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(54) RANDOM ACCESS PROCEDURES WITH A VIRTUAL CELL

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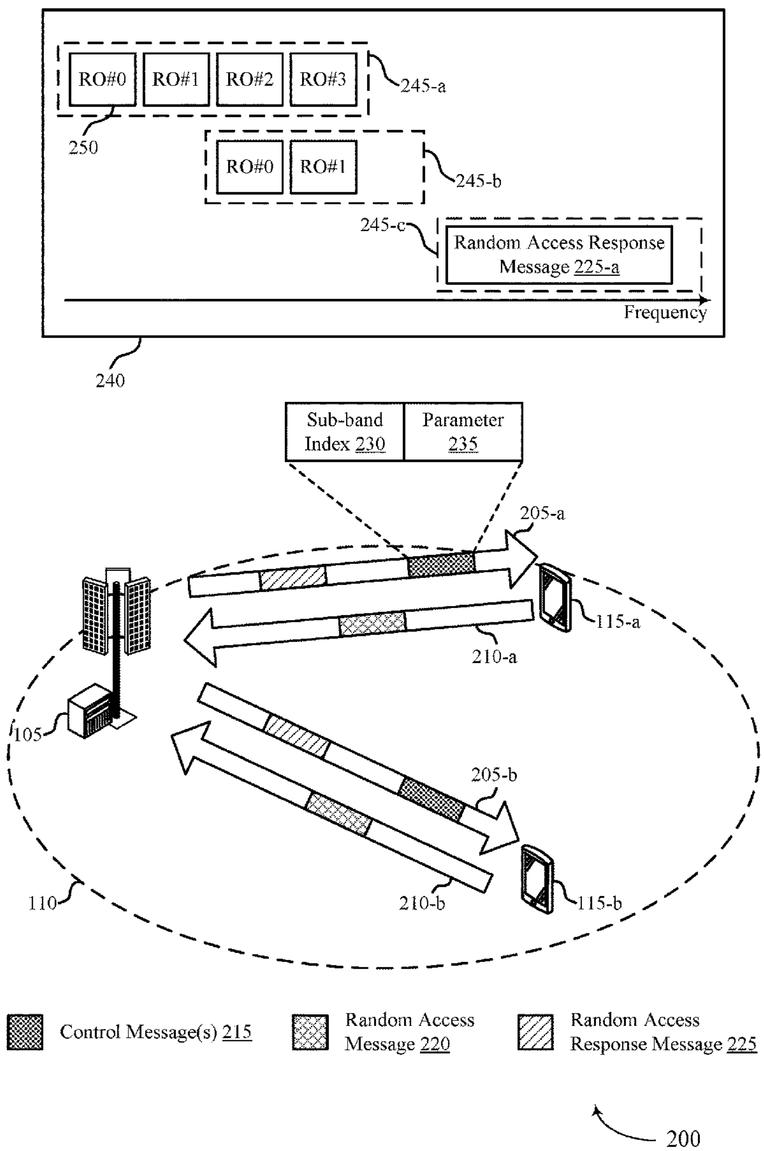
(57) ABSTRACT

Methods, systems, and devices for wireless communications are described. A user equipment (UE) may receive one or more control messages from a network entity that include a sub-band index and a parameter associated with a quantity of random access (RA) occasions. The UE may transmit an RA message to the network entity via an RA occasion of a specific sub-band based on the sub-band index and the parameter. The UE may receive, from the network entity, a random access response (RAR) message that is associated with the index of the sub-band, the RA occasion, or both. In some examples, the RAR message may be associated with a sub-band based on including the sub-band index, the parameter, or both in one or more portions of the RAR message.



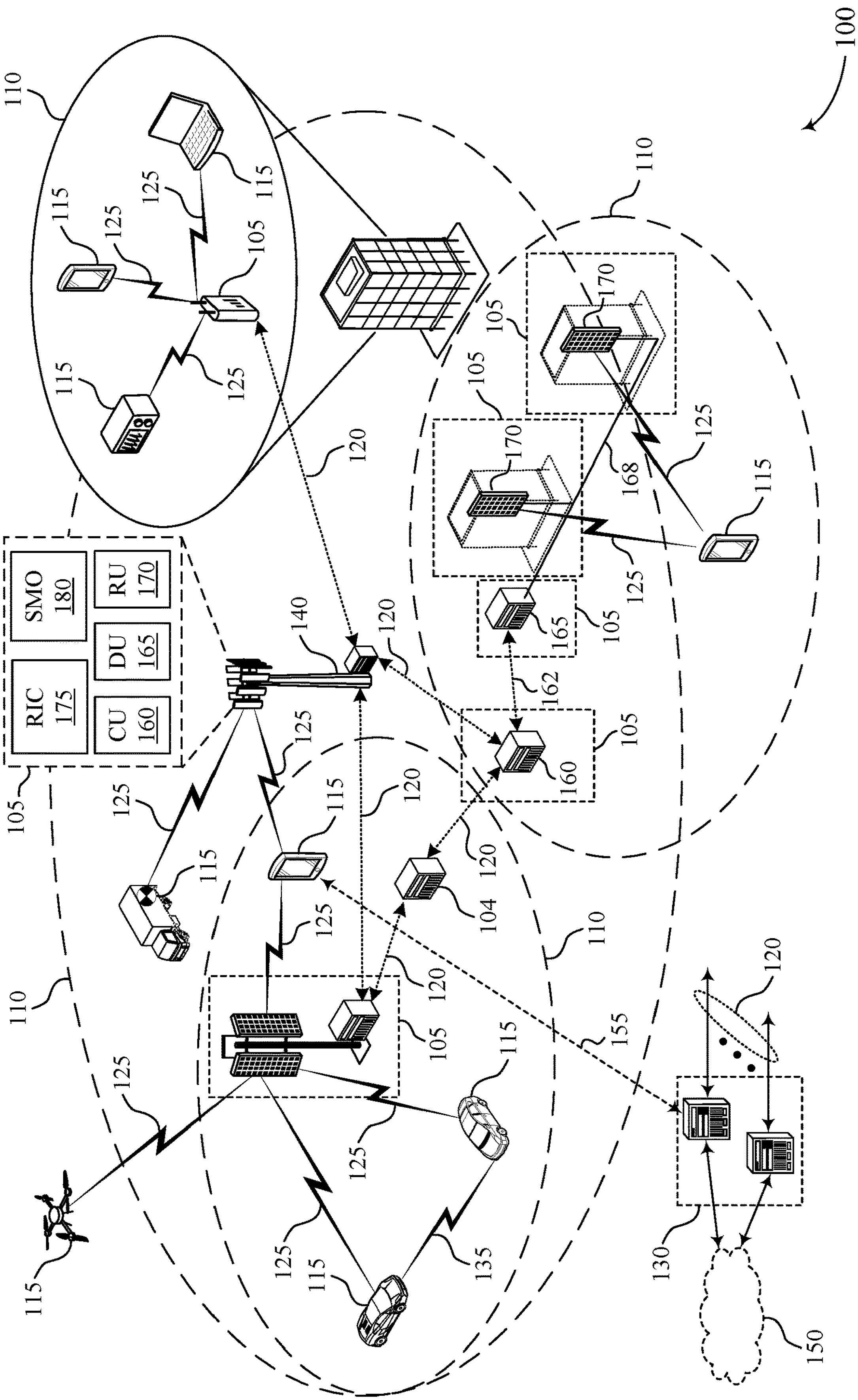


FIG. 1

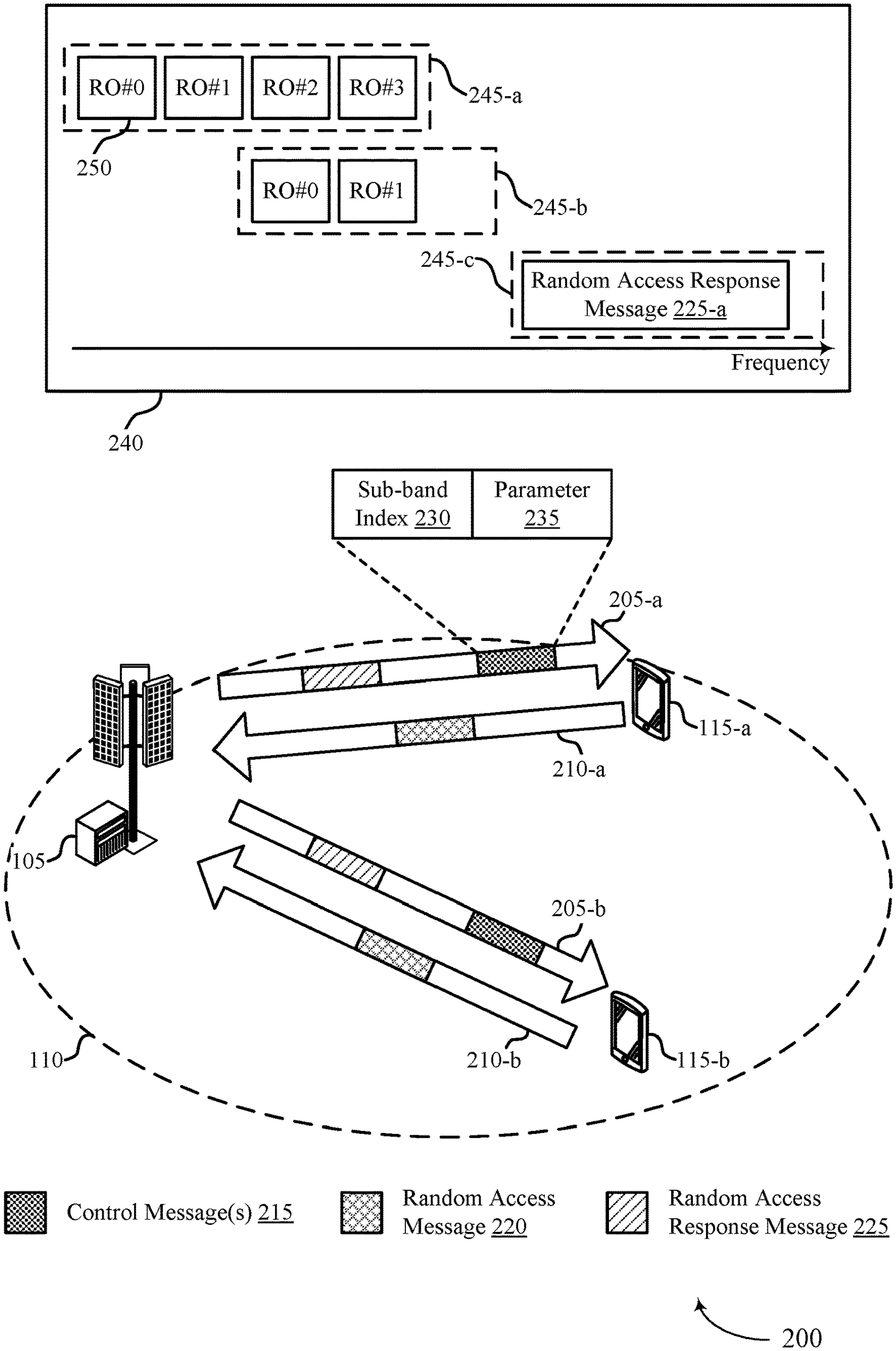

RO#0
RO#1
RO#2
RO#3
245-a
250
RO#0
RO#1
245-b
245-c
Random Access Response Message 225-a
Frequency
240
Sub-band Index 230
Parameter 235
205-a
115-a
210-a
105
205-b
110
210-b
115-b
Control Message(s) 215
Random Access Message 220
Random Access Response Message 225
200

FIG. 2

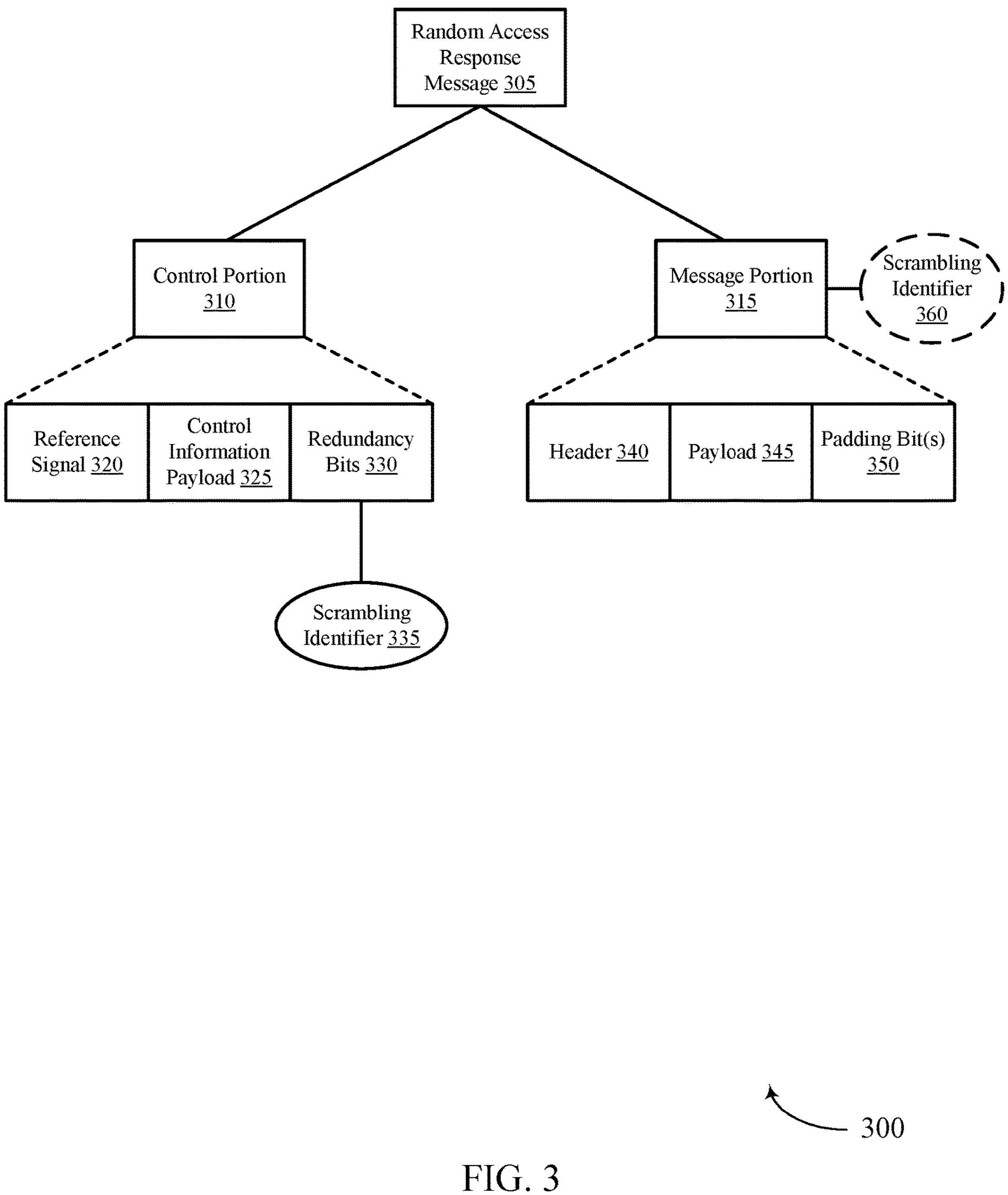

Random Access Response Message 305
Control Portion 310
Message Portion 315
Scrambling Identifier 360
Reference Signal 320
Control Information Payload 325
Redundancy Bits 330
Header 340
Payload 345
Padding Bit(s) 350
Scrambling Identifier 335
300

FIG. 3

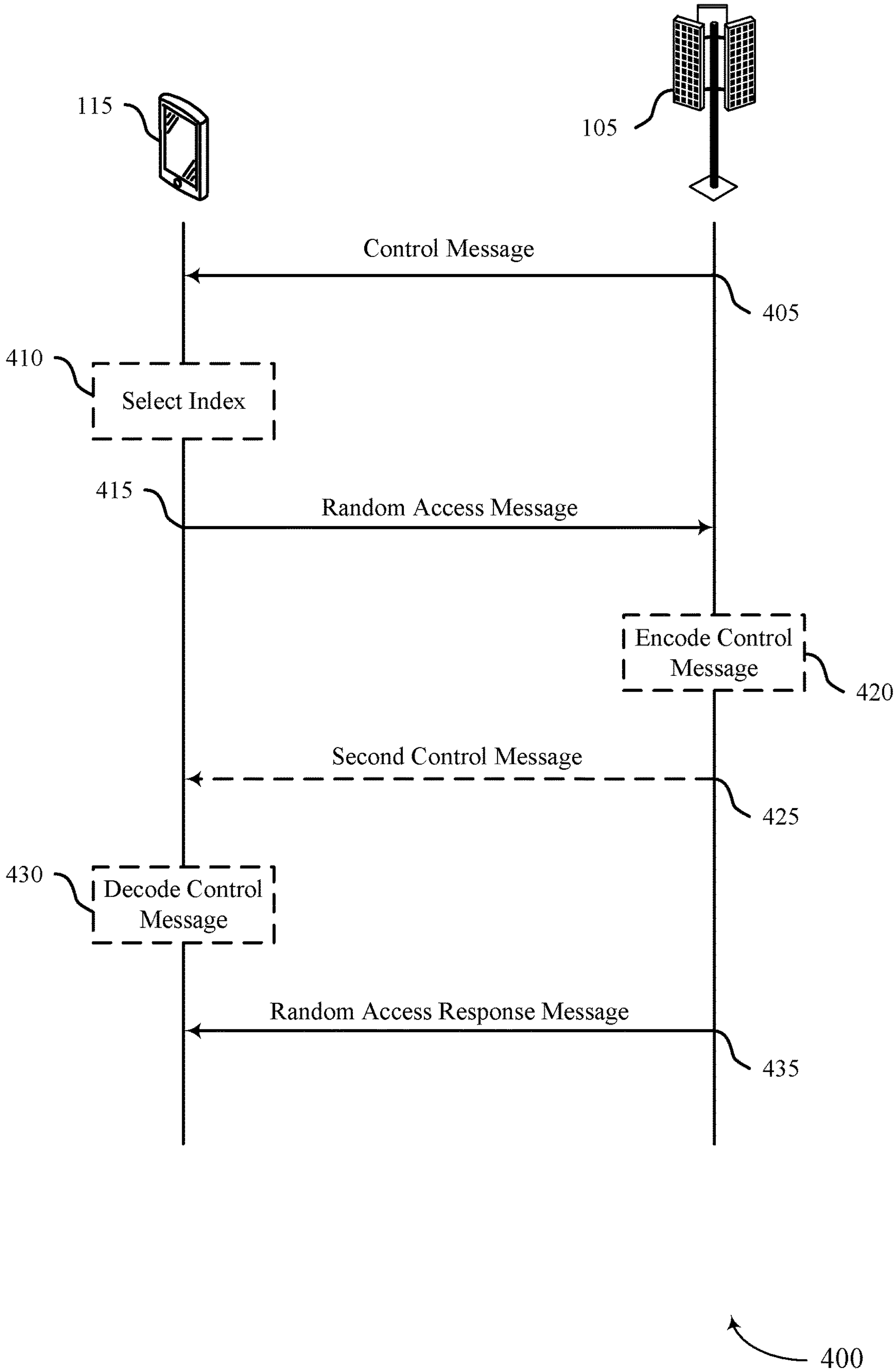

115
105
Control Message
405
410
Select Index
415
Random Access Message
Encode Control Message
420
Second Control Message
425
430
Decode Control Message
Random Access Response Message
435
400

