RACH OCCASION GROUP FOR PREAMBLE REPETITIONS

TECHNICAL FIELD

[0001] The present disclosure relates to wireless communications, and more specifically to a user equipment (UE), a base station, processors for wireless communication and methods for random access channel (RACH) occasion (RO) groups for preamble repetitions.

BACKGROUND

[0002] A wireless communications system may include one or multiple network communication devices, such as base stations, which may be otherwise known as an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. Each network communication devices, such as a base station may support wireless communications for one or multiple user communication devices, which may be otherwise known as user equipment (UE), or other suitable terminology. The wireless communications system may support wireless communications with one or multiple user communication devices by utilizing resources of the wireless communication system (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers). Additionally, the wireless communications system may support wireless communications across various radio access technologies including third generation (3G) radio access technology, fourth generation (4G) radio access technology, fifth generation (5G) radio access technology, among other suitable radio access technologies beyond 5G (e.g., sixth generation (6G)).

[0003] In 5G new radio (NR) systems, the random-access procedure is utilized for various purposes. For example, the random-access procedure may be utilized by a UE in initial access to find a cell to camp on; or utilized by a radio resource control (RRC) IDLE/INACTIVE UE to switch to a RRC Connected mode to start data transmission/reception; or utilized by a RRC Connected UE to re-establish the lost uplink (UL) synchronization, etc. Enhancements on the random-access procedure are still needed.

SUMMARY

[0004] The present disclosure relates to methods, apparatuses, and systems that support RO groups for preamble repetitions. By determining two sets of valid ROs, the RO group(s) for preamble repetitions may be determined accordingly. In this way, a scheme for preamble repetitions with the existence of different types of ROs may be designed.

[0005] In a first aspect of the solution, a user equipment determines a first set of valid random access channel (RACH) occasions (ROs) and a second set of valid ROs. The user equipment determines one or more RO groups for a number of preamble repetitions based on at least one of the first set of valid ROs or the second set of valid ROs. In this way, a scheme for preamble repetitions with the existence of different types of ROs may be designed.

[0006] In some implementations of the method and apparatuses described herein, the first set of valid ROs and the second set of valid ROs may be determined accordingly, based on at least one of the following: a first physical RACH (PRACH) configuration for the first set of valid ROs and a second PRACH configuration for the second set of valid ROs; a first mapping of a plurality of synchronization signal and physical broadcast channel (PBCH) block (SSBs) to the first set of valid ROs and a second mapping of the plurality of SSBs to the second set of valid ROs, wherein the first mapping and the second mapping are separately performed; or types of time units, wherein the first set of valid ROs are in at least one of subband full duplex (SBFD) time units configured as flexible or non-SBFD time units and the second set of valid ROs are in SBFD time units configured as downlink (DL), or wherein the first set of valid ROs are in at least one of SBFD time units configured as flexible or non-SBFD time units and the second set of valid ROs are in at least one of SBFD time units configured as DL or SBFD time units configured as flexible.

[0007] In some implementations of the method and apparatuses described herein, determining the one or more RO groups may include at least one of the following: determining a first set of RO groups based on the first set of valid ROs; or determining a second set of RO groups based on the second set of valid ROs.

[0008] In some implementations of the method and apparatuses described herein, the first set of RO groups may be determined based on a first RO offset indicating a number of valid ROs among the first set of valid ROs between respective starting ROs of two RO

groups among the first set of RO groups. The second set of RO groups may be determined based on a second RO offset indicating a number of valid ROs among the second set of valid ROs between respective starting ROs of two RO groups among the second set of RO groups.

[0009] In some implementations of the method and apparatuses described herein, the first set of RO groups and the second set of RO groups may be determined based on a RO offset. For the first set of RO groups, the RO offset indicates a number of valid ROs among the first set of valid ROs between respective starting ROs of two RO groups among the first set of RO groups. For the second set of RO groups, the RO offset indicates a number of valid ROs among the second set of valid ROs between respective starting ROs of two RO groups among the second set of RO groups.

[0010] Some implementations of the method and apparatuses described herein may further include: receiving, from a network entity, an indication indicating one of the first set of valid ROs or the second set of valid ROs to be used for determining the one or more RO groups.

[0011] In some implementations of the method and apparatuses described herein, the two RO groups among the first set of RO groups are consecutive RO groups mapped to the same SSB and having the same frequency domain resources. The two RO groups among the second set of RO groups are consecutive RO groups mapped to the same SSB and having the same frequency domain resources.

[0012] In some implementations of the method and apparatuses described herein, determining the one or more RO groups may include: determining one set of RO groups comprising the one or more RO groups based on the first set of valid ROs and the second set of valid ROs, wherein ROs in an RO group among the set of RO groups belong to a same set of valid ROs.

[0013] In some implementations of the method and apparatuses described herein, the set of RO groups may include a first RO group and a second RO group subsequent to the first RO group. The first RO group and the second RO group are mapped to the same SSB and have the same frequency domain resources. The ROs in the second RO group are after the ROs in the first RO group in time domain; or a starting RO in the second RO group is after a starting RO in the first RO group in time domain.

[0014] In some implementations of the method and apparatuses described herein, ROs in the first RO group belong to the first set of valid ROs, and ROs in the second RO group belong to the second set of valid ROs.

[0015] Some implementations of the method and apparatuses described herein may further include: transmitting, to a network entity, a PRACH transmission with the number of preamble repetitions in one RO group among the one or more RO groups.

[0016] Some implementations of the method and apparatuses described herein may further include: receiving, from the network entity, an indication that ROs in the one RO group are from the first set of valid ROs or an indication that ROs in the one RO group are from the second set of valid ROs.

[0017] Some implementations of the method and apparatuses described herein may further include: transmitting, to a network entity, an indication that valid ROs determined based on a first PRACH configuration are supported.

[0018] Some implementations of the method and apparatuses described herein may further include: transmitting, to a network entity, an indication that valid ROs determined based on two PRACH configurations are supported.

[0019] Some implementations of the method and apparatuses described herein may further include: transmitting, to a network entity, an indication that valid ROs determined based on a second PRACH configuration are supported.

[0020] In some implementations of the method and apparatuses described herein, the user equipment is in a radio resource control (RRC) active mode.

[0021] In some implementations of the method and apparatuses described herein, the first set of valid ROs and the second set of valid ROs may be determined based on a default PRACH configuration, wherein the default PRACH configuration is one of the following: a first PRACH configuration; or the first PRACH configuration and a second PRACH configuration.

[0022] In some implementations of the method and apparatuses described herein, the user equipment is in a RRC inactive mode or a RRC idle mode.

[0023] In some implementations of the method and apparatuses described herein, the first PRACH configuration may be associated with RO configuration in at least one of

SBFD time units configured as flexible or non-SBFD time units. The second PRACH configuration may be associated with RO configuration in SBFD time units configured as DL.

[0024] In some implementations of the method and apparatuses described herein, the first PRACH configuration may be associated with RO configuration in at least one of SBFD time units configured as flexible or non-SBFD time units. The second PRACH configuration may be associated with RO configuration in at least one of SBFD time units configured as DL or SBFD time units configured as flexible.

[0025] In a second aspect of the solution, a network entity determines a first set of valid random access channel (RACH) occasions (ROs) and a second set of valid ROs. The user equipment determines one or more RO groups for a number of preamble repetitions based on at least one of the first set of valid ROs or the second set of valid ROs. In this way, a scheme for preamble repetitions with the existence of different types of ROs may be designed.

[0026] In some implementations of the method and apparatuses described herein, the first set of valid ROs and the second set of valid ROs may be determined accordingly, based on at least one of the following: a first physical RACH (PRACH) configuration for the first set of valid ROs and a second PRACH configuration for the second set of valid ROs; a first mapping of a plurality of synchronization signal and physical broadcast channel (PBCH) block (SSBs) to the first set of valid ROs and a second mapping of the plurality of SSBs to the second set of valid ROs, wherein the first mapping and the second mapping are separately performed; or types of time units, wherein the first set of valid ROs are in at least one of subband full duplex (SBFD) time units configured as flexible or non-SBFD time units and the second set of valid ROs are in SBFD time units configured as downlink (DL), or wherein the first set of valid ROs are in at least one of SBFD time units configured as flexible or non-SBFD time units and the second set of valid ROs are in at least one of SBFD time units configured as DL or SBFD time units configured as flexible.

[0027] In some implementations of the method and apparatuses described herein, determining the one or more RO groups may include at least one of the following: determining a first set of RO groups based on the first set of valid ROs; or determining a second set of RO groups based on the second set of valid ROs.

[0028] In some implementations of the method and apparatuses described herein, the first set of RO groups may be determined based on a first RO offset indicating a number of valid ROs among the first set of valid ROs between respective starting ROs of two RO groups among the first set of RO groups. The second set of RO groups may be determined based on a second RO offset indicating a number of valid ROs among the second set of valid ROs between respective starting ROs of two RO groups among the second set of RO groups.

[0029] In some implementations of the method and apparatuses described herein, the first set of RO groups and the second set of RO groups may be determined based on a RO offset. For the first set of RO groups, the RO offset indicates a number of valid ROs among the first set of valid ROs between respective starting ROs of two RO groups among the first set of RO groups. For the second set of RO groups, the RO offset indicates a number of valid ROs among the second set of valid ROs between respective starting ROs of two RO groups among the second set of RO groups.

[0030] Some implementations of the method and apparatuses described herein may further include: transmitting, to a user equipment, an indication indicating one of the first set of valid ROs or the second set of valid ROs to be used for determining the one or more RO groups.

[0031] In some implementations of the method and apparatuses described herein, the two RO groups among the first set of RO groups are consecutive RO groups mapped to the same SSB and having the same frequency domain resources. The two RO groups among the second set of RO groups are consecutive RO groups mapped to the same SSB and having the same frequency domain resources.

[0032] In some implementations of the method and apparatuses described herein, determining the one or more RO groups may include: determining one set of RO groups comprising the one or more RO groups based on the first set of valid ROs and the second set of valid ROs, wherein ROs in an RO group among the set of RO groups belong to a same set of valid ROs.

[0033] In some implementations of the method and apparatuses described herein, the set of RO groups may include a first RO group and a second RO group subsequent to the first RO group. The first RO group and the second RO group are mapped to the same SSB and have the same frequency domain resources. The ROs in the second RO group

are after the ROs in the first RO group in time domain; or a starting RO in the second RO group is after a starting RO in the first RO group in time domain.

[0034] In some implementations of the method and apparatuses described herein, ROs in the first RO group belong to the first set of valid ROs, and ROs in the second RO group belong to the second set of valid ROs.

[0035] Some implementations of the method and apparatuses described herein may further include: receiving, from a user equipment, a PRACH transmission with the number of preamble repetitions in one RO group among the one or more RO groups.

[0036] Some implementations of the method and apparatuses described herein may further include: transmitting, to the user equipment, an indication that ROs in the one RO group are from the first set of valid ROs or an indication that ROs in the one RO group are from the second set of valid ROs.

[0037] Some implementations of the method and apparatuses described herein may further include: receiving, from a network entity, an indication that valid ROs determined based on a first PRACH configuration are supported.

[0038] Some implementations of the method and apparatuses described herein may further include: receiving, from a network entity, an indication that valid ROs determined based on two PRACH configurations are supported.

[0039] Some implementations of the method and apparatuses described herein may further include: receiving, from a network entity, an indication that valid ROs determined based on a second PRACH configuration are supported.

[0040] In some implementations of the method and apparatuses described herein, the user equipment is in a radio resource control (RRC) active mode.

[0041] In some implementations of the method and apparatuses described herein, the first set of valid ROs and the second set of valid ROs may be determined based on a default PRACH configuration, wherein the default PRACH configuration is one of the following: a first PRACH configuration; or the first PRACH configuration and a second PRACH configuration.

[0042] In some implementations of the method and apparatuses described herein, the user equipment is in a RRC inactive mode or a RRC idle mode.

[0043] In some implementations of the method and apparatuses described herein, the first PRACH configuration may be associated with RO configuration in at least one of SBFD time units configured as flexible or non-SBFD time units. The second PRACH configuration may be associated with RO configuration in SBFD time units configured as DL.

[0044] In some implementations of the method and apparatuses described herein, the first PRACH configuration may be associated with RO configuration in at least one of SBFD time units configured as flexible or non-SBFD time units. The second PRACH configuration may be associated with RO configuration in at least one of SBFD time units configured as DL or SBFD time units configured as flexible.

BRIEF DESCRIPTION OF THE DRAWINGS

[0045] FIG. 1A illustrates an example of a wireless communications system that supports RO groups for preamble repetitions in accordance with aspects of the present disclosure.

[0046] FIG. 1B illustrates an example of an NR 4-step random-access procedure that supports RO groups for preamble repetitions in accordance with some example embodiments of the present disclosure.

