)$, and $K2 = \text{floor}(C/M)$.
- [0137] If $M1 > 0$, ROG m , $m = 0, 1, \dots, M1-1$, consists of RO for PRACH repetition with indices $m \cdot K1 + k$, $k = 0, 1, \dots, K1-1$, ROG m , $m = M1, M1+1, \dots, M-1$, consists of RO for PRACH repetition with indices $M1 \cdot K1 + (m - M1) \cdot K2 + k$, $k = 0, 1, \dots, K2-1$.
- [0138] In some embodiments, a set of ROs within multiple ROs for an attempt of PRACH with same or different preambles are consecutive in time domain.
- [0139] In a third possible solution of the present application, each of ROs within multiple ROs for an attempt of multiple PRACH transmission (e.g. with same or

different preambles) are mapped to one PUSCH and/or DMRS. In other words, when multiple PRACH transmission is enabled, the corresponding PUSCH can also be with repetition and the repetition number of PUSCH is equal to the number of multiple PRACH. In this case, each of PRACH transmission can be associated to a PUSCH, as shown in FIG. 13.

[0140] In some embodiments, the time offset between multiple ROs which are used for multiple PRACH transmission and PUSCHs for multiple PUSCH transmission is based on the last ROs within the multiple ROs or last slot which includes the last RO of the multiple PRACH transmission.

[0141] In a fourth possible solution of the present application, a pre-defined rule is established between multiple PRACH and PUSCH, for example, a scale factor K is introduced for RO-to-PO, and the value of K is a real number (for example, 1, 0.5, 0.25). When the factor of K is configured as 0.25 and the number of multiple PRACH transmission is M , the number of repetition of PUSCH is equal to: $M \times 0.25$.

[0142] In some embodiments, the time offset between multiple ROs which are used for multiple PRACH transmission and PUSCHs for multiple PUSCH transmission is based on the last ROs or any one RO or any one fixed RO or any a set of ROs within the multiple ROs or last slot which includes the last RO or any one RO or any one fixed RO or any a set of ROs of the multiple PRACH transmission.

[0143] FIG. 14 illustrates a wireless communication method according to yet another embodiment of the present application. Referring to FIG. 14 in conjunction with FIG. 3, the method 400 includes the following. In Step 410, the UE transmits to the base station a uplink control information (UCI) or configured grant uplink control information (CG-UCI) indicating multiple transmission occasions (TOs) or un-used transmission occasions (TOs) within more than one configured grant (CG) configurations. With this method, better communication performance is achieved.

[0144] Further details on how to determine the relationship between a UCI and multiple TOs (Transmission Occasion) or multiple un-used TOs within more than one CG (configured grant) configurations are described as follows.

[0145] This disclosure proposes method (s) to determine the relationship between a UCI and multiple TOs within more than one CG configurations. More than a field within a UCI and joint coding of multiple TOs within more than one CG configurations can be used. The following methods can be considered. In some embodiments, the UCI is used to indicate the un-used TOs within a CG configuration which is carried by the first actual transmission TOs.

[0146] In a first possible solution of the present application, a UCI can be used to indicate a set of TOs within more than one CG configurations, each one of C

G have a corresponding bits field within the UCI and the mapping rules between CG and the bits field within UCI is pre-defined. For instance, as shown in FIG. 15, more than one bits field can be included by a UCI and each one of the bits field can be used to indicate the un-used TOs within a corresponding CG configuration, where the size of the multiple field size is the same and the highest field is associated to the lowest index of the CG within a cell, similar as others, e.g. field 1 is associated to CG1, field 2 is associated to CG2, field 3 is associated to CG 3,, and so on.

[0147] In some embodiments, the highest field is associated to the highest index of the CGs within a cell, similar as others,

[0148] In some embodiments, the highest field is associated to the highest index of the CGs within a cell, similar as others, as shown in FIG. 16, field 1 is associated to CG12, field 2 is associated to CG11, field 3 is associated to CG 10,, and so on.

[0149] In some embodiments, a bit field can be introduced within a UCI to indicate the CG configuration index, then the TOs within the corresponding CG configuration can be indicated as un-used TOs.

[0150] In a second possible solution of the present application, a UCI can be used to indicate the TOs as un-used TOs within more than one CG configurations and 2 set of bits field can be used to indicate the un-used TOs within more than one CG configurations, one of bits fields is used to indicate a set of CG configuration, one bits field is used to indicate a set of un-used TOs within CG configurations.

With this case, the corresponding configure list of CG information and un-used TOs should be configured. As show in Table 5 and Table 6 respectively, where more than one TO (s) and/or more than one CG (s) can be configured within an index. 2 sets of field can be included by the UCI, one bits field within the UCI indicates the index of table 5, which is the information of the Un-used TOs within the CG configurations, one bits field within the UCI indicates the index of table 6, which is the information of the related CG configurations. For instances, when the UCI indicates the “1” and “1”, then the {TO2, TO3, TO4, TO5, TO6, TO7, TO8} within {CG5, CG6, CG7, CG8} are indicated as un-used TOs.

[0151] Table 5. Un-used TOs within configurations

Index	Un-used TO index
0	1,2,3,4,5,6,7,8
1	2,3,4,5,6,7,8
2	5,6,7,8
3	8
.....	

[0152] Table 6. CG configuration index

Index	CG configuration index
0	1,2,3,4,5,6,7,8,9,10,11,12
1	5,6,7,8
2	3
3	4
4	1,2,3,4,
.....	

[0153] In some embodiments, a bit field can be defined in a UCI which is used to indicate the CC information, the UCI can indicate the un-used TOs within more than one CG configurations across CCs.

[0154] In a third possible solution of the present application, a UCI can be used to indicate the TOs as un-used TOs within more than one CG configurations and a bits field can be used to indicate the un-used TOs within more than one CG configurations, with this case, the CG configurations and un-used TOs can be coding combination, as show in Table 7, where, more than one Un-sued TOs and/or C G configurations can be configured within an index of the table. When the UCI indicates index 1, then the {TO2, TO3, TO4, TO5} within {CG1, CG2} are indicated as un-used TOs. When the UCI indicates index 2, when the {TO5, TO6, TO7, T O8} within {CG 4} are indicated as un-used TOs.

[0155] Table 7. CG and un-used TOs joint coding

index	Un-used TO or CG index	CG index or un-used TO
1	2,3,4,5	1,2
2	5,6,7,8	4
3	8	3
.....		

[0156] In a fourth possible solution of the present application, a CG configurations information and/or a time unit can be indicated by a UCI, with this case, the TOs during the time unit within the indicated CG configurations are indicates as un-used TOs.

[0157] In some embodiments, 1 bit can be introduced into the CG-UCI which used to distinguish the type of CG-UCI, e.g. CG-UCI for NR-U or CG-UCI for R-18 or CG-UCI for XR.