FIG. 4

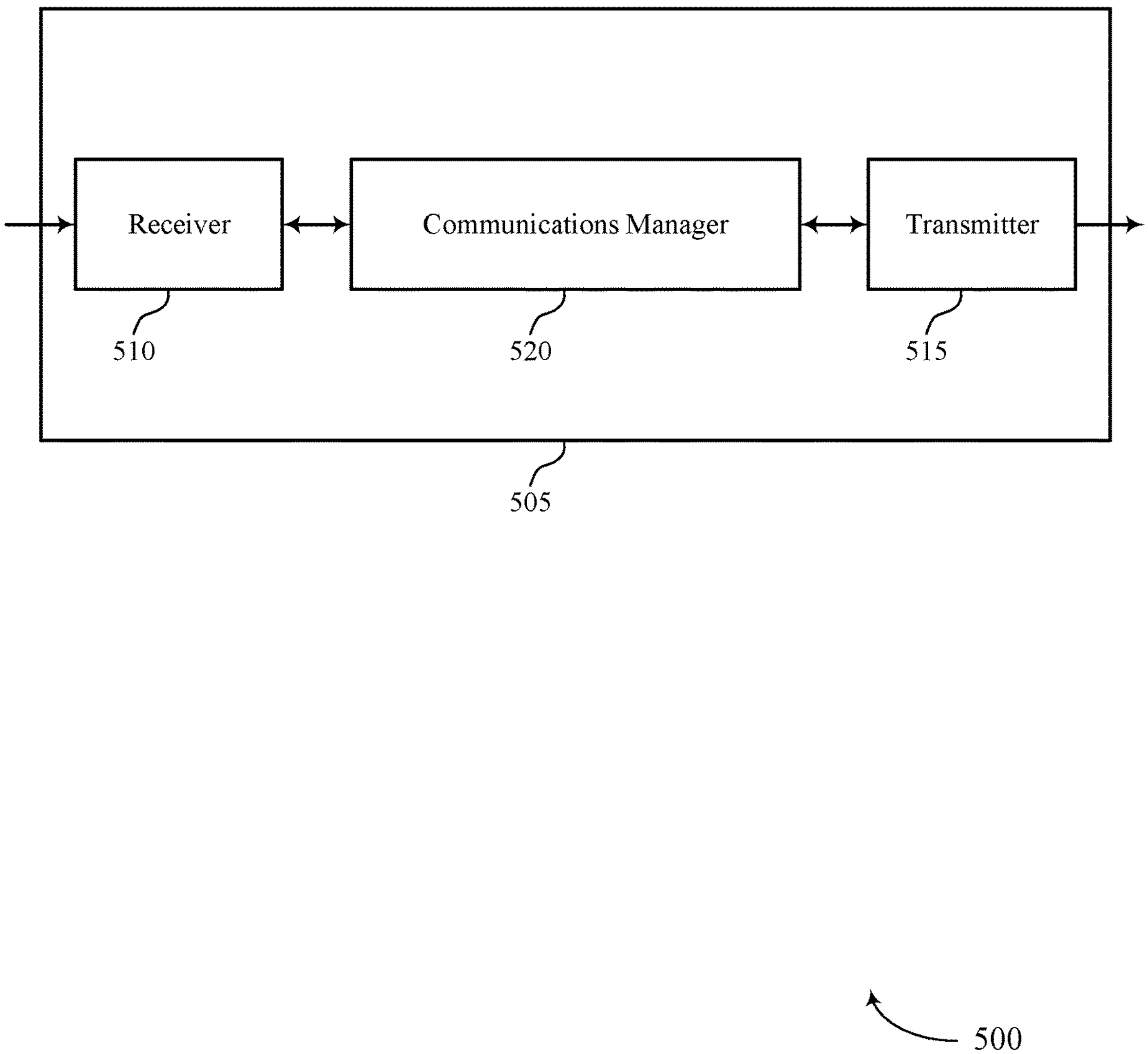
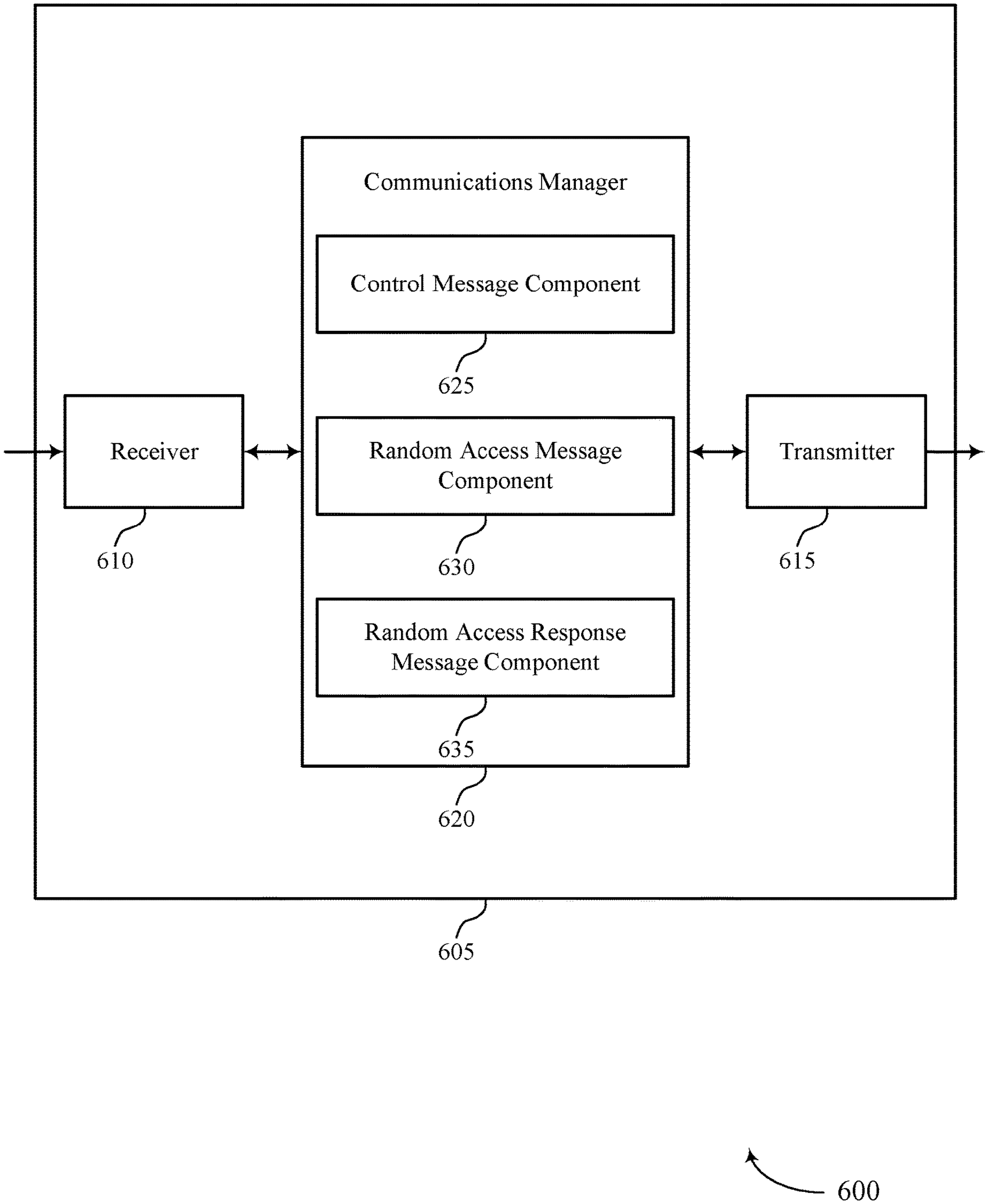

Receiver
Communications Manager
Transmitter
510
520
515
505
500

FIG. 5



Communications Manager
Control Message Component
625
Receiver
Random Access Message Component
Transmitter
610
630
615
Random Access Response Message Component
635
620
605
600

FIG. 6

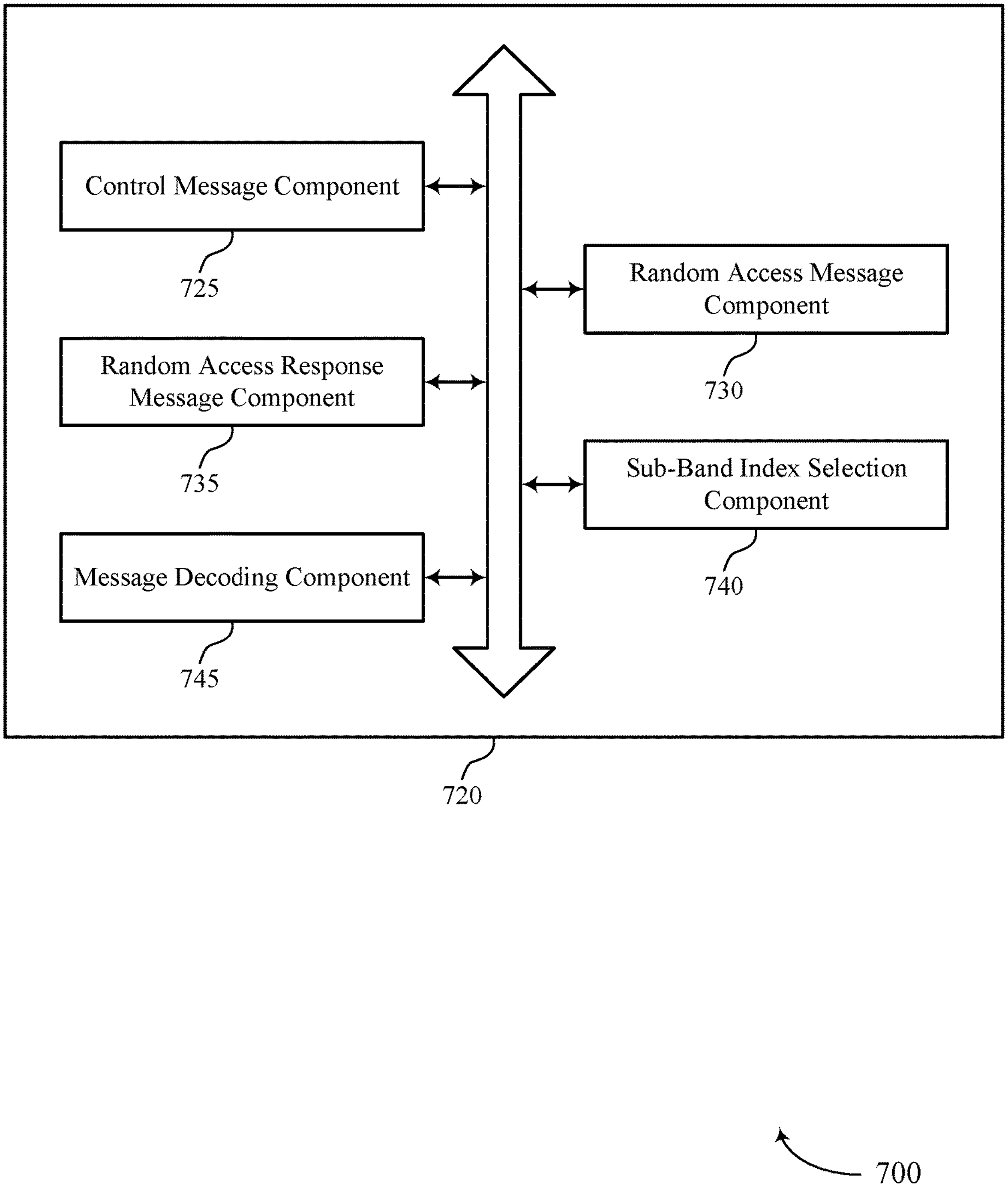

Control Message Component
725
Random Access Response Message Component
735
Message Decoding Component
745
Random Access Message Component
730
Sub-Band Index Selection Component
740
720
700

FIG. 7

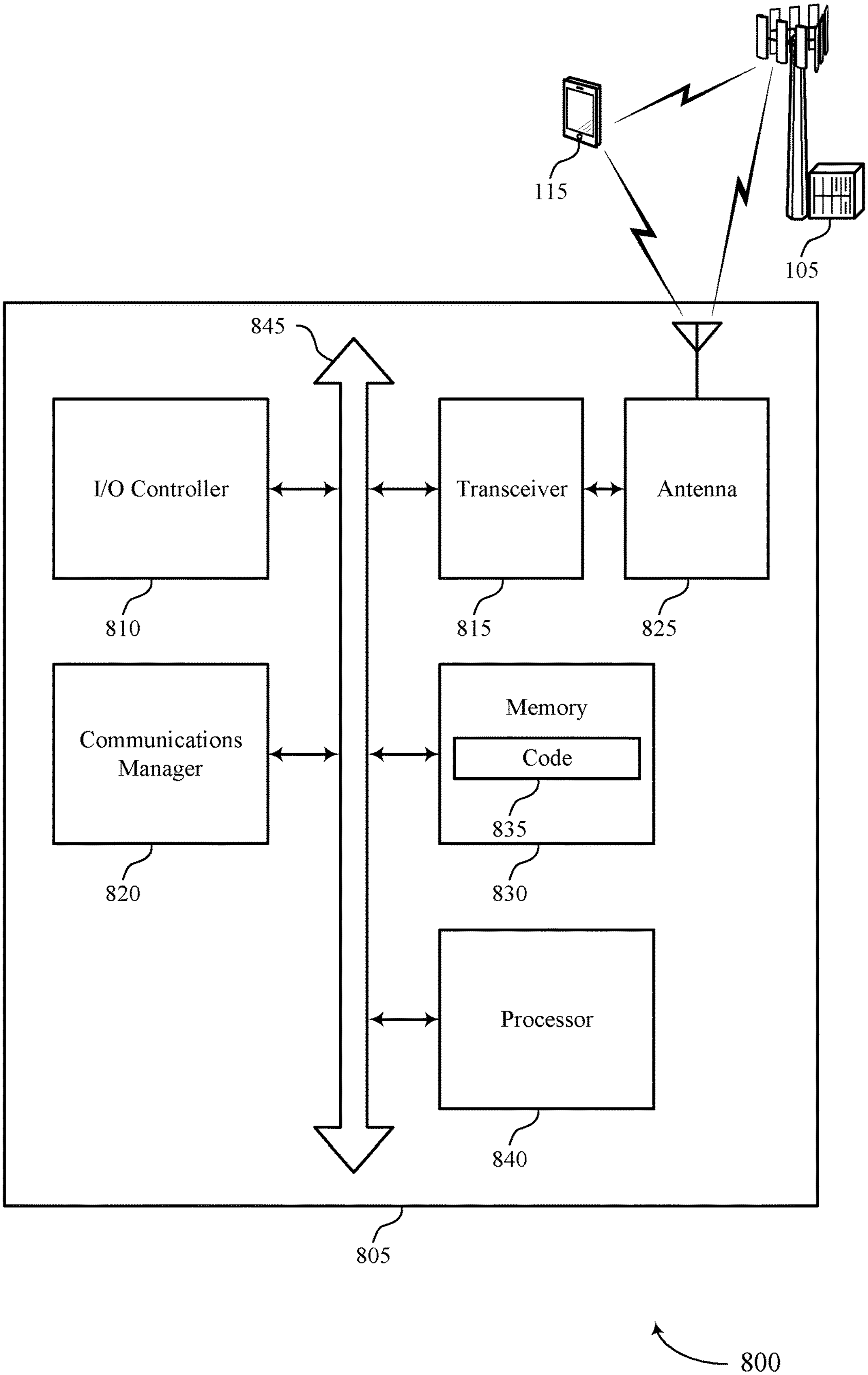

115
105
845
I/O Controller
Transceiver
Antenna
810
815
825
Communications Manager
Memory
Code
835
820
830
Processor
840
805
800

FIG. 8

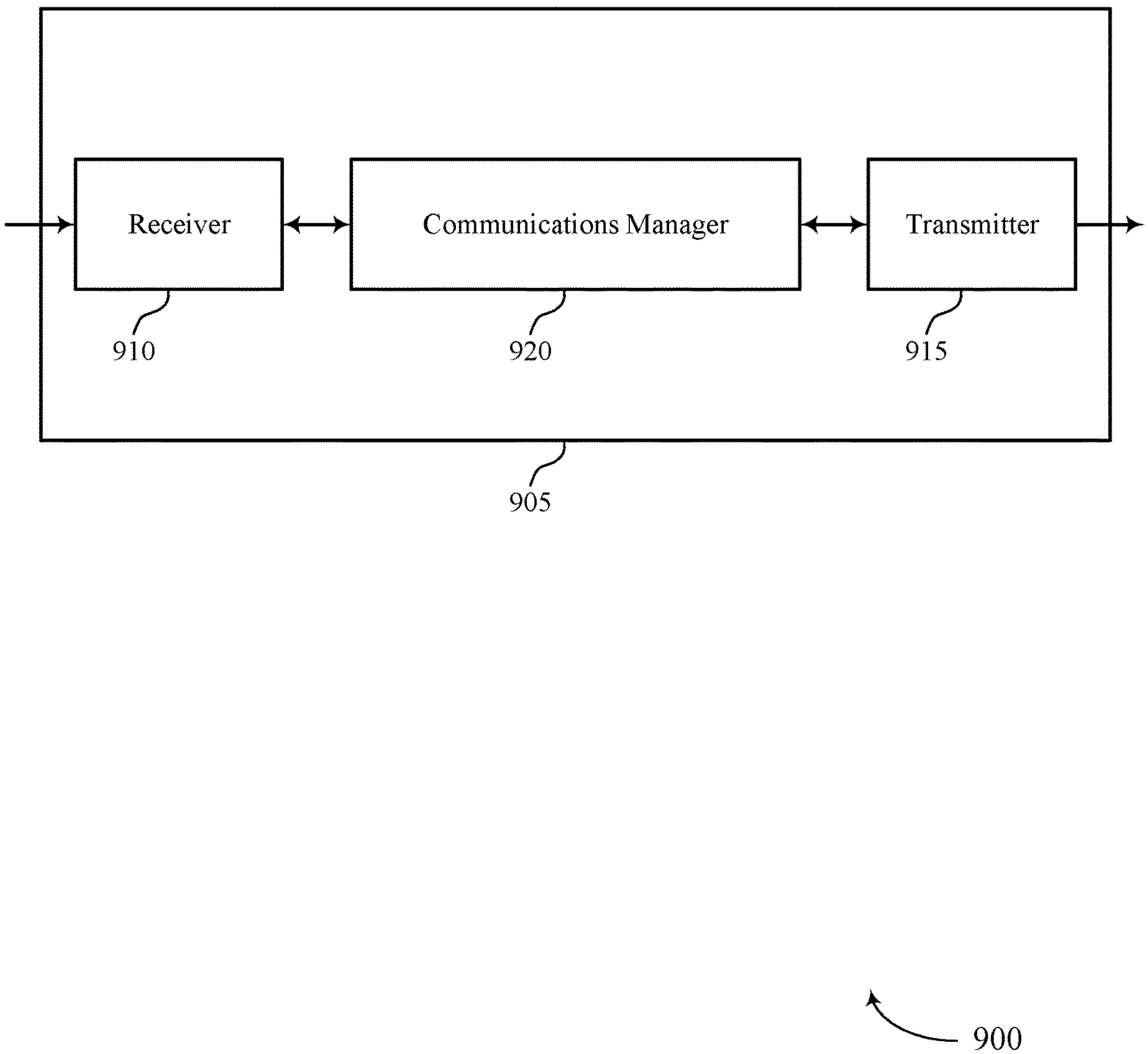

Receiver
Communications Manager
Transmitter
910
920
915
905
900

FIG. 9

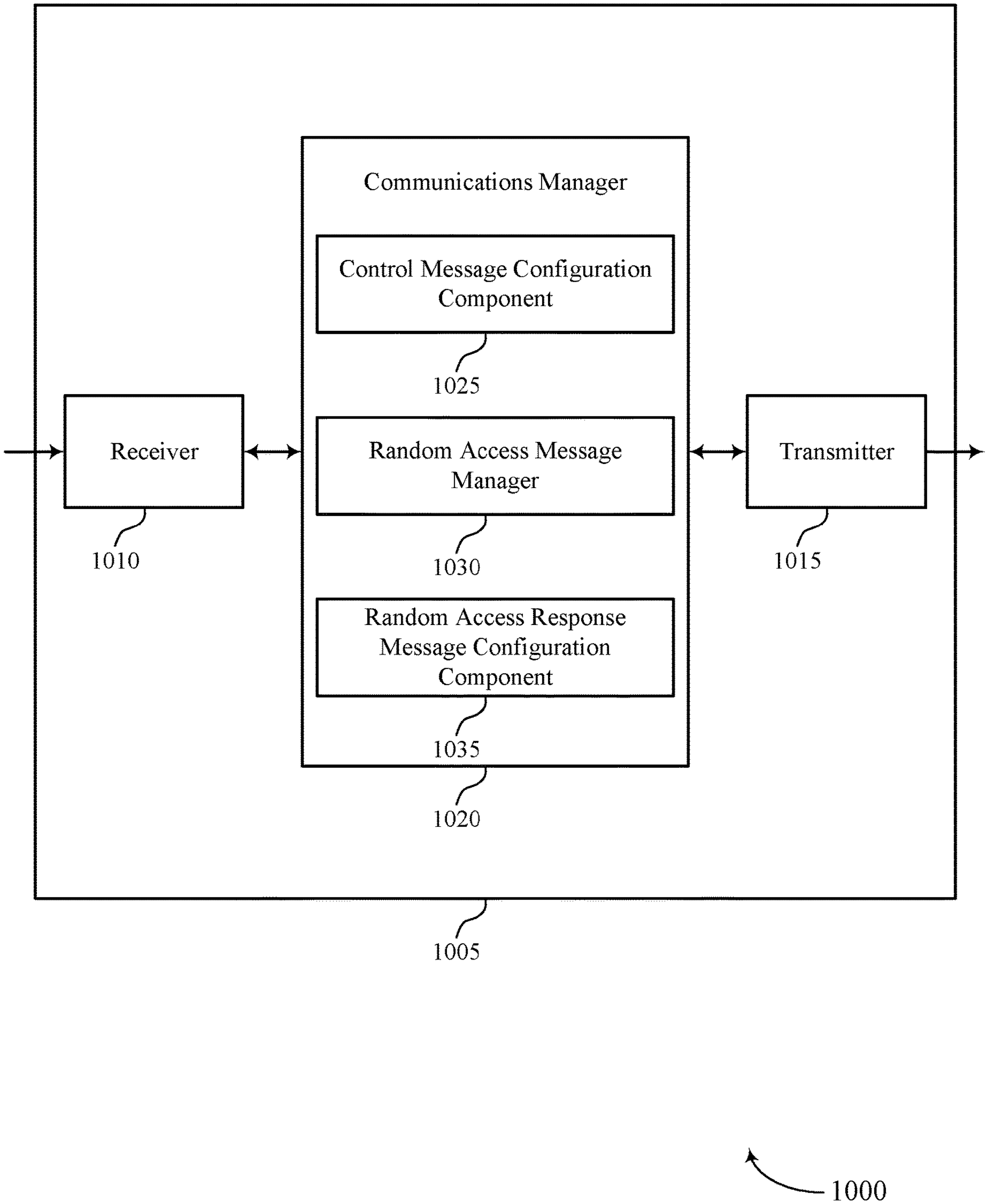

Communications Manager
Control Message Configuration Component
1025
Receiver
Random Access Message Manager
Transmitter
1010
1030
1015
Random Access Response Message Configuration Component
1035
1020
1005
1000