[0047] FIG. 1C illustrates an example of determination of valid ROs in accordance with some example embodiments of the present disclosure.

[0048] FIG. 1D illustrates an example of frequency-division-multiplexed (FDMed) ROs in a same time occasion in accordance with some example embodiments of the present disclosure.

[0049] FIG. 1E illustrates an example of a structure of overall random access channel (RACH) resources that supports RO groups for preamble repetitions in accordance with some example embodiments of the present disclosure.

[0050] FIGS. 1F through 1H illustrate examples of associations between ROs and SSBs that supports RO groups for preamble repetitions in accordance with some example embodiments of the present disclosure.

[0051] FIG. 1I illustrates an example of determination of multiple RO groups for preamble repetitions in related solutions.

[0052] FIG. 1J illustrates an example diagram of a subband full duplex scheme.

[0053] FIGS. 1K-1O illustrate examples of determination of valid ROs in accordance with some example embodiments of the present disclosure.

[0054] FIG. 1P illustrates an example of two approaches for determination of multiple RO groups from two sets of valid ROs in related solutions.

[0055] FIG. 2 illustrates an example signaling chart of a communication process that supports RO groups for preamble repetitions in accordance with some example embodiments of the present disclosure.

[0056] FIGS. 3A-3C illustrate examples of RO groups for preamble repetitions from two sets of valid ROs in accordance with some example embodiments of the present disclosure.

[0057] FIG. 4 illustrates an example of two sets of RO groups for preamble repetitions from two sets of valid ROs in accordance with some example embodiments of the present disclosure.

[0058] FIGS. 5A-5B illustrate examples of one set of RO groups for preamble repetitions from two sets of valid ROs in accordance with some example embodiments of the present disclosure.

[0059] FIG. 6 illustrates an example of a device that supports RO groups for preamble repetitions in accordance with aspects of the present disclosure.

[0060] FIG. 7 illustrates an example of a processor that supports RO groups for preamble repetitions in accordance with aspects of the present disclosure.

[0061] FIG. 8 illustrates a flowchart of a method that supports RO groups for preamble repetitions in accordance with aspects of the present disclosure.

[0062] Throughout the drawings, the same or similar reference numerals represent the same or similar elements.

DETAILED DESCRIPTION

[0063] Principles of the present disclosure will now be described with reference to some 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 limitation as to the scope of the disclosure. The disclosure described herein may be implemented in various manners other than the ones described below.

[0064] 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.

[0065] References in the present disclosure to "one embodiment," "an example embodiment," "an embodiment," "some embodiments," and the like indicate that the embodiment(s) described may include a particular feature, structure, or characteristic, but it is not necessary that every embodiment includes the particular feature, structure, or characteristic. Moreover, such phrases do not necessarily refer to the same embodiment(s). Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

[0066] It shall be understood that although the terms "first" and "second" or the like may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another element. For example, a first element could also be termed as a second element, and similarly, a second element could also be termed as a first element, without departing from the scope of embodiments. As used herein, the term "and/or" includes any and all combinations of one or more of the listed terms.

[0067] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of example embodiments. 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. It will be further understood that the terms "comprises", "comprising", "has", "having", "includes" and/or "including", when used herein, specify the presence of stated features, elements, and/or components etc., but do not preclude the presence or addition of one or more other features, elements, components and/ or combinations thereof.

[0068] As used herein, the term "communication network" refers to a network following any suitable communication standards, such as, 5G NR, long term evolution

(LTE), LTE-advanced (LTE-A), wideband code division multiple access (WCDMA), high-speed packet access (HSPA), narrow band internet of things (NB-IoT), and so on. Further, the communications between a terminal device and a network device in the communication network may be performed according to any suitable generation communication protocols, including but not limited to, the first generation (1G), the second generation (2G), 2.5G, 2.75G, the third generation (3G), the fourth generation (4G), 4.5G, the fifth generation (5G) communication protocols, and/or any other protocols either currently known or to be developed in the future. Embodiments of the present disclosure may be applied in various communication systems. Given the rapid development in communications, there will also be future type communication technologies and systems in which the present disclosure may be embodied. It should not be seen as limiting the scope of the present disclosure to only the aforementioned systems.

[0069] As used herein, the term "network device" generally refers to a node in a communication network via which a terminal device can access the communication network and receive services therefrom. The network device may refer to a base station (BS) or an access point (AP), for example, a node B (NodeB or NB), a radio access network (RAN) node, an evolved NodeB (eNodeB or eNB), an NR NB (also referred to as a gNB), a remote radio unit (RRU), a radio header (RH), an infrastructure device for a V2X (vehicle-to-everything) communication, a transmission and reception point (TRP), a reception point (RP), a remote radio head (RRH), a relay, an integrated access and backhaul (IAB) node, a low power node such as a femto BS, a pico BS, and so forth, depending on the applied terminology and technology.

[0070] As used herein, the term "terminal device" generally refers to any end device that may be capable of wireless communications. By way of example rather than a limitation, a terminal device may also be referred to as a communication device, a user equipment (UE), an end user device, a subscriber station (SS), an unmanned aerial vehicle (UAV), a portable subscriber station, a mobile station (MS), or an access terminal (AT). The terminal device may include, but is not limited to, a mobile phone, a cellular phone, a smart phone, a voice over IP (VoIP) phone, a wireless local loop phone, a tablet, a wearable terminal device, a personal digital assistant (PDA), a portable computer, a desktop computer, an image capture terminal device such as a digital camera, a gaming terminal device, a music storage and playback appliance, a vehicle-mounted wireless terminal device, a wireless endpoint, a mobile station, laptop-embedded equipment (LEE),

laptop-mounted equipment (LME), a USB dongle, a smart device, wireless customer-premises equipment (CPE), an internet of things (IoT) device, a watch or other wearable, a head-mounted display (HMD), a vehicle, a drone, a medical device (for example, a remote surgery device), an industrial device (for example, a robot and/or other wireless devices operating in an industrial and/or an automated processing chain contexts), a consumer electronics device, a device operating on commercial and/or industrial wireless networks, and the like. In the following description, the terms: "terminal device," "communication device," "terminal," "user equipment" and "UE," may be used interchangeably.

[0071] In an NR 4-step random-access procedure, the UE firstly transmits a PRACH preamble in Msg1 to the base station, and then receives a Random-Access Response (RAR) in Msg2, indicating reception of the preamble. A PRACH preamble transmission is associated with a downlink (DL) RS. This association can help a serving base station to identify an uplink spatial reception filter or beam to receive a PRACH preamble and can help a UE to identify an uplink spatial transmission filter or beam to transmit a PRACH preamble. The PRACH preamble transmission takes place in RACH occasions (ROs), each of which occupies multiple consecutive resource blocks in frequency domain. In time domain, the ROs are configured in every PRACH configuration period. The UE needs to determine valid ROs among the ROs configured in the time domain and frequency domain. For example, for a time division duplex (TDD) configuration, a RO within or overlapping with DL symbols is considered invalid. The valid ROs are associated with SSBs that may be transmitted with different beams. In order to increase the reliability of a PRACH transmission, the PRACH transmission may be repeatedly transmitted in a RO group associated with the same SSB.

[0072] In order to realize the superior data rate and latency, 5G spectrum on higher frequency band is inevitable. In order to overcome the coverage reduction on such carriers, in 3GPP Release19, a duplexing scheme is to be introduced so as to enable simultaneous use of downlink and uplink within a TDD carrier using non-overlapped frequency resource. The duplexing scheme could be named as subband full duplex (SBFD). The intention of the SBFD scheme is to extend the duration over which uplink transmission could occur for improved the uplink coverage and capacity. The introduction of the SBFD scheme might complicate the determination of RO groups. Further studies on the determination of RO groups are still needed.

[0073] In view of the above, embodiments of the present disclosure provide a solution for determination of RO groups. In an aspect of the solution, a user equipment determines a first set of ROs and a second set of valid ROs. The user equipment determines one or more RO groups for a number of preamble repetitions based on at least one of the first set of valid ROs or the second set of valid ROs. By determining two sets of valid ROs, the RO group(s) for preamble repetitions may be determined accordingly. In this way, a scheme for preamble repetitions with the existence of different types of ROs may be designed.

[0074] Aspects of the present disclosure are described in the context of a wireless communications system.

[0075] FIG. 1A illustrates an example of a wireless communications system 100 that supports RO groups for preamble repetitions in accordance with aspects of the present disclosure. The wireless communications system 100 may include one or more network entities 102 (also referred to as network equipment (NE)), one or more UEs 104, a core network 106, and a packet data network 108. The wireless communications system 100 may support various radio access technologies. In some implementations, the wireless communications system 100 may be a 4G network, such as an LTE network or an LTE-Advanced (LTE-A) network. In some other implementations, the wireless communications system 100 may be a 5G network, such as an NR network. In other implementations, the wireless communications system 100 may be a combination of a 4G network and a 5G network, or other suitable radio access technology including Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20. The wireless communications system 100 may support radio access technologies beyond 5G. Additionally, the wireless communications system 100 may support technologies, such as time division multiple access (TDMA), frequency division multiple access (FDMA), or code division multiple access (CDMA), etc.

[0076] The one or more network entities 102 may be dispersed throughout a geographic region to form the wireless communications system 100. One or more of the network entities 102 described herein may be or include or may be referred to as a network node, a base station, a network element, a radio access network (RAN), a base transceiver station, an access point, a NodeB, an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. A network entity 102 and a UE 104 may communicate via a

communication link 110, which may be a wireless or wired connection. For example, a network entity 102 and a UE 104 may perform wireless communication (e.g., receive signaling, transmit signaling) over a Uu interface.

[0077] A network entity 102 may provide a geographic coverage area 112 for which the network entity 102 may support services (e.g., voice, video, packet data, messaging, broadcast, etc.) for one or more UEs 104 within the geographic coverage area 112. For example, a network entity 102 and a UE 104 may support wireless communication of signals related to services (e.g., voice, video, packet data, messaging, broadcast, etc.) according to one or multiple radio access technologies. In some implementations, a network entity 102 may be moveable, for example, a satellite associated with a non-terrestrial network. In some implementations, different geographic coverage areas 112 associated with the same or different radio access technologies may overlap, but the different geographic coverage areas 112 may be associated with different network entities 102. Information and signals described herein may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[0078] The one or more UEs 104 may be dispersed throughout a geographic region of the wireless communications system 100. A UE 104 may include or may be referred to as a mobile device, a wireless device, a remote device, a remote unit, a handheld device, or a subscriber device, or some other suitable terminology. In some implementations, the UE 104 may be referred to as a unit, a station, a terminal, or a client, among other examples. Additionally, or alternatively, the UE 104 may be referred to as an Internet-of-Things (IoT) device, an Internet-of-Everything (IoE) device, or machine-type communication (MTC) device, among other examples. In some implementations, a UE 104 may be stationary in the wireless communications system 100. In some other implementations, a UE 104 may be mobile in the wireless communications system 100.

[0079] The one or more UEs 104 may be devices in different forms or having different capabilities. Some examples of UEs 104 are illustrated in FIG. 1A. A UE 104 may be capable of communicating with various types of devices, such as the network entities 102, other UEs 104, or network equipment (e.g., the core network 106, the packet data network

108, a relay device, an integrated access and backhaul (IAB) node, or another network equipment), as shown in FIG. 1A. Additionally, or alternatively, a UE 104 may support communication with other network entities 102 or UEs 104, which may act as relays in the wireless communications system 100.

[0080] A UE 104 may also be able to support wireless communication directly with other UEs 104 over a communication link 114. For example, a UE 104 may support wireless communication directly with another UE 104 over a device-to-device (D2D) communication link. In some implementations, such as vehicle-to-vehicle (V2V) deployments, vehicle-to-everything (V2X) deployments, or cellular-V2X deployments, the communication link 114 may be referred to as a sidelink. For example, a UE 104 may support wireless communication directly with another UE 104 over a PC5 interface.

[0081] A network entity 102 may support communications with the core network 106, or with another network entity 102, or both. For example, a network entity 102 may interface with the core network 106 through one or more backhaul links 116 (e.g., via an S1, N2, N2, or another network interface). The network entities 102 may communicate with each other over the backhaul links 116 (e.g., via an X2, Xn, or another network interface). In some implementations, the network entities 102 may communicate with each other directly (e.g., between the network entities 102). In some other implementations, the network entities 102 may communicate with each other or indirectly (e.g., via the core network 106). In some implementations, one or more network entities 102 may include subcomponents, such as an access network entity, which may be an example of an access node controller (ANC). An ANC may communicate with the one or more UEs 104 through one or more other access network transmission entities, which may be referred to as a radio heads, smart radio heads, or transmission-reception points (TRPs).