[0158] In some embodiments, at least one of the following bits field can be included by the CG-UCI: an index of a set of ROs or the time value of K or the index of TOs or a field which used to distinguish different CG-UCIs or the number of un-used TOs or HARQ-ID indicate field or CG configuration indicate field or CC indicate field. Where CG configuration indicate field which is used to indicate

te the one or more CG index, CC indicate field which is used to indicate one or more CCs, time value of K which is used to determine the start/end of un-used TOs' location.

- [0159] FIG. 17 illustrates a wireless communication method according to yet another embodiment of the present application. Referring to FIG. 17 in conjunction with FIG. 3, the method 500 includes the following. In Step 510, the UE is configured by the base station with a configured grant (CG) configuration including more than one transmission occasions (TOs), wherein HARQ-ID of all of transmission occasions (TOs) within the CG configuration are determined. With this method, better communication performance is achieved.
- [0160] Further details on how to determine the resource/transmission occasions within a CG configuration are described as follows.
- [0161] This disclosure proposes method (s) to determine the resource/transmission occasions within a CG configuration, mainly focus on a semi-static way to determine the HARQ-ID of all of the TOs within a CG configuration, especially for the case when the TOs with repetition is considered. For the multiple TOs can be used for transmission over more than one TBs, so the HARQ-ID for each TO or each a set of TO must be different to avoid the ambiguity between UE and gNB for retransmission, where TO means transmission occasion.
- [0162] The HARQ-ID for the TOs within a CG configuration can be determined as following:
- [0163] For configured uplink grants neither configured with harq-ProcID-Offset2 nor with cg-RetransmissionTimer, the HARQ Process ID associated with the first symbol of a UL transmission is derived from the following equation: HARQ Process ID = $\lfloor \text{CURRENT_symbol} / \text{periodicity} \rfloor + \text{TO_index} \bmod \text{nrofHARQ-Processes}$
- [0164] For configured uplink grants with harq-ProcID-Offset2, the HARQ Process ID associated with the first symbol of a UL transmission is derived from the following equation: HARQ Process ID = $\lfloor \text{CURRENT_symbol} / \text{periodicity} \rfloor + \text{TO_index} \bmod \text{nrofHARQ-Processes} + \text{harq-ProcID-Offset2}$
- [0165] where $\text{CURRENT_symbol} = (\text{SFN} \times \text{numberOfSlotsPerFrame} \times \text{numberOfSymbolsPerSlot} + \text{slot number in the frame} \times \text{numberOfSymbolsPerSlot} + \text{symbol number in the slot})$, and $\text{numberOfSlotsPerFrame}$ and $\text{numberOfSymbolsPerSlot}$ refer to the number of consecutive slots per frame and the number of consecutive symbols per slot, The TO_index is the index of the TOs within a CG configuration, and is an integer and the CURRENT_symbol is based on the first TOs or first actual transmission TOs or first TO configured by gNB.

- [0166] In some embodiments, the HARQ-ID for the TOs within a CG configuration can be determined as following:
- [0167] For configured uplink grants neither configured with harq-ProcID-Offset2 nor with cg-RetransmissionTimer, the HARQ Process ID associated with the first symbol of a UL transmission is derived from the following equation: HARQ Process ID = $\lfloor \text{CURRENT_symbol} / \text{periodicity} \rfloor + \text{TO_index1} \bmod \text{nrofHARQ-Processes}$
- [0168] For configured uplink grants with harq-ProcID-Offset2, the HARQ Process ID associated with the first symbol of a UL transmission is derived from the following equation: HARQ Process ID = $\lfloor \text{CURRENT_symbol} / \text{periodicity} \rfloor + \text{TO_index1} \bmod \text{nrofHARQ-Processes} + \text{harq-ProcID-Offset2}$
- [0169] where $\text{CURRENT_symbol} = (\text{SFN} \times \text{numberOfSlotsPerFrame} \times \text{numberOfSymbolsPerSlot} + \text{slot number in the frame} \times \text{numberOfSymbolsPerSlot} + \text{symbol number in the slot})$, and $\text{numberOfSlotsPerFrame}$ and $\text{numberOfSymbolsPerSlot}$ refer to the number of consecutive slots per frame and the number of consecutive symbols per slot, The TO_index1 is the virtual index of a set of TOs within a CG configuration, and is an integer, where, the set of TOs with the same virtual index which have the same HARQ-ID. The CURRENT_symbol is based on the first TOs or first actual transmission TOs or first TO configured by gNB. Where the virtual index of a set of TOs within a CG configuration can be determined as following:
- [0170] As shown in FIG. 18, 8 TOs are configured within a CG configuration, and {TO1, TO2} grouped set 1 and the virtual index is 1, and {TO3, TO4} grouped set 2 and the virtual index is 2, and {TO5, TO6} grouped set 3 and the virtual index is 3, and {TO7, TO8} grouped set 4 and the virtual index is 4. In some embodiments, the number of the set of TOs is associated to the repetition of TOs.
- [0171] FIG. 19 illustrates a wireless communication method according to yet another embodiment of the present application. Referring to FIG. 19 in conjunction with FIG. 3, the method 600 includes the following. In Step 610, the multiplexing rules between a configured grant (CG) -uplink control information (UCI) and the UCIs (e.g. HARQ-ACK and/or CSI and/or CSI-part and/or CSI-part2 and/or CG-UCI and/or SR and/or other type UCI, etc.) is determined. With this method, better communication performance is achieved.
- [0172] Further details on how to determine the multiplexing rules between different types of CG-UCI and other UCIs are described as follows.
- [0173] This disclosure proposes method (s) to determine the multiplexing rules between different type of CG-UCI and other UCIs (e.g. HARQ-ACK, SR, CSI part 1, CSI part 2, CSI.) , mainly focus on more than one UCIs (CG-UCIs and/or other UCIs) are multiplexed PUSCH (especially for CG-PUSCH) . The same type of CG-UCIs

can be regarded as an entity for encoding and new type of CG-UCI (CG-UCI for R-18 or the CG-UCI which is different from the CG-UCI for NR-U) or priority rules between more than one types of UCIs can be considered. In some embodiments, when higher layer parameter cg-UCI-Multiplexing (a parameter used to enable multiplexing) is configured, then the new type of CG-UCI (denote as CG-UCI 1) can be combination encoding with HARQ-ACK, the bits sequence is determined as: $A = O_CG-UCI1 + O_ACK$ or $A = O_ACK + O_CG-UCI1$, where $O_CG-UCI1$ and/or O_ACK are the CG-UCI bits sequence and HARQ-ACK sequence respectively. In some embodiments, when both of CG-UCI for NR-U (denote as CG-UCI0) or R-18 (e.g. XR) (denote as CG-UCI1) are configured and/or cg-UCI-Multiplexing (a parameter used to enable multiplexing) is configured, then both of CG-UCI and HARQ-ACK can be combination encoding (means), the bits sequence are determined as: $B = O_CG-UCI0 + O_CG-UCI1 + O_ACK$ or $B = O_CG-UCI1 + O_CG-UCI0 + O_ACK$ or $B = O_ACK + O_CG-UCI0 + O_CG-UCI1$ or $B = O_ACK + O_CG-UCI1 + O_CG-UCI0$ or $B = O_CG-UCI0 + O_ACK + O_CG-UCI1$ or $B = O_CG-UCI1 + O_ACK + O_CG-UCI0$. In some embodiments, when both of CG-UCI for NR-U (denote as CG-UCI0) and/or R-18 (e.g. XR) (denote as CG-UCI1) are configured and/or cg-UCI-Multiplexing (a parameter used to enable multiplexing) is configured, the CG-UCI 0 and CG-UCI 1 can be combination encoding (in other word, it can be regarded as an entity) . In some embodiments, when both of CG-UCI for NR-U (denote as CG-UCI0) and/or R-18 (e.g. XR) (denote as CG-UCI1) are configured and/or cg-UCI-Multiplexing (a parameter used to enable multiplexing) is configured, the CG-UCI 0 and/or CG-UCI 1 can be set as highest priority.