FIG. 10

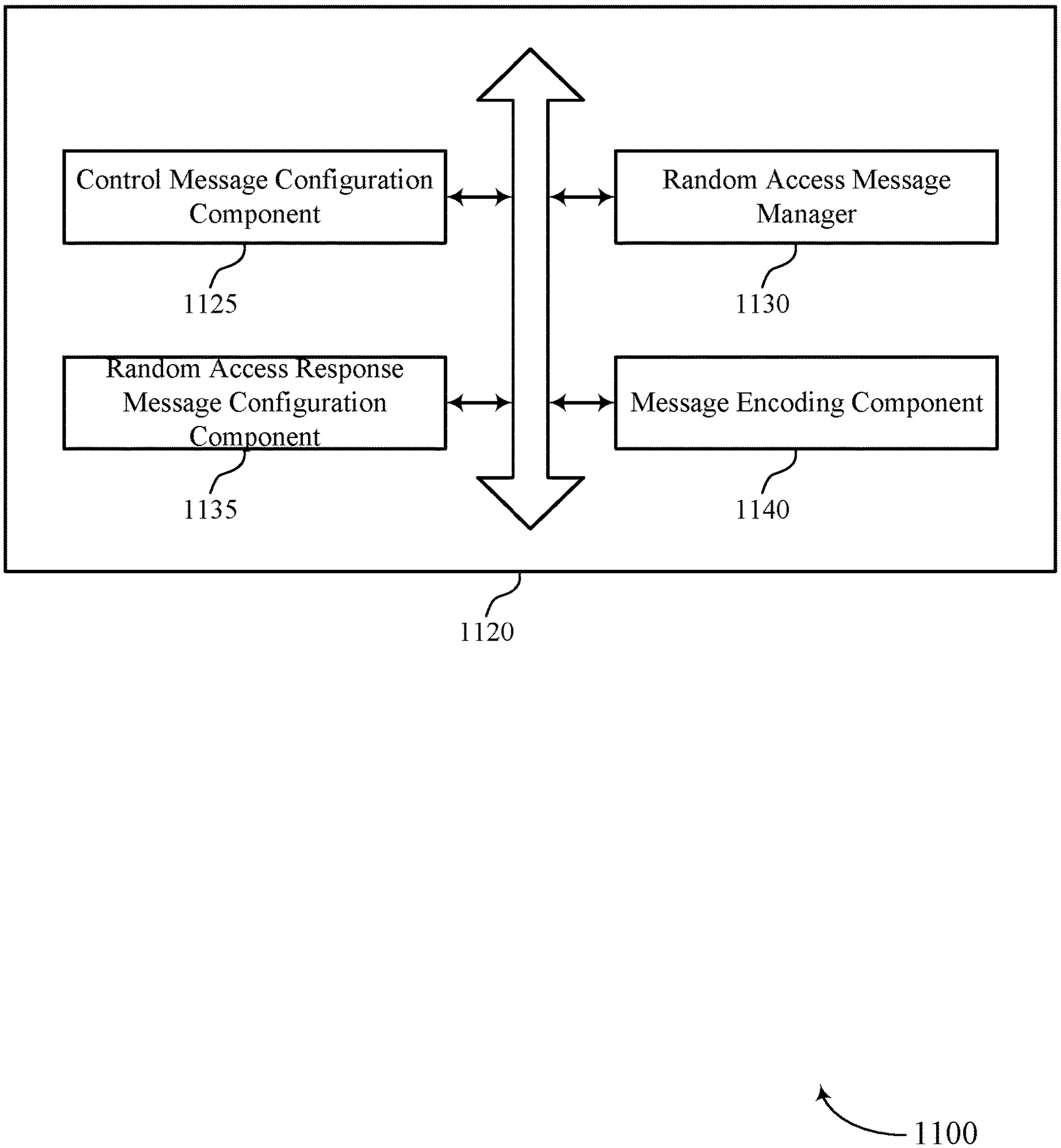

Control Message Configuration Component
1125
Random Access Message Manager
1130
Random Access Response Message Configuration Component
1135
Message Encoding Component
1140
1120
1100

FIG. 11

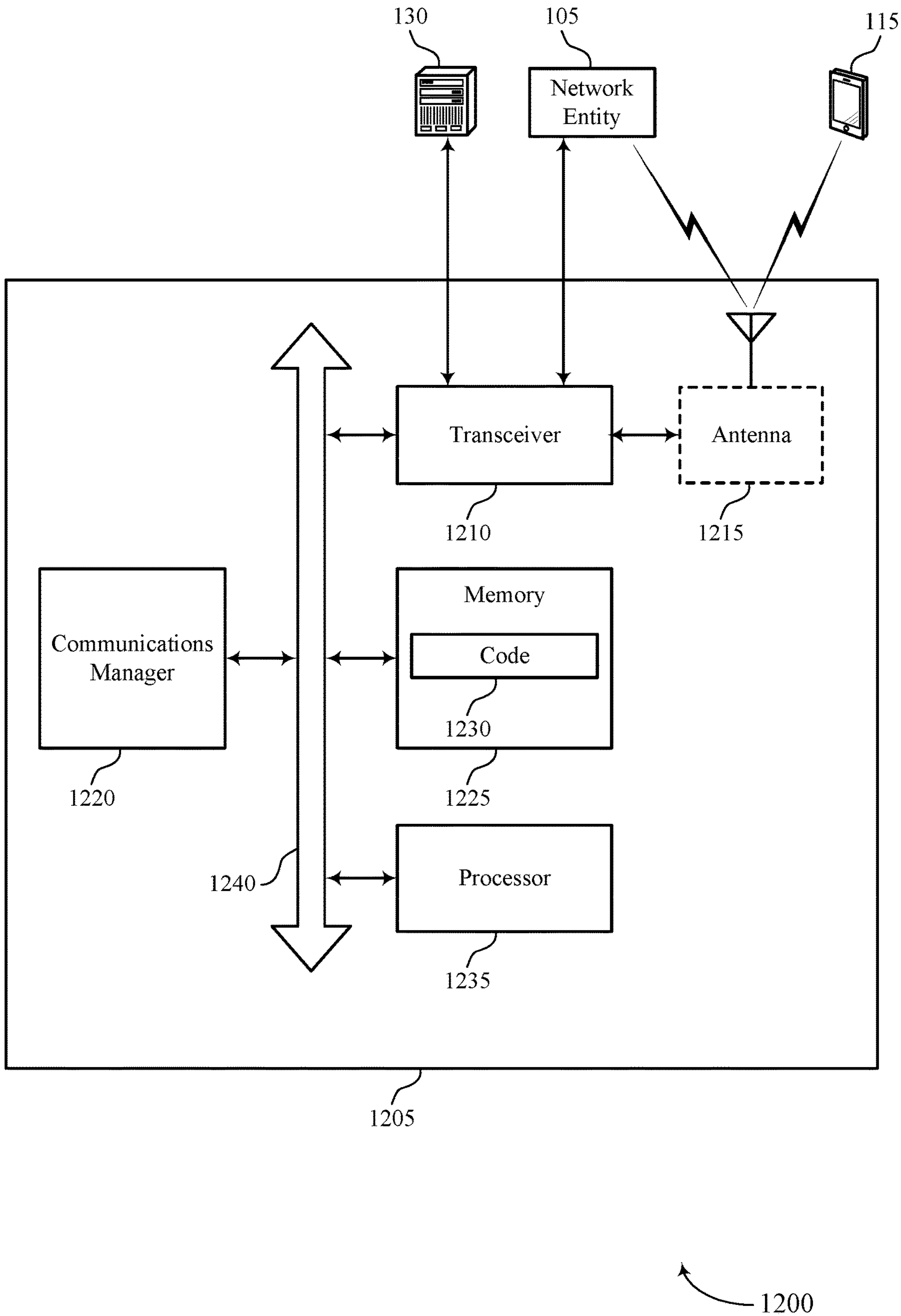

130
105
Network Entity
115
Transceiver
Antenna
1210
1215
Communications Manager
Memory
Code
1230
1220
1225
1240
Processor
1235
1205
1200

FIG. 12

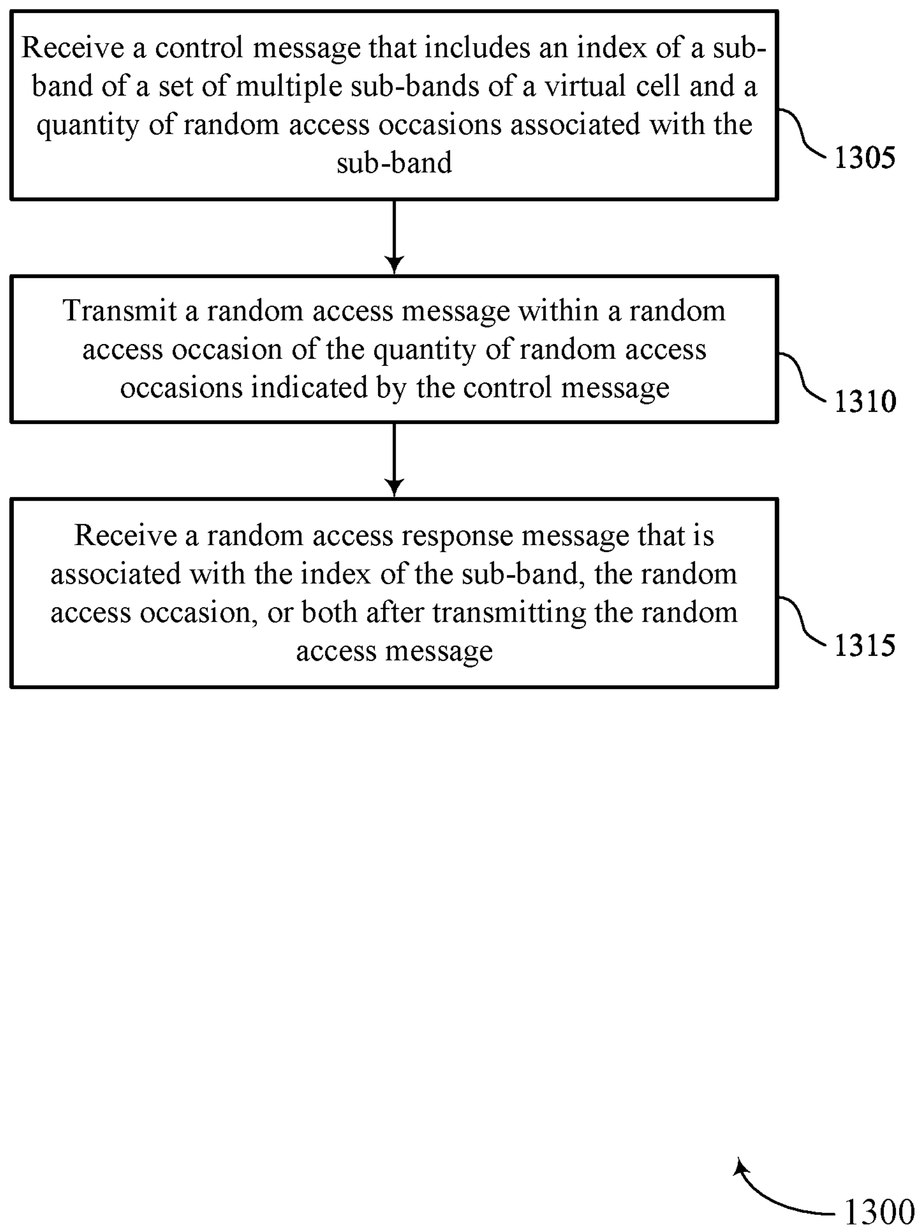

Receive a control message that includes an index of a sub-band of a set of multiple sub-bands of a virtual cell and a quantity of random access occasions associated with the sub-band
1305
Transmit a random access message within a random access occasion of the quantity of random access occasions indicated by the control message
1310
Receive a random access response message that is associated with the index of the sub-band, the random access occasion, or both after transmitting the random access message
1315
1300

FIG. 13

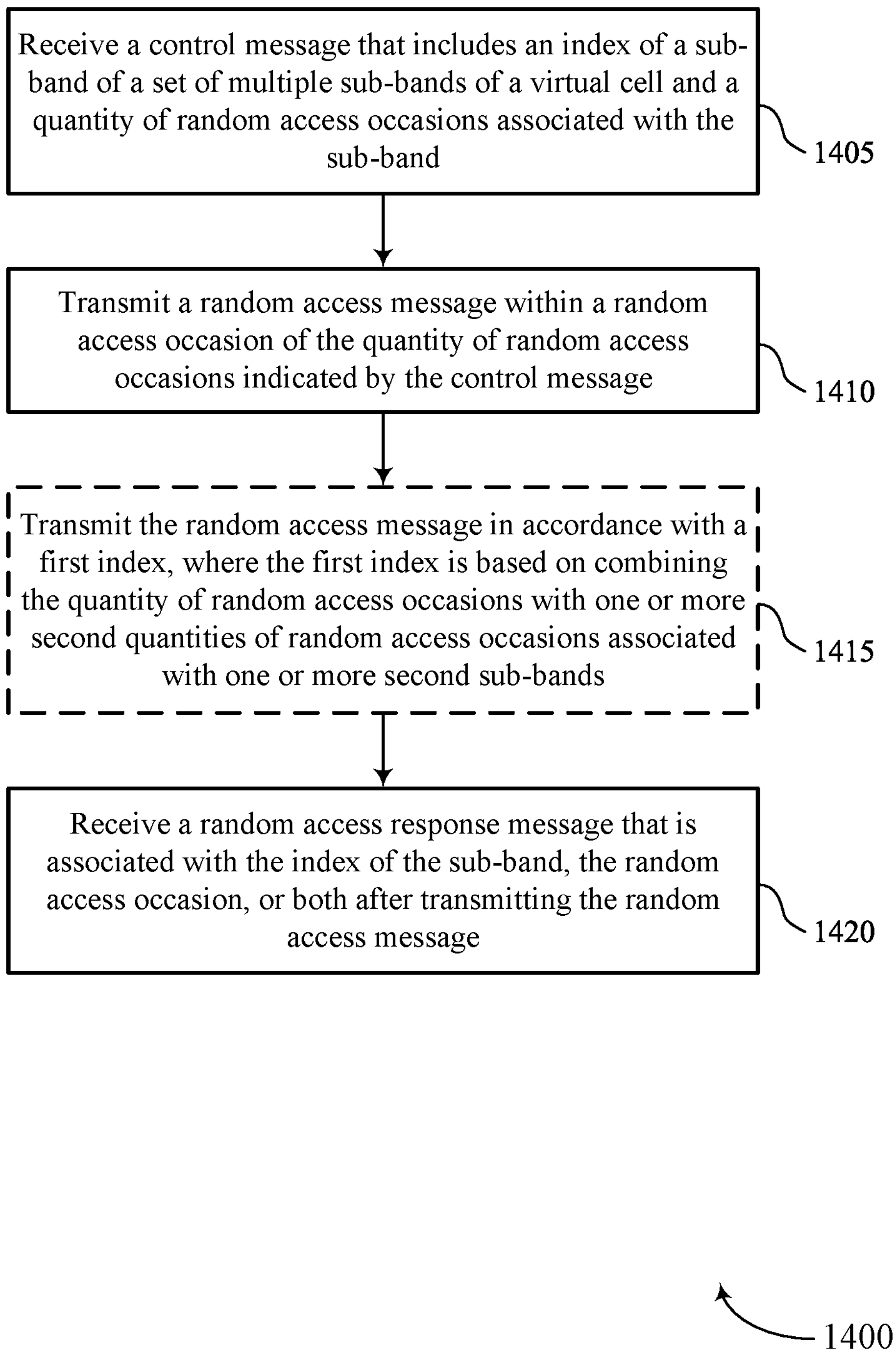

Receive a control message that includes an index of a sub-band of a set of multiple sub-bands of a virtual cell and a quantity of random access occasions associated with the sub-band
1405
Transmit a random access message within a random access occasion of the quantity of random access occasions indicated by the control message
1410
Transmit the random access message in accordance with a first index, where the first index is based on combining the quantity of random access occasions with one or more second quantities of random access occasions associated with one or more second sub-bands
1415
Receive a random access response message that is associated with the index of the sub-band, the random access occasion, or both after transmitting the random access message
1420
1400

FIG. 14

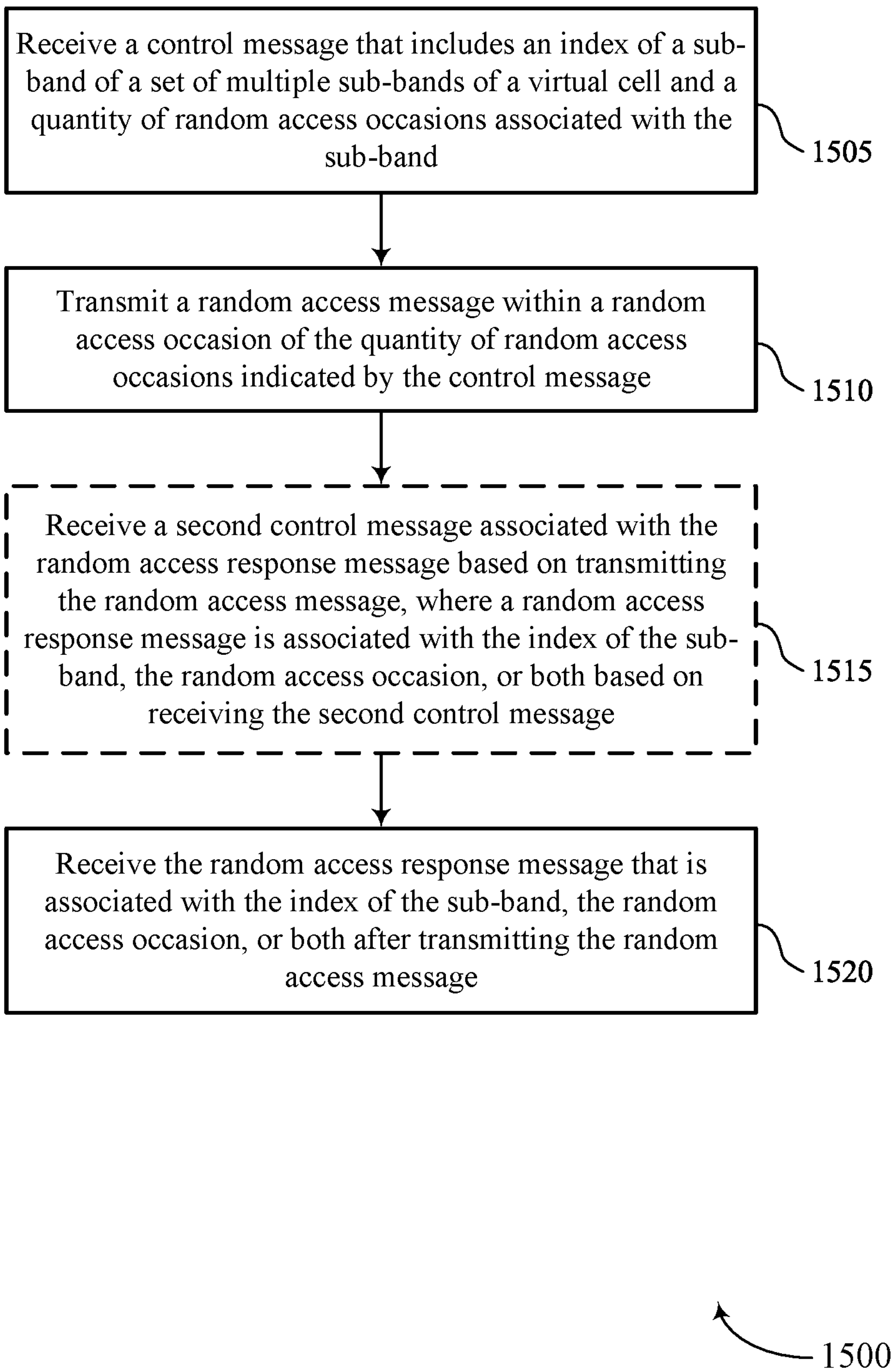

Receive a control message that includes an index of a sub-band of a set of multiple sub-bands of a virtual cell and a quantity of random access occasions associated with the sub-band
1505
Transmit a random access message within a random access occasion of the quantity of random access occasions indicated by the control message
1510
Receive a second control message associated with the random access response message based on transmitting the random access message, where a random access response message is associated with the index of the sub-band, the random access occasion, or both based on receiving the second control message
1515
Receive the random access response message that is associated with the index of the sub-band, the random access occasion, or both after transmitting the random access message
1520
1500

FIG. 15

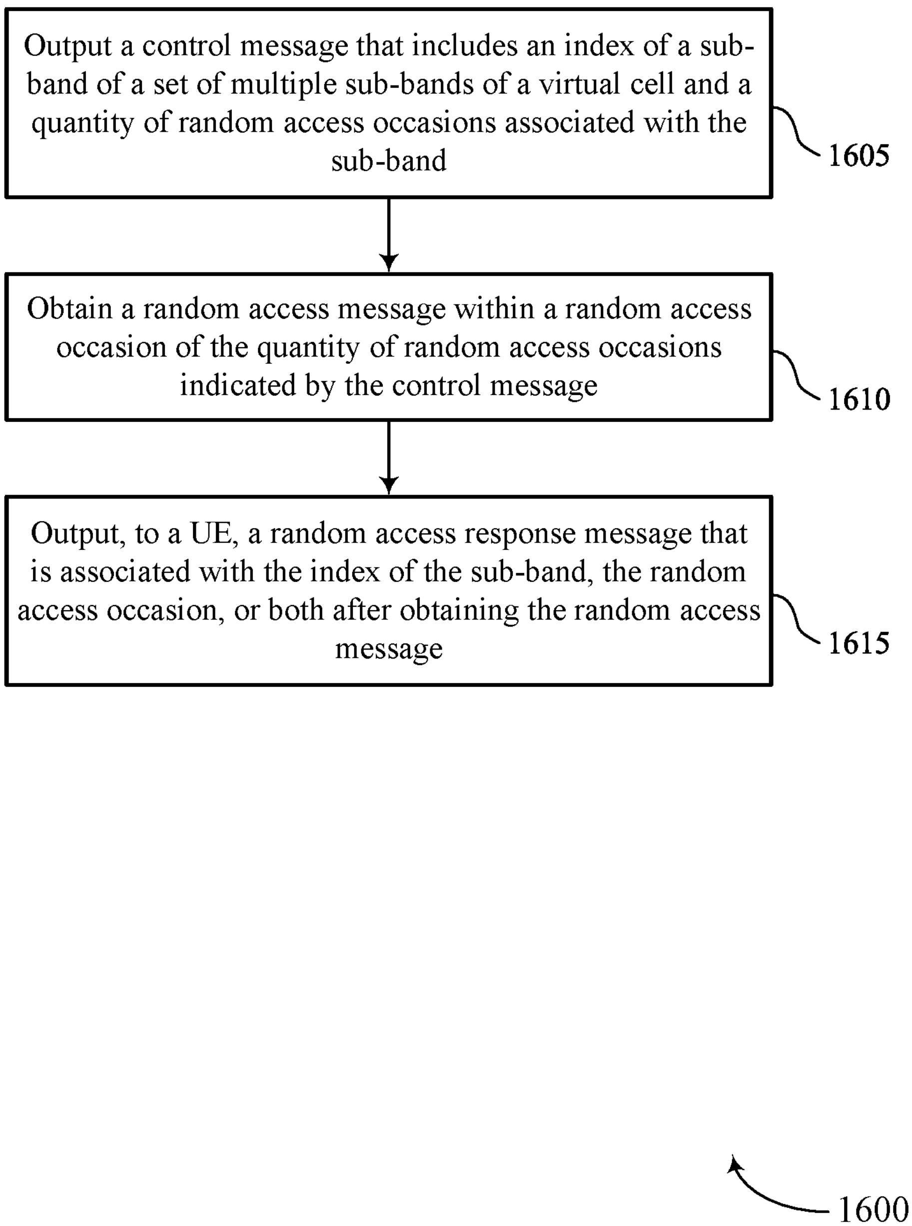

Output a control message that includes an index of a sub-band of a set of multiple sub-bands of a virtual cell and a quantity of random access occasions associated with the sub-band
1605
Obtain a random access message within a random access occasion of the quantity of random access occasions indicated by the control message
1610
Output, to a UE, a random access response message that is associated with the index of the sub-band, the random access occasion, or both after obtaining the random access message
1615
1600