[0082] In some implementations, a network entity 102 may be configured in a disaggregated architecture, which may be configured to utilize a protocol stack physically or logically distributed among two or more network entities 102, such as an integrated access backhaul (IAB) network, an open RAN (O-RAN) (e.g., a network configuration sponsored by the O-RAN Alliance), or a virtualized RAN (vRAN) (e.g., a cloud RAN (C-RAN)). For example, a network entity 102 may include one or more of a central unit (CU), a distributed unit (DU), a radio unit (RU), a RAN Intelligent Controller (RIC) (e.g., a

Near-Real Time RIC (Near-RT RIC), a Non-Real Time RIC (Non-RT RIC)), a Service Management and Orchestration (SMO) system, or any combination thereof.

[0083] An RU may also be referred to as a radio head, a smart radio head, a remote radio head (RRH), a remote radio unit (RRU), or a transmission reception point (TRP). One or more components of the network entities 102 in a disaggregated RAN architecture may be co-located, or one or more components of the network entities 102 may be located in distributed locations (e.g., separate physical locations). In some implementations, one or more network entities 102 of a disaggregated RAN architecture may be implemented as virtual units (e.g., a virtual CU (VCU), a virtual DU (VDU), a virtual RU (VRU)).

[0084] Split of functionality between a CU, a DU, and an RU may be flexible and may support different functionalities depending upon which functions (e.g., network layer functions, protocol layer functions, baseband functions, radio frequency functions, and any combinations thereof) are performed at a CU, a DU, or an RU. For example, a functional split of a protocol stack may be employed between a CU and a DU such that the CU may support one or more layers of the protocol stack and the DU may support one or more different layers of the protocol stack. In some implementations, the CU may host upper protocol layer (e.g., a layer 3 (L3), a layer 2 (L2)) functionality and signaling (e.g., Radio Resource Control (RRC), service data adaption protocol (SDAP), Packet Data Convergence Protocol (PDCP)). The CU may be connected to one or more DUs or RUs, and the one or more DUs or RUs may host lower protocol layers, such as a layer 1 (L1) (e.g., physical (PHY) layer) or an L2 (e.g., radio link control (RLC) layer, medium access control (MAC) layer) functionality and signaling, and may each be at least partially controlled by the CU.

[0085] Additionally, or alternatively, a functional split of the protocol stack may be employed between a DU and an RU such that the DU may support one or more layers of the protocol stack and the RU may support one or more different layers of the protocol stack. The DU may support one or multiple different cells (e.g., via one or more RUs). In some implementations, a functional split between a CU and a DU, or between a DU and an RU may be within a protocol layer (e.g., some functions for a protocol layer may be performed by one of a CU, a DU, or an RU, while other functions of the protocol layer are performed by a different one of the CU, the DU, or the RU).

[0086] A CU may be functionally split further into CU control plane (CU-CP) and CU user plane (CU-UP) functions. A CU may be connected to one or more DUs via a midhaul communication link (e.g., F1, F1-c, F1-u), and a DU may be connected to one or more RUs via a fronthaul communication link (e.g., open fronthaul (FH) interface). In some implementations, a midhaul communication link or a fronthaul communication link may be implemented in accordance with an interface (e.g., a channel) between layers of a protocol stack supported by respective network entities 102 that are in communication via such communication links.

[0087] The core network 106 may support user authentication, access authorization, tracking, connectivity, and other access, routing, or mobility functions. The core network 106 may be an evolved packet core (EPC), or a 5G core (5GC), which may include a control plane entity that manages access and mobility (e.g., a mobility management entity (MME), an access and mobility management functions (AMF)) and a user plane entity that routes packets or interconnects to external networks (e.g., a serving gateway (S-GW), a Packet Data Network (PDN) gateway (P-GW), or a user plane function (UPF)). In some implementations, the control plane entity may manage non-access stratum (NAS) functions, such as mobility, authentication, and bearer management (e.g., data bearers, signal bearers, etc.) for the one or more UEs 104 served by the one or more network entities 102 associated with the core network 106.

[0088] The core network 106 may communicate with the packet data network 108 over one or more backhaul links 116 (e.g., via an S1, N2, N2, or another network interface). The packet data network 108 may include an application server 118. In some implementations, one or more UEs 104 may communicate with the application server 118. A UE 104 may establish a session (e.g., a protocol data unit (PDU) session, or the like) with the core network 106 via a network entity 102. The core network 106 may route traffic (e.g., control information, data, and the like) between the UE 104 and the application server 118 using the established session (e.g., the established PDU session). The PDU session may be an example of a logical connection between the UE 104 and the core network 106 (e.g., one or more network functions of the core network 106).

[0089] In the wireless communications system 100, the network entities 102 and the UEs 104 may use resources of the wireless communications system 100 (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g.,

subcarriers, carriers)) to perform various operations (e.g., wireless communications). In some implementations, the network entities 102 and the UEs 104 may support different resource structures. For example, the network entities 102 and the UEs 104 may support different frame structures. In some implementations, such as in 4G, the network entities 102 and the UEs 104 may support a single frame structure. In some other implementations, such as in 5G and among other suitable radio access technologies, the network entities 102 and the UEs 104 may support various frame structures (i.e., multiple frame structures). The network entities 102 and the UEs 104 may support various frame structures based on one or more numerologies.

[0090] One or more numerologies may be supported in the wireless communications system 100, and a numerology may include a subcarrier spacing and a cyclic prefix. A first numerology (e.g., μ=0) may be associated with a first subcarrier spacing (e.g., 15 kHz) and a normal cyclic prefix. In some implementations, the first numerology (e.g., μ=0) associated with the first subcarrier spacing (e.g., 15 kHz) may utilize one slot per subframe. A second numerology (e.g., μ=1) may be associated with a second subcarrier spacing (e.g., 30 kHz) and a normal cyclic prefix. A third numerology (e.g., μ=2) may be associated with a third subcarrier spacing (e.g., 60 kHz) and a normal cyclic prefix or an extended cyclic prefix. A fourth numerology (e.g., μ=3) may be associated with a fourth subcarrier spacing (e.g., 120 kHz) and a normal cyclic prefix. A fifth numerology (e.g., μ=4) may be associated with a fifth subcarrier spacing (e.g., 240 kHz) and a normal cyclic prefix.

[0091] A time interval of a resource (e.g., a communication resource) may be organized according to frames (also referred to as radio frames). Each frame may have a duration, for example, a 10 millisecond (ms) duration. In some implementations, each frame may include multiple subframes. For example, each frame may include 10 subframes, and each subframe may have a duration, for example, a 1 ms duration. In some implementations, each frame may have the same duration. In some implementations, each subframe of a frame may have the same duration.

[0092] Additionally or alternatively, a time interval of a resource (e.g., a communication resource) may be organized according to slots. For example, a subframe may include a number (e.g., quantity) of slots. The number of slots in each subframe may also depend on the one or more numerologies supported in the wireless communications

system 100. For instance, the first, second, third, fourth, and fifth numerologies (i.e., μ=0, μ=1, μ=2, μ=3, μ=4) associated with respective subcarrier spacings of 15 kHz, 30 kHz, 60 kHz, 120 kHz, and 240 kHz may utilize a single slot per subframe, two slots per subframe, four slots per subframe, eight slots per subframe, and 16 slots per subframe, respectively. Each slot may include a number (e.g., quantity) of symbols (e.g., OFDM symbols). In some implementations, the number (e.g., quantity) of slots for a subframe may depend on a numerology. For a normal cyclic prefix, a slot may include 14 symbols. For an extended cyclic prefix (e.g., applicable for 60 kHz subcarrier spacing), a slot may include 12 symbols. The relationship between the number of symbols per slot, the number of slots per subframe, and the number of slots per frame for a normal cyclic prefix and an extended cyclic prefix may depend on a numerology. It should be understood that reference to a first numerology (e.g., μ=0) associated with a first subcarrier spacing (e.g., 15 kHz) may be used interchangeably between subframes and slots.

[0093] In the wireless communications system 100, an electromagnetic (EM) spectrum may be split, based on frequency or wavelength, into various classes, frequency bands, frequency channels, etc. By way of example, the wireless communications system 100 may support one or multiple operating frequency bands, such as frequency range designations FR1 (410 MHz – 7.125 GHz), FR2 (24.25 GHz – 52.6 GHz), FR3 (7.125 GHz – 24.25 GHz), FR4 (52.6 GHz – 114.25 GHz), FR4a or FR4-1 (52.6 GHz – 71 GHz), and FR5 (114.25 GHz – 300 GHz). In some implementations, the network entities 102 and the UEs 104 may perform wireless communications over one or more of the operating frequency bands. In some implementations, FR1 may be used by the network entities 102 and the UEs 104, among other equipment or devices for cellular communications traffic (e.g., control information, data). In some implementations, FR2 may be used by the network entities 102 and the UEs 104, among other equipment or devices for short-range, high data rate capabilities.

[0094] FR1 may be associated with one or multiple numerologies (e.g., at least three numerologies). For example, FR1 may be associated with a first numerology (e.g., μ=0), which includes 15 kHz subcarrier spacing; a second numerology (e.g., μ=1), which includes 30 kHz subcarrier spacing; and a third numerology (e.g., μ=2), which includes 60 kHz subcarrier spacing. FR2 may be associated with one or multiple numerologies (e.g., at least 2 numerologies). For example, FR2 may be associated with a third

numerology (e.g., μ=2), which includes 60 kHz subcarrier spacing; and a fourth numerology (e.g., μ=3), which includes 120 kHz subcarrier spacing.

[0095] FIG. 1B illustrates an example of an NR 4-step random-access procedure 120 that supports RO groups for preamble repetitions in accordance with some example embodiments of the present disclosure. For the purpose of discussion, the procedure 120 will be described with reference to FIG. 1A. The procedure 120 may involve a UE 104 and a network entity 102 as illustrated in FIG. 1A. It is noted that the 4-step random-access procedure is merely for illustration, and not for limitation. Embodiments of the present disclosure may apply to other random-access procedures.

[0096] In the random-access procedure 120, the UE 104 may firstly transmit 122 a Msg1 including a preamble to the network entity 102. After receiving the Msg1, the network entity 102 may transmit 124 a RAR in Msg2 to the UE 104, indicating the reception of the preamble and providing necessary information for the transmission of Msg3. The RAR may be received by the UE 104 in a RAR window, which starts after a time gap after the UE 104 transmits the Msg1. The UE 104 may then transmit 126 a Msg3 to the network entity 102. The network entity 102 may transmit 128 a Msg4 to the UE 104. The Msg3 and Msg4 may be used to solve potential collisions due to simultaneous transmissions of the same preamble from different UEs to the network entity 102.

[0097] The PRACH Msg1 transmission takes place in ROs, each of which occupies multiple consecutive resource blocks in frequency domain. In time domain, ROs are configured in every PRACH configuration period, which contains a set of radio frames. Within a PRACH configuration period, a subset of subframes is indicated to contain a set of PRACH slots. Within each PRACH slot, there might be a set of RACH occasions available for PRACH Msg1 transmission. Besides, in frequency domain, the network entity may configure FDMed ROs. A parameter *msg1-FDM* indicates the number of FDMed ROs in frequency domain. The starting position of the first RO in frequency domain is also configured by the network entity.

[0098] The UE needs to determine valid ROs among the ROs configured in the time domain and frequency domain. Specifically, for a TDD configuration, a RO in a PRACH slot is considered valid if the RO is within UL symbols of the cell common configuration *tdd-UL-DL-ConfigCommon* or if it doesn't overlap with or precede a DL symbol

configured by *tdd-UL-DL-ConfigCommon* or SSB in a slot, and is at least a gap (>=0 symbols) after the last DL symbol or SSB.

[0099] FIG. 1C illustrates an example 130 of determination of valid ROs in accordance with some example embodiments of the present disclosure. In the example 130 in FIG. 1C, a slot pattern "DDDDDDFUUU" may be indicated by *tdd-UL-DL-ConfigCommon*. The slot pattern is merely for illustration, other slot patterns are also possible.

[0100] The PRACH configuration index indicates that within a PRACH resource periodicity of 10ms, the slots in subframes {0,1,2,3,4,5,6,7,8,9} are PRACH slots. Here it is assumed that one subframe contains one slot (i.e., with 15kHz subcarrier spacing), therefore, each slot is indicated as a PRACH slot in the example 130. Since the slots in subframes {0,1,2,3,4,5} are DL slots, and thus do not meet the condition of valid PRACH slots, these slots are PRACH slots with invalid ROs. The slots in subframes {6,7,8,9} are PRACH slots with valid ROs since the slots in subframes {7,8,9} are UL slots and the slots in subframe {6} are flexible slots. In frequency domain, the network entity may configure FDMed ROs. FIG. 1D illustrates an example 131 of FDMed ROs in a same time occasion in accordance with some example embodiments of the present disclosure. For example, the parameter *msg1-FDM* indicates that the number of FDMed ROs in frequency domain is 2. In a PRACH slot with valid ROs, two FDMed ROs may be configured in the same time occasion. Unless explicitly indicated, a "RO" hereinafter refers to a valid RO.