- [0174] In some embodiments, If uci-MuxWithDiffPrio or a parameter enable different priority of UCI (include at least one of CG-UCI and HARQ-ACK and CSI.) is configured, and HARQ-ACK bits associated with priority index 0, HARQ-ACK bits associated with priority index 1 and/or CG-UCI 0 (CG-UCI for NR-U) or CG-UCI 1 (CG-UCI for R-18, e.g. XR) associated with priority index 1 or index 0, and CSI part 1 or CSI or CSI part 2 if any are transmitted on a PUSCH or a CG-PUSCH, the following UCI bit sequences are generated as: A1, B1 and C1 or A1 and B1 or A1. Where A1 is a bits sequences for HARQ-ACK with high priority (e.g. priority index 1) or a bits sequences for CG UCI 0 with high priority (e.g. priority index 1) or a bits sequences for CG UCI 1 with high priority (e.g. priority index 1) or a bits sequences for HARQ-ACK+ CG-UCI 0 or CG-UCI 0 + HARQ-ACK with high priority (e.g. priority index 1) or a bits sequences for CG UCI 0 + CG-UCI 1 + HARQ-ACK or CG UCI 1 +CG-UCI 0 + HARQ-ACK with high priority (e.g. priority index 1) .

- [0175] If CSI part 1 is also transmitted on the PUSCH and the PUSCH is associated with priority index 1, where B1 is a bit sequences for CSI or CSI-part1 or CSI-part 2 bits sequences, where C1 is a bit sequences for HARQ-ACK bits with priority index 0.
- [0176] Alternatively, where B1 is a bit sequences for HARQ-ACK with priority with index 0, where C1 is a bits sequences for CSI or CSI part 1 or CSI part 2 with priority with index 0.
- [0177] Alternatively, if uci-MuxWithDiffPrio or a parameter enable different priority of UCI (include at least one of CG-UCI and HARQ-ACK and CSI.) is configured, and HARQ-ACK bits associated with priority index 0, HARQ-ACK bits associated with priority index 1 and/or CG-UCI 0 (CG-UCI for NR-U) or CG-UCI 1 (CG-UCI for R-18, e.g. XR) associated with priority index 1 or index 0, and CSI part 1 or CSI or CSI part 2 if any are transmitted on a PUSCH or a CG-PUSCH associated with priority 0, the following UCI bit sequences are generated as : a1, b1 and c1 or a1 and b1 or a1. Where a1 is a bits sequences for HARQ-ACK with high priority (e.g. priority index 1) . Where b1 is a bits sequences for a bits sequences for CG UCI 0 with low priority (e.g. priority index 0) or a bits sequences for CG UCI 1 with low priority (e.g. priority index 0) or a bits sequences for HARQ-ACK+ CG-UCI 0 or CG-UCI 0 + HARQ-ACK with low priority (e.g. priority index 0) or a bits sequences for CG UCI 0 + CG-UCI 1 +HARQ-ACK or CG UCI 1 + CG-UCI 0 + HARQ-ACK with low priority (e.g. priority index 0) . Where c1 is the bits sequences for CSI or CSI-part1 or CSI-part2 bits sequences with low priority (e.g. priority index 0) .
- [0178] Commercial interests for some embodiments are as follows. 1. Solving issues in the prior art. 2. Realizing cell coverage enhancement. 3. Providing a good communication performance. Some embodiments of the present application are used by 5G-NR chipset vendors, V2X communication system development vendors, automakers including cars, trains, trucks, buses, bicycles, motorcycles, helmets, and etc., drones (unmanned aerial vehicles) , smartphone makers, communication devices for public safety use, AR/VR device maker for example gaming, conference/seminar, education purposes. Some embodiments of the present application are a combination of “techniques/processes” that can be adopted in 3GPP specification to create an end product. Some embodiments of the present application could be adopted in the 5G NR unlicensed band communications. Some embodiments of the present application propose technical mechanisms.
- [0179] The embodiment of the present application further provides a computer readable storage medium for storing a computer program. The computer

er readable storage medium enables a computer to execute corresponding processes implemented by the UE/BS in each of the methods of the embodiments of the present application. For brevity, details will not be described herein again.

[0180] The embodiment of the present application further provides a computer program product including computer program instructions. The computer program product enables a computer to execute corresponding processes implemented by the UE/BS in each of the methods of the embodiments of the present application. For brevity, details will not be described herein again.

[0181] The embodiment of the present application further provides a computer program. The computer program enables a computer to execute corresponding processes implemented by the UE/BS in each of the methods of the embodiments of the present application. For brevity, details will not be described herein again.

[0182] The non-transitory computer readable medium may include at least one from a group consisting of: a hard disk, a CD-ROM, an optical storage device, a magnetic storage device, a Read Only Memory, a Programmable Read Only Memory, an Erasable Programmable Read Only Memory, EPROM, an Electrically Erasable Programmable Read Only Memory and a Flash memory. In an embodiment where the elements are implemented using software, the software may be stored in a computer-readable medium and loaded into a computing system using, for example, removable storage drive. A control module (in this example, software instructions or executable computer program code), when executed by the processor in the computer system, causes a processor to perform the functions of the invention as described herein.

[0183] Furthermore, the inventive concept can be applied to any circuit for performing signal processing functionality within a network element. It is further envisaged that, for example, a semiconductor manufacturer may employ the inventive concept in a design of a stand-alone device, such as a microcontroller of a digital signal processor (DSP), or application-specific integrated circuit (ASIC) and/or any other sub-system element.

[0184] A person of ordinary skill in the art may be aware that, in combination with the examples described in the embodiments disclosed in this specification, units and algorithm steps may be implemented by electronic hardware or a combination of computer software and electronic hardware. Whether the functions are performed by hardware or software depends on particular applications and design constraint conditions of the technical solutions. A person skilled in the art may use different approaches to implement the described functions for each particular applicat

ion, but it should not be considered that the implementation goes beyond the scope of the present application.