FIG. 16

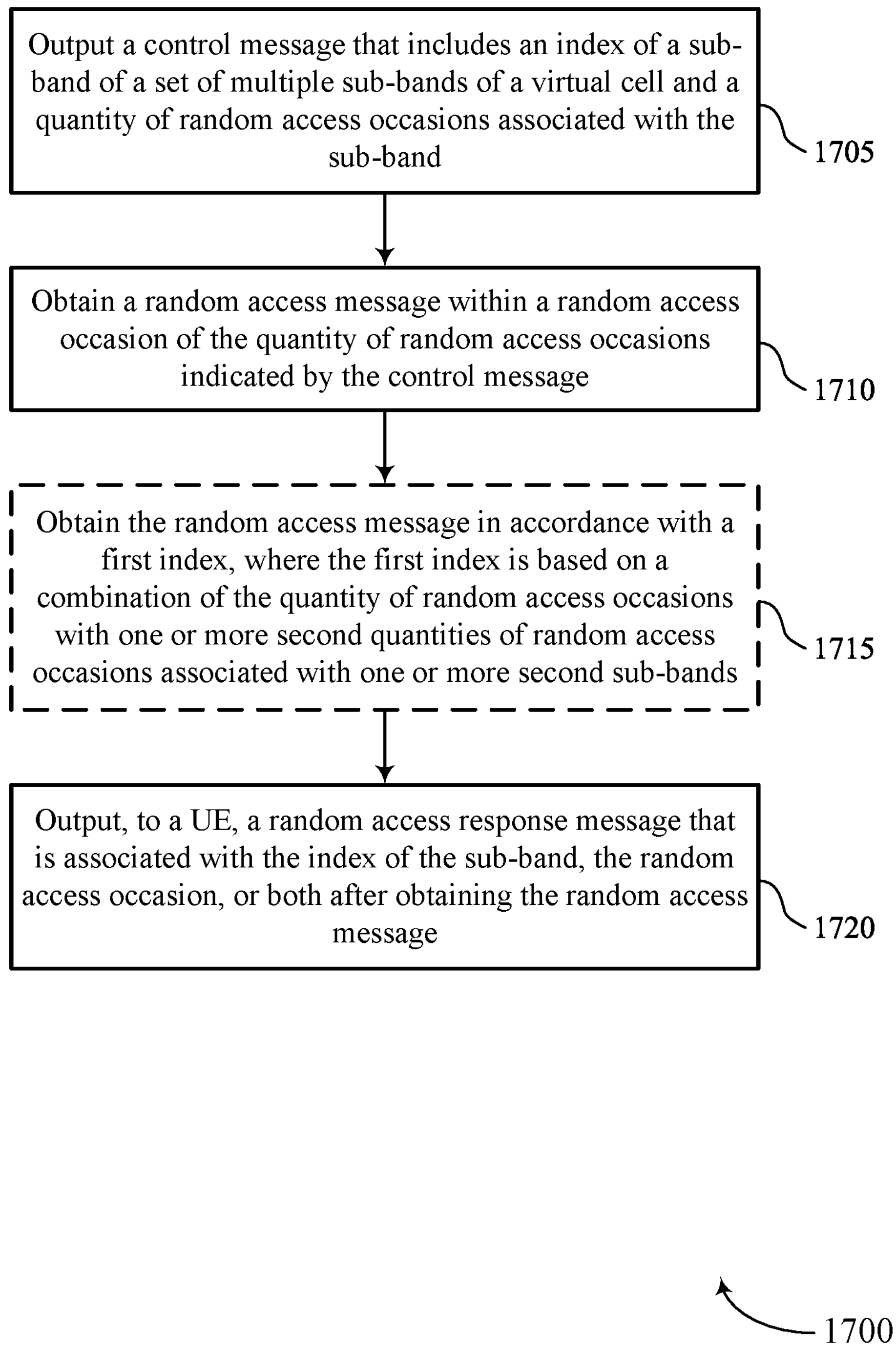

Output a control message that includes an index of a sub-band of a set of multiple sub-bands of a virtual cell and a quantity of random access occasions associated with the sub-band
1705
Obtain a random access message within a random access occasion of the quantity of random access occasions indicated by the control message
1710
Obtain the random access message in accordance with a first index, where the first index is based on a combination of the quantity of random access occasions with one or more second quantities of random access occasions associated with one or more second sub-bands
1715
Output, to a UE, a random access response message that is associated with the index of the sub-band, the random access occasion, or both after obtaining the random access message
1720
1700

FIG. 17

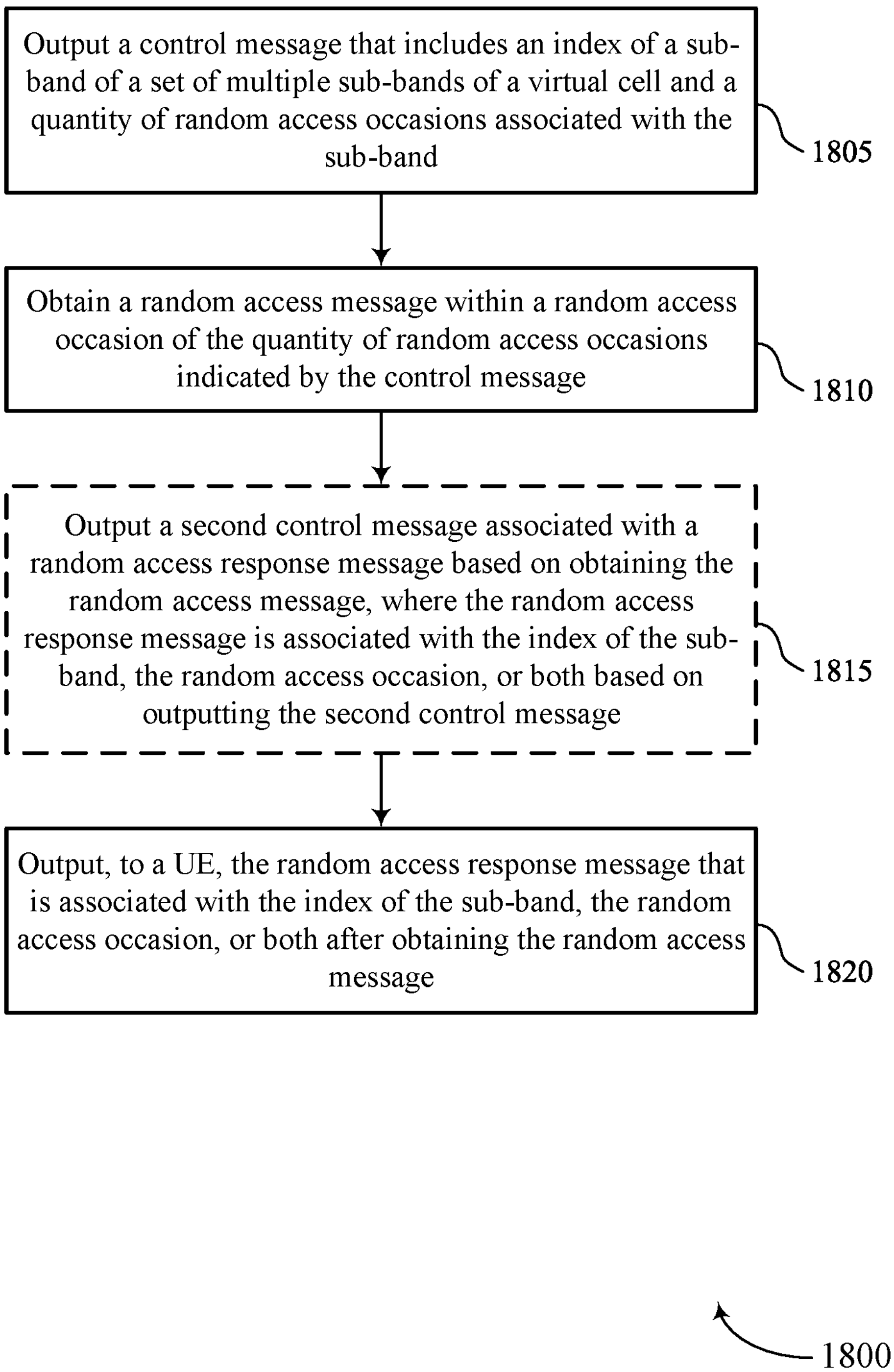

Output a control message that includes an index of a sub-band of a set of multiple sub-bands of a virtual cell and a quantity of random access occasions associated with the sub-band
1805
Obtain a random access message within a random access occasion of the quantity of random access occasions indicated by the control message
1810
Output a second control message associated with a random access response message based on obtaining the random access message, where the random access response message is associated with the index of the sub-band, the random access occasion, or both based on outputting the second control message
1815
Output, to a UE, the random access response message that is associated with the index of the sub-band, the random access occasion, or both after obtaining the random access message
1820
1800

FIG. 18

RANDOM ACCESS PROCEDURES WITH A VIRTUAL CELL

FIELD OF TECHNOLOGY

[0001] The following relates to wireless communications, including random access procedures with a virtual cell.

BACKGROUND

[0002] Wireless communications systems are widely deployed to provide various types of communication content such as voice, video, packet data, messaging, broadcast, and so on. These systems may be capable of supporting communication with multiple users by sharing the available system resources (e.g., time, frequency, and power). Examples of such multiple-access systems include fourth generation (4G) systems such as Long Term Evolution (LTE) systems, LTE-Advanced (LTE-A) systems, or LTE-A Pro systems, and fifth generation (5G) systems which may be referred to as New Radio (NR) systems. These systems may employ technologies such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), or discrete Fourier transform spread orthogonal frequency division multiplexing (DFT-S-OFDM). A wireless multiple-access communications system may include one or more base stations, each supporting wireless communication for communication devices, which may be known as user equipment (UE).

SUMMARY

[0003] The described techniques relate to improved methods, systems, devices, and apparatuses that support random access procedures with a virtual cell. For example, the described techniques may enable devices of a wireless communications network to perform random access (RA) procedures based on sub-band configurations of a virtual cell. In some examples, a user equipment (UE) may receive, from a network entity, one or more control messages that include a sub-band index and one or more parameters (e.g., a parameter associated with a quantity of random access occasions). Accordingly, the UE may perform a random access procedure in accordance with the sub-band index and the one or more parameters indicated via the one or more control messages. In some examples, the UE may transmit, to the network entity, a random access message via resources of a specific sub-band based on the sub-band index and the one or more parameters. The UE may receive, in response from the network entity, a random access response (RAR) message, that is associated with the specific sub-band. In some examples, the RAR message may be associated with a sub-band based on including a sub-band index and/or one or more parameters (e.g., in a control channel portion of a RAR, in a shared channel portion of a RAR, or both). Such techniques may improve communication reliability in a wireless communications system by supporting enhanced random access procedures that account for various sub-band configurations (e.g., for fragmented spectrum and virtual cell environments).

[0004] A method for wireless communications by a UE is described. The method may include receiving a control message that includes an index of a sub-band of a set of multiple sub-bands of a virtual cell and a quantity of RA occasions associated with the sub-band, transmitting a RA message within a RA occasion of the quantity of RA occasions indicated by the control message, and receiving a RAR message that is associated with the index of the sub-band, the RA occasion, or both after transmitting the RA message.

[0005] A UE for wireless communications is described. The UE may include one or more memories storing processor executable code, and one or more processors coupled with the one or more memories. The one or more processors may individually or collectively operable to execute the code to cause the UE to receive a control message that includes an index of a sub-band of a set of multiple sub-bands of a virtual cell and a quantity of RA occasions associated with the sub-band, transmit a RA message within a RA occasion of the quantity of RA occasions indicated by the control message, and receive an RAR message that is associated with the index of the sub-band, the RA occasion, or both after transmitting the RA message.

[0006] Another UE for wireless communications is described. The UE may include means for receiving a control message that includes an index of a sub-band of a set of multiple sub-bands of a virtual cell and a quantity of RA occasions associated with the sub-band, means for transmitting an RA message within an RA occasion of the quantity of RA occasions indicated by the control message, and means for receiving an RAR message that is associated with the index of the sub-band, the RA occasion, or both after transmitting the RA message.

[0007] A non-transitory computer-readable medium storing code for wireless communications is described. The code may include instructions executable by one or more processors to receive a control message that includes an index of a sub-band of a set of multiple sub-bands of a virtual cell and a quantity of RA occasions associated with the sub-band, transmit an RA message within an RA occasion of the quantity of RA occasions indicated by the control message, and receive an RAR message that is associated with the index of the sub-band, the RA occasion, or both after transmitting the RA message.

[0008] In some examples of the method, UEs, and non-transitory computer-readable medium described herein, transmitting the RA message may include operations, features, means, or instructions for transmitting the RA message in accordance with a first index, where the first index may be based on combining the quantity of RA occasions with one or more second quantities of RA occasions associated with one or more second sub-bands.

[0009] Some examples of the method, UEs, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for selecting a second index of the RA occasion based on the index of the sub-band and the quantity of RA occasions, where the first index may be based on combining the second index with the combined quantity of RA occasions, and where the second index may be a sub-band specific index and the first index may be a non-sub-band specific index.

[0010] Some examples of the method, UEs, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for transmitting the RA message in accordance with a temporary identifier, the temporary identifier being associated with a first type of RA procedure and the first index, where the temporary identifier may be different than one or more second temporary identifiers associated with a second type of RA procedure based on the first index.

[0011] In some examples of the method, UEs, and non-transitory computer-readable medium described herein, receiving the RAR message may include operations, features, means, or instructions for receiving a second control message associated with the RAR message based on transmitting the RA message, where the RAR message may be associated with the index of the sub-band, the RA occasion, or both based on receiving the second control message.

[0012] In some examples of the method, UEs, and non-transitory computer-readable medium described herein, the second control message includes one or more fields that indicate the index of the sub-band, the RA occasion, or both.

[0013] Some examples of the method, UEs, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for decoding the second control message in accordance with the index of the sub-band, the RA occasion, or both based on one or more cyclic redundancy check bits of the second control message, a reference signal scrambling identifier of the second control message, a bit interleaving pattern of the second control message, or any combination thereof, where receiving the RAR message may be based on decoding the second control message.

[0014] In some examples of the method, UEs, and non-transitory computer-readable medium described herein, receiving the RAR message may include operations, features, means, or instructions for receiving, via the RAR message, an indication of the index of the sub-band, an indication of the RA occasion, or both.

[0015] In some examples of the method, UEs, and non-transitory computer-readable medium described herein, receiving the indication may include operations, features, means, or instructions for receiving the indication of the index of the sub-band, the indication of the RA occasion of the RAR message, or both via a medium access control (MAC) header of the RAR message, a MAC payload, one or more padding bits of the RAR message, a reference signal scrambling identifier of the RAR message, or a combination thereof.

[0016] In some examples of the method, UEs, and non-transitory computer-readable medium described herein, receiving the RAR message may include operations, features, means, or instructions for receiving the RAR message in accordance with the index of the sub-band, the RA occasion, or both based on first information included in a second control message associated with the RAR message and second information included in the RAR message.

[0017] In some examples of the method, UEs, and non-transitory computer-readable medium described herein, the quantity of RA occasions may be based on a type of RA procedure.

[0018] In some examples of the method, UEs, and non-transitory computer-readable medium described herein, at least a first sub-band of the set of multiple sub-bands and a second sub-band of the set of multiple sub-bands may be non-contiguous in a frequency domain.

[0019] A method for wireless communications by a network entity is described. The method may include outputting a control message that includes an index of a sub-band of a set of multiple sub-bands of a virtual cell and a quantity of RA occasions associated with the sub-band, obtaining an RA message within an RA occasion of the quantity of RA occasions indicated by the control message, and outputting, to a UE, an RAR message that is associated with the index of the sub-band, the RA occasion, or both after obtaining the RA message.

[0020] A network entity for wireless communications is described. The network entity may include one or more memories storing processor executable code, and one or more processors coupled with the one or more memories. The one or more processors may individually or collectively operable to execute the code to cause the network entity to output a control message that includes an index of a sub-band of a set of multiple sub-bands of a virtual cell and a quantity of RA occasions associated with the sub-band, obtain an RA message within an RA occasion of the quantity of RA occasions indicated by the control message, and output, to a UE, an RAR message that is associated with the index of the sub-band, the RA occasion, or both after obtaining the RA message.

[0021] Another network entity for wireless communications is described. The network entity may include means for outputting a control message that includes an index of a sub-band of a set of multiple sub-bands of a virtual cell and a quantity of RA occasions associated with the sub-band, means for obtaining an RA message within an RA occasion of the quantity of RA occasions indicated by the control message, and means for outputting, to a UE, an RAR message that is associated with the index of the sub-band, the RA occasion, or both after obtaining the RA message.

[0022] A non-transitory computer-readable medium storing code for wireless communications is described. The code may include instructions executable by one or more processors to output a control message that includes an index of a sub-band of a set of multiple sub-bands of a virtual cell and a quantity of RA occasions associated with the sub-band, obtain an RA message within an RA occasion of the quantity of RA occasions indicated by the control message, and output, to a UE, an RAR message that is associated with the index of the sub-band, the RA occasion, or both after obtaining the RA message.

[0023] In some examples of the method, network entities, and non-transitory computer-readable medium described herein, obtaining the RA message may include operations, features, means, or instructions for obtaining the RA message in accordance with a first index, where the first index may be based on a combination of the quantity of RA occasions with one or more second quantities of RA occasions associated with one or more second sub-bands.

[0024] In some examples of the method, network entities, and non-transitory computer-readable medium described herein, the first index may be based on a combination of a second index of the RA occasion and the combined quantity of RA occasions, the second index based on the index of the sub-band and the quantity of RA occasions and the second index may be a sub-band specific index and the first index may be a non-sub-band specific index.

[0025] Some examples of the method, network entities, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for obtaining the RA message in accordance with a temporary identifier, the temporary identifier being associated with a first type of RA procedure and the first index, where the temporary identifier may be different than one or more second temporary identifiers associated with a second type of RA procedure based on the first index.

[0026] In some examples of the method, network entities, and non-transitory computer-readable medium described herein, outputting the RAR message may include operations, features, means, or instructions for outputting a second control message associated with the RAR message based on obtaining the RA message, where the RAR message may be associated with the index of the sub-band, the RA occasion, or both based on outputting the second control message.

[0027] In some examples of the method, network entities, and non-transitory computer-readable medium described herein, the second control message includes one or more fields that indicate the index of the sub-band, the RA occasion, or both.

[0028] Some examples of the method, network entities, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for encoding the second control message in accordance with the index of the sub-band, the RA occasion, or both based on one or more cyclic redundancy check bits of the second control message, a reference signal scrambling identifier of the second control message, a bit interleaving pattern of the second control message, or any combination thereof.

[0029] In some examples of the method, network entities, and non-transitory computer-readable medium described herein, outputting the RAR message may include operations, features, means, or instructions for outputting, via the RAR message, an indication of the index of the sub-band, an indication of the RA occasion, or both.

[0030] In some examples of the method, network entities, and non-transitory computer-readable medium described herein, outputting the indication may include operations, features, means, or instructions for outputting the indication of the index of the sub-band, the indication of the RA occasion of the RAR message, or both via a MAC header of the RAR message, a MAC payload, one or more padding bits of the RAR message, a reference signal scrambling identifier of the RAR message, or a combination thereof.

[0031] In some examples of the method, network entities, and non-transitory computer-readable medium described herein, outputting the RAR message may include operations, features, means, or instructions for outputting the RAR message in accordance with the index of the sub-band, the RA occasion, or both based on including first information in a second control message associated with the RAR message and second information in the RAR message.

[0032] In some examples of the method, network entities, and non-transitory computer-readable medium described herein, the quantity of RA occasions may be based on a type of RA procedure.

[0033] In some examples of the method, network entities, and non-transitory computer-readable medium described herein, at least a first sub-band of the set of multiple sub-bands and a second sub-band of the set of multiple sub-bands may be non-contiguous in a frequency domain.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] FIG. **1** shows an example of a wireless communications system that supports random access procedures with a virtual cell in accordance with one or more aspects of the present disclosure.

[0035] FIG. **2** shows an example of a wireless communications system that supports random access procedures with a virtual cell in accordance with one or more aspects of the present disclosure.

[0036] FIG. **3** shows an example of a message structure that supports random access procedures with a virtual cell in accordance with one or more aspects of the present disclosure.

[0037] FIG. **4** shows an example of a process flow that supports random access procedures with a virtual cell in accordance with one or more aspects of the present disclosure.

[0038] FIGS. **5** and **6** show block diagrams of devices that support random access procedures with a virtual cell in accordance with one or more aspects of the present disclosure.

[0039] FIG. **7** shows a block diagram of a communications manager that supports random access procedures with a virtual cell in accordance with one or more aspects of the present disclosure.

[0040] FIG. **8** shows a diagram of a system including a device that supports random access procedures with a virtual cell in accordance with one or more aspects of the present disclosure.

[0041] FIGS. **9** and **10** show block diagrams of devices that support random access procedures with a virtual cell in accordance with one or more aspects of the present disclosure.

[0042] FIG. **11** shows a block diagram of a communications manager that supports random access procedures with a virtual cell in accordance with one or more aspects of the present disclosure.

[0043] FIG. **12** shows a diagram of a system including a device that supports random access procedures with a virtual cell in accordance with one or more aspects of the present disclosure.

[0044] FIGS. **13** through **18** show flowcharts illustrating methods that support random access procedures with a virtual cell in accordance with one or more aspects of the present disclosure.

DETAILED DESCRIPTION

[0045] Some wireless communications systems may utilize virtual cells to support a fragmented frequency spectrum, which may enable next generation radio access technologies (RATs) to improve utilization efficiency while satisfying bandwidth constraints. For instance, a virtual cell may include a set of multiple sub-bands (e.g., uplink sub-bands, downlink sub-bands) that may be non-contiguous in a frequency domain (e.g., may occupy non-contiguous frequency resources). The set of sub-bands may include one or more sub-bands (e.g., for different uplink bandwidth parts (BWPs)) that occupy at least a portion of same frequency resources (e.g., respective sub-bands may overlap with one another). Moreover, to support random access (RA) procedures, a network entity may configure one or more physical random access channel (PRACH) occasions (ROs) for each respective sub-band of a virtual cell. However, some RA procedures may not consider overlapping resources between multiple sub-bands. For instance, each sub-band may be associated with a respective set of ROs and random access response (RAR) messages (e.g., from a network entity) may be based on an RO index. However, ROs of different sub-bands may be associated with a same RO indexing.