[0101] The valid ROs are associated with SSBs that may be transmitted with different beams. A SSB consist of a primary synchronization signal (PSS)/a secondary synchronization signal (SSS) and physical broadcast channel (PBCH) signal for the UE to sync. to the DL, to obtain the cell ID, and to acquire the major system information. Usually, different SSBs are transmitted with different beams. The UE will measure the channel status of each SSB, select the one with a good channel quality, and transmit a preamble in a RO associated with the selected SSB to transmit a PRACH. In this way, the transmitted PRACH is associated with the beam corresponding to the selected SSB. With this, the preamble can be received by the network entity using a proper receipt beam, which is assumed to be correspondent with a selected beam for SSB transmission.

[0102] FIG. 1E illustrates an example of a structure 140 of overall RACH resources that supports RO groups for preamble repetitions in accordance with some example embodiments of the present disclosure. In the example structure 140, a PRACH configuration period may contain 10 subframes, e.g., subframe #0 to subframe #9. Within the PRACH configuration period, subframe #0 and subframe #6 are indicated to contain a set of PRACH slots. A PRACH slot is configured with two ROs in the time domain and four ROs (i.e., *msg1-FDM* = 4) in the frequency domain. As shown in FIG. 1D, RO#0 to RO#7 are available for PRACH Msg1 transmission in a PRACH slot in subframe #0, and RO#8 to RO#15 are available for PRACH Msg1 transmission in a PRACH slot in subframe #6.

[0103] The indexes of available SSBs can be obtained in the system information. For example, SSB indexes provided by *ssb-PositionsInBurst* in SIB1 or in *ServingCellConfigCommon* are mapped to valid ROs in the following order where the parameters are described in technical specification (TS) 38.211: first, in an increasing order of preamble indexes within a single RO; second, in an increasing order of frequency resource indexes for frequency multiplexed ROs; third, in an increasing order of time resource indexes for time multiplexed ROs within a PRACH slot; fourth, in an increasing order of indexes for PRACH slots.

[0104] The association between SSBs and ROs can be one-to-one (1-to-1), many-to-one (N-to-1), or one-to-many (1-to-N) depending on the network configuration. This may be determined by a parameter *SSB-PerRACH-Occasion*.

[0105] FIGS. 1F through 1H illustrate examples of associations 150A, 150B and 150C between ROs and SSBs that supports RO groups for preamble repetitions in accordance with some example embodiments of the present disclosure. As shown in FIGS. 1F through 1H, eight SSBs, e.g., SSB#0 to SSB#7, are assumed.

[0106] In the example association 150A, there is one RO in the frequency domain. The parameter *SSB-PerRACH-Occasion* = 1 for the association 150A. Each RO among the RO#0 to RO#7 is mapped to one corresponding SSB. For example, RO#0 is mapped to SSB#0 and RO#1 is mapped to SSB#1.

[0107] In the example association 150B, there is one RO in the frequency domain. The parameter *SSB-PerRACH-Occasion* = 2 for the association 150B. Each RO among

the RO#0 to RO#7 is mapped to two corresponding SSBs. For example, RO#0 is mapped to SSB#0 and SSB#1 and RO#1 is mapped to SSB#2 and SSB#3.

[0108] In the example association 150C, there are two FDMed ROs in the frequency domain. The parameter *SSB-PerRACH-Occasion* = 1/2 for the association 150C. Two ROs among the RO#0 to RO#15 are mapped to one corresponding SSBs. For example, RO#0 and RO#1 are mapped to SSB#0 and RO#2 and RO#3 are mapped to SSB#1.

[0109] A SSB-to-RO association period, starting from frame 0, for mapping SSB indexes to ROs is the smallest integer number of the PRACH configuration periods such that $N_{\mathrm{Tx}}^{\mathrm{SSB}}$ SSB indexes are mapped at least once to the ROs within the SSB-to-RO association period, where $N_{\mathrm{Tx}}^{\mathrm{SSB}}$ is the number of SSBs actually transmitted by the network entity. A UE obtains $N_{\mathrm{Tx}}^{\mathrm{SSB}}$ from the value of *ssb-PositionsInBurst* in SIB1 or in *ServingCellConfigCommon*. If after an integer number of SSB indexes to ROs mapping cycles within the SSB-to-RO association period there is a set of ROs or PRACH preambles that are not mapped to $N_{\mathrm{Tx}}^{\mathrm{SSB}}$ SSB indexes, no SSB indexes are mapped to the set of ROs or PRACH preambles.

[0110] An SSB-to-RO association pattern period includes one or more SSB-to-RO association periods and is determined so that a pattern between ROs and SSB indexes repeats at most every 160 msec. ROs not associated with SSB indexes after an integer number of SSB-to-RO association periods, if any, are not used for PRACH transmissions.

[0111] Having repeated PRACH transmission in multiple ROs associated with the same beam (i.e., the same SSB) would increase the reliability of the PRACH transmission. The candidate number $N_{\mathrm{preamble}}^{\mathrm{rep}}$ of repetitions for PRACH transmissions, e.g. {2,4,8}, is/are explicitly configured. For a PRACH transmission with $N_{\mathrm{preamble}}^{\mathrm{rep}}$ preamble repetitions, all respective valid ROs are consecutive in time, use same frequency resources, and are associated with a same SSB index. For different numbers of repetitions, different preambles would be used for identification with single repetition. In other words, the network entity may be aware of the number of repetitions for a PRACH transmission based on a received preamble associated with the number of repetitions.

[0112] For a PRACH transmission with $N_{\mathrm{preamble}}^{\mathrm{rep}}$ preamble repetitions, a time period, starting from frame 0, is the smallest integer number of SSB-to-RO association pattern periods such that $N_{\mathrm{Tx}}^{\mathrm{SSB}}$ SSB indexes are mapped to $N_{\mathrm{preamble}}^{\mathrm{rep}}$ ROs within the time period

at least once for each configured number $N_{\text{preamble}}^{\text{rep}}$ of preamble repetitions. The set of $N_{\text{preamble}}^{\text{rep}}$ ROs for a PRACH transmission repeats every time period.

[0113] For a PRACH transmission with $N_{\text{preamble}}^{\text{rep}}$ preamble repetitions within a time period for $N_{\text{preamble}}^{\text{rep}}$ preamble repetitions associated with an SSB, if the parameter *TimeOffsetBetweenStartingRO* is provided, for each frequency resource index for frequency multiplexed ROs, the first valid RO of the first $N_{\text{preamble}}^{\text{rep}}$ preamble repetitions is the first valid RO, and the first valid RO of subsequent $N_{\text{preamble}}^{\text{rep}}$ preamble repetitions is after *TimeOffsetBetweenStartingRO* consecutive valid ROs in time from the first valid RO corresponding to the previous $N_{\text{preamble}}^{\text{rep}}$ preamble repetitions. For a PRACH transmission with $N_{\text{preamble}}^{\text{rep}}$ preamble repetitions within a time period for $N_{\text{preamble}}^{\text{rep}}$ preamble repetitions associated with an SSB, if the parameter *TimeOffsetBetweenStartingRO* is not provided, for each frequency resource index for frequency multiplexed ROs, the first valid RO of the first $N_{\text{preamble}}^{\text{rep}}$ preamble repetitions is the first valid RO, and the first valid RO of subsequent $N_{\text{preamble}}^{\text{rep}}$ preamble repetitions, if any, is determined after the ROs determined for the previous $N_{\text{preamble}}^{\text{rep}}$ preamble repetitions according to the following ordering of valid ROs: first, in an increasing order of frequency resource indexes for frequency multiplexed ROs; and second, in an increasing order of time resource indexes for time multiplexed ROs.

[0114] FIG. 1I illustrates an example 160 of determination of multiple RO groups for preamble repetitions in related solutions. As shown in FIG. 1I, assuming SSBs #0~#7 are used, and these SSBs are mapped to valid ROs. The number of preamble repetitions is two, i.e., $N_{\text{preamble}}^{\text{rep}} = 2$. Two valid ROs 161 and 162 for the first two preamble repetitions may form the first RO group, and two valid ROs 163 and 164 for the second two preamble repetitions may form the second RO group. If the parameter *TimeOffsetBetweenStartingRO* is not configured, then the ROs 163 and 164 for the second two preamble repetitions should be after the ROs 161 and 162 for the first two preamble repetitions. If the parameter *TimeOffsetBetweenStartingRO* is configured, then the number of valid ROs between the first RO (or starting RO) 161 for the first two preamble repetitions and the first RO (or starting RO) 163 for the second two preamble repetitions should be equal to the configured *TimeOffsetBetweenStartingRO*.

[0115] As mentioned above, in order to realize the superior data rate and latency, 5G spectrum on higher frequency band is inevitable. To overcome the coverage reduction on such carriers, a duplexing scheme (referred to as a SBFD scheme) is to be introduced so as to enable simultaneous use of downlink and uplink within a TDD carrier using non-overlapped frequency resource. The intention of this scheme is to extend the duration over which uplink transmission could occur for improved the uplink coverage and capacity. The simultaneous use of DL and UL is only at the base station side and not at the UE side. An example 170 of a duplexing scheme could be seen in FIG. 1J. In the example of FIG. 1J, two downlink (DL) subbands are duplexed with an uplink (UL) subband in slot #0 and slot #1. The UL subband could be configured, and the SBFD symbol/slot could be configured in a DL symbol/slot or a flexible symbol/slot configured by *TDD-UL-DL-ConfigCommon*.

[0116] There may be multiple symbol types in a system adopting the subband full duplex scheme. The symbol formats include DL, flexible, SBFD, and UL. For example, a DL or UL symbol may mean that the transmission direction on this symbol is DL or UL. For example, a flexible symbol may mean that a UE cannot make any assumptions on the transmission direction of this symbol. For example, an SBFD symbol may mean that this symbol can support simultaneous DL and UL transmissions in gNB side. For example, a symbol being SBFD may mean the symbol being indicated as DL with a UL frequency region or a UL subband; the symbol being indicated as flexible with a UL frequency region or a UL subband; or the symbol being indicated as flexible and a DL reception and a UL reception being configured to be performed in the symbol simultaneously (e.g., configured by a BS for a UE). For example, an SBFD symbol may include a UL frequency domain resource or UL subband and be initially indicated or configured by a high layer configuration or an SFI from a BS as downlink or flexible (for example, there could be at least two subbands or frequency domain regions with different transmission directions in this symbol). For example, a BS may simultaneously perform a DL transmission and a UL reception in an SBFD symbol while a UE can only perform a DL reception or a UL transmission. For example, an SBFD symbol may be configured with a UL subband, a DL subband, a flexible subband or any combination thereof. For example, an SBFD symbol may include a UL subband configuration. A slot format being SBFD may mean that a slot includes only SBFD symbol or some SBFD symbols. A slot format being SBFD could be named as a SBFD slot.

[0117] If a SBFD symbol/ slot is configured for a SBFD-aware UE, considering the access latency, the PRACH could also be transmitted in the SBFD symbol/slot. Various options may be implemented for RO configuration in the SBFD symbol/slot. FIGS. 1K-1O illustrate examples of determination of valid ROs in accordance with some example embodiments of the present disclosure. It should be understood that the examples shown in FIGS. 1K-1O are merely for illustration, other PRACH configurations and principles for determination of valid ROs are also possible. In the following description, the terms "RACH configuration", "PRACH configuration" and "RO configuration" may be used interchangeably.

[0118] In a first option, one single RACH configuration may be used for determining the valid ROs in SBFD symbols/slots and non-SBFD symbols/slots. In other words, the RACH configuration for UEs not supporting the SBFD scheme could also be used by the SBFD-aware UEs for determining the ROs in SBFD symbols/slots. The ROs within the UL subband in SBFD symbols/slots may be valid for the SBFD-aware UEs. In the following description, the terms "non-SBFD-aware UEs" and "UEs not supporting the SBFD scheme" may be used interchangeably, and the terms "SBFD-aware UEs" and "UEs supporting the SBFD scheme" may be used interchangeably.

[0119] For example, only one PRACH configuration may be provided to the SBFD-aware UEs. This PRACH configuration may be the same configuration as provided to UEs not supporting the SBFD scheme. The configured ROs in SBFD symbols/slots may be determined in a similar manner as the configured ROs in non-SBFD symbols/slots. The SBFD-aware UEs may determine the valid ROs in SBFD symbols/slots including SBFD symbols/slots configured as DL and SBFD symbols/slots configured as flexible, and the valid ROs configured in non-SBFD symbols/slots. FIGS. 1K and 1L shows examples of determination of valid ROs based on only one PRACH configuration in accordance with some example embodiments of the present disclosure.