[0185] While the present application has been described in connection with what is considered the most practical and preferred embodiments, it is understood that the present application is not limited to the disclosed embodiments but is intended to cover various arrangements made without departing from the scope of the broadest interpretation of the appended claims.

Claims

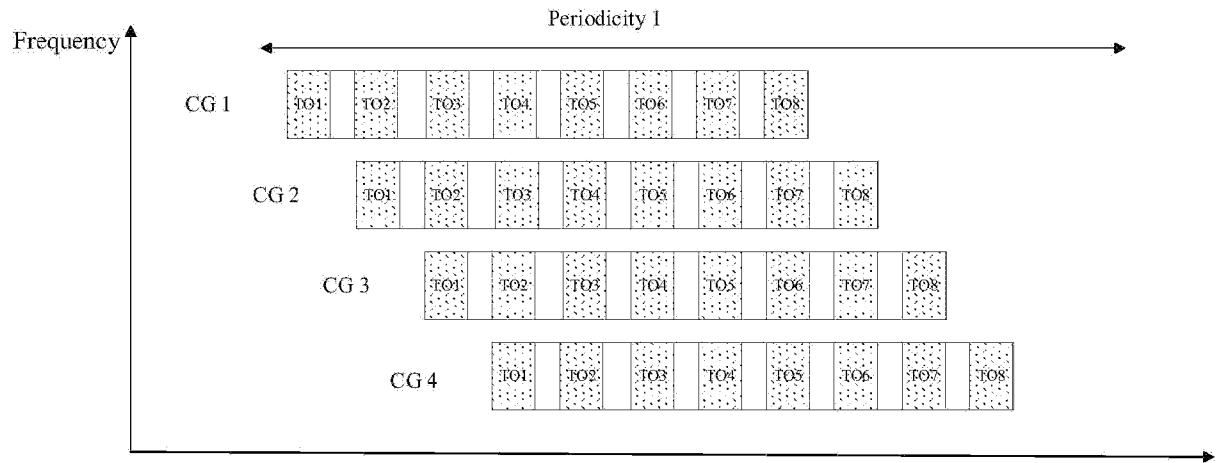
- [Claim 1] A wireless communication method, performed by a user equipment (UE), the method comprising:
being configured with a repetition number of physical random access channel (PRACH) for random access.
- [Claim 2] The method of claim 1, wherein the repetition number of PRACH is configured by radio resource control (RRC) signaling.
- [Claim 3] The method of claim 1, wherein the repetition number of PRACH is indicated by downlink control information (DCI).
- [Claim 4] The method of claim 3, wherein the repetition number of PRACH is indicated by a table of PRACH Mask Index.
- [Claim 5] The method of claim 3, wherein the repetition number of PRACH is indicated by a field in DCI.
- [Claim 6] The method of claim 1, wherein candidate values of PRACH repetition are configured by RRC, and one of the candidate values is indicated by DCI.
- [Claim 7] The method of claim 1, wherein each state of frequency domain resource assignment (FDRA) in DCI is used to indicate one of candidate values of PRACH repetition.
- [Claim 8] A wireless communication method, performed by a user equipment (UE), the method comprising:
detecting random access response (RAR) of MSGA in a RAR window based on MSGB-radio network temporary identifier (RNTI).
- [Claim 9] The method of claim 8, wherein the MSGB-RNTI is based on a valid PRACH occasion within multiple PRACH occasions for multiple PRACH transmission of MSGA.
- [Claim 10] The method of claim 8, wherein the MSGB-RNTI is based on a set of valid PRACH occasions within multiple PRACH occasions for multiple PRACH transmission of MSGA.
- [Claim 11] The method of claim 8, wherein the MSGB-RNTI is based on beam index of MSGA.
- [Claim 12] The method of claim 8, wherein the RAR window starts from at least one symbol after a last symbol of last physical uplink shared channel (PUSCH) occasion corresponding to multiple PRACH transmission.

- [Claim 13] The method of claim 8, wherein the RAR window starts from at least one symbol after a last symbol of last PUSCH occasion corresponding to each of multiple PRACH transmission.
- [Claim 14] The method of claim 8, wherein the RAR window starts from at least one symbol after each last symbol of last PUSCH occasion within a set of PUSCH occasions within MSGA.
- [Claim 15] A wireless communication method, performed by a user equipment (UE), the method comprising:
transmitting MSGA on physical random access channel (PRACH) and physical uplink shared channel (PUSCH), wherein a set of random access channel (RACH) occasions (ROs) for multiple PRACH are associated to a PUSCH.
- [Claim 16] The method of claim 15, wherein multiple ROs for an attempt of multiple PRACH transmissions are mapped to one PUSCH and/or demodulation reference signal (DMRS).
- [Claim 17] The method of claim 15, wherein a set of ROs within multiple ROs for an attempt of multiple PRACH transmissions are mapped to one PUSCH and/or DMRS.
- [Claim 18] The method of claim 15, wherein each of ROs within multiple ROs for an attempt of multiple PRACH transmissions are mapped to one PUSCH and/or DMRS.
- [Claim 19] The method of claim 15, wherein a time offset between PUSCH occasion (PO) and ROs is based on a last RO within the multiple ROs for multiple PRACH transmission.
- [Claim 20] The method of claim 15, wherein a time offset between PO and ROs is based on a PRACH slot which includes a last RO within the multiple ROs used for multiple PRACH transmission.
- [Claim 21] The method of claim 15, wherein a time offset between the multiple ROs which are used for multiple PRACH transmission and PUSCHs for the multiple PUSCH transmission is based on last ROs within the multiple ROs or a last slot which includes the last RO of the multiple PRACH transmission.
- [Claim 22] The method of claim 15, wherein a pre-defined rule is established between multiple PRACH and PUSCH.
- [Claim 23] A wireless communication method, performed by a base station (BS), the method comprising:
configuring a user equipment (UE) with a repetition number of physical random access channel (PRACH) for random access.