Thus, different user equipments (UEs) operating on different sub-bands may each select an RO with a same index, which may result in conflicting (e.g., ambiguous) RAR messages. Thus, performing such RA procedures via a virtual cell may result in increased processing complexity, increased latency, and increased energy consumption.

[0046] In accordance with one or more techniques described herein, a wireless communications system may support enhanced RA procedures to resolve conflicts (e.g., collisions, contentions) associated with one or more sub-bands of a virtual cell. In some examples, a network entity may transmit (e.g., output) one or more control messages to a UE that indicates (e.g., identifies, conveys) a sub-band index and a frequency division multiplexing (FDM) parameter (e.g., a quantity of ROs) configured for the sub-band. A UE may select (e.g., derive, calculate, determine) an RO index based on the sub-band index and the FDM parameter. The selected index may be a unique across all sub-bands of the virtual cell (e.g., an accumulative RO index). Additionally, or alternatively, a network entity may associate a RAR message to a specific sub-band RO (e.g., to a target UE operating on a specific sub-band) based on including a sub-band index and/or a sub-band specific RO index in one or more fields of a control message (e.g., a physical downlink control channel (PDCCH) message) associated with the RAR message. Additionally, or alternatively, the network may associate the RAR message to a sub-band specific RO by including the sub-band index and/or the sub-band specific RO index in one or more portions of a shared channel message (e.g., a physical downlink shared channel (PDSCH) message) associated with the RAR message. Thus, a wireless communications system may be configured to account for (e.g., resolve) conflicts in RA procedures associated with virtual cells, which may provide support for next generation RATs and may result in improved communication reliability, improved coordination between devices, and reduced latency, among other benefits.

[0047] Aspects of the disclosure are initially described in the context of wireless communications systems. Aspects of the disclosure are further illustrated by and described with reference to message structures, process flows, apparatus diagrams, system diagrams, and flowcharts that relate to RA procedures with a virtual cell.

[0048] FIG. **1** shows an example of a wireless communications system **100** that supports RA procedures with a virtual cell in accordance with one or more aspects of the present disclosure. The wireless communications system **100** may include one or more network entities **105**, one or more UEs **115**, and a core network **130**. In some examples, the wireless communications system **100** may be a Long Term Evolution (LTE) network, an LTE-Advanced (LTE-A) network, an LTE-A Pro network, a New Radio (NR) network, or a network operating in accordance with other systems and radio technologies, including future systems and radio technologies not explicitly mentioned herein.

[0049] The network entities **105** may be dispersed throughout a geographic area to form the wireless communications system **100** and may include devices in different forms or having different capabilities. In various examples, a network entity **105** may be referred to as a network element, a mobility element, a radio access network (RAN) node, or network equipment, among other nomenclature. In some examples, network entities **105** and UEs **115** may wirelessly communicate via one or more communication links **125** (e.g., a radio frequency (RF) access link). For example, a network entity **105** may support a coverage area **110** (e.g., a geographic coverage area) over which the UEs **115** and the network entity **105** may establish one or more communication links **125**. The coverage area **110** may be an example of a geographic area over which a network entity **105** and a UE **115** may support the communication of signals according to one or more radio access technologies (RATs).

[0050] The UEs **115** may be dispersed throughout a coverage area **110** of the wireless communications system **100**, and each UE **115** may be stationary, or mobile, or both at different times. The UEs **115** may be devices in different forms or having different capabilities. Some example UEs **115** are illustrated in FIG. **1**. The UEs **115** described herein may be capable of supporting communications with various types of devices, such as other UEs **115** or network entities **105**, as shown in FIG. **1**.

[0051] As described herein, a node of the wireless communications system **100**, which may be referred to as a network node, or a wireless node, may be a network entity **105** (e.g., any network entity described herein), a UE **115** (e.g., any UE described herein), a network controller, an apparatus, a device, a computing system, one or more components, or another suitable processing entity configured to perform any of the techniques described herein. For example, a node may be a UE **115**. As another example, a node may be a network entity **105**. As another example, a first node may be configured to communicate with a second node or a third node. In one aspect of this example, the first node may be a UE **115**, the second node may be a network entity **105**, and the third node may be a UE **115**. In another aspect of this example, the first node may be a UE **115**, the second node may be a network entity **105**, and the third node may be a network entity **105**. In yet other aspects of this example, the first, second, and third nodes may be different relative to these examples. Similarly, reference to a UE **115**, network entity **105**, apparatus, device, computing system, or the like may include disclosure of the UE **115**, network entity **105**, apparatus, device, computing system, or the like being a node. For example, disclosure that a UE **115** is configured to receive information from a network entity **105** also discloses that a first node is configured to receive information from a second node.

[0052] In some examples, network entities **105** may communicate with the core network **130**, or with one another, or both. For example, network entities **105** may communicate with the core network **130** via one or more backhaul communication links **120** (e.g., in accordance with an S1, N2, N3, or other interface protocol). In some examples, network entities **105** may communicate with one another via a backhaul communication link **120** (e.g., in accordance with an X2, Xn, or other interface protocol) either directly (e.g., directly between network entities **105**) or indirectly (e.g., via a core network **130**). In some examples, network entities **105** may communicate with one another via a midhaul communication link **162** (e.g., in accordance with a midhaul interface protocol) or a fronthaul communication link **168** (e.g., in accordance with a fronthaul interface protocol), or any combination thereof. The backhaul communication links **120**, midhaul communication links **162**, or fronthaul communication links **168** may be or include one or more wired links (e.g., an electrical link, an optical fiber link), one or more wireless links (e.g., a radio link, a wireless optical link), among other examples or various combinations thereof. A UE **115** may communicate with the core network **130** via a communication link **155**.

[0053] One or more of the network entities **105** described herein may include or may be referred to as a base station **140** (e.g., a base transceiver station, a radio base station, an NR base station, an access point, a radio transceiver, a NodeB, an eNodeB (eNB), a next-generation NodeB or a giga-NodeB (either of which may be referred to as a gNB), a 5G NB, a next-generation eNB (ng-eNB), a Home NodeB, a Home eNodeB, or other suitable terminology). In some examples, a network entity **105** (e.g., a base station **140**) may be implemented in an aggregated (e.g., monolithic, standalone) base station architecture, which may be configured to utilize a protocol stack that is physically or logically integrated within a single network entity **105** (e.g., a single RAN node, such as a base station **140**).

[0054] In some examples, a network entity **105** may be implemented in a disaggregated architecture (e.g., a disaggregated base station architecture, a disaggregated RAN architecture), which may be configured to utilize a protocol stack that is physically or logically distributed among two or more network entities **105**, 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 **105** may include one or more of a central unit (CU) **160**, a distributed unit (DU) **165**, a radio unit (RU) **170**, a RAN Intelligent Controller (RIC) **175** (e.g., a Near-Real Time RIC (Near-RT RIC), a Non-Real Time RIC (Non-RT RIC)), a Service Management and Orchestration (SMO) **180** system, or any combination thereof. An RU **170** 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 **105** in a disaggregated RAN architecture may be co-located, or one or more components of the network entities **105** may be located in distributed locations (e.g., separate physical locations). In some examples, one or more network entities **105** 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)).

[0055] The split of functionality between a CU **160**, a DU **165**, and an RU **170** is flexible and may support different functionalities depending on which functions (e.g., network layer functions, protocol layer functions, baseband functions, RF functions, and any combinations thereof) are performed at a CU **160**, a DU **165**, or an RU **170**. For example, a functional split of a protocol stack may be employed between a CU **160** and a DU **165** such that the CU **160** may support one or more layers of the protocol stack and the DU **165** may support one or more different layers of the protocol stack. In some examples, the CU **160** may host upper protocol layer (e.g., layer 3 (L3), layer 2 (L2)) functionality and signaling (e.g., Radio Resource Control (RRC), service data adaption protocol (SDAP), Packet Data Convergence Protocol (PDCP)). The CU **160** may be connected to one or more DUs **165** or RUs **170**, and the one or more DUs **165** or RUs **170** may host lower protocol layers, such as layer 1 (L1) (e.g., physical (PHY) layer) or 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 **160**. Additionally, or alternatively, a functional split of the protocol stack may be employed between a DU **165** and an RU **170** such that the DU **165** may support one or more layers of the protocol stack and the RU **170** may support one or more different layers of the protocol stack. The DU **165** may support one or multiple different cells (e.g., via one or more RUs **170**). In some cases, a functional split between a CU **160** and a DU **165**, or between a DU **165** and an RU **170** may be within a protocol layer (e.g., some functions for a protocol layer may be performed by one of a CU **160**, a DU **165**, or an RU **170**, while other functions of the protocol layer are performed by a different one of the CU **160**, the DU **165**, or the RU **170**). A CU **160** may be functionally split further into CU control plane (CU-CP) and CU user plane (CU-UP) functions. A CU **160** may be connected to one or more DUs **165** via a midhaul communication link **162** (e.g., F1, F1-c, F1-u), and a DU **165** may be connected to one or more RUs **170** via a fronthaul communication link **168** (e.g., open fronthaul (FH) interface). In some examples, a midhaul communication link **162** or a fronthaul communication link **168** may be implemented in accordance with an interface (e.g., a channel) between layers of a protocol stack supported by respective network entities **105** that are in communication via such communication links.

[0056] In wireless communications systems (e.g., wireless communications system **100**), infrastructure and spectral resources for radio access may support wireless backhaul link capabilities to supplement wired backhaul connections, providing an IAB network architecture (e.g., to a core network **130**). In some cases, in an IAB network, one or more network entities **105** (e.g., IAB nodes **104**) may be partially controlled by each other. One or more IAB nodes **104** may be referred to as a donor entity or an IAB donor. One or more DUs **165** or one or more RUs **170** may be partially controlled by one or more CUs **160** associated with a donor network entity **105** (e.g., a donor base station **140**). The one or more donor network entities **105** (e.g., IAB donors) may be in communication with one or more additional network entities **105** (e.g., IAB nodes **104**) via supported access and backhaul links (e.g., backhaul communication links **120**). IAB nodes **104** may include an IAB mobile termination (IAB-MT) controlled (e.g., scheduled) by DUs **165** of a coupled IAB donor. An IAB-MT may include an independent set of antennas for relay of communications with UEs **115**, or may share the same antennas (e.g., of an RU **170**) of an IAB node **104** used for access via the DU **165** of the IAB node **104** (e.g., referred to as virtual IAB-MT (vIAB-MT)). In some examples, the IAB nodes **104** may include DUs **165** that support communication links with additional entities (e.g., IAB nodes **104**, UEs **115**) within the relay chain or configuration of the access network (e.g., downstream). In such cases, one or more components of the disaggregated RAN architecture (e.g., one or more IAB nodes **104** or components of IAB nodes **104**) may be configured to operate according to the techniques described herein.

[0057] For instance, an access network (AN) or RAN may include communications between access nodes (e.g., an IAB donor), IAB nodes **104**, and one or more UEs **115**. The IAB donor may facilitate connection between the core network **130** and the AN (e.g., via a wired or wireless connection to the core network **130**). That is, an IAB donor may refer to a RAN node with a wired or wireless connection to core network **130**. The IAB donor may include a CU **160** and at least one DU **165** (e.g., and RU **170**), in which case the CU

160 may communicate with the core network **130** via an interface (e.g., a backhaul link). IAB donor and IAB nodes **104** may communicate via an F1 interface according to a protocol that defines signaling messages (e.g., an F1 AP protocol). Additionally, or alternatively, the CU **160** may communicate with the core network via an interface, which may be an example of a portion of backhaul link, and may communicate with other CUs **160** (e.g., a CU **160** associated with an alternative IAB donor) via an Xn-C interface, which may be an example of a portion of a backhaul link.

[0058] An IAB node **104** may refer to a RAN node that provides IAB functionality (e.g., access for UEs **115**, wireless self-backhauling capabilities). A DU **165** may act as a distributed scheduling node towards child nodes associated with the IAB node **104**, and the IAB-MT may act as a scheduled node towards parent nodes associated with the IAB node **104**. That is, an IAB donor may be referred to as a parent node in communication with one or more child nodes (e.g., an IAB donor may relay transmissions for UEs through one or more other IAB nodes **104**). Additionally, or alternatively, an IAB node **104** may also be referred to as a parent node or a child node to other IAB nodes **104**, depending on the relay chain or configuration of the AN. Therefore, the IAB-MT entity of IAB nodes **104** may provide a Uu interface for a child IAB node **104** to receive signaling from a parent IAB node **104**, and the DU interface (e.g., DUs **165**) may provide a Uu interface for a parent IAB node **104** to signal to a child IAB node **104** or UE **115**.

[0059] For example, IAB node **104** may be referred to as a parent node that supports communications for a child IAB node, or referred to as a child IAB node associated with an IAB donor, or both. The IAB donor may include a CU **160** with a wired or wireless connection (e.g., a backhaul communication link **120**) to the core network **130** and may act as parent node to IAB nodes **104**. For example, the DU **165** of IAB donor may relay transmissions to UEs **115** through IAB nodes **104**, or may directly signal transmissions to a UE **115**, or both. The CU **160** of IAB donor may signal communication link establishment via an F1 interface to IAB nodes **104**, and the IAB nodes **104** may schedule transmissions (e.g., transmissions to the UEs **115** relayed from the IAB donor) through the DUs **165**. That is, data may be relayed to and from IAB nodes **104** via signaling via an NR Uu interface to MT of the IAB node **104**. Communications with IAB node **104** may be scheduled by a DU **165** of IAB donor and communications with IAB node **104** may be scheduled by DU **165** of IAB node **104**.

[0060] In the case of the techniques described herein applied in the context of a disaggregated RAN architecture, one or more components of the disaggregated RAN architecture may be configured to support RA procedures with a virtual cell as described herein. For example, some operations described as being performed by a UE **115** or a network entity **105** (e.g., a base station **140**) may additionally, or alternatively, be performed by one or more components of the disaggregated RAN architecture (e.g., IAB nodes **104**, DUs **165**, CUs **160**, RUs **170**, RIC **175**, SMO **180**).

[0061] A UE **115** may include or may be referred to as a mobile device, a wireless device, a remote device, a handheld device, or a subscriber device, or some other suitable terminology, where the "device" may also be referred to as a unit, a station, a terminal, or a client, among other examples. A UE **115** may also include or may be referred to as a personal electronic device such as a cellular phone, a personal digital assistant (PDA), a tablet computer, a laptop computer, or a personal computer. In some examples, a UE **115** may include or be referred to as a wireless local loop (WLL) station, an Internet of Things (IoT) device, an Internet of Everything (IoE) device, or a machine type communications (MTC) device, among other examples, which may be implemented in various objects such as appliances, or vehicles, meters, among other examples.

[0062] The UEs **115** described herein may be able to communicate with various types of devices, such as other UEs **115** that may sometimes act as relays as well as the network entities **105** and the network equipment including macro eNBs or gNBs, small cell eNBs or gNBs, or relay base stations, among other examples, as shown in FIG. **1**.

[0063] The UEs **115** and the network entities **105** may wirelessly communicate with one another via one or more communication links **125** (e.g., an access link) using resources associated with one or more carriers. The term "carrier" may refer to a set of RF spectrum resources having a defined physical layer structure for supporting the communication links **125**. For example, a carrier used for a communication link **125** may include a portion of a RF spectrum band (e.g., a bandwidth part (BWP)) that is operated according to one or more physical layer channels for a given radio access technology (e.g., LTE, LTE-A, LTE-A Pro, NR). Each physical layer channel may carry acquisition signaling (e.g., synchronization signals, system information), control signaling that coordinates operation for the carrier, user data, or other signaling. The wireless communications system **100** may support communication with a UE **115** using carrier aggregation or multi-carrier operation. A UE **115** may be configured with multiple downlink component carriers and one or more uplink component carriers according to a carrier aggregation configuration. Carrier aggregation may be used with both frequency division duplexing (FDD) and time division duplexing (TDD) component carriers. Communication between a network entity **105** and other devices may refer to communication between the devices and any portion (e.g., entity, sub-entity) of a network entity **105**. For example, the terms "transmitting," "receiving," or "communicating," when referring to a network entity **105**, may refer to any portion of a network entity **105** (e.g., a base station **140**, a CU **160**, a DU **165**, a RU **170**) of a RAN communicating with another device (e.g., directly or via one or more other network entities **105**).

[0064] In some examples, such as in a carrier aggregation configuration, a carrier may also have acquisition signaling or control signaling that coordinates operations for other carriers. A carrier may be associated with a frequency channel (e.g., an evolved universal mobile telecommunication system terrestrial radio access (E-UTRA) absolute RF channel number (EARFCN)) and may be identified according to a channel raster for discovery by the UEs **115**. A carrier may be operated in a standalone mode, in which case initial acquisition and connection may be conducted by the UEs **115** via the carrier, or the carrier may be operated in a non-standalone mode, in which case a connection is anchored using a different carrier (e.g., of the same or a different radio access technology).

[0065] The communication links **125** shown in the wireless communications system **100** may include downlink transmissions (e.g., forward link transmissions) from a network entity **105** to a UE **115**, uplink transmissions (e.g., return link transmissions) from a UE **115** to a network entity

105, or both, among other configurations of transmissions. Carriers may carry downlink or uplink communications (e.g., in an FDD mode) or may be configured to carry downlink and uplink communications (e.g., in a TDD mode).

[0066] A carrier may be associated with a particular bandwidth of the RF spectrum and, in some examples, the carrier bandwidth may be referred to as a "system bandwidth" of the carrier or the wireless communications system **100**. For example, the carrier bandwidth may be one of a set of bandwidths for carriers of a particular radio access technology (e.g., 1.4, 3, 5, 10, 15, 20, 40, or 80 megahertz (MHz)). Devices of the wireless communications system **100** (e.g., the network entities **105**, the UEs **115**, or both) may have hardware configurations that support communications using a particular carrier bandwidth or may be configurable to support communications using one of a set of carrier bandwidths. In some examples, the wireless communications system **100** may include network entities **105** or UEs **115** that support concurrent communications using carriers associated with multiple carrier bandwidths. In some examples, each served UE **115** may be configured for operating using portions (e.g., a sub-band, a BWP) or all of a carrier bandwidth.

[0067] Signal waveforms transmitted via a carrier may be made up of multiple subcarriers (e.g., using multi-carrier modulation (MCM) techniques such as orthogonal frequency division multiplexing (OFDM) or discrete Fourier transform spread OFDM (DFT-S-OFDM)). In a system employing MCM techniques, a resource element may refer to resources of one symbol period (e.g., a duration of one modulation symbol) and one subcarrier, in which case the symbol period and subcarrier spacing may be inversely related. The quantity of bits carried by each resource element may depend on the modulation scheme (e.g., the order of the modulation scheme, the coding rate of the modulation scheme, or both), such that a relatively higher quantity of resource elements (e.g., in a transmission duration) and a relatively higher order of a modulation scheme may correspond to a relatively higher rate of communication. A wireless communications resource may refer to a combination of an RF spectrum resource, a time resource, and a spatial resource (e.g., a spatial layer, a beam), and the use of multiple spatial resources may increase the data rate or data integrity for communications with a UE **115**.

[0068] One or more numerologies for a carrier may be supported, and a numerology may include a subcarrier spacing (Δf) and a cyclic prefix. A carrier may be divided into one or more BWPs having the same or different numerologies. In some examples, a UE **115** may be configured with multiple BWPs. In some examples, a single BWP for a carrier may be active at a given time and communications for the UE **115** may be restricted to one or more active BWPs.

[0069] The time intervals for the network entities **105** or the UEs **115** may be expressed in multiples of a basic time unit which may, for example, refer to a sampling period of $T_s=1/(\Delta f_{max}\cdot N_f)$ seconds, for which Δf_{max} may represent a supported subcarrier spacing, and Ne may represent a supported discrete Fourier transform (DFT) size. Time intervals of a communications resource may be organized according to radio frames each having a specified duration (e.g., 10 milliseconds (ms)). Each radio frame may be identified by a system frame number (SFN) (e.g., ranging from 0 to 1023).

[0070] Each frame may include multiple consecutively-numbered subframes or slots, and each subframe or slot may have the same duration. In some examples, a frame may be divided (e.g., in the time domain) into subframes, and each subframe may be further divided into a quantity of slots. Alternatively, each frame may include a variable quantity of slots, and the quantity of slots may depend on subcarrier spacing. Each slot may include a quantity of symbol periods (e.g., depending on the length of the cyclic prefix prepended to each symbol period). In some wireless communications systems **100**, a slot may further be divided into multiple mini-slots associated with one or more symbols. Excluding the cyclic prefix, each symbol period may be associated with one or more (e.g., N_f) sampling periods. The duration of a symbol period may depend on the subcarrier spacing or frequency band of operation.

[0071] A subframe, a slot, a mini-slot, or a symbol may be the smallest scheduling unit (e.g., in the time domain) of the wireless communications system **100** and may be referred to as a transmission time interval (TTI). In some examples, the TTI duration (e.g., a quantity of symbol periods in a TTI) may be variable. Additionally, or alternatively, the smallest scheduling unit of the wireless communications system **100** may be dynamically selected (e.g., in bursts of shortened TTIs (STTIs)).

[0072] Physical channels may be multiplexed for communication using a carrier according to various techniques. A physical control channel and a physical data channel may be multiplexed for signaling via a downlink carrier, for example, using one or more of time division multiplexing (TDM) techniques, frequency division multiplexing (FDM) techniques, or hybrid TDM-FDM techniques. A control region (e.g., a control resource set (CORESET)) for a physical control channel may be defined by a set of symbol periods and may extend across the system bandwidth or a subset of the system bandwidth of the carrier. One or more control regions (e.g., CORESETs) may be configured for a set of the UEs **115**. For example, one or more of the UEs **115** may monitor or search control regions for control information according to one or more search space sets, and each search space set may include one or multiple control channel candidates in one or more aggregation levels arranged in a cascaded manner. An aggregation level for a control channel candidate may refer to an amount of control channel resources (e.g., control channel elements (CCEs)) associated with encoded information for a control information format having a given payload size. Search space sets may include common search space sets configured for sending control information to multiple UEs **115** and UE-specific search space sets for sending control information to a specific UE **115**.

[0073] A network entity **105** may provide communication coverage via one or more cells, for example a macro cell, a small cell, a hot spot, or other types of cells, or any combination thereof. The term "cell" may refer to a logical communication entity used for communication with a network entity **105** (e.g., using a carrier) and may be associated with an identifier for distinguishing neighboring cells (e.g., a physical cell identifier (PCID), a virtual cell identifier (VCID), or others). In some examples, a cell also may refer to a coverage area **110** or a portion of a coverage area **110** (e.g., a sector) over which the logical communication entity operates. Such cells may range from smaller areas (e.g., a structure, a subset of structure) to larger areas depending on various factors such as the capabilities of the network entity **105**. For example, a cell may be or include a building, a subset of a building, or exterior spaces between or overlapping with coverage areas **110**, among other examples.