[0120] In the example 180A in FIG. 1K, the configured ROs in SBFD symbols/slots may be determined based on the PRACH configuration in a similar manner as the configured ROs in non-SBFD symbols/slots. The configured ROs in SBFD symbols/slots configured as flexible and in non-SBFD symbols/slots for SBFD-aware UEs are valid. The configured ROs in the SBFD symbols/slots configured as DL are in the UL subband and thus are valid. In this way, the valid ROs in SBFD symbols/slots configured as DL

occupy the same frequency domain resources as the valid ROs in SBFD symbols/slots configured as flexible and the valid ROs in non-SBFD symbols/slots.

[0121] In the example 180B in FIG. 1L, the configured ROs in SBFD symbols/slots may be determined based on the PRACH configuration in a similar manner as the configured ROs in non-SBFD symbols/slots. The configured ROs in the UL subband of the SBFD symbols/slots configured as DL are valid and the configured ROs in the DL subband(s) of the SBFD symbols/slots configured as DL are invalid.

[0122] In the first option, the ROs in non-SBFD symbols/slots that are valid for non-SBFD-aware UEs are also valid for SBFD-aware UEs in corresponding SBFD symbols/slots configured as flexible and corresponding non-SBFD symbols/slots. The ROs in SBFD symbols/slots configured as DL by *tdd-UL-DL-ConfigurationCommon* are valid if at least the time and frequency resources of the ROs are fully within the UL usable PRBs, and not overlapped with SSB.

[0123] In other words, there may be a common set of valid ROs for the SBFD-aware UEs and for the UEs not supporting the SBFD scheme. The common set of valid ROs may be in the SBFD symbols/slots configured as flexible and non-SBFD symbols/slots for the SBFD-aware UEs. There may also be an additional set of valid ROs for the SBFD-aware UEs in SBFD symbols/slots configured as DL. A SSB-to-RO mapping may be jointly performed for the common set of valid ROs. Another SSB-to-RO mapping may be jointly performed for the additional set of valid ROs.

[0124] In the second option, two separate RACH configurations may be used, including a first RACH configuration applicable for both the SBFD-aware UEs and the UEs not supporting the SBFD scheme and a second RACH configuration only applicable for the SBFD-aware UEs. The first RACH configuration is used for determining the ROs in flexible symbols/slots and in UL symbols/slots, and the second RACH configuration is used for determining the ROs in SBFD symbols/slots. Both the two RACH configurations could be aware for the SBFD-aware UEs.

[0125] For example, two PRACH configurations may be provided to the SBFD-aware UEs. The valid ROs determined based on the first RACH configuration may be common for the SBFD-aware UEs and for the UEs not supporting the SBFD scheme. The common set of valid ROs may be in the SBFD symbols/slots configured as flexible and non-SBFD symbols/slots for the SBFD-aware UEs. An additional set of valid ROs

may be determined based on the second RACH configuration for the SBFD-aware UEs. The additional set of valid ROs may include ROs in SBFD symbols/slots configured as DL. In some cases, the additional set of valid ROs may also include ROs in SBFD symbols/slots configured as flexible, if any. A SSB-to-RO mapping may be jointly performed for the common set of valid ROs. Another SSB-to-RO mapping may be jointly performed for the additional set of valid ROs. FIGS. 1M and 1O shows examples of determination of valid ROs based on two PRACH configurations in accordance with some example embodiments of the present disclosure.

[0126] In the example 190A in FIG. 1M, a first set of valid ROs may be determined in SBFD symbols/slots configured as flexible and non-SBFD symbols/slots based on the first PRACH configuration. The first set of valid ROs are common for the SBFD-aware UEs and for the UEs not supporting the SBFD scheme. A second set of valid ROs may be determined in SBFD symbols/slots configured as DL based on the second PRACH configuration. The second set of valid ROs are additional ROs for the SBFD-aware UEs. In other words, the additional set of valid ROs may include ROs determined in SBFD symbols/slots configured as DL based on the second PRACH configuration. The ROs determined in SBFD symbols/slots configured as flexible based on the second PRACH configuration are not valid.

[0127] In the example 190B in FIG. 1N, a first set of valid ROs may be determined in SBFD symbols/slots configured as flexible and non-SBFD symbols/slots based on the first PRACH configuration. The first set of valid ROs are common for the SBFD-aware UEs and for the UEs not supporting the SBFD scheme. A second set of valid ROs may be determined in SBFD symbols/slots configured as DL and in SBFD symbols/slots configured as flexible based on the second PRACH configuration. The second set of valid ROs are additional ROs for the SBFD-aware UEs. In other words, the additional set of valid ROs may include ROs determined in SBFD symbols/slots configured as DL and ROs in SBFD symbols/slots configured as flexible based on the second PRACH configuration.

[0128] In the example 190C in FIG. 1O, a first set of valid ROs may be determined in SBFD symbols/slots configured as flexible and non-SBFD symbols/slots based on the first PRACH configuration. The first set of valid ROs are common for the SBFD-aware UEs and for the UEs not supporting the SBFD scheme. A second set of valid ROs may

be determined in SBFD symbols/slots configured as DL and in SBFD symbols/slots configured as flexible based on the second PRACH configuration. The second set of valid ROs are additional ROs for the SBFD-aware UEs. In other words, the additional set of valid ROs may include ROs determined in SBFD symbols/slots configured as DL and ROs in SBFD symbols/slots configured as flexible based on the second PRACH configuration. The RO configured by the second PRACH configuration is not valid in the SBFD symbol configured as flexible if the RO is overlapped with valid ROs configured by the first PRACH configuration.

[0129] In the first and second options, the common set of valid ROs and the additional set of valid ROs may be used for preamble repetitions for the SBFD-aware UEs. Assuming these ROs are used for PRACH repetition, determination of the ROs for PRACH repetitions should be designed. In the following description, the terms "PRACH repetition" and "preamble repetition" may be used interchangeably.

[0130] In an assumption where PRACH repetitions across SBFD symbols/slots and non-SBFD symbols/slots are supported, there would be a case that a RO could be used for PRACH repetitions across non-SBFD symbols/slots by UEs not supporting the SBFD scheme and can also be used for PRACH repetition across SBFD symbols/slots and non-SBFD symbols/slots by SBFD-aware UEs. In such event, the gNB couldn't know the real repetition location, and cannot perform the repetition combination.

[0131] FIG. 1P illustrates an example of two approaches for determination of multiple RO groups from two sets of valid ROs in related solutions. In the example shown in FIG. 1P, the valid ROs in SBFD symbols/slots configured as flexible and in UL symbols/slots occupy the same frequency resources as the valid ROs in SBFD symbols/slots configured as DL. There may be two approaches for determining a RO group associated with SSB#0 with a repetition number of 2. In a first approach, the preamble repetitions may only be transmitted in the flexible symbols/slots and UL symbols/slots. The RO group for the preamble repetition may include the ROs 191 and 193 in the SBFD symbols/slots configured as flexible. In a second approach, the preamble repetitions may be transmitted across the SBFD symbols/slots and non-SBFD symbols/slots. The RO 191 in the SBFD symbol/slot configured as flexible and the RO 192 in the SBFD symbol/slot configured as DL may consist a RO group for the preamble repetitions. If the base station receives

a preamble on the RO 191, the base station does not know whether the preamble repetition is in the RO 193 or in the RO 192.

[0132] Different preambles may be used to distinguish whether the preamble is for preamble repetitions across only flexible/UL symbols/slots or for preamble repetitions across SBFD symbols/slots and non-SBFD symbols/slots. Considering there are multiple configured repetition numbers, for example, repetition 2 times, 4 times or 8 times, which are also distinguished by different preambles. In other words, for a same repetition number, different preambles should be used for preamble repetitions across only flexible/UL symbols/slots or for preamble repetitions across SBFD symbols/slots and non-SBFD symbols/slots. For different repetition numbers, the different preambles should also be used for preamble repetitions across only flexible/UL symbols/slots or for preamble repetitions across SBFD symbols/slots and non-SBFD symbols/slots. This means that further preamble division is needed. Considering that the preambles are limited, and has been used for many situations, it would be difficult to use more preambles to distinguish the preamble repetition type.

[0133] In some embodiments of the present disclosure, only preamble repetitions across flexible/UL symbols/slots or preamble repetitions across SBFD symbols/slots are supported. Thus, PRACH repetitions could only be transmitted in one symbol type.

[0134] Even if PRACH repetitions are limited into SBFD symbols/slots, considering that the SBFD symbols/slots could be configured in flexible symbols/slots or DL symbols/slots and that there might be valid ROs in flexible symbols/slots for UEs not supporting the SBFD scheme, if PRACH repetitions are transmitted in SBFD symbols/slots configured as flexible, there still might be overlapped ROs between preamble repetitions across flexible/UL symbols/slots or preamble repetitions across SBFD symbols/slots, as shown in FIGS. 1K-1O. Therefore, the determination of RO groups for preamble repetitions needs to be discussed.

[0135] In addition, for SBFD-aware UEs, both preamble repetitions across flexible/UL symbols/slots or preamble repetitions across SBFD symbols/slots may be supported, and a scheme for determining which preamble repetitions should be used needs to be discussed.

[0136] Reference is now made to FIG. 2, which illustrates an example signaling chart of a communication process that supports RO groups for preamble repetitions in

accordance with some example embodiments of the present disclosure. For the purpose of discussion, the process 200 will be described with reference to FIG. 1A. The process 200 may involve the UE 104 and the network entity 102. It is to be understood that the steps and the order of the steps in FIG. 2 are merely for illustration, and not for limitation. It is to be understood that process 200 may further include additional blocks not shown and/or omit some shown blocks, and the scope of the present disclosure is not limited in this regard.

[0137] As shown in FIG. 2, the UE 104 determines (202) a first set of valid ROs and a second set of valid ROs. The UE 104 then determines (204) one or more RO groups for a number of preamble repetitions based on at least one of the first set of valid ROs or the second set of valid ROs. Similarly, the network entity 102 determines (206) the first set of valid ROs and the second set of valid ROs. The network entity 102 then determines (208) one or more RO groups for a number of preamble repetitions based on at least one of the first set of valid ROs or the second set of valid ROs. The network entity 102 and the UE 104 may determine valid ROs and RO groups in a similar manner and thus may have a common understanding on the resources for preamble repetitions.

[0138] In some embodiments, the first set of valid ROs and the second set of valid ROs may be determined accordingly, based on a first PRACH configuration for the first set of valid ROs and a second PRACH configuration for the second set of valid ROs. In other words, if a valid RO is determined based on the first PRACH configuration, this valid RO may be determined to belong to the first set of valid ROs; and if a valid RO is determined based on the second PRACH configuration, this valid RO may be determined to belong to the second set of valid ROs.

[0139] Alternatively or additionally, the first set of valid ROs and the second set of valid ROs may be determined accordingly, based on a first mapping of a plurality of SSBs to the first set of valid ROs and a second mapping of the plurality of SSBs to the second set of valid ROs. The first mapping and the second mapping are separately performed. In other words, the ROs in a same set of valid ROs are associated with a joint SSB-to-RO mapping.

[0140] Alternatively or additionally, the first set of valid ROs and the second set of valid ROs may be determined accordingly, based on types of time units. In an example, the first set of valid ROs are in at least one of SBFD time units configured as flexible or

non-SBFD time units, and the second set of valid ROs are in SBFD time units configured as DL. In other words, if a valid RO is in a SBFD time unit configured as flexible or in a non-SBFD time unit, this valid RO may be determined belong to the first set of valid ROs; and if a valid RO is in a SBFD time unit configured as DL, this valid RO may be determined belong to the second set of valid ROs. In another example, the first set of valid ROs are in at least one of SBFD time units configured as flexible or non-SBFD time units, and the second set of valid ROs are in at least one of SBFD time units configured as DL or SBFD time units configured as flexible. If a valid RO is in a non-SBFD time unit, this valid RO may be determined belong to the first set of valid ROs; and if a valid RO is in a SBFD time unit configured as DL, this valid RO may be determined belong to the second set of valid ROs. If a valid RO is in a SBFD time unit configured as flexible, this valid RO may be determined belong to the first set of valid ROs or the second set of valid ROs based on the PRACH configuration or the SSB-to-RO mapping.

[0141] In this way, the valid ROs may be divided into two sets based on these predefined rules. Other predefined rules are also possible. For example, the common set of valid ROs as described with reference to FIGS. 1K-1O may be determined as the first set of valid ROs based on at least one predefined rule. The additional set of valid ROs as described with reference to FIGS. 1K-1O may be determined as the second set of valid ROs based on at least one predefined rule.