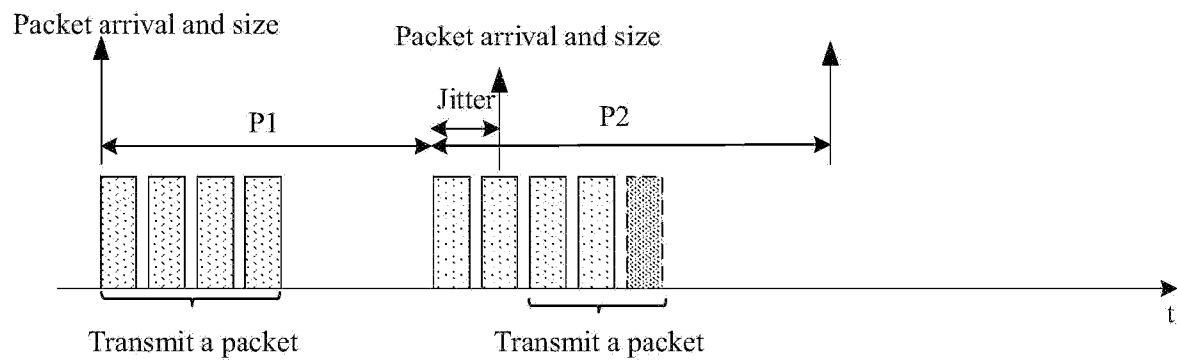
- [Claim 24] The method of claim 23, wherein the repetition number of PRACH is configured by radio resource control (RRC) signaling.
- [Claim 25] The method of claim 23, wherein the repetition number of PRACH is indicated by downlink control information (DCI) .
- [Claim 26] The method of claim 25, wherein the repetition number of PRACH is indicated by a table of PRACH Mask Index.
- [Claim 27] The method of claim 25, wherein the repetition number of PRACH is indicated by a field in DCI.
- [Claim 28] The method of claim 23, wherein candidate values of PRACH repetition are configured by RRC, and one of the candidate values is indicated by DCI.
- [Claim 29] The method of claim 23, wherein each state of frequency domain resource assignment (FDRA) in DCI is used to indicate one of candidate values of PRACH repetition.
- [Claim 30] A wireless communication method, performed by a base station (BS) , the method comprising:
calculating MSGB-radio network temporary identifier (RNTI) for a user equipment (UE) to detect random access response (RAR) of MSGA in an RAR window based on the MSGB-RNTI.
- [Claim 31] The method of claim 30, wherein the MSGB-RNTI is calculated based on a valid PRACH occasion within multiple PRACH occasions for multiple PRACH transmission of MSGA.
- [Claim 32] The method of claim 30, wherein the MSGB-RNTI is calculated based on a set of valid PRACH occasions within multiple PRACH occasions for multiple PRACH transmission of MSGA.
- [Claim 33] The method of claim 30, wherein the MSGB-RNTI is calculated based on beam index of MSGA.
- [Claim 34] A wireless communication method, performed by a base station (BS) , the method comprising:
receiving MSGA on physical random access channel (PRACH) and physical uplink shared channel (PUSCH) , wherein a set of random access channel (RACH) occasions (ROs) for multiple PRACH are associated to a PUSCH.
- [Claim 35] The method of claim 34, wherein multiple ROs for an attempt of multiple PRACH transmission are mapped to one PUSCH and/or demodulation reference signal (DMRS) .

- [Claim 36] The method of claim 34, wherein a set of ROs within multiple ROs for an attempt of multiple PRACH transmission are mapped to one PUSCH and/or DMRS.
- [Claim 37] The method of claim 34, wherein each of ROs within multiple ROs for an attempt of multiple PRACH transmission are mapped to one PUSCH and/or DMRS.
- [Claim 38] The method of claim 34, wherein a time offset between PUSCH occasion (PO) and ROs is based on a last RO within the multiple ROs for multiple PRACH transmission.
- [Claim 39] The method of claim 34, wherein a time offset between PO and ROs is based on a PRACH slot which includes a last RO within the multiple ROs used for multiple PRACH transmission.
- [Claim 40] The method of claim 34, wherein a time offset between the multiple ROs which are used for multiple PRACH transmission and PUSCHs for the multiple PUSCH transmission is based on last ROs within the multiple ROs or a last slot which includes the last RO of the multiple PRACH transmission.
- [Claim 41] The method of claim 34, wherein a pre-defined rule is established between multiple PRACH and PUSCH.
- [Claim 42] A user equipment (UE) , comprising a processor, configured to call and run program instructions stored in a memory, to execute the method of any of claims 1 to 7.
- [Claim 43] A user equipment (UE) , comprising a processor, configured to call and run program instructions stored in a memory, to execute the method of any of claims 8 to 14.
- [Claim 44] A user equipment (UE) , comprising a processor, configured to call and run program instructions stored in a memory, to execute the method of any of claims 15 to 22.
- [Claim 45] A base station (BS) , comprising a processor, configured to call and run program instructions stored in a memory, to execute the method of any of claims 23 to 29.
- [Claim 46] A base station (BS) , comprising a processor, configured to call and run program instructions stored in a memory, to execute the method of any of claims 30 to 33.
- [Claim 47] A base station (BS) , comprising a processor, configured to call and run program instructions stored in a memory, to execute the method of any of claims 34 to 41.

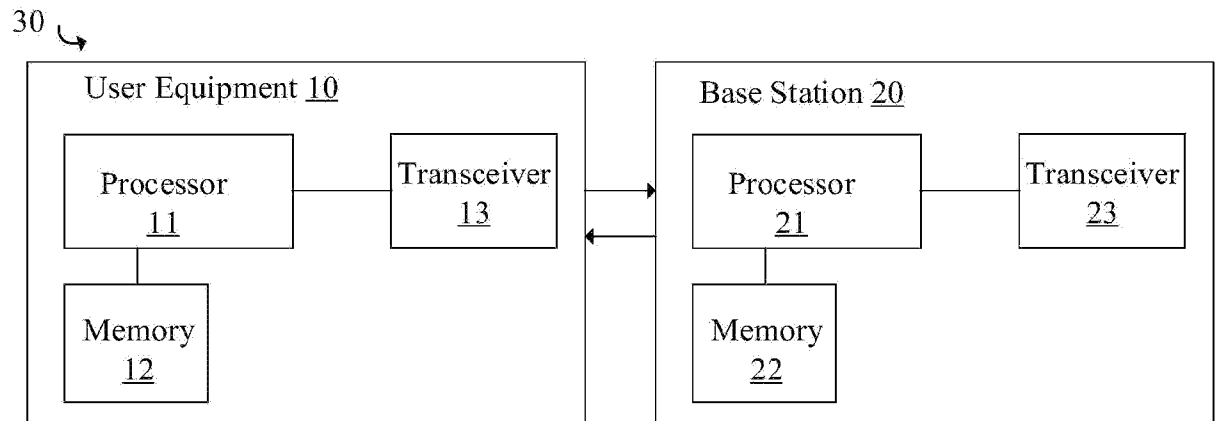
[Fig. 1]



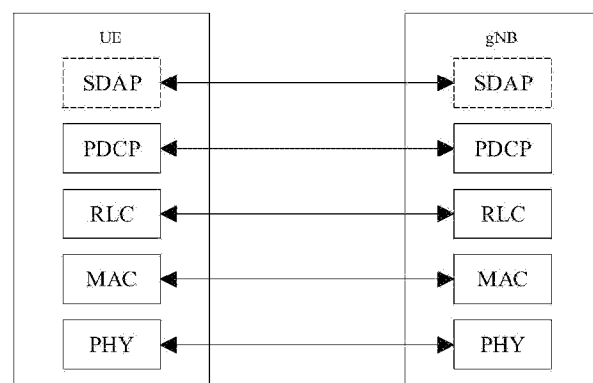
[Fig. 2]