[0074] A macro cell generally covers a relatively large geographic area (e.g., several kilometers in radius) and may allow unrestricted access by the UEs **115** with service subscriptions with the network provider supporting the macro cell. A small cell may be associated with a lower-powered network entity **105** (e.g., a lower-powered base station **140**), as compared with a macro cell, and a small cell may operate using the same or different (e.g., licensed, unlicensed) frequency bands as macro cells. Small cells may provide unrestricted access to the UEs **115** with service subscriptions with the network provider or may provide restricted access to the UEs **115** having an association with the small cell (e.g., the UEs **115** in a closed subscriber group (CSG), the UEs **115** associated with users in a home or office). A network entity **105** may support one or multiple cells and may also support communications via the one or more cells using one or multiple component carriers.

[0075] In some examples, a carrier may support multiple cells, and different cells may be configured according to different protocol types (e.g., MTC, narrowband IoT (NB-IoT), enhanced mobile broadband (eMBB)) that may provide access for different types of devices.

[0076] In some examples, a network entity **105** (e.g., a base station **140**, an RU **170**) may be movable and therefore provide communication coverage for a moving coverage area **110**. In some examples, different coverage areas **110** associated with different technologies may overlap, but the different coverage areas **110** may be supported by the same network entity **105**. In some other examples, the overlapping coverage areas **110** associated with different technologies may be supported by different network entities **105**. The wireless communications system **100** may include, for example, a heterogeneous network in which different types of the network entities **105** provide coverage for various coverage areas **110** using the same or different radio access technologies.

[0077] The wireless communications system **100** may support synchronous or asynchronous operation. For synchronous operation, network entities **105** (e.g., base stations **140**) may have similar frame timings, and transmissions from different network entities **105** may be approximately aligned in time. For asynchronous operation, network entities **105** may have different frame timings, and transmissions from different network entities **105** may, in some examples, not be aligned in time. The techniques described herein may be used for either synchronous or asynchronous operations.

[0078] Some UEs **115**, such as MTC or IoT devices, may be low cost or low complexity devices and may provide for automated communication between machines (e.g., via Machine-to-Machine (M2M) communication). M2M communication or MTC may refer to data communication technologies that allow devices to communicate with one another or a network entity **105** (e.g., a base station **140**) without human intervention. In some examples, M2M communication or MTC may include communications from devices that integrate sensors or meters to measure or capture information and relay such information to a central server or application program that uses the information or presents the information to humans interacting with the application program. Some UEs **115** may be designed to collect information or enable automated behavior of machines or other devices. Examples of applications for MTC devices include smart metering, inventory monitoring, water level monitoring, equipment monitoring, healthcare monitoring, wildlife monitoring, weather and geological event monitoring, fleet management and tracking, remote security sensing, physical access control, and transaction-based business charging.

[0079] Some UEs **115** may be configured to employ operating modes that reduce power consumption, such as half-duplex communications (e.g., a mode that supports one-way communication via transmission or reception, but not transmission and reception concurrently). In some examples, half-duplex communications may be performed at a reduced peak rate. Other power conservation techniques for the UEs **115** include entering a power saving deep sleep mode when not engaging in active communications, operating using a limited bandwidth (e.g., according to narrowband communications), or a combination of these techniques. For example, some UEs **115** may be configured for operation using a narrowband protocol type that is associated with a defined portion or range (e.g., set of subcarriers or resource blocks (RBs)) within a carrier, within a guard-band of a carrier, or outside of a carrier.

[0080] The wireless communications system **100** may be configured to support ultra-reliable communications or low-latency communications, or various combinations thereof. For example, the wireless communications system **100** may be configured to support ultra-reliable low-latency communications (URLLC). The UEs **115** may be designed to support ultra-reliable, low-latency, or critical functions. Ultra-reliable communications may include private communication or group communication and may be supported by one or more services such as push-to-talk, video, or data. Support for ultra-reliable, low-latency functions may include prioritization of services, and such services may be used for public safety or general commercial applications. The terms ultra-reliable, low-latency, and ultra-reliable low-latency may be used interchangeably herein.

[0081] In some examples, a UE **115** may be configured to support communicating directly with other UEs **115** via a device-to-device (D2D) communication link **135** (e.g., in accordance with a peer-to-peer (P2P), D2D, or sidelink protocol). In some examples, one or more UEs **115** of a group that are performing D2D communications may be within the coverage area **110** of a network entity **105** (e.g., a base station **140**, an RU **170**), which may support aspects of such D2D communications being configured by (e.g., scheduled by) the network entity **105**. In some examples, one or more UEs **115** of such a group may be outside the coverage area **110** of a network entity **105** or may be otherwise unable to or not configured to receive transmissions from a network entity **105**. In some examples, groups of the UEs **115** communicating via D2D communications may support a one-to-many (1:M) system in which each UE **115** transmits to each of the other UEs **115** in the group. In some examples, a network entity **105** may facilitate the scheduling of resources for D2D communications. In some other examples, D2D communications may be carried out between the UEs **115** without an involvement of a network entity **105**.

[0082] In some systems, a D2D communication link **135** may be an example of a communication channel, such as a sidelink communication channel, between vehicles (e.g., UEs **115**). In some examples, vehicles may communicate using vehicle-to-everything (V2X) communications, vehicle-to-vehicle (V2V) communications, or some combination of these. A vehicle may signal information related to traffic conditions, signal scheduling, weather, safety, emergencies, or any other information relevant to a V2X system. In some examples, vehicles in a V2X system may communicate with roadside infrastructure, such as roadside units, or with the network via one or more network nodes (e.g., network entities **105**, base stations **140**, RUs **170**) using vehicle-to-network (V2N) communications, or with both.

[0083] The core network **130** may provide user authentication, access authorization, tracking, Internet Protocol (IP) connectivity, and other access, routing, or mobility functions. The core network **130** may be an evolved packet core (EPC) or 5G core (5GC), which may include at least one control plane entity that manages access and mobility (e.g., a mobility management entity (MME), an access and mobility management function (AMF)) and at least one 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)). The control plane entity may manage non-access stratum (NAS) functions such as mobility, authentication, and bearer management for the UEs **115** served by the network entities **105** (e.g., base stations **140**) associated with the core network **130**. User IP packets may be transferred through the user plane entity, which may provide IP address allocation as well as other functions. The user plane entity may be connected to IP services **150** for one or more network operators. The IP services **150** may include access to the Internet, Intranet(s), an IP Multimedia Subsystem (IMS), or a Packet-Switched Streaming Service.

[0084] The wireless communications system **100** may operate using one or more frequency bands, which may be in the range of 300 megahertz (MHz) to 300 gigahertz (GHz). Generally, the region from 300 MHz to 3 GHz is known as the ultra-high frequency (UHF) region or decimeter band because the wavelengths range from approximately one decimeter to one meter in length. UHF waves may be blocked or redirected by buildings and environmental features, which may be referred to as clusters, but the waves may penetrate structures sufficiently for a macro cell to provide service to the UEs **115** located indoors. Communications using UHF waves may be associated with smaller antennas and shorter ranges (e.g., less than 100 kilometers) compared to communications using the smaller frequencies and longer waves of the high frequency (HF) or very high frequency (VHF) portion of the spectrum below 300 MHz.

[0085] The wireless communications system **100** may also operate using a super high frequency (SHF) region, which may be in the range of 3 GHz to 30 GHz, also known as the centimeter band, or using an extremely high frequency (EHF) region of the spectrum (e.g., from 30 GHz to 300 GHz), also known as the millimeter band. In some examples, the wireless communications system **100** may support millimeter wave (mmW) communications between the UEs **115** and the network entities **105** (e.g., base stations **140**, RUs **170**), and EHF antennas of the respective devices may be smaller and more closely spaced than UHF antennas. In some examples, such techniques may facilitate using antenna arrays within a device. The propagation of EHF transmissions, however, may be subject to even greater attenuation and shorter range than SHF or UHF transmissions. The techniques disclosed herein may be employed across transmissions that use one or more different frequency regions, and designated use of bands across these frequency regions may differ by country or regulating body.

[0086] The wireless communications system **100** may utilize both licensed and unlicensed RF spectrum bands. For example, the wireless communications system **100** may employ License Assisted Access (LAA), LTE-Unlicensed (LTE-U) radio access technology, or NR technology using an unlicensed band such as the 5 GHz industrial, scientific, and medical (ISM) band. While operating using unlicensed RF spectrum bands, devices such as the network entities **105** and the UEs **115** may employ carrier sensing for collision detection and avoidance. In some examples, operations using unlicensed bands may be based on a carrier aggregation configuration in conjunction with component carriers operating using a licensed band (e.g., LAA). Operations using unlicensed spectrum may include downlink transmissions, uplink transmissions, P2P transmissions, or D2D transmissions, among other examples.

[0087] A network entity **105** (e.g., a base station **140**, an RU **170**) or a UE **115** may be equipped with multiple antennas, which may be used to employ techniques such as transmit diversity, receive diversity, multiple-input multiple-output (MIMO) communications, or beamforming. The antennas of a network entity **105** or a UE **115** may be located within one or more antenna arrays or antenna panels, which may support MIMO operations or transmit or receive beamforming. For example, one or more base station antennas or antenna arrays may be co-located at an antenna assembly, such as an antenna tower. In some examples, antennas or antenna arrays associated with a network entity **105** may be located at diverse geographic locations. A network entity **105** may include an antenna array with a set of rows and columns of antenna ports that the network entity **105** may use to support beamforming of communications with a UE **115**. Likewise, a UE **115** may include one or more antenna arrays that may support various MIMO or beamforming operations. Additionally, or alternatively, an antenna panel may support RF beamforming for a signal transmitted via an antenna port.

[0088] The network entities **105** or the UEs **115** may use MIMO communications to exploit multipath signal propagation and increase spectral efficiency by transmitting or receiving multiple signals via different spatial layers. Such techniques may be referred to as spatial multiplexing. The multiple signals may, for example, be transmitted by the transmitting device via different antennas or different combinations of antennas. Likewise, the multiple signals may be received by the receiving device via different antennas or different combinations of antennas. Each of the multiple signals may be referred to as a separate spatial stream and may carry information associated with the same data stream (e.g., the same codeword) or different data streams (e.g., different codewords). Different spatial layers may be associated with different antenna ports used for channel measurement and reporting. MIMO techniques include single-user MIMO (SU-MIMO), for which multiple spatial layers are transmitted to the same receiving device, and multiple-user MIMO (MU-MIMO), for which multiple spatial layers are transmitted to multiple devices.

[0089] Beamforming, which may also be referred to as spatial filtering, directional transmission, or directional reception, is a signal processing technique that may be used at a transmitting device or a receiving device (e.g., a network entity **105**, a UE **115**) to shape or steer an antenna beam (e.g., a transmit beam, a receive beam) along a spatial path between the transmitting device and the receiving device. Beamforming may be achieved by combining the signals communicated via antenna elements of an antenna array such that some signals propagating along particular orientations with respect to an antenna array experience constructive interference while others experience destructive interference. The adjustment of signals communicated via the antenna elements may include a transmitting device or a receiving device applying amplitude offsets, phase offsets, or both to signals carried via the antenna elements associated with the device. The adjustments associated with each of the antenna elements may be defined by a beamforming weight set associated with a particular orientation (e.g., with respect to the antenna array of the transmitting device or receiving device, or with respect to some other orientation).

[0090] A network entity **105** or a UE **115** may use beam sweeping techniques as part of beamforming operations. For example, a network entity **105** (e.g., a base station **140**, an RU **170**) may use multiple antennas or antenna arrays (e.g., antenna panels) to conduct beamforming operations for directional communications with a UE **115**. Some signals (e.g., synchronization signals, reference signals, beam selection signals, or other control signals) may be transmitted by a network entity **105** multiple times along different directions. For example, the network entity **105** may transmit a signal according to different beamforming weight sets associated with different directions of transmission. Transmissions along different beam directions may be used to identify (e.g., by a transmitting device, such as a network entity **105**, or by a receiving device, such as a UE **115**) a beam direction for later transmission or reception by the network entity **105**.

[0091] Some signals, such as data signals associated with a particular receiving device, may be transmitted by transmitting device (e.g., a transmitting network entity **105**, a transmitting UE **115**) along a single beam direction (e.g., a direction associated with the receiving device, such as a receiving network entity **105** or a receiving UE **115**). In some examples, the beam direction associated with transmissions along a single beam direction may be determined based on a signal that was transmitted along one or more beam directions. For example, a UE **115** may receive one or more of the signals transmitted by the network entity **105** along different directions and may report to the network entity **105** an indication of the signal that the UE **115** received with a highest signal quality or an otherwise acceptable signal quality.

[0092] In some examples, transmissions by a device (e.g., by a network entity **105** or a UE **115**) may be performed using multiple beam directions, and the device may use a combination of digital precoding or beamforming to generate a combined beam for transmission (e.g., from a network entity **105** to a UE **115**). The UE **115** may report feedback that indicates precoding weights for one or more beam directions, and the feedback may correspond to a configured set of beams across a system bandwidth or one or more sub-bands. The network entity **105** may transmit a reference signal (e.g., a cell-specific reference signal (CRS), a channel state information reference signal (CSI-RS)), which may be precoded or unprecoded. The UE **115** may provide feedback for beam selection, which may be a precoding matrix indicator (PMI) or codebook-based feedback (e.g., a multi-panel type codebook, a linear combination type codebook, a port selection type codebook). Although these techniques are described with reference to signals transmitted along one or more directions by a network entity **105** (e.g., a base station **140**, an RU **170**), a UE **115** may employ similar techniques for transmitting signals multiple times along different directions (e.g., for identifying a beam direction for subsequent transmission or reception by the UE **115**) or for transmitting a signal along a single direction (e.g., for transmitting data to a receiving device).

[0093] A receiving device (e.g., a UE **115**) may perform reception operations in accordance with multiple receive configurations (e.g., directional listening) when receiving various signals from a transmitting device (e.g., a network entity **105**), such as synchronization signals, reference signals, beam selection signals, or other control signals. For example, a receiving device may perform reception in accordance with multiple receive directions by receiving via different antenna subarrays, by processing received signals according to different antenna subarrays, by receiving according to different receive beamforming weight sets (e.g., different directional listening weight sets) applied to signals received at multiple antenna elements of an antenna array, or by processing received signals according to different receive beamforming weight sets applied to signals received at multiple antenna elements of an antenna array, any of which may be referred to as "listening" according to different receive configurations or receive directions. In some examples, a receiving device may use a single receive configuration to receive along a single beam direction (e.g., when receiving a data signal). The single receive configuration may be aligned along a beam direction determined based on listening according to different receive configuration directions (e.g., a beam direction determined to have a highest signal strength, highest signal-to-noise ratio (SNR), or otherwise acceptable signal quality based on listening according to multiple beam directions).

[0094] The wireless communications system **100** may be a packet-based network that operates according to a layered protocol stack. In the user plane, communications at the bearer or PDCP layer may be IP-based. An RLC layer may perform packet segmentation and reassembly to communicate via logical channels. A MAC layer may perform priority handling and multiplexing of logical channels into transport channels. The MAC layer also may implement error detection techniques, error correction techniques, or both to support retransmissions to improve link efficiency. In the control plane, an RRC layer may provide establishment, configuration, and maintenance of an RRC connection between a UE **115** and a network entity **105** or a core network **130** supporting radio bearers for user plane data. A PHY layer may map transport channels to physical channels.

[0095] The UEs **115** and the network entities **105** may support retransmissions of data to increase the likelihood that data is received successfully. Hybrid automatic repeat request (HARQ) feedback is one technique for increasing the likelihood that data is received correctly via a communication link (e.g., a communication link **125**, a D2D communication link **135**). HARQ may include a combination of error detection (e.g., using a cyclic redundancy check (CRC)), forward error correction (FEC), and retransmission (e.g., automatic repeat request (ARQ)). HARQ may improve throughput at the MAC layer in poor radio conditions (e.g., low signal-to-noise conditions). In some examples, a device may support same-slot HARQ feedback, in which case the device may provide HARQ feedback in a specific slot for data received via a previous symbol in the slot. In some other examples, the device may provide HARQ feedback in a subsequent slot, or according to some other time interval.

[0096] Some wireless communications systems **100** (e.g., some network entities **105**) may utilize virtual cells to support a fragmented frequency spectrum, which may enable next generation RATs to improve utilization efficiency while satisfying bandwidth constraints. For instance, a virtual cell (e.g., of one or more network entities **105**) may allocate a set of multiple sub-bands (e.g., uplink BWPs, downlink BWPs) that may be non-contiguous in a frequency domain (e.g., may not occupy contiguous frequency resources). At least some of the sub-bands of the set may overlap with one another in a frequency domain. However, some RA procedures of the wireless communications system **100** may not account for such overlapping frequency resources in different sub-bands. For instance, a RAR message may be based on an RO index. Due to the non-contiguous characteristic of one or more sub-bands, different ROs associated with different sub-bands may correspond to a same RO index and may result in conflicting (e.g., ambiguous) RAR messages. Thus, utilizing virtual cells may result in increased processing complexity, increased latency, and increased energy consumption.

[0097] In accordance with one or more techniques described herein, a wireless communications system **100** may resolve conflicts associated with RA procedures associated with non-contiguous sub-bands of a virtual cell. In some examples, a network entity **105** may transmit one or more control messages to a UE **115** that indicates a sub-band index and a frequency division multiplexing (FDM) parameter (e.g., a quantity of ROs) configured for the sub-band. A UE **115** may derive an RO index based on the sub-band index and the FDM parameter. The derived index may be a unique across all sub-bands of the virtual cell (e.g., an accumulative RO index). Additionally, or alternatively, a network entity may associate a RAR message to a sub-band specific RO based on including a sub-band index and/or a sub-band specific RO index in one or more portions of a control message (e.g., a PDDCH portion of the RAR message) message associated with the RAR message. Additionally, or alternatively, the network may associate the RAR message to a sub-band specific RO by including the sub-band index and/or the sub-band specific RO index in one or more portions of a shared channel message (e.g., a PDSCH portion of the RAR message). Thus, a wireless communications system **100** may be configured to resolve potential conflicts in RA procedures associated with virtual cells, which may result in improved communication reliability, improved coordination between devices, and reduced latency, among other benefits.

[0098] FIG. **2** shows an example of a wireless communications system **200** that supports RA procedures with a virtual cell in accordance with one or more aspects of the present disclosure. The wireless communications system **200** may implement or be implemented by aspects of the wireless communications system **100** as described with reference to FIG. **1**. For example, the wireless communications system **200** may include a network entity **105** and one or more UEs **115** within a coverage area **110**, which may be examples corresponding devices as described with reference to FIG. **1**. For example, the network entity **105** may communicate with a UE **115**-*a* and a UE **115**-*b* via respective communication links **205** (e.g., uplink communication link **205**-*a* and uplink communication link **205**-*b*) and communication links **210** (e.g., downlink communication link **210**-*a* and downlink communication link **210**-*b*). The communication links **205** and the communication links **210** may be examples of or include downlink communication interfaces, uplink communication interfaces, or other communication interfaces. In some examples, the wireless communications system **200** may support enhanced RA procedures (e.g., for virtual cell environments, type 1 RA procedures, type 2 RA procedures) based on signaling between the network entity **105** and one or more UEs **115** including one or more control messages **215**, one or more RA messages **220** (e.g., PRACH messages), one or more RAR messages **225**, and other messages. Although a network entity **105**, a UE **115**-*a* are shown as example devices of the wireless communications system **200**, the disclosed techniques may be applied by any combination of devices described herein (e.g., including any quantity of UEs **115**, network entities **105**, or other devices).

[0099] The wireless communications system **200** may support a fragmented spectrum (e.g., a fragmented frequency spectrum), and the devices of the wireless communications system **200** may communicate via one or more component carriers (CCs). In some cases (e.g., for a cell site with one or more CCs), a bandwidth (e.g., a system bandwidth) of each CC may span a set of RBs that are contiguous in a frequency domain. Accordingly, the bandwidth for each CC may be constrained (e.g., lower bounded) by a threshold (e.g., minimum) channel bandwidth of a UE **115**. The threshold channel bandwidth of UE may be based on a RAT (e.g., RAT-dependent) and may be preconfigured (e.g., hard-coded) for each operating band (e.g., 1.4 MHz for LTE, May 10, 2020 MHz (subcarrier spacing (SCS) and band dependent) for NR frequency range one (FR1)).

[0100] A frequency spectrum of the wireless communications system **200** (e.g., of the fragmented spectrum) may include refarmed spectrum (e.g., frequency spectrum that may be repurposed from other RATs). The refarmed spectrum may be associated with a relatively narrow bandwidth and may be scattered (e.g., non-contiguous) in the frequency domain. Thus, it may be challenging to leverage such resources (e.g., frequency spectrum resources) for dynamic spectrum sharing (e.g., or carrier aggregation (CA) techniques). For example, without a spectrum aggregation with other CCs to meet threshold (e.g., minimum) channel bandwidth constraints, one or more refarmed CCs (e.g., associated with bandwidths of less than 5 MHz) may not be suitable for standalone (SA) deployment (e.g., of NR/5G).

[0101] In some cases, the wireless communications system **200** may support virtual cells to integrate fragmented spectrum (e.g., refarmed from another RAT). A virtual cell may include one or more sub-bands (e.g., RB groups, an aggregation of one or more non-contiguous sub-bands), which may provide increased flexibility to the wireless communications system **200**. For instance, the one or more sub-bands may be configured to overcome a constraint associated with spectrum refarming and CA techniques (e.g., based on limited bandwidth), improve the utilization efficiency of fragmented (e.g., refarmed) resources, and enhance a co-existence of different UE types or use cases in the wireless communications system **200**.