[0142] In some embodiments, the UE 104 may determine at least one RO group and ROs in the same RO group may belong to the same set of valid ROs. Therefore, ROs in a RO group should meet the same rule as the set of valid ROs.

[0143] In an example, a first rule may be that all ROs in the same RO group should be in SBFD symbols/slots configured as DL. A second rule may be that all ROs in the same RO group should be in non-SBFD symbols/slots or in SBFD symbols/slots configured as flexible.

[0144] Alternatively or additionally, a third rule may be that all ROs in the same RO group should be additional ROs for SBFD-aware UEs. A fourth rule may be that all ROs in the same RO group should be common RO for SBFD-aware UEs and UEs not supporting the SBFD scheme.

[0145] Alternatively or additionally, a fifth rule may be that all ROs in the same RO group should be from the ROs with joint SSB to RO mapping

[0146] Alternatively or additionally, a sixth rule may be that all ROs in the same RO group should be ROs in SBFD symbols/slots configured as DL or ROs configured by the second PRACH configuration in SBFD symbols/slots configured as flexible. A seventh rule may be that all ROs in the same RO group should be in ROs in non-SBFD symbols/slots or ROs configured by first the first PRACH configuration in SBFD symbols/slots configured as flexible.

[0147] FIGS. 3A-3C illustrate examples of RO groups for preamble repetitions from two sets of valid ROs in accordance with some example embodiments of the present disclosure.

[0148] In the example 300A in FIG. 3A, the UE may determine the valid ROs in SBFD symbols/slots and valid ROs in non-SBFD symbols/slots based on one PRACH configuration. The determination of valid ROs in FIG. 3A may be similar to the examples in FIGS. 1K and 1L.

[0149] In an example, all ROs in the same RO group should meet one of the first and second rules. For example, all ROs in the same RO group should be in SBFD symbols/slots configured as DL; or, all ROs in the same RO group should be in non-SBFD symbols/slots or in SBFD symbols/slots configured as flexible. As shown in FIG. 3A, the valid ROs 312 and 314 in the same RO group are both in SBFD symbols/slots configured as DL; and the valid ROs 311 and 313 in the same RO group are both in non-SBFD symbols/slots or in SBFD symbols/slots configured as flexible.

[0150] Alternatively, all ROs in the same RO group should meet one of the third and fourth rules. For example, the ROs in SBFD symbols/slots configured as DL are additional ROs for SBFD-aware UEs and the ROs in SBFD symbols/slots configured as flexible and non-SBFD symbols/slots are common ROs for SBFD-aware UEs and UEs not supporting the SBFD schemes in this case. All ROs in the same RO group should be additional ROs for SBFD-aware UEs; or, all ROs in the same RO group should be common ROs for SBFD-aware UEs and UEs not supporting the SBFD schemes.

[0151] Alternatively, all ROs in the same RO group should meet the fifth rules. For example, the SSB-to-RO mapping for ROs in SBFD symbols/slots configured as DL are separately performed with the SSB-to-RO mapping for ROs in SBFD symbols/slots configured as flexible and non-SBFD symbols/slots. All ROs in the same RO group should be from the ROs with joint SSB-to-RO mapping.

[0152] In the example 300B in FIG. 3B, the UE may determine the valid ROs in SBFD symbols/slots configured as flexible and non-SBFD symbols/slots based on the first PRACH configuration, but determine the valid ROs in SBFD symbols/slots configured as DL based on the second PRACH configuration. The determination of valid ROs in FIG. 3B may be similar to the examples in FIG. 1M.

[0153] In an example, all ROs in the same RO group should meet one of the first and second rules. For example, all ROs in the same RO group should be in SBFD symbols/slots configured as DL; or, all ROs in the same RO group should be in non-SBFD symbols/slots or in SBFD symbols/slots configured as flexible. As shown in FIG. 3A, the valid ROs 321 and 325 in the same RO group are both in non-SBFD symbols/slots or in SBFD symbols/slots configured as flexible; the valid ROs 322 and 326 in the same RO group are both in non-SBFD symbols/slots or in SBFD symbols/slots configured as flexible; the valid ROs 323 and 327 in the same RO group are both in SBFD symbols/slots configured as DL; and the valid ROs 324 and 328 in the same RO group are both in SBFD symbols/slots configured as DL.

[0154] Alternatively, all ROs in the same RO group should meet one of the third and fourth rules. For example, the ROs in SBFD symbols/slots configured as DL are additional ROs for SBFD-aware UEs and the ROs in SBFD symbols/slots configured as flexible and non-SBFD symbols/slots are common ROs for SBFD-aware UEs and UEs not supporting the SBFD schemes in this case. All ROs in the same RO group should be additional ROs for SBFD-aware UEs; or, all ROs in the same RO group should be common ROs for SBFD-aware UEs and UEs not supporting the SBFD schemes.

[0155] Alternatively, all ROs in the same RO group should meet the fifth rules. For example, the SSB-to-RO mapping for ROs in SBFD symbols/slots configured as DL are separately performed with the SSB-to-RO mapping for ROs in SBFD symbols/slots configured as flexible and non-SBFD symbols/slots. All ROs in the same RO group should be from the ROs with joint SSB-to-RO mapping.

[0156] Considering that the ROs in SBFD symbols/slots configured as DL and the ROs in SBFD symbols/slots configured as flexible and non-SBFD symbols/slots are determined based on different PRACH configurations. All ROs in the same RO group should be ROs in SBFD symbols/slots configured as DL configured by the second PRACH configuration; or, all ROs in the same RO group should be ROs in non-SBFD

symbols/slots or ROs in SBFD symbols/slots configured as flexible configured by first the first PRACH configuration.

[0157] In the example 300C in FIG. 3C, the UE may determine a part of valid ROs in SBFD symbols/slots configured as flexible and valid ROs in non-SBFD symbols/slots based on the first PRACH configuration, and determine valid ROs in SBFD symbols/slots configured as DL and the other part of valid ROs in SBFD symbols/slots configured as flexible based on the second PRACH configuration. The determination of valid ROs in FIG. 3C may be similar to the examples in FIGS. 1N and 1O.

[0158] In an example, all ROs in the same RO group should meet one of the third and fifth rules. For example, the ROs in SBFD symbols/slots configured as DL and the ROs configured by second PRACH configuration in SBFD symbols/slots configured as flexible are additional ROs for SBFD-aware UEs; and the ROs configured by the first PRACH configuration in SBFD symbols/slots configured as flexibles/slots and in non-SBFD symbols/slots are common ROs for SBFD-aware UEs and UEs not supporting the SBFD schemes in this case. All ROs in the same RO group should be additional ROs for SBFD-aware UEs; or, all ROs in the same RO group should be common ROs for SBFD-aware UEs and UEs not supporting the SBFD schemes. The valid ROs 331 and 338 in the same RO group are both common ROs for SBFD-aware UEs and UEs not supporting the SBFD schemes; the valid ROs 334 and 339 in the same RO group are both common ROs for SBFD-aware UEs and UEs not supporting the SBFD schemes; the valid ROs 332 and 336 in the same RO group are both additional ROs for SBFD-aware UEs; the valid ROs 333 and 337 in the same RO group are both additional ROs for SBFD-aware UEs; the valid ROs 335 and 340 in the same RO group are both additional ROs for SBFD-aware UEs.

[0159] Alternatively, all ROs in the same RO group should meet the fifth rules. For example, the SSB-to-RO mapping for RO in SBFD symbols/slots configured as DL and SSB-to-RO mapping for ROs configured by the second PRACH configuration in SBFD symbols/slots configured as flexible are joint performed, which is separately performed with the SSB-to-RO mapping for ROs configured by the first PRACH configuration in SBFD symbols/slots configured as flexible and in non-SBFD symbols/slots. All ROs in the same RO group should be from the ROs with joint SSB-to-RO mapping.

[0160] Alternatively, all ROs in the same RO group should meet one of the sixth and seventh rules. All ROs in the same RO group should be ROs in SBFD symbols/slots configured as DL or ROs configured by the second PRACH configuration in SBFD symbols/slots configured as flexible; or all ROs in the same RO group should be in ROs in non-SBFD symbols/slots or ROs configured by first the first PRACH configuration in SBFD symbols/slots configured as flexible.

[0161] Turning back to FIG. 2, in some embodiments, when determining the one or more RO groups, the UE 104 may determine a first set of RO groups based on the first set of valid ROs. Alternatively or additionally, the UE 104 may determine a second set of RO groups based on the second set of valid ROs. In this way, the ROs in one RO group belong to the same set of valid ROs.

[0162] In some embodiments, the UE 104 may determine two sets of RO groups and transmit the preamble repetitions in one RO group among the two sets of RO groups.

[0163] Alternatively, the UE 104 may receive, from the network entity 102, an indication indicating one of the first set of valid ROs or the second set of valid ROs to be used for determining the one or more RO groups. If the UE 104 receives an indication of the first set of valid ROs, the UE 104 may determine the first set of RO groups based on the first set of valid ROs and transmit the preamble repetitions in one RO group among the first set of RO groups. If the UE 104 receives an indication of the second set of valid ROs, the UE 104 may determine the second set of RO groups based on the first set of valid ROs and transmit the preamble repetitions in one RO group among the first set of RO groups.

[0164] In other words, the UE 104 may determine two sets of RO groups. In some implementations, different predefine rules may be used for different sets of RO groups. For example, for the first set of RO groups, all ROs in each RO group should meet one of the second rule, the fourth rule or the seventh rule. For the second set of RO groups, all ROs in each RO group should meet one of the first rule, the third rule or the sixth rule. Alternatively or additionally, all ROs in each RO group should meet the fifth rule, e.g., should be from joint SSB-to-RO mapping, and ROs from different sets of RO groups should be from separate SSB-to-RO mappings.

[0165] In some embodiments, the first set of RO groups may be determined based on a first RO offset indicating a number of valid ROs among the first set of valid ROs

between respective starting ROs of two RO groups among the first set of RO groups. The second set of RO groups may be determined based on a second RO offset indicating a number of valid ROs among the second set of valid ROs between respective starting ROs of two RO groups among the second set of RO groups. In other words, one offset (e.g., *TimeOffsetBetweenStartingRO*) may be configured for each set of RO group. The first offset may be used to determine the RO groups in first set of RO groups, and the second offset may be used to determine the RO groups in second set of RO groups.

[0166] In some embodiments, the first set of RO groups and the second set of RO groups may be determined based on a RO offset. For the first set of RO groups, the RO offset indicates a number of valid ROs among the first set of valid ROs between respective starting ROs of two RO groups among the first set of RO groups. For the second set of RO groups, the RO offset indicates a number of valid ROs among the second set of valid ROs between respective starting ROs of two RO groups among the second set of RO groups.

[0167] In other words, the configured offset (e.g., *TimeOffsetBetweenStartingRO*) may have different meanings for the two sets of RO groups. For the first set of RO groups, the configured offset is the number of valid ROs in the first set of ROs between respective starting ROs; and for the second set of RO groups, the configured offset is the number of valid ROs in the second set of ROs between respective starting ROs .

[0168] In some embodiments, the UE 104 may receive, from the network entity 102, an indication indicating one of the first set of valid ROs or the second set of valid ROs to be used for determining the one or more RO groups. If the UE 104 receives an indication of the first set of valid ROs, the UE 104 may determine the first set of RO groups based on RO offset, and the number of valid ROs among the first set of valid ROs between respective starting ROs of two RO groups among the first set of RO groups may equal to the RO offset. If the UE 104 receives an indication of the second set of valid ROs, the UE 104 may determine the second set of RO groups based on RO offset, and the number of valid ROs among the second set of valid ROs between respective starting ROs of two RO groups among the second set of RO groups may equal to the RO offset.

[0169] In some embodiments, the two RO groups among the first set of RO groups are consecutive RO groups mapped to the same SSB and having the same frequency domain resources, and the two RO groups among the second set of RO groups are

consecutive RO groups mapped to the same SSB and having the same frequency domain resources.

[0170] For each set of RO groups, when determining the RO groups for $N_{\text{preamble}}^{\text{rep}}$ preamble repetitions, if the parameter *TimeOffsetBetweenStartingRO* is provided, for each frequency resource index for frequency multiplexed ROs, the first valid RO of the first $N_{\text{preamble}}^{\text{rep}}$ preamble repetitions is the first valid RO in the set of RO groups. The first valid RO of subsequent $N_{\text{preamble}}^{\text{rep}}$ preamble repetitions is after *TimeOffsetBetweenStartingRO* consecutive valid ROs in time from the first valid RO corresponding to the previous $N_{\text{preamble}}^{\text{rep}}$ preamble repetitions. If the parameter *TimeOffsetBetweenStartingRO* is not provided, for each frequency resource index for frequency multiplexed ROs, the first valid RO of the first $N_{\text{preamble}}^{\text{rep}}$ preamble repetitions is the first valid RO in the set of RO groups. The first valid RO of subsequent $N_{\text{preamble}}^{\text{rep}}$ preamble repetitions, if any, is determined after the ROs determined for the previous $N_{\text{preamble}}^{\text{rep}}$ preamble repetitions according to the following ordering of valid ROs: first, in an increasing order of frequency resource indexes for frequency multiplexed ROs; and second, in an increasing order of time resource indexes for time multiplexed ROs.