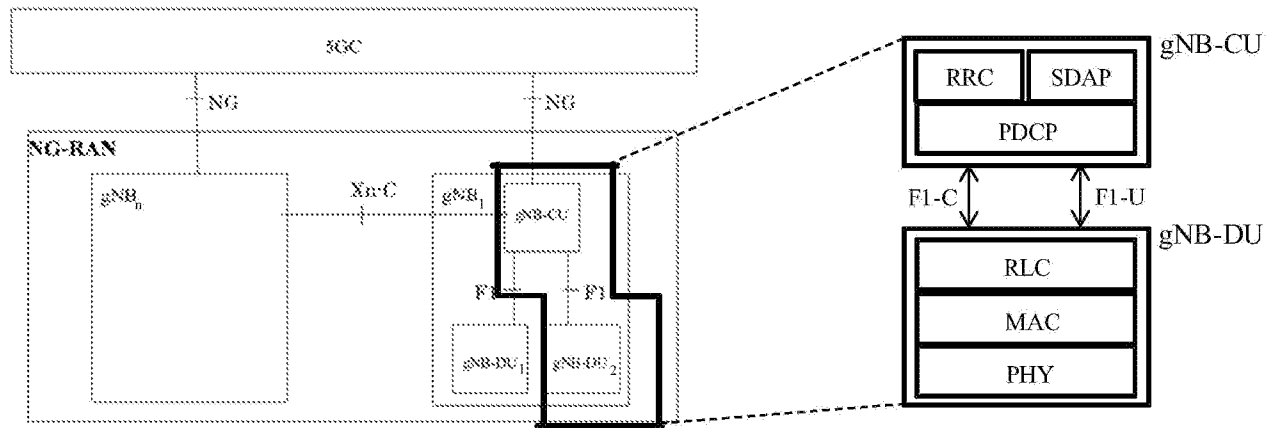
[Fig. 3]



[Fig. 4]



[Fig. 5]



[Fig. 6]

100 →

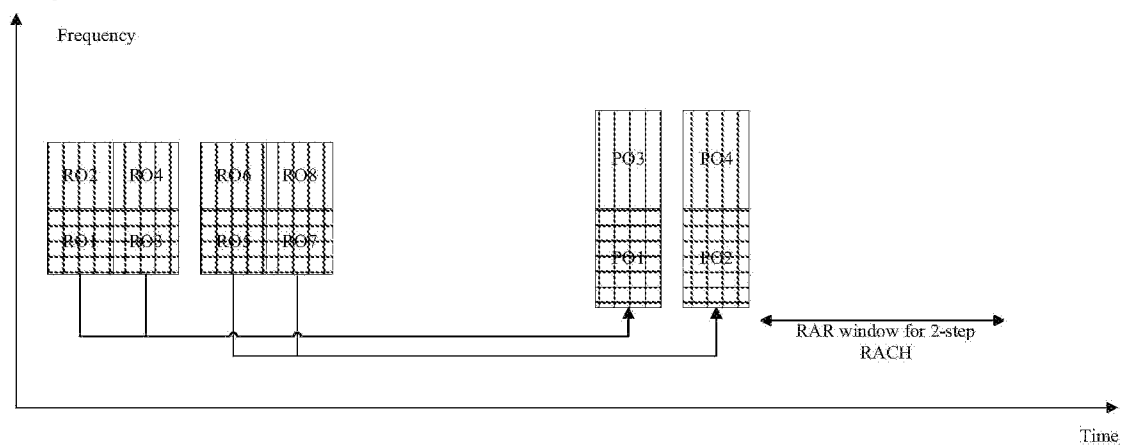
110 → being configured with a repetition number of PRACH for random access

[Fig. 7]

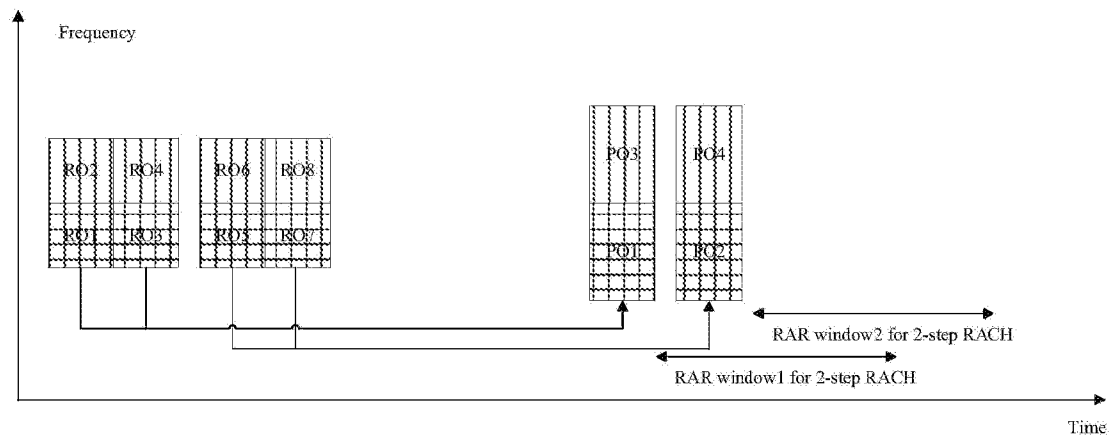
200 →

210 → detecting RAR of MSGA in an RAR window based on MSGB-RNTI

[Fig. 8]



[Fig. 9]

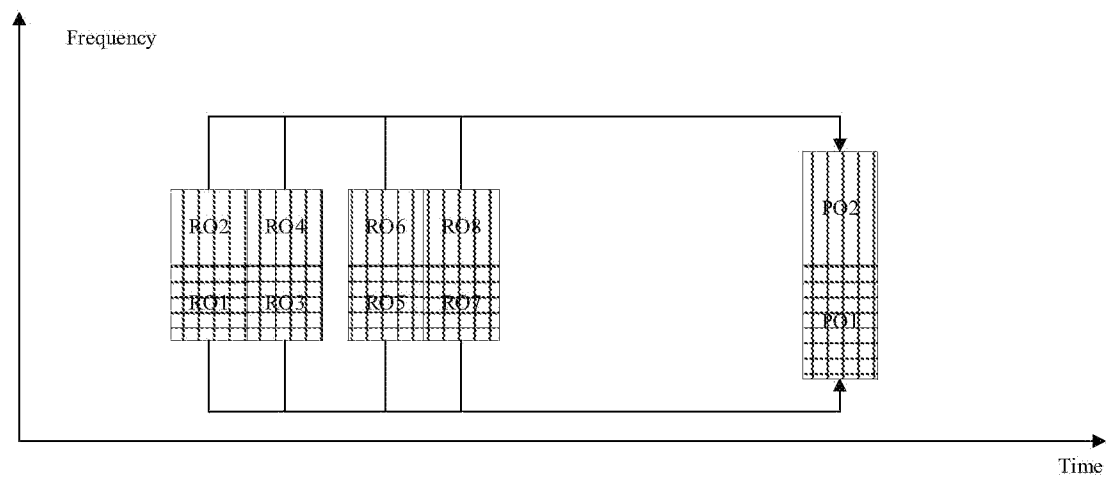


[Fig. 10]