[0102] In some cases, a pair of downlink and uplink BWPs may be configured for the virtual cell. The downlink BWP, the uplink BWP, or both may include one or more sub-bands, which may be non-contiguous in the frequency domain. In some cases, the downlink BWP may occupy common resources across all BWP configurations (e.g., to reduce complexity in cell searching or other broadcast signal processing). Moreover, center frequencies for downlink BWPs and uplink BWPs may not be aligned. As a non-limiting example, a virtual cell may include a first sub-band (e.g., that includes a 3 MHz frequency band and a 1.4 MHz frequency band), a second sub-band (e.g., that includes three 1.4 MHz frequency bands), and a third sub-band (e.g., that includes a 5 MHz frequency band). In a first configuration, a first uplink BWP may include the first sub-band and the second sub-band, and a first downlink BWP may include the third sub-band. In a second configuration, a second uplink BWP may include the first sub-band, and a second downlink BWP may include the third sub-band. In a third configuration, a third uplink BWP may include each of the first sub-band, the second sub-band, and the third sub-band, and a third downlink BWP may include the third sub-band (e.g., the third downlink BWP may be fully contained within the bandwidth of the third uplink BWP). Thus, some systems (e.g., sixth generation (6G) systems) may support various BWP configurations including virtual cells that include various sub-bands, which may overlap in a frequency domain (e.g., may occupy the same resources).

[0103] To support RA procedures (e.g., by a UE **115**), a network entity **105** may configure one or more ROs **250** on one or more sub-bands of a virtual cell. For instance, one or more UEs **115** may transmit an RA message **220** to the network entity **105**, and the network entity **105** may respond with a RAR message **225**. In some cases, a configuration of a RAR message **225** (e.g., a random access-radio network temporary identifier (RA-RNTI) calculation, a msgB-radio network temporary identifier (RNTI) calculation) may be based on RO indexing within an active uplink BWP (e.g., a BWP-specific RO index in the frequency domain). However, in the presence of multiple BWPs configured across various sub-bands of a virtual cell, such methods may result in conflicts between RA procedures associated with different BWPs (e.g., between RACH procedures of different UEs). For instance, different ROs **250** that occupy different time and frequency resources may be mapped to a same RO index in a frequency domain, and thus, may be associated with a same RAR message configuration (e.g., a same RA-RNTI or msgB-RNTI).

[0104] As an illustrative example, the network entity **105** and the UEs **115** may utilize a resource configuration **240**. A UE **115**-*a* may operate on a first uplink BWP **245**-*a* of a virtual cell (e.g., associated with one or more network entities **105**), and a UE **115**-*b* may operate on a second uplink BWP **245**-*b* of the virtual cell. The first uplink BWP **245**-*a* may be configured with, for example, four ROs **250** (e.g., frequency division multiplexed (FDM) ROs for a four-step RA procedure at one time instance, RO #0, RO #1, RO #2, and RO #3). The second uplink BWP **245**-*b* may be configured with, for example, two ROs **250** (e.g., FDM ROs for a two-step RA procedure at one time instance, RO #0, RO #1), which may at least partially overlap with the ROs **250** configured in the first uplink BWP **245**-*a*. The UE **115**-*a* may select RO #0 (e.g., a preamble identifier) of the first uplink BWP **245**-*a* to use for transmission of an RA message **220**. Additionally, the UE **115**-*b* may select RO #0 (e.g., a same preamble identifier) of the second uplink BWP **245**-*b* to use of transmission of an RA message **220**. That is, both the UE **115**-*a* and the UE **115**-*b* may select ROs **250** that are associated with a same RO index (e.g., #0).

[0105] However, because a RAR message **225** may be based on an RO index a same RAR message **225**-*a* (e.g., on a same downlink BWP **245**-*c*) may be configured for (e.g., linked to) the first uplink BWP **245**-*a* and the second uplink BWP **245**-*b* (e.g., a same RA-RNTI for RO #0). That is, different ROs **250** on different frequency resources may be mapped to a same RA-RNTI (e.g., may collide). Thus, both the UE **115**-*a* and the UE **115**-*b* may monitor for a same RAR message **225**-*a* (e.g., an RAR message **225** scheduled by a same RA-RNTI on the downlink BWP **245**-*c*), which may result in a collision in reception of the RAR message **225**-*a* (e.g., even though there may be no resource collision between the resource selection between the UE **115**-*a* and the UE **115**-*b*). In another example, the UE **115**-*a* may select a first preamble identifier on RO #1 of the first uplink BWP **245**-*a*, and the UE **115**-*b* may select a second preamble (e.g., different from the first preamble) on RO #1 of the second uplink BWP **245**-*b*. Accordingly, the UE **115**-*a* (e.g., or the UE **115**-*b*) may attempt to decode a message (e.g., a PDCCH message and a PDSCH message) targeting the UE **115**-*b* (e.g., or the UE **115**-*a*) if the network entity **105** is not able to align a timeline of PRACH processing for different ROs **250** (e.g., resulting in uplink interference between UEs **115**). Such methods may result in additional complexity of network entity **105** and UE **115** implementation and may adversely affect a latency profile and a power profile of UEs **115** operating on different UL BWPs **245** of the virtual cell.

[0106] In accordance with techniques described herein, the wireless communications system **200** and the devices therein may support methods to improve RA procedures and reduce message contention (e.g., collision). In some examples, the wireless communications system **200** may support a joint indication of a sub-band index **230** and a parameter **235** (e.g., an FDM parameter **235**, or one or more parameters **235**). An uplink carrier (e.g., an uplink BWP **245**) of a virtual cell may include a quantity of sub-bands (e.g., $N_u>0$ sub-bands), and the sub-bands may be ordered sequentially in an ascending order of frequency (e.g., when $N_u>1$). If a sub-band on the virtual cell is configured for both an uplink carrier and a downlink carrier, the sub-band index **230** associated with uplink carrier may be different from the sub-band index **230** associated with downlink carrier.

[0107] In some examples, a UE may calculate an RO index in the frequency domain based on one or more FDM parameters **235** of ROs **250** and one or more sub-band indexes **230**. For example, if a sub-band of the uplink carrier is configured with ROs **250** for an RA procedure (e.g., of Type-Q), the network entity **105** may communicate (e.g., indicate, convey, transmit) the FDM parameter **235** and the sub-band index **230** to a UE **115** via one or more control messages **215** (e.g., one or more system information (SI) messages, one or more RRC messages). The sub-band index **230** may be a sub-band specific index, l, where $l \in \{0, 1, \ldots, \text{total quantity of sub-bands configured for the UL carrier of a virtual cell}-1\}$. The FDM parameter **235** may be a quantity of FDM ROs **250** configured for an RA procedure (e.g., of Type Q) on a sub-band, l, which may be represented as N_Q^l (e.g., $N_Q^l>0$).

[0108] An RA procedure may be a four-step RA procedure (e.g., Q=1) or a two-step RA procedure (e.g., Q=2). If a sub-band of an uplink carrier is not configured with ROs **250**

for RA procedure of Type-Q, the quantity of FDM ROs **250** may be set to 0, or may not be provided to a UE **115** (e.g., $N_Q^l=0$ if the FDM parameter **235** of ROs **250** is not provided for RA procedure of Type-Q). Accordingly, the wireless communications system **200** may support unique indexing for ROs **250** of respective sub-bands (e.g., sub-band specific RO indexing). For example, if a sub-band l is configured with $N_Q^l>0$ ROs **250** for Type-Q RA procedure, the N_Q^l ROs **250** may be ordered in an ascending order of frequency (e.g., as $0, 1, \ldots, n_{l,Q}, \ldots, N_Q^l-1$). In such examples, $n_{l,Q}$ may be a sub-band specific RO index on sub-band l, which may be configured for a type-Q RA procedure (e.g., $0\leq n_{l,Q}\leq N_Q^l-1$).

[0109] In some examples, the sub-band index **230** and the FDM parameter **235** may support accumulative (e.g., absolute) RO indexing in a frequency domain (e.g., indexing of ROs **250** that considers ROs **250** across multiple BWPs). For example, a UE **115** may select an RO **250** indexed by $n_{l,Q}$ from sub-band l to perform an RA procedure of type-Q. An accumulative RO index in a frequency domain (e.g., $F_{id,Q}$) may be calculated according to Equation 1.

$$F_{id,Q} = n_{l,Q} + \sum_{k=0}^{l-1} N_Q^k \qquad \text{Equation 1}$$

[0110] In Equation 1, $n_{l,Q}$ may be a sub-band specific RO index for sub-band l of an uplink carrier, where $0\leq n_{l,Q}\leq N_Q^l$. In some examples, if a sub-band k of the uplink carrier is not configured with an RO **250** for a type-Q RA procedure, $N_Q^k=0$. Accordingly, by applying a calculation in accordance with Equation 1, a UE **115** (e.g., and a network entity **105**) may determine an accumulative RO index. The accumulative RO index may be based on combining each RO **250** over the quantity (e.g., range) of ROs **250** indicated by the parameter **235** (e.g., N_Q^l, based on the summation operation of Equation 1) as well as the selected RO associated with the sub-band index **230** (e.g., $n_{l,Q}$, based on the addition of $n_{l,Q}$ in Equation 1). In such examples, a group RNTI for Type-Q RA procedure may be calculated based on $F_{id,Q}$, (e.g., the accumulative RO index in the frequency domain).

[0111] If an RO **250** is common among (e.g., shared by) multiple types of RA procedures, the accumulative RO index in the frequency domain may separately calculated for each type of RA procedure. In some examples, a range of group RNTI (e.g., M bits, M≥16) for different types of RA procedure may not overlap (e.g., may occupy different ranges of group RNTI values). The accumulative RO index may account for various ROs **250** spread across different uplink BWPs **245** (e.g., based on utilizing Equation 1). As a non-limiting example, Equation 1 may produce different indexes (e.g., and thus different RNTIs) for the RO #0 of the first uplink BWP **245**-*a* and for RO #0 of the second uplink BWP **245**-*b*. That is, the two RO #0s configured for a same type of RA procedure (e.g., Type-1 RA) may be mapped to different locations in the frequency domain, which may correspond to different values of the accumulative RO index in the frequency domain. As another non-limiting example, Equation 1 may produce a same index (e.g., and thus a same RNTI) for RO #2 of the first uplink BWP **245**-*a* and for RO #0 of the second uplink BWP **245**-*b*. That is, the RO #2 of the first uplink BWP **245**-*a* and the RO #0 of the second uplink BWP **245**-*b* configured for a same type of RA procedure (e.g., Type-1 RA) may be mapped to a same location in the frequency domain, which correspond to a same accumulative RO index in the frequency domain.

[0112] In some examples, the network entity **105** may additionally, or alternatively, include the sub-band index **230** and/or the FDM parameter **235** as part of the RAR message **225**, which may be described in greater detail herein, including with reference to FIG. **3**. Accordingly, the devices of the wireless communications system **200** may utilize techniques that improve reliability of RA procedures for virtual cells (e.g., a fragmented spectrum, non-contiguous sub-band allocations). For instance, the network entity **105** and one or more UEs **115** may resolve potential collisions associated with RA procedures (e.g., between multiple RA messages **220**, multiple RAR messages **225**) for devices that operate on partially overlapping BWPs within a same virtual cell based on communicating the sub-band index **230** and the FDM parameter **235**. Thus, the wireless communications system **200** may support improved latency associate with RA procedures and improved coordination between devices, among other benefits.

[0113] FIG. **3** shows an example of a message structure **300** that supports RA procedures with a virtual cell in accordance with one or more aspects of the present disclosure. For example, the message structure **300** may show a structure of a RAR message **305**, which may be an example of an RAR message **225** as described with reference to FIG. **2**. In some examples, to resolve potential collisions (e.g., ambiguity) between various RAR messages **305** corresponding to RA messages associated with UEs **115** from different uplink BWPs (e.g., including different sub-bands) of a virtual cell, a network entity **105** may transmit a RAR message **305** to one or more UEs **115**, which may include, in one or more portions, a sub-band index, l (e.g., a sub-band index **230**) and/or one or more parameters (e.g., a sub-band specific RO index, $n_{l,Q}$, an FDM parameter **235**).

[0114] In some examples, a collision (e.g., ambiguity) encountered by a UE **115** in decoding a RAR of a Type-Q RA procedure may be mitigated by enhancements to a control portion **310** of the RAR message **305** (e.g., a control channel portion, a PDCCH associated with the RAR message **305**). For instance, the RAR message **305** for Type-Q RA procedure may be transmitted (e.g., by a network entity **105** to a UE **115**) on a message portion **315** (e.g., a shared channel portion, a PDSCH) that is scheduled by the control portion **310** (e.g., the enhanced PDCCH). The message portion **315** may carry a MAC protocol data unit (PDU) that includes one or more MAC RARs or MAC subPDUs. The one or more MAC RARs or MAC subPDUs may target a group of UEs **115** that have selected a same RO (e.g., an RO **250**) and transmitted PRACH preambles configured on the shared RO. The control portion **310** may be associated with scheduling the message portion **315** carrying RAR for Type-Q RA procedure, and a CRC of a payload of the control portion **310** (e.g., the PDCCH payload) may be scrambled by a group RNTI that is associated with the shared RO configured for Type-Q RA procedure (e.g., an RA-RNTI of Type-1 RA procedure may be associated with a msgB-RNTI of Type-2 RA procedure).

[0115] The control portion **310** may be enhanced to include (e.g., encode, map, indicate) information associated with a sub-band index and a sub-band specific RO index in one or more fields (e.g., entries, portions) of the control portion **310**. In a first example, the sub-band index (e.g., l), and/or the sub-band specific RO index of the shared RO (e.g., $n_{l,Q}$) may be mapped to one or more fields (e.g., downlink control information (DCI) fields) of the control information payload **325** (e.g., a PDCCH payload). That is, the sub-band index and/or the sub-band specific RO index may be explicitly signaled via the control information payload **325**. In a second example, the control portion **310** may include the sub-band index and/or the sub-band specific RO index in one or more redundancy bits **330** (e.g., CRC bits generation, CRC bits for the PDCCH payload). In a third example, the sub-band index and/or the sub-band specific RO index may be mapped (e.g., encoded in) a scrambling identifier **335** of a reference signal **320** of the control portion **310** (e.g., a scrambling identifier of a demodulation reference signal (DMRS) of the PDCCH). In a fourth example, the sub-band index and/or the sub-band specific RO index may be included (e.g., encoded) in a bit interleaving pattern of the control portion **310**. In some examples, the sub-band index and/or the sub-band specific RO index may be mapped to (e.g., included in, encoded in) a combination of fields of the control portion **310** (e.g., including a hybrid combination of the example described herein).

[0116] Additionally, or alternatively, the message portion **315** may be enhanced to include (e.g., encode, map, indicate) information associated with a sub-band index and a sub-band specific RO index in one or more fields (e.g., entries, portions) of the message portion **315**, which may mitigate collisions and ambiguity in RA procedures. For example, an RAR message **305** for a type-Q RA procedure may be transmitted via a PDSCH, which may carry (e.g., include, communicate) a message portion **315** (e.g., a MAC PDU). The message portion **315** may include that includes a header **340** (e.g., a MAC sub-header, a MAC sub-PDU header), a payload **345** (e.g., one or more MAC RAR messages, a MAC sub-PDU), and one or more padding bits **350** (e.g., MAC PDU padding bits). In some examples, the message portion **315** may also be associated with a scrambling identifier **360**.

[0117] The information associated with a sub-band index and a sub-band specific RO index in may be included in the message portion **315** in accordance with various examples. In a first example, the sub-band index (e.g., l), and/or the sub-band specific RO index of the shared RO (e.g., $n_{l,Q}$) may be mapped to the header **340** (e.g., the MAC sub-header). In a second example, the sub-band index and/or the sub-band specific RO index of the shared RO may be mapped to the payload **345** (e.g., a payload of a MAC sub-PDU). In a third example, the sub-band index and/or the sub-band specific RO index of the shared RO may be mapped to the one or more padding bits **350** (e.g., padding bits of the MAC PDU). In a fourth example, the sub-band index and/or the sub-band specific RO index of the shared RO may be mapped to the scrambling identifier **360** (e.g., a scrambling identifier of a DMRS associated with the PDSCH). In some examples, the sub-band index and/or the sub-band specific RO index may be mapped to (e.g., included in, encoded in) a combination of fields of the message portion **315** (e.g., including a hybrid combination of the example described herein).

[0118] In another example, the sub-band index and/or the sub-band specific RO index may be mapped to a combination of fields across both of the control portion **310** and the message portion **315** (e.g., a joint PDDCH and RAR enhancement) in accordance with one or more examples described herein. For example, one or more fields of the control portion **310** may be used to indicate at least a first portion (e.g., three most significant bits) of the sub-band index and/or the sub-band specific RO index and one or more fields of the message portion **315** may be used to indicate at least a second portion (e.g., two least significant bits) of the sub-band index and/or the sub-band specific RO index (e.g., based on a payload size constraint, based on a bit width constraint).

[0119] Thus, by enhancing the control portion **310**, the message portion **315**, or both to include the sub-band index and/or the sub-band specific RO index (e.g., l, $n_{l,Q}$), a RAR message **305** may be uniquely coded such that a target UE **115** may successfully receive (e.g., decode) the RAR message **305** while other UEs **115** may fail to receive (e.g., decode) the RAR message **305**. Accordingly, collisions between different RAR messages **305** for different UEs **115** operating on different sub-bands of a virtual cell may be mitigated thus increasing reliability of communications and improved device coordination in wireless communications systems.

[0120] FIG. **4** shows an example of a process flow **400** that supports RA procedures with a virtual cell in accordance with one or more aspects of the present disclosure. In some examples, process flow **400** may implement aspects of the wireless communications system **100**, the wireless communications system **200**, and the message structure **300**. For example, the process flow **400** may support signaling between a UE **115** and a network entity **105** (e.g., a virtual cell) to mitigate collisions and ambiguities in RA procedures on a virtual cell. The UE **115** and the network entity **105** of the process flow **400** may be examples of corresponding devices herein, including with reference to FIGS. **1** and **2**.

[0121] In the following description of process flow **400**, the operations between the UE **115** and the network entity **105** may be performed in a different order than the order shown, or other operations may be added or removed from the process flow **400**. For example, some operations may also be left out of process flow **400**, or may be performed in different orders or at different times. Further, although some operations or signaling may be shown to occur at different times for discussion purposes, these operations may actually occur at the same time. Although the UE **115** and the network entity **105** are shown performing the operations of process flow **400**, some aspects of some operations may also be performed by one or more other wireless or network devices.

[0122] At **405**, the UE **115** may receive a control message (e.g., a control message **215**, an SI message, an RRC message) that includes an index of a sub-band (e.g., l) of a set of multiple of sub-bands of a virtual cell and a quantity of RA occasions (e.g., ROs, No) associated with the sub-band, which may be output (e.g., transmitted) by the network entity **105**. In some examples, the quantity of RA occasions may be based on a type of RA procedure (e.g., a type 1 RA procedure, a type 2 RA procedure). In some examples, at least a first sub-band of the set of multiple of sub-bands and a second sub-band of the set of multiple of sub-bands may be non-contiguous in a frequency domain.

[0123] At **410**, the UE may, in some examples, select (e.g., derive, calculate, determine, identify) a first index (e.g., $F_{id,Q}$, an accumulative RO index, a PRACH resource) based on combining the quantity of RA occasions with one or more second quantities of RA occasions associated with one or more second sub-bands (e.g., from other sub-bands, $\Sigma_{k=0}^{l-1} N_Q^l$). In some examples, the UE may select a second index (e.g., $n_{l,Q}$) of an RA occasion based on the index of the sub-band and the quantity of RA occasions. In such examples, the first index may be based on combining the second index with the combined quantity of RA occasions (e.g., $F_{id,Q}=n_{l,Q}+\Sigma_{k=0}^{l-1} N_Q^k$ for all sub-bands, k). The second index may be a sub-band specific index and the first index may be a non-sub-band specific index (e.g., an accumulative RO index, an absolute RO index).

[0124] At **415**, the UE **115** may transmit an RA message (e.g., an RA message **220**, a PRACH for Type 1 or Type 2 RA procedure) within an RA occasion of the quantity of RA occasions indicated by the control message, which may be obtained (e.g., received) by a network entity **105**. In some examples, the UE **115** may transmit the RA message in accordance with the index selections of **410** (e.g., based on $F_{id,Q}$). In some examples, the UE **115** may transmit the RA message in accordance with a temporary identifier, and the temporary identifier may be associated with a first type of RA procedure and the first index (e.g., a group RNTI calculated based on $F_{id,Q}$). In some examples, a temporary identifier for a first type of RA may be different than one or more second temporary identifiers associated with a second type of RA procedure based on the first index (e.g., range of group RNTI values for different types of RA procedure may not overlap based on the accumulative RO index).

[0125] At **420**, the network entity **105** may, in some examples, encode a second control message (e.g., a control portion **310** of a RAR message **305**) in accordance with the index of the sub-band (e.g., l), the RA occasion (e.g., $n_{l,Q}$), or both based on one or more fields of the second control message (e.g., a control information payload **325**), one or more CRC bits of the second control message (e.g., redundancy bits **330**), a reference signal scrambling identifier of the second control message (e.g., a scrambling identifier **335** of a reference signal **320**), a bit interleaving pattern of the second control message, some other field of the second control message, or any combination thereof.

[0126] At **425**, the UE **115** may, in some examples, receive the second control message, which may be associated with an RAR message, which may be output by the network entity **105**. The UE **115** may receive the RAR message based on transmitting the RA message. In some examples, the RAR message may be associated with the index of the sub-band, the RA occasion, or both based on the UE **115** receiving the second control message. In some examples, the second control message may include one or more fields that indicate the index of the sub-band, the RA occasion, or both.

[0127] At **430**, the UE **115** may, in some examples, decode the second control message in accordance with the index of the sub-band, the RA occasion, or both. For example, the UE **115** may decode the second control message based on one or more CRC bits of the second control message, a reference signal scrambling identifier of the second control message, a bit interleaving pattern of the second control message, or any combination thereof. In some examples, the UE **115** may receive an RAR message based on decoding the second control message.

[0128] At **435**, the UE **115** may receive an RAR message (e.g., an RAR message **225**, an RAR message **305**) that is associated with the index of the sub-band, the RA occasion, or both, which may be output by the network entity **105**. The UE **115** may receive the RAR message after (e.g., based on, in response to) transmitting the RA message. In some examples, the UE **115** may receive, via the RAR message, an indication of the index of the sub-band, an indication of the RA occasion, or both. In some examples, the UE may receive the indication of the index of the sub-band, the indication of the RA occasion of the RAR message, or both via a MAC header of the RAR message, a MAC payload (e.g., of the RAR message), one or more padding bits of the RAR message, a reference signal scrambling identifier of the RAR message, or a combination thereof. In some examples, the UE **115** may receive the RAR message in accordance with the index of the sub-band, the RA occasion, or both based on first information (e.g., a first portion of the index of the sub-band and/or the indication of the RA occasion of the RAR message) included in a second control message associated with the RAR message and second information (e.g., a second portion of the index of the sub-band and/or the indication of the RA occasion of the RAR message) included in the RAR message.