[0171] FIG. 4 illustrates an example 400 of two sets of RO groups for preamble repetitions from two sets of valid ROs in accordance with some example embodiments of the present disclosure. There are two sets of valid ROs available for the SBFD-aware UE. The first set of valid ROs include common ROs that are also valid for UEs not supporting the SBFD scheme. The second set of valid ROs include additional ROs for the SBFD-aware UE.

[0172] The first set of ROs groups may be determined from the first set of valid ROs and the second set of ROs groups may be determined from the second set of valid ROs. For example, the RO group consisting of the RO 411 and the RO 412 and the RO group consisting the RO 421 and the RO 422 belong to the first set of RO groups. The RO group consisting of the RO 431 and the RO 432 and the RO group consisting the RO 441 and the RO 442 belong to the second set of RO groups.

[0173] Turning back to FIG. 2, in some embodiments, when determining the one or more RO groups, the UE 104 may determine one set of RO groups comprising the one or more RO groups based on the first set of valid ROs and the second set of valid ROs. ROs

in an RO group among the set of RO groups belong to a same set of valid ROs. Thus, ROs in different RO groups may meet different predefined rules.

[0174] In some embodiments, the set of RO groups may include a first RO group and a second RO group subsequent to the first RO group. The first RO group and the second RO group may be mapped to the same SSB and have the same frequency domain resources.

[0175] In some implementations, the ROs in the second RO group are after the ROs in the first RO group in time domain. In other words, for the same frequency index and the same SSB index, the first RO (or the starting RO) for the subsequent RO group should be after all ROs determined for the previous RO group.

[0176] FIG. 5A illustrates an example 500A of one set of RO groups for preamble repetitions from two sets of valid ROs in accordance with some example embodiments of the present disclosure. In the example 500A, there are two sets of valid ROs available for the SBFD-aware UE. The first set of valid ROs include common ROs that are also valid for UEs not supporting the SBFD scheme. The second set of valid ROs include additional ROs for the SBFD-aware UE. One set of RO groups are determined from the two sets of valid ROs and ROs in the same RO group belong to the same set of valid ROs. The first RO group is determined to include the RO 511 and the RO 512. The second RO group having the same frequency domain resource as the first RO group is determined to include the RO 521 and the RO 522, such that all ROs of the subsequent RO group are after all ROs of the previous RO group.

[0177] Alternatively, a starting RO in the second RO group is after a starting RO in the first RO group in time domain. In some embodiments, ROs in the first RO group belong to the first set of valid ROs, and ROs in the second RO group belong to the second set of valid ROs. In other words, for the same frequency index, the first RO (or the starting RO) for the subsequent RO group should be after the first RO (or the starting RO) of the previous RO group if the ROs in the two RO groups are from different sets of valid ROs.

[0178] FIG. 5B illustrates an example 500B of one set of RO groups for preamble repetitions from two sets of valid ROs in accordance with some example embodiments of the present disclosure. In the example 500B, there are two sets of valid ROs available for the SBFD-aware UE. The first set of valid ROs include common ROs that are also valid for UEs not supporting the SBFD scheme. The second set of valid ROs include additional

ROs for the SBFD-aware UE. One set of RO groups are determined from the two sets of valid ROs and ROs in the same RO group belong to the same set of valid ROs. The first RO group is determined to include the RO 531 and the RO 532 from the first set of valid ROs. The second RO group having the same frequency domain resource as the first RO group is determined to include the RO 541 and the RO 542 from the second set of valid ROs, such that the starting RO of the second RO group is after the starting RO of the first RO group. The third RO group having the same frequency domain resource as the first and second RO groups is determined to include the RO 551 and the RO 552 from the second set of valid ROs, such that the starting RO of the third RO group is after the starting RO of the first RO group and all ROs of the third RO group are after all ROs of the second RO group. It can be seen that for the same frequency index, there could be two RO groups overlapped with each other in time domain if the ROs in the two RO groups meet different predefined rules (i.e., the ROs in the two RO groups belong to different sets of valid ROs).

[0179] In some embodiments, the UE 104 may transmit (210), to the network entity 102, a PRACH transmission 212 with the number of preamble repetitions in one RO group among the one or more RO groups. Accordingly, the network entity 102 may receive (214) the PRACH transmission 212 with the number of preamble repetitions in the RO group. Since there is no overlapped ROs between the two RO sets, the network entity 102 would be aware the location of preamble repetitions when receiving a preamble.

[0180] In some embodiments, the UE 104 may receive, from the network entity 102, an indication that ROs in the one RO group are from the first set of valid ROs or an indication that ROs in the one RO group are from the second set of valid ROs. In this way, the UE 104 may be aware to use which set of valid ROs to determine the RO group for PRACH transmission with repetitions.

[0181] In some embodiments, the UE 104 may transmit, to the network entity 102, an indication that valid ROs determined based on a first PRACH configuration are supported. The network entity 102 may thus be aware that the UE 104 may determine the valid ROs only based on the first PRACH configuration. In some embodiments, the UE 104 may transmit, to the network entity 102, an indication that valid ROs determined based on two PRACH configurations are supported. Alternatively, the UE 104 may transmit, to the network entity 102, an indication that valid ROs determined based on a

second PRACH configuration are supported. The network entity 102 may thus be aware that the UE 104 may determine the valid ROs based on both the first and second PRACH configurations. In some embodiments, the UE 104 is in a radio resource control (RRC) active mode.

[0182] For example, considering that the valid ROs may be determined based on one PRACH configuration or two PRACH configurations, and the UE is not required to support both determination options, thus, the UE in RRC connected mode may report its capability about supporting using one PRACH configuration or two PRACH configurations to determine the valid ROs. Then, the network entity 102 may explicitly or implicitly indicate whether one PRACH configuration or two PRACH configurations is to be used to determine the valid ROs. For example, the network entity 102 may provide an additional configuration for determining the valid ROs, and the UE 104 may determine the valid ROs based on two PRACH configurations; otherwise, the UE 104 may determine the valid ROs based on one PRACH configuration.

[0183] In some embodiments, the first set of valid ROs and the second set of valid ROs may be determined based on a default PRACH configuration. In some implementations, the default PRACH configuration is a first PRACH configuration. Alternatively, the default PRACH configuration is the first PRACH configuration and a second PRACH configuration. In some embodiments, the UE 104 is in a RRC inactive mode or a RRC idle mode. For example, in RRC idle/inactive mode, there is no capability report about supporting using one PRACH configuration or two PRACH configurations to determine the valid ROs, one option for the PRACH configuration may be used as the default option. For example, the UE 104 may use one PRACH configuration by default. Alternatively, the UE 104 may use two PRACH configurations by default. Then after the UE 104 is RRC connected, the UE 104 may report its capability about supporting using one PRACH configuration or two PRACH configurations to determine the valid ROs; and then, the network entity 102 may explicitly or implicitly indicate whether one PRACH configuration or two PRACH configurations is to be used to determine the valid ROs.

[0184] In some embodiments, the first PRACH configuration is associated with RO configuration in at least one of SBFD time units configured as flexible or non-SBFD time

units, and the second PRACH configuration is associated with RO configuration in SBFD time units configured as DL.

[0185] In some embodiments, the first PRACH configuration is associated with RO configuration in at least one of SBFD time units configured as flexible or non-SBFD time units, and the second PRACH configuration is associated with RO configuration in at least one of SBFD time units configured as DL or SBFD time units configured as flexible.

[0186] If both the first PRACH configuration and the second PRACH configuration are used to determine the valid ROs, the first set of valid ROs may be determined based on the first PRACH configuration and the second set of valid ROs may be determined based on the second PRACH configurations. If only the first PRACH configuration is used to determine the valid ROs, the first set of valid ROs are determined based on the first PRACH configuration in SBFD time units configured as flexible and non-SBFD time units, and the second set of valid ROs are determined based on the first PRACH configuration in SBFD time units configured as DL.

[0187] FIG. 6 illustrates an example of a device 600 that supports RO groups for preamble repetitions in accordance with aspects of the present disclosure. The device 600 may be an example of a network entity 102 or a UE 104 as described herein. The device 600 may support wireless communication with one or more network entities 102, UEs 104, or any combination thereof. The device 600 may include components for bi-directional communications including components for transmitting and receiving communications, such as a processor 602, a memory 604, a transceiver 606, and, optionally, an I/O controller 608. These components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

[0188] The processor 602, the memory 604, the transceiver 606, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. For example, the processor 602, the memory 604, the transceiver 606, or various combinations or components thereof may support a method for performing one or more of the operations described herein.

[0189] In some implementations, the processor 602, the memory 604, the transceiver 606, or various combinations or components thereof may be implemented in hardware

(e.g., in communications management circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), a field-programmable gate array (FPGA) or other programmable logic device, a discrete gate or transistor logic, discrete hardware components, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure. In some implementations, the processor 602 and the memory 604 coupled with the processor 602 may be configured to perform one or more of the functions described herein (e.g., executing, by the processor 602, instructions stored in the memory 604).

[0190] For example, the processor 602 may support wireless communication at the device 600 in accordance with examples as disclosed herein. The processor 602 may be configured to operable to support a means for determining a first set of valid random access channel (RACH) occasions (ROs) and a second set of valid ROs; and a means for determining one or more RO groups for a number of preamble repetitions based on at least one of the first set of valid ROs or the second set of valid ROs.

[0191] The processor 602 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, a microcontroller, an ASIC, an FPGA, a programmable logic device, a discrete gate or transistor logic component, a discrete hardware component, or any combination thereof). In some implementations, the processor 602 may be configured to operate a memory array using a memory controller. In some other implementations, a memory controller may be integrated into the processor 602. The processor 602 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 604) to cause the device 600 to perform various functions of the present disclosure such that the device 600 may perform any process of the disclosure as discussed with reference to FIGS. 2 to 6.

[0192] The memory 604 may include random access memory (RAM) and read-only memory (ROM). The memory 604 may store computer-readable, computer-executable code including instructions that, when executed by the processor 602 cause the device 600 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. In some implementations, the code may not be directly executable by the processor 602 but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some implementations, the memory 604 may include, among other

things, a basic I/O system (BIOS) which may control basic hardware or software operation such as the interaction with peripheral components or devices.

[0193] The I/O controller 608 may manage input and output signals for the device 600. The I/O controller 608 may also manage peripherals not integrated into the device M02. In some implementations, the I/O controller 608 may represent a physical connection or port to an external peripheral. In some implementations, the I/O controller 608 may utilize an operating system such as iOS®, ANDROID®, MS-WINDOWS®, OS/2®, UNIX®, LINUX®, or another known operating system. In some implementations, the I/O controller 608 may be implemented as part of a processor, such as the processor 606. In some implementations, a user may interact with the device 600 via the I/O controller 608 or via hardware components controlled by the I/O controller 608.

[0194] In some implementations, the device 600 may include a single antenna 610. However, in some other implementations, the device 600 may have more than one antenna 610 (i.e., multiple antennas), including multiple antenna panels or antenna arrays, which may be capable of concurrently transmitting or receiving multiple wireless transmissions. The transceiver 606 may communicate bi-directionally, via the one or more antennas 610, wired, or wireless links as described herein. For example, the transceiver 606 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 606 may also include a modem to modulate the packets, to provide the modulated packets to one or more antennas 610 for transmission, and to demodulate packets received from the one or more antennas 610. The transceiver 606 may include one or more transmit chains, one or more receive chains, or a combination thereof.

[0195] A transmit chain may be configured to generate and transmit signals (e.g., control information, data, packets). The transmit chain may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation (QAM). The transmit chain may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over

the wireless medium. The transmit chain may also include one or more antennas 610 for transmitting the amplified signal into the air or wireless medium.

[0196] A receive chain may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receive chain may include one or more antennas 610 for receive the signal over the air or wireless medium. The receive chain may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receive chain may include at least one demodulator configured to demodulate the receive signal and obtain the transmitted data by reversing the modulation technique applied during transmission of the signal. The receive chain may include at least one decoder for decoding the processing the demodulated signal to receive the transmitted data.