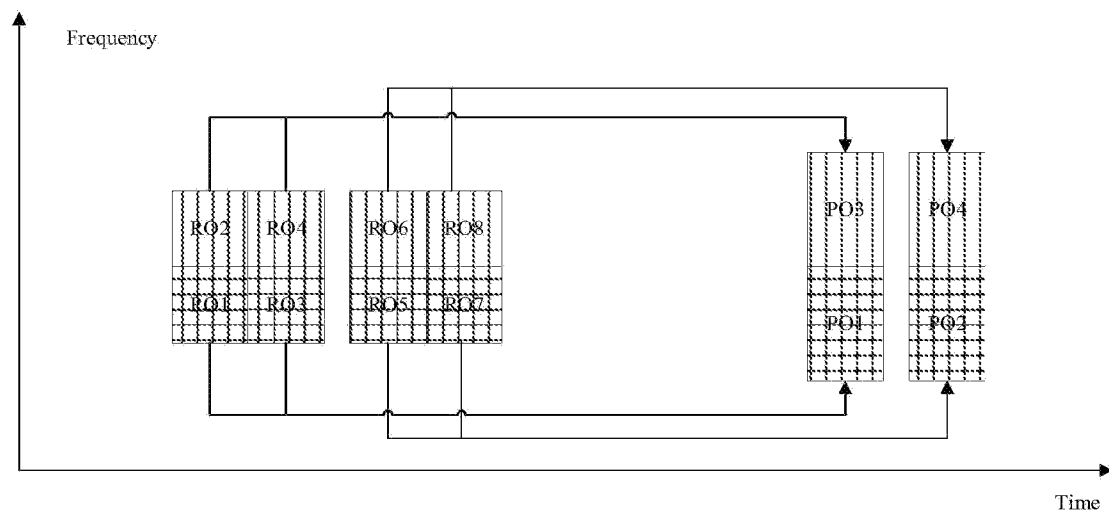
300

310 transmitting MSGA on PRACH and PUSCH, wherein a set of RACH occasions (ROs) for multiple PRACH are associated to a PUSCH

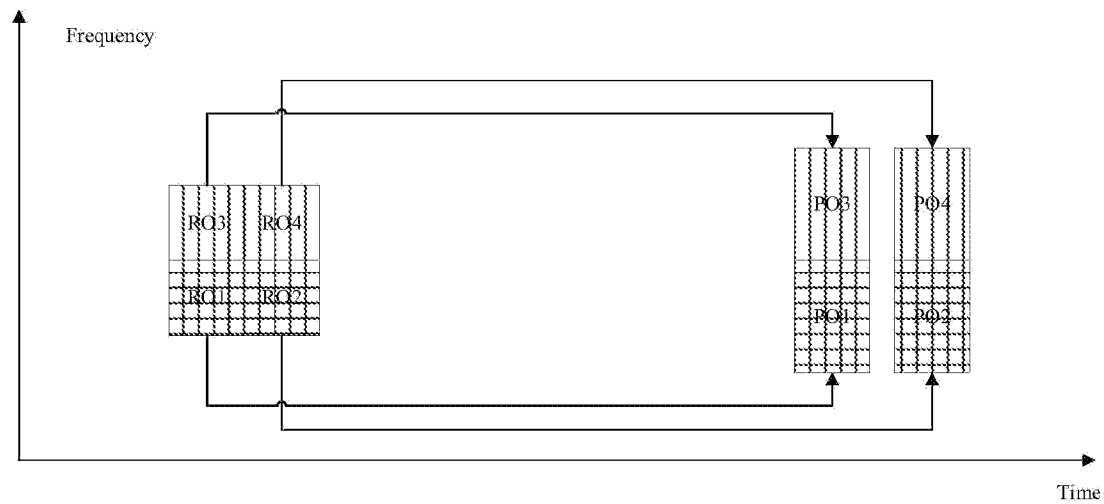
[Fig. 11]



[Fig. 12]



[Fig. 13]

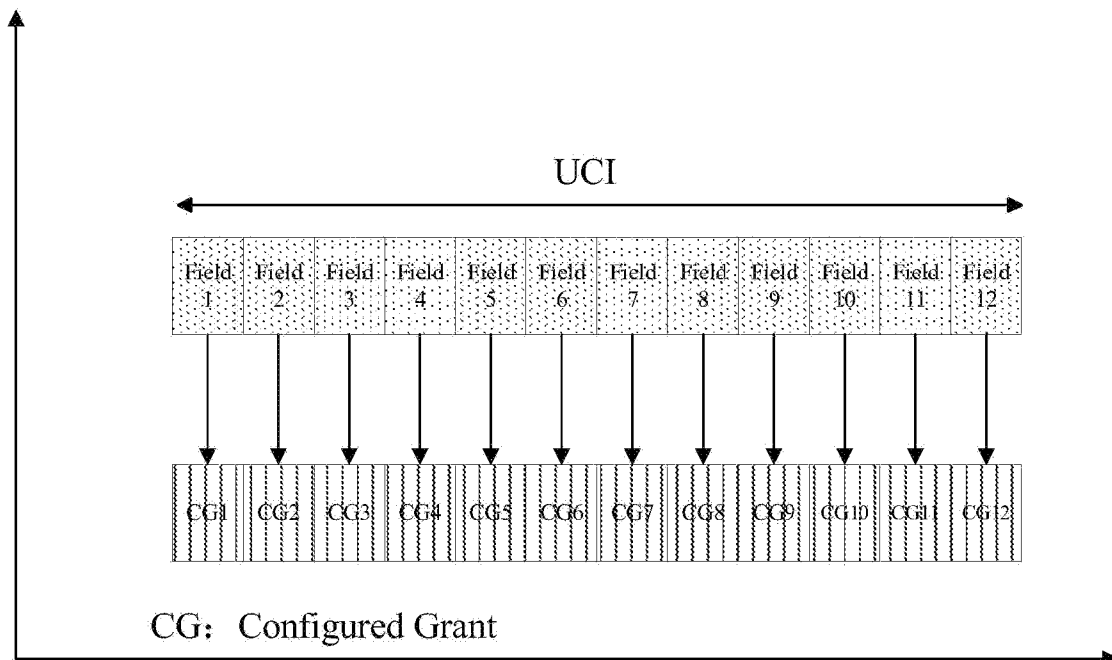


[Fig. 14]

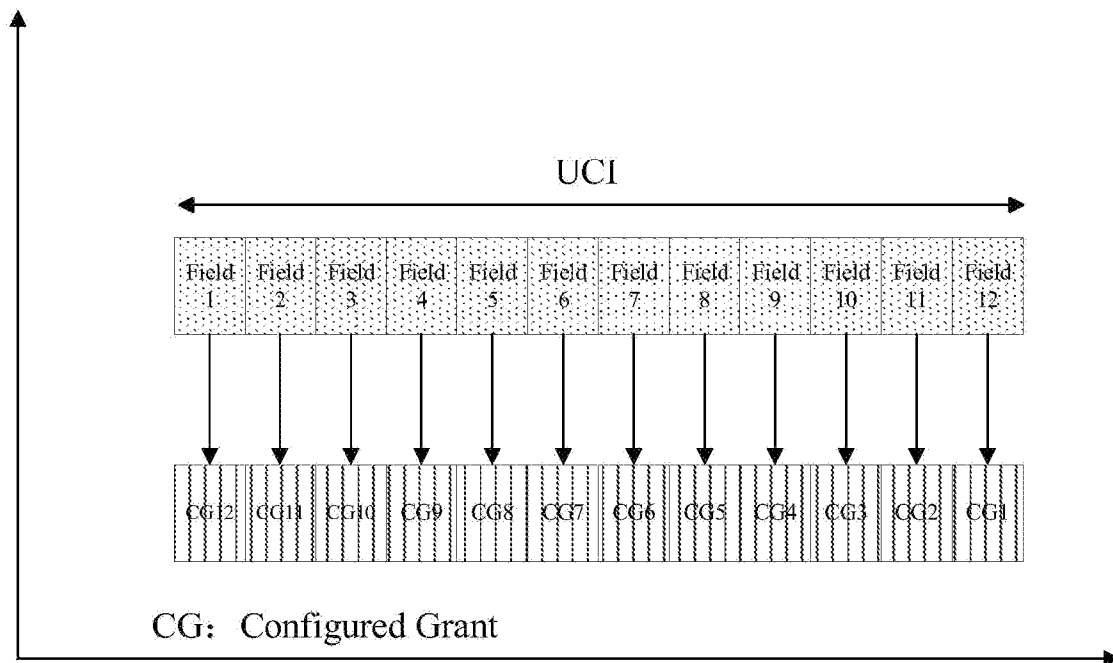
400

410 transmitting a UCI or CG-UCI indicating multiple TOs or un-used TOs within more than one CG configurations

[Fig. 15]



[Fig. 16]

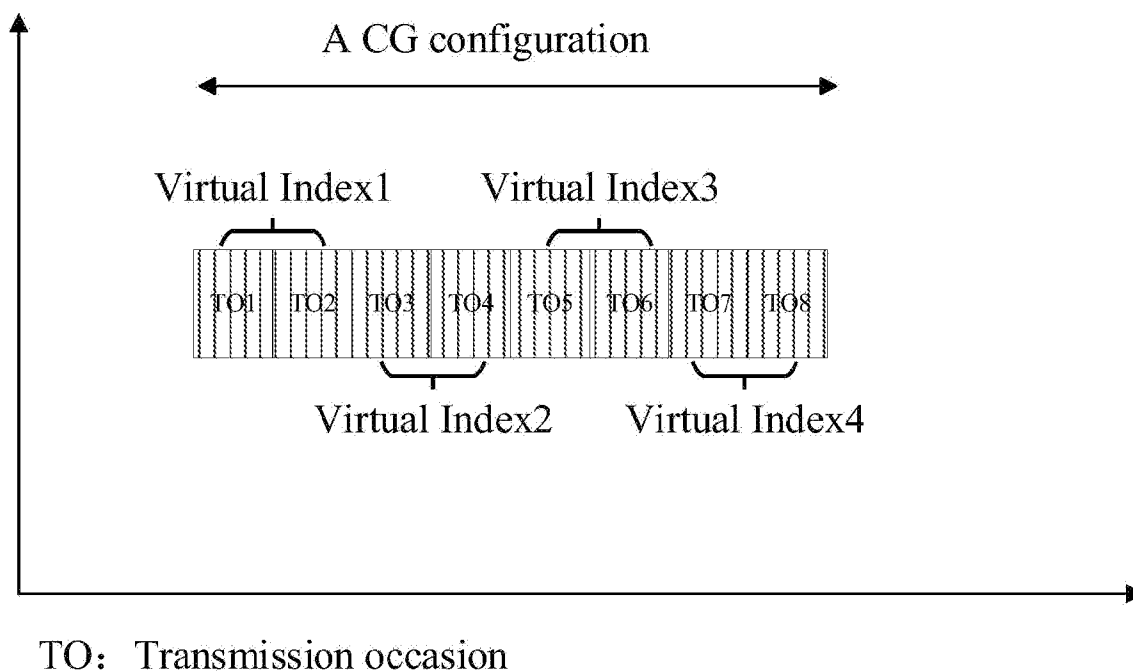


[Fig. 17]

500 →

510 → being configured with a CG configuration including more than one TOs, wherein HARQ-ID of all of TOs within the CG configuration are determined

[Fig. 18]



[Fig. 19]
600 →



INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2023/087066

A. CLASSIFICATION OF SUBJECT MATTER

H04W74/08(2009.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H04W 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)

CNTCT,ENTXT,DWPI,CNKL,3GPP:2-step,random,access,RA,RACH,PRACH,MSG,MSG,MSG,RAR,repitition,coverage,enhancement>window,RNTI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2021231816 A1 (CONVIDA WIRELESS, LLC) 18 November 2021 (2021-11-18) description, paragraphs [269]-[277]	1-7、15-29、34-42、44-45、47
X	CN 114080047 A (VIVO MOBILE COMMUNICATION CO, LTD) 22 February 2022 (2022-02-22) description, paragraphs [42]-[76]、[202]	8-14、30-33、43、46
A	CN 115516991 A (INNOVATIVE TECHNOLOGY LAB CO., LTD.) 23 December 2022 (2022-12-23) the whole document	1-47
A	US 2021120581 A1 (ELECTRONICS AND TELECOMMUNICATIONS RESEARCH INSTITUTE) 22 April 2021 (2021-04-22) the whole document	1-47

☐ 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

“D” document cited by the applicant in the international application

“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

23 November 2023

Date of mailing of the international search report

30 November 2023

Name and mailing address of the ISA/CN

CHINA NATIONAL INTELLECTUAL PROPERTY
ADMINISTRATION
6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing
100088, China

Authorized officer

LI,WanLu

Telephone No. (+86) 010-53961647

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2023/087066

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
WO	2021231816	A1	18 November 2021	US	2023188261	A1	15 June 2023
				EP	4151038	A1	22 March 2023
				CN	115553043	A	30 December 2022
CN	114080047	A	22 February 2022	WO	2022033475	A1	17 February 2022
				US	2023189351	A1	15 June 2023
				EP	4199632	A1	21 June 2023
CN	115516991	A	23 December 2022	KR	20210133423	A	08 November 2021
				US	2023085104	A1	16 March 2023
				WO	2021221381	A1	04 November 2021
				EP	4145942	A1	08 March 2023
US	2021120581	A1	22 April 2021	KR	20200110201	A	23 September 2020
				CA	3096830	A1	17 September 2020
				WO	2020184954	A1	17 September 2020
				CN	111972030	A	20 November 2020
				IN	202017044317	A	17 September 2021
				EP	3941147	A1	19 January 2022
				JP	2022523604	W	26 April 2022