[0197] FIG. 7 illustrates an example of a processor 700 that supports RO groups for preamble repetitions in accordance with aspects of the present disclosure. The processor 700 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 700 may be implemented in a device or its components as described herein. For example, the device may be an example of a network entity 102 or a UE 104 as described herein. The processor 700 may include a controller 702 configured to perform various operations in accordance with examples as described herein. The processor 700 may optionally include at least one memory 704, such as L1/L2/L3 cache. Additionally, or alternatively, the processor 700 may optionally include one or more arithmetic-logic units (ALUs) 706. One or more of these components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

[0198] The processor 700 may be a processor chipset and include a protocol stack (e.g., a software stack) executed by the processor chipset to perform various operations (e.g., receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) in accordance with examples as described herein. The processor chipset may include one or more cores, one or more caches (e.g., memory local to or included in the processor chipset (e.g., the processor 700) or other memory (e.g., random access memory (RAM), read-only memory (ROM), dynamic RAM (DRAM), synchronous dynamic RAM (SDRAM), static RAM (SRAM),

ferroelectric RAM (FeRAM), magnetic RAM (MRAM), resistive RAM (RRAM), flash memory, phase change memory (PCM), and others).

[0199] The controller 702 may be configured to manage and coordinate various operations (e.g., signaling, receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) of the processor 700 to cause the processor 700 to support various operations in accordance with examples as described herein. For example, the controller 702 may operate as a control unit of the processor 700, generating control signals that manage the operation of various components of the processor 700. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[0200] The controller 702 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 704 and determine subsequent instruction(s) to be executed to cause the processor 700 to support various operations in accordance with examples as described herein. The controller 702 may be configured to track memory address of instructions associated with the memory 704. The controller 702 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 702 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 700 to cause the processor 700 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 702 may be configured to manage flow of data within the processor 700. The controller 702 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 700.

[0201] The memory 704 may include one or more caches (e.g., memory local to or included in the processor 700 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementation, the memory 704 may reside within or on a processor chipset (e.g., local to the processor 700). In some other implementations, the memory 704 may reside external to the processor chipset (e.g., remote to the processor 700).

[0202] The memory 704 may store computer-readable, computer-executable code including instructions that, when executed by the processor 700, cause the processor 700

to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. The controller 702 and/or the processor 700 may be configured to execute computer-readable instructions stored in the memory 704 to cause the processor 700 to perform various functions. For example, the processor 700 and/or the controller 702 may be coupled with or to the memory 704, and the processor 700, the controller 702, and the memory 704 may be configured to perform various functions described herein. In some examples, the processor 700 may include multiple processors and the memory 704 may include multiple memories. One or more of the multiple processors may be coupled with one or more of the multiple memories, which may, individually or collectively, be configured to perform various functions herein.

[0203] The one or more ALUs 706 may be configured to support various operations in accordance with examples as described herein. In some implementation, the one or more ALUs 706 may reside within or on a processor chipset (e.g., the processor 700). In some other implementations, the one or more ALUs 706 may reside external to the processor chipset (e.g., the processor 700). One or more ALUs 706 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 706 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 706 be configured with a variety of logical and arithmetic circuits, including adders, subtractors, shifters, and logic gates, to process and manipulate the data according to the operation. Additionally, or alternatively, the one or more ALUs 706 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 706 to handle conditional operations, comparisons, and bitwise operations.

[0204] For example, the processor 700 may support wireless communication in accordance with examples as disclosed herein. The processor 700 may be configured to or operable to support a means for a means for determining a first set of valid random access channel (RACH) occasions (ROs) and a second set of valid ROs; and a means for determining one or more RO groups for a number of preamble repetitions based on at least one of the first set of valid ROs or the second set of valid ROs.

[0205] FIG. 8 illustrates a flowchart of a method 800 that supports RO groups for preamble repetitions in accordance with aspects of the present disclosure. The operations

of the method 800 may be implemented by a device or its components as described herein. For example, the operations of the method 800 may be performed by a network entity 102 or a UE 104 as described herein. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

[0206] At 805, the method may include determining a first set of valid random access channel (RACH) occasions (ROs) and a second set of valid ROs. The operations of 805 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 805 may be performed by a device as described with reference to FIG. 1A.

[0207] At 810, the method may include determining one or more RO groups for a number of preamble repetitions based on at least one of the first set of valid ROs or the second set of valid ROs. The operations of 810 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 810 may be performed by a device as described with reference to FIG. 1A.

[0208] It should be noted that the methods described herein describes possible implementations, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible. Further, aspects from two or more of the methods may be combined.

[0209] The various illustrative blocks and components described in connection with the disclosure herein may be implemented or performed with a general-purpose processor, a DSP, an ASIC, a CPU, an FPGA or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but in the alternative, the processor may be any processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices (e.g., a combination of a DSP and a microprocessor, multiple microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

[0210] The functions described herein may be implemented in hardware, software executed by a processor, firmware, or any combination thereof. If implemented in

software executed by a processor, the functions may be stored on or transmitted over as one or more instructions or code on a computer-readable medium. Other examples and implementations are within the scope of the disclosure and appended claims. For example, due to the nature of software, functions described herein may be implemented using software executed by a processor, hardware, firmware, hardwiring, or combinations of any of these. Features implementing functions may also be physically located at various positions, including being distributed such that portions of functions are implemented at different physical locations.

[0211] Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that may be accessed by a general-purpose or special-purpose computer. By way of example, non-transitory computer-readable media may include RAM, ROM, electrically erasable programmable ROM (EEPROM), flash memory, compact disk (CD) ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other non-transitory medium that may be used to carry or store desired program code means in the form of instructions or data structures and that may be accessed by a general-purpose or special-purpose computer, or a general-purpose or special-purpose processor.

[0212] As used herein, including in the claims, an article "a" before an element is unrestricted and understood to refer to "at least one" of those elements or "one or more" of those elements. The terms "a," "at least one," "one or more," and "at least one of one or more" may be interchangeable. As used herein, including in the claims, "or" as used in a list of items (e.g., a list of items prefaced by a phrase such as "at least one of" or "one or more of" or "one or both of") indicates an inclusive list such that, for example, a list of at least one of A, B, or C means A or B or C or AB or AC or BC or ABC (i.e., A and B and C). Also, as used herein, the phrase "based on" shall not be construed as a reference to a closed set of conditions. For example, an example step that is described as "based on condition A" may be based on both a condition A and a condition B without departing from the scope of the present disclosure. In other words, as used herein, the phrase "based on" shall be construed in the same manner as the phrase "based at least in part on. Further, as used herein, including in the claims, a "set" may include one or more elements.

[0213] The description herein is provided to enable a person having ordinary skill in the art to make or use the disclosure. Various modifications to the disclosure will be apparent to a person having ordinary skill in the art, and the generic principles defined herein may be applied to other variations without departing from the scope of the disclosure. Thus, the disclosure is not limited to the examples and designs described herein but is to be accorded the broadest scope consistent with the principles and novel features disclosed herein.

CLAIMS

What is claimed is:

1. A user equipment comprising:

a processor; and

a transceiver coupled to the processor,

wherein the processor is configured to:

determine a first set of valid random access channel (RACH) occasions (ROs) and a second set of valid ROs, and

determine one or more RO groups for a number of preamble repetitions based on at least one of the first set of valid ROs or the second set of valid ROs.

2. The user equipment of claim 1, wherein the first set of valid ROs and the second set of valid ROs are determined accordingly, based on at least one of the following:

a first physical RACH (PRACH) configuration for the first set of valid ROs and a second PRACH configuration for the second set of valid ROs;

a first mapping of a plurality of synchronization signal and physical broadcast channel (PBCH) block (SSBs) to the first set of valid ROs and a second mapping of the plurality of SSBs to the second set of valid ROs, wherein the first mapping and the second mapping are separately performed;

types of time units, wherein the first set of valid ROs are in at least one of subband full duplex (SBFD) time units configured as flexible or non-SBFD time units, and the second set of valid ROs are in SBFD time units configured as downlink (DL); or

types of time units, wherein the first set of valid ROs are in at least one of SBFD time units configured as flexible or non-SBFD time units, and the second set of valid ROs are in at least one of SBFD time units configured as DL or SBFD time units configured as flexible.

3. The user equipment of claim 1, wherein determining the one or more RO groups comprises at least one of the following:

determining a first set of RO groups based on the first set of valid ROs; or

determining a second set of RO groups based on the second set of valid ROs.

4. The user equipment of claim 3, wherein the first set of RO groups is determined based on a first RO offset indicating a number of valid ROs among the first set of valid ROs between respective starting ROs of two RO groups among the first set of RO groups; and

wherein the second set of RO groups is determined based on a second RO offset indicating a number of valid ROs among the second set of valid ROs between respective starting ROs of two RO groups among the second set of RO groups.

5. The user equipment of claim 3, wherein the first set of RO groups and the second set of RO groups are determined based on a RO offset,

wherein, for the first set of RO groups, the RO offset indicates a number of valid ROs among the first set of valid ROs between respective starting ROs of two RO groups among the first set of RO groups; and

wherein, for the second set of RO groups, the RO offset indicates a number of valid ROs among the second set of valid ROs between respective starting ROs of two RO groups among the second set of RO groups.

6. The user equipment of claim 5, wherein the processor is further configured to:

receive, via the transceiver from a network entity, an indication indicating one of the first set of valid ROs or the second set of valid ROs to be used for determining the one or more RO groups.

7. The user equipment of claim 4 or 5, wherein the two RO groups among the first set of RO groups are consecutive RO groups mapped to the same SSB and having the same frequency domain resources, and the two RO groups among the second set of RO groups are consecutive RO groups mapped to the same SSB and having the same frequency domain resources.

8. The user equipment of claim 1, wherein determining the one or more RO groups comprises:

determining one set of RO groups comprising the one or more RO groups based on the first set of valid ROs and the second set of valid ROs, wherein ROs in an RO group among the set of RO groups belong to a same set of valid ROs.

9. The user equipment of claim 8, wherein the set of RO groups comprises a first RO group and a second RO group subsequent to the first RO group, the first RO group and the second RO group are mapped to the same SSB and have the same frequency domain resources, and

wherein the ROs in the second RO group are after the ROs in the first RO group in time domain; or

wherein a starting RO in the second RO group is after a starting RO in the first RO group in time domain.

10. The user equipment of claim 9, wherein ROs in the first RO group belong to the first set of valid ROs, and ROs in the second RO group belong to the second set of valid ROs.

11. The user equipment of claim 3 or 8, wherein the processor is further configured to:

transmit, via the transceiver to a network entity, a PRACH transmission with the number of preamble repetitions in one RO group among the one or more RO groups.

12. The user equipment of claim 11, wherein the processor is further configured to:

receive, via the transceiver from the network entity, an indication that ROs in the one RO group are from the first set of valid ROs or an indication that ROs in the one RO group are from the second set of valid ROs.

13. The user equipment of claim 1, the processor is further configured to:

transmit, via the transceiver to a network entity, one of the following:

an indication that valid ROs determined based on a first PRACH configuration are supported;

an indication that valid ROs determined based on two PRACH configurations are supported; or

an indication that valid ROs determined based on a second PRACH configuration are supported,

wherein the user equipment is in a radio resource control (RRC) active mode.

14. The user equipment of claim 1, wherein the first set of valid ROs and the second set of valid ROs are determined based on a default PRACH configuration, wherein the default PRACH configuration is one of the following:

a first PRACH configuration; or

the first PRACH configuration and a second PRACH configuration.

15. The user equipment of claim 14, wherein the user equipment is in a RRC inactive mode or a RRC idle mode.

16. The user equipment of any of claims 13-15, wherein the first PRACH configuration is associated with RO configuration in at least one of SBFD time units configured as flexible or non-SBFD time units, and the second PRACH configuration is associated with RO configuration in SBFD time units configured as DL.

17. The user equipment of any of claims 13-15, wherein the first PRACH configuration is associated with RO configuration in at least one of SBFD time units configured as flexible or non-SBFD time units, and the second PRACH configuration is associated with RO configuration in at least one of SBFD time units configured as DL or SBFD time units configured as flexible.

18. A network entity comprising:

a processor; and

a transceiver coupled to the processor,

wherein the processor is configured to:

determine a first set of valid random access channel (RACH) occasions (ROs) and a second set of valid ROs, and

determine one or more RO groups for a number of preamble repetitions based on at least one of the first set of valid ROs or the second set of valid ROs.

19. A method performed by a user equipment, the method comprising:

determining a first set of valid random access channel (RACH) occasions (ROs) and a second set of valid ROs, and

determining one or more RO groups for a number of preamble repetitions based on at least one of the first set of valid ROs or the second set of valid ROs.

20. A processor for wireless communication, comprising:

at least one memory; and

a controller coupled with the at least one memory and configured to cause the controller to:

determine a first set of valid random access channel (RACH) occasions (ROs) and a second set of valid ROs, and

determine one or more RO groups for a number of preamble repetitions based on at least one of the first set of valid ROs or the second set of valid ROs.