[0129] FIG. **5** shows a block diagram **500** of a device **505** that supports RA procedures with a virtual cell in accordance with one or more aspects of the present disclosure. The device **505** may be an example of aspects of a UE **115** as described herein. The device **505** may include a receiver **510**, a transmitter **515**, and a communications manager **520**. The device **505**, or one or more components of the device **505** (e.g., the receiver **510**, the transmitter **515**, and the communications manager **520**), may include at least one processor, which may be coupled with at least one memory, to, individually or collectively, support or enable the described techniques. Each of these components may be in communication with one another (e.g., via one or more buses).

[0130] The receiver **510** may provide a means for receiving information such as packets, user data, control information, or any combination thereof associated with various information channels (e.g., control channels, data channels, information channels related to random access procedures with a virtual cell). Information may be passed on to other components of the device **505**. The receiver **510** may utilize a single antenna or a set of multiple antennas.

[0131] The transmitter **515** may provide a means for transmitting signals generated by other components of the device **505**. For example, the transmitter **515** may transmit information such as packets, user data, control information, or any combination thereof associated with various information channels (e.g., control channels, data channels, information channels related to random access procedures with a virtual cell). In some examples, the transmitter **515** may be co-located with a receiver **510** in a transceiver module. The transmitter **515** may utilize a single antenna or a set of multiple antennas.

[0132] The communications manager **520**, the receiver **510**, the transmitter **515**, or various combinations thereof or various components thereof may be examples of means for performing various aspects of random access procedures with a virtual cell as described herein. For example, the communications manager **520**, the receiver **510**, the transmitter **515**, or various combinations or components thereof may be capable of performing one or more of the functions described herein.

[0133] In some examples, the communications manager **520**, the receiver **510**, the transmitter **515**, or various combinations or components thereof may be implemented in hardware (e.g., in communications management circuitry). The hardware may include at least one of a processor, a digital signal processor (DSP), a central processing unit (CPU), an application-specific integrated circuit (ASIC), a field-programmable gate array (FPGA) or other programmable logic device, a microcontroller, discrete gate or transistor logic, discrete hardware components, or any combination thereof configured as or otherwise supporting, individually or collectively, a means for performing the functions described in the present disclosure. In some examples, at least one processor and at least one memory coupled with the at least one processor may be configured to perform one or more of the functions described herein (e.g., by one or more processors, individually or collectively, executing instructions stored in the at least one memory).

[0134] Additionally, or alternatively, the communications manager **520**, the receiver **510**, the transmitter **515**, or various combinations or components thereof may be implemented in code (e.g., as communications management software or firmware) executed by at least one processor. If implemented in code executed by at least one processor, the functions of the communications manager **520**, the receiver **510**, the transmitter **515**, or various combinations or components thereof may be performed by a general-purpose processor, a DSP, a CPU, an ASIC, an FPGA, a microcontroller, or any combination of these or other programmable logic devices (e.g., configured as or otherwise supporting, individually or collectively, a means for performing the functions described in the present disclosure).

[0135] In some examples, the communications manager **520** may be configured to perform various operations (e.g., receiving, obtaining, monitoring, outputting, transmitting) using or otherwise in cooperation with the receiver **510**, the transmitter **515**, or both. For example, the communications manager **520** may receive information from the receiver **510**, send information to the transmitter **515**, or be integrated in combination with the receiver **510**, the transmitter **515**, or both to obtain information, output information, or perform various other operations as described herein.

[0136] The communications manager **520** may support wireless communications in accordance with examples as disclosed herein. For example, the communications manager **520** is capable of, configured to, or operable to support a means for receiving a control message that includes an index of a sub-band of a set of multiple sub-bands of a virtual cell and a quantity of random access occasions associated with the sub-band. The communications manager **520** is capable of, configured to, or operable to support a means for transmitting a random access message within a random access occasion of the quantity of random access occasions indicated by the control message. The communications manager **520** is capable of, configured to, or operable to support a means for receiving a random access response message that is associated with the index of the sub-band, the random access occasion, or both after transmitting the random access message.

[0137] By including or configuring the communications manager **520** in accordance with examples as described herein, the device **505** (e.g., at least one processor controlling or otherwise coupled with the receiver **510**, the transmitter **515**, the communications manager **520**, or a combination thereof) may support techniques for more efficient utilization of communication resources, among other benefits.

[0138] FIG. **6** shows a block diagram **600** of a device **605** that supports random access procedures with a virtual cell in accordance with one or more aspects of the present disclosure. The device **605** may be an example of aspects of a device **505** or a UE **115** as described herein. The device **605** may include a receiver **610**, a transmitter **615**, and a communications manager **620**. The device **605**, or one or more components of the device **605** (e.g., the receiver **610**, the transmitter **615**, and the communications manager **620**), may include at least one processor, which may be coupled with at least one memory, to support the described techniques. Each of these components may be in communication with one another (e.g., via one or more buses).

[0139] The receiver **610** may provide a means for receiving information such as packets, user data, control information, or any combination thereof associated with various information channels (e.g., control channels, data channels, information channels related to random access procedures with a virtual cell). Information may be passed on to other components of the device **605**. The receiver **610** may utilize a single antenna or a set of multiple antennas.

[0140] The transmitter **615** may provide a means for transmitting signals generated by other components of the device **605**. For example, the transmitter **615** may transmit information such as packets, user data, control information, or any combination thereof associated with various information channels (e.g., control channels, data channels, information channels related to random access procedures with a virtual cell). In some examples, the transmitter **615** may be co-located with a receiver **610** in a transceiver module. The transmitter **615** may utilize a single antenna or a set of multiple antennas.

[0141] The device **605**, or various components thereof, may be an example of means for performing various aspects of random access procedures with a virtual cell as described herein. For example, the communications manager **620** may include a control message component **625**, a random access message component **630**, a random access response message component **635**, or any combination thereof. The communications manager **620** may be an example of aspects of a communications manager **520** as described herein. In some examples, the communications manager **620**, or various components thereof, may be configured to perform various operations (e.g., receiving, obtaining, monitoring, outputting, transmitting) using or otherwise in cooperation with the receiver **610**, the transmitter **615**, or both. For example, the communications manager **620** may receive information from the receiver **610**, send information to the transmitter **615**, or be integrated in combination with the receiver **610**, the transmitter **615**, or both to obtain information, output information, or perform various other operations as described herein.

[0142] The communications manager **620** may support wireless communications in accordance with examples as disclosed herein. The control message component **625** is capable of, configured to, or operable to support a means for receiving a control message that includes an index of a sub-band of a set of multiple sub-bands of a virtual cell and a quantity of random access occasions associated with the sub-band. The random access message component **630** is capable of, configured to, or operable to support a means for transmitting a random access message within a random access occasion of the quantity of random access occasions indicated by the control message. The random access response message component **635** is capable of, configured to, or operable to support a means for receiving a random access response message that is associated with the index of the sub-band, the random access occasion, or both after transmitting the random access message.

[0143] FIG. **7** shows a block diagram **700** of a communications manager **720** that supports random access procedures with a virtual cell in accordance with one or more aspects of the present disclosure. The communications manager **720** may be an example of aspects of a communications manager **520**, a communications manager **620**, or both, as described herein. The communications manager **720**, or various components thereof, may be an example of means for performing various aspects of random access procedures with a virtual cell as described herein. For example, the communications manager **720** may include a control message component **725**, a random access message component **730**, a random access response message component **735**, a sub-band index selection component **740**, a message decoding component **745**, or any combination thereof. Each of these components, or components or subcomponents thereof (e.g., one or more processors, one or more memories), may communicate, directly or indirectly, with one another (e.g., via one or more buses).

[0144] The communications manager **720** may support wireless communications in accordance with examples as disclosed herein. The control message component **725** is capable of, configured to, or operable to support a means for receiving a control message that includes an index of a sub-band of a set of multiple sub-bands of a virtual cell and a quantity of random access occasions associated with the sub-band. The random access message component **730** is capable of, configured to, or operable to support a means for transmitting a random access message within a random access occasion of the quantity of random access occasions indicated by the control message. The random access response message component **735** is capable of, configured to, or operable to support a means for receiving a random access response message that is associated with the index of the sub-band, the random access occasion, or both after transmitting the random access message.

[0145] In some examples, to support transmitting the random access message, the random access response message component **735** is capable of, configured to, or operable to support a means for transmitting the random access message in accordance with a first index, where the first index is based on combining the quantity of random access occasions with one or more second quantities of random access occasions associated with one or more second sub-bands.

[0146] In some examples, the sub-band index selection component **740** is capable of, configured to, or operable to support a means for selecting a second index of the random access occasion based on the index of the sub-band and the quantity of random access occasions, where the first index is based on combining the second index with the combined quantity of random access occasions, and where the second index is a sub-band specific index and the first index is a non-sub-band specific index.

[0147] In some examples, the random access message component **730** is capable of, configured to, or operable to support a means for transmitting the random access message in accordance with a temporary identifier, the temporary identifier being associated with a first type of random access procedure and the first index, where the temporary identifier is different than one or more second temporary identifiers associated with a second type of random access procedure based on the first index.

[0148] In some examples, to support receiving the random access response message, the control message component **725** is capable of, configured to, or operable to support a means for receiving a second control message associated with the random access response message based on transmitting the random access message, where the random access response message is associated with the index of the sub-band, the random access occasion, or both based on receiving the second control message.

[0149] In some examples, the second control message includes one or more fields that indicate the index of the sub-band, the random access occasion, or both.

[0150] In some examples, the message decoding component **745** is capable of, configured to, or operable to support a means for decoding the second control message in accordance with the index of the sub-band, the random access occasion, or both based on one or more cyclic redundancy check bits of the second control message, a reference signal scrambling identifier of the second control message, a bit interleaving pattern of the second control message, or any combination thereof, where receiving the random access response message is based on decoding the second control message.

[0151] In some examples, to support receiving the random access response message, the random access response message component **735** is capable of, configured to, or operable to support a means for receiving, via the random access response message, an indication of the index of the sub-band, an indication of the random access occasion, or both.

[0152] In some examples, to support receiving the indication, the random access response message component **735** is capable of, configured to, or operable to support a means for receiving the indication of the index of the sub-band, the indication of the random access occasion of the random access response message, or both via a MAC header of the random access response message, a MAC payload, one or more padding bits of the random access response message, a reference signal scrambling identifier of the random access response message, or a combination thereof.

[0153] In some examples, to support receiving the random access response message, the random access response message component **735** is capable of, configured to, or operable to support a means for receiving the random access response message in accordance with the index of the sub-band, the random access occasion, or both based on first information included in a second control message associated with the random access response message and second information included in the random access response message.

[0154] In some examples, the quantity of random access occasions is based on a type of random access procedure.

[0155] In some examples, at least a first sub-band of the set of multiple sub-bands and a second sub-band of the set of multiple sub-bands are non-contiguous in a frequency domain.

[0156] FIG. **8** shows a diagram of a system **800** including a device **805** that supports random access procedures with a virtual cell in accordance with one or more aspects of the present disclosure. The device **805** may be an example of or include the components of a device **505**, a device **605**, or a UE **115** as described herein. The device **805** may communicate (e.g., wirelessly) with one or more network entities **105**, one or more UEs **115**, or any combination thereof. The device **805** may include components for bi-directional voice and data communications including components for transmitting and receiving communications, such as a communications manager **820**, an input/output (I/O) controller **810**, a transceiver **815**, an antenna **825**, at least one memory **830**, code **835**, and at least one processor **840**. These components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more buses (e.g., a bus **845**).

[0157] The I/O controller **810** may manage input and output signals for the device **805**. The I/O controller **810** may also manage peripherals not integrated into the device **805**. In some cases, the I/O controller **810** may represent a physical connection or port to an external peripheral. In some cases, the I/O controller **810** may utilize an operating system such as iOS®, ANDROID®, MS-DOS®, MS-WINDOWS®, OS/2®, UNIX®, LINUX®, or another known operating system. Additionally, or alternatively, the I/O controller **810** may represent or interact with a modem, a keyboard, a mouse, a touchscreen, or a similar device. In some cases, the I/O controller **810** may be implemented as part of one or more processors, such as the at least one processor **840**. In some cases, a user may interact with the device **805** via the I/O controller **810** or via hardware components controlled by the I/O controller **810**.

[0158] In some cases, the device **805** may include a single antenna **825**. However, in some other cases, the device **805** may have more than one antenna **825**, which may be capable of concurrently transmitting or receiving multiple wireless transmissions. The transceiver **815** may communicate bi-directionally, via the one or more antennas **825**, wired, or wireless links as described herein. For example, the transceiver **815** may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver **815** may also include a modem to modulate the packets, to provide the modulated packets to one or more antennas **825** for transmission, and to demodulate packets received from the one or more antennas **825**. The transceiver **815**, or the transceiver **815** and one or more antennas **825**, may be an example of a transmitter **515**, a transmitter **615**, a receiver **510**, a receiver **610**, or any combination thereof or component thereof, as described herein.

[0159] The at least one memory **830** may include random access memory (RAM) and read-only memory (ROM). The at least one memory **830** may store computer-readable, computer-executable code **835** including instructions that, when executed by the at least one processor **840**, cause the device **805** to perform various functions described herein. The code **835** may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. In some cases, the code **835** may not be directly executable by the at least one processor **840** but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some cases, the at least one memory **830** may contain, 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.

[0160] The at least one processor **840** 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 cases, the at least one processor **840** may be configured to operate a memory array using a memory controller. In some other cases, a memory controller may be integrated into the at least one processor **840**. The at least one processor **840** may be configured to execute computer-readable instructions stored in a memory (e.g., the at least one memory **830**) to cause the device **805** to perform various functions (e.g., functions or tasks supporting random access procedures with a virtual cell). For example, the device **805** or a component of the device **805** may include at least one processor **840** and at least one memory **830** coupled with or to the at least one processor **840**, the at least one processor **840** and at least one memory **830** configured to perform various functions described herein. In some examples, the at least one processor **840** may include multiple processors and the at least one memory **830** 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. In some examples, the at least one processor **840** may be a component of a processing system, which may refer to a system (such as a series) of machines, circuitry (including, for example, one or both of processor circuitry (which may include the at least one processor **840**) and memory circuitry (which may include the at least one memory **830**)), or components, that receives or obtains inputs and processes the inputs to produce, generate, or obtain a set of outputs. The processing system may be configured to perform one or more of the functions described herein. For example, the at least one processor **840** or a processing system including the at least one processor **840** may be configured to, configurable to, or operable to cause the device **805** to perform one or more of the functions described herein. Further, as described herein, being "configured to," being "configurable to," and being "operable to" may be used interchangeably and may be associated with a capability, when executing code stored in the at least one memory **830** or otherwise, to perform one or more of the functions described herein.

[0161] The communications manager **820** may support wireless communications in accordance with examples as disclosed herein. For example, the communications manager **820** is capable of, configured to, or operable to support a means for receiving a control message that includes an index of a sub-band of a set of multiple sub-bands of a virtual cell and a quantity of random access occasions associated with the sub-band. The communications manager **820** is capable of, configured to, or operable to support a means for transmitting a random access message within a random access occasion of the quantity of random access occasions indicated by the control message. The communications manager **820** is capable of, configured to, or operable to support a means for receiving a random access response message that is associated with the index of the sub-band, the random access occasion, or both after transmitting the random access message.

[0162] By including or configuring the communications manager **820** in accordance with examples as described herein, the device **805** may support techniques for improved communication reliability, reduced latency (e.g., associated with RA procedures), and improved coordination between devices, among other benefits.

[0163] In some examples, the communications manager **820** may be configured to perform various operations (e.g., receiving, monitoring, transmitting) using or otherwise in cooperation with the transceiver **815**, the one or more antennas **825**, or any combination thereof. Although the communications manager **820** is illustrated as a separate component, in some examples, one or more functions described with reference to the communications manager **820** may be supported by or performed by the at least one processor **840**, the at least one memory **830**, the code **835**, or any combination thereof. For example, the code **835** may include instructions executable by the at least one processor **840** to cause the device **805** to perform various aspects of random access procedures with a virtual cell as described herein, or the at least one processor **840** and the at least one memory **830** may be otherwise configured to, individually or collectively, perform or support such operations.

[0164] FIG. **9** shows a block diagram **900** of a device **905** that supports random access procedures with a virtual cell in accordance with one or more aspects of the present disclosure. The device **905** may be an example of aspects of a network entity **105** as described herein. The device **905** may include a receiver **910**, a transmitter **915**, and a communications manager **920**. The device **905**, or one or more components of the device **905** (e.g., the receiver **910**, the transmitter **915**, and the communications manager **920**), may include at least one processor, which may be coupled with at least one memory, to, individually or collectively, support or enable the described techniques. Each of these components may be in communication with one another (e.g., via one or more buses).

[0165] The receiver **910** may provide a means for obtaining (e.g., receiving, determining, identifying) information such as user data, control information, or any combination thereof (e.g., I/Q samples, symbols, packets, protocol data units, service data units) associated with various channels (e.g., control channels, data channels, information channels, channels associated with a protocol stack). Information may be passed on to other components of the device **905**. In some examples, the receiver **910** may support obtaining information by receiving signals via one or more antennas. Additionally, or alternatively, the receiver **910** may support obtaining information by receiving signals via one or more wired (e.g., electrical, fiber optic) interfaces, wireless interfaces, or any combination thereof.

[0166] The transmitter **915** may provide a means for outputting (e.g., transmitting, providing, conveying, sending) information generated by other components of the device **905**. For example, the transmitter **915** may output information such as user data, control information, or any combination thereof (e.g., I/Q samples, symbols, packets, protocol data units, service data units) associated with various channels (e.g., control channels, data channels, information channels, channels associated with a protocol stack). In some examples, the transmitter **915** may support outputting information by transmitting signals via one or more antennas. Additionally, or alternatively, the transmitter **915** may support outputting information by transmitting signals via one or more wired (e.g., electrical, fiber optic) interfaces, wireless interfaces, or any combination thereof. In some examples, the transmitter **915** and the receiver **910** may be co-located in a transceiver, which may include or be coupled with a modem.

[0167] The communications manager **920**, the receiver **910**, the transmitter **915**, or various combinations thereof or various components thereof may be examples of means for performing various aspects of random access procedures with a virtual cell as described herein. For example, the communications manager **920**, the receiver **910**, the transmitter **915**, or various combinations or components thereof may be capable of performing one or more of the functions described herein.

[0168] In some examples, the communications manager **920**, the receiver **910**, the transmitter **915**, or various combinations or components thereof may be implemented in hardware (e.g., in communications management circuitry). The hardware may include at least one of a processor, a DSP, a CPU, an ASIC, an FPGA or other programmable logic device, a microcontroller, discrete gate or transistor logic, discrete hardware components, or any combination thereof configured as or otherwise supporting, individually or collectively, a means for performing the functions described in the present disclosure. In some examples, at least one processor and at least one memory coupled with the at least one processor may be configured to perform one or more of the functions described herein (e.g., by one or more processors, individually or collectively, executing instructions stored in the at least one memory).

[0169] Additionally, or alternatively, the communications manager **920**, the receiver **910**, the transmitter **915**, or various combinations or components thereof may be implemented in code (e.g., as communications management software or firmware) executed by at least one processor. If implemented in code executed by at least one processor, the functions of the communications manager **920**, the receiver **910**, the transmitter **915**, or various combinations or components thereof may be performed by a general-purpose processor, a DSP, a CPU, an ASIC, an FPGA, a microcontroller, or any combination of these or other programmable logic devices (e.g., configured as or otherwise supporting, individually or collectively, a means for performing the functions described in the present disclosure).

[0170] In some examples, the communications manager **920** may be configured to perform various operations (e.g., receiving, obtaining, monitoring, outputting, transmitting) using or otherwise in cooperation with the receiver **910**, the transmitter **915**, or both. For example, the communications manager **920** may receive information from the receiver **910**, send information to the transmitter **915**, or be integrated in combination with the receiver **910**, the transmitter **915**, or both to obtain information, output information, or perform various other operations as described herein.

[0171] The communications manager **920** may support wireless communications in accordance with examples as disclosed herein. For example, the communications manager **920** is capable of, configured to, or operable to support a means for outputting a control message that includes an index of a sub-band of a set of multiple sub-bands of a virtual cell and a quantity of random access occasions associated with the sub-band. The communications manager **920** is capable of, configured to, or operable to support a means for obtaining a random access message within a random access occasion of the quantity of random access occasions indicated by the control message. The communications manager **920** is capable of, configured to, or operable to support a means for outputting, to a UE, a random access response message that is associated with the index of the sub-band, the random access occasion, or both after obtaining the random access message.

[0172] By including or configuring the communications manager **920** in accordance with examples as described herein, the device **905** (e.g., at least one processor controlling or otherwise coupled with the receiver **910**, the transmitter **915**, the communications manager **920**, or a combination thereof) may support techniques for more efficient utilization of communication resources, among other benefits.

[0173] FIG. **10** shows a block diagram **1000** of a device **1005** that supports random access procedures with a virtual cell in accordance with one or more aspects of the present disclosure. The device **1005** may be an example of aspects of a device **905** or a network entity **105** as described herein. The device **1005** may include a receiver **1010**, a transmitter **1015**, and a communications manager **1020**. The device **1005**, or one or more components of the device **1005** (e.g., the receiver **1010**, the transmitter **1015**, and the communications manager **1020**), may include at least one processor, which may be coupled with at least one memory, to support the described techniques. Each of these components may be in communication with one another (e.g., via one or more buses).

[0174] The receiver **1010** may provide a means for obtaining (e.g., receiving, determining, identifying) information such as user data, control information, or any combination thereof (e.g., I/Q samples, symbols, packets, protocol data units, service data units) associated with various channels (e.g., control channels, data channels, information channels, channels associated with a protocol stack). Information may be passed on to other components of the device **1005**. In some examples, the receiver **1010** may support obtaining information by receiving signals via one or more antennas. Additionally, or alternatively, the receiver **1010** may support obtaining information by receiving signals via one or more wired (e.g., electrical, fiber optic) interfaces, wireless interfaces, or any combination thereof.

[0175] The transmitter **1015** may provide a means for outputting (e.g., transmitting, providing, conveying, sending) information generated by other components of the device **1005**. For example, the transmitter **1015** may output information such as user data, control information, or any combination thereof (e.g., I/Q samples, symbols, packets, protocol data units, service data units) associated with various channels (e.g., control channels, data channels, information channels, channels associated with a protocol stack). In some examples, the transmitter **1015** may support outputting information by transmitting signals via one or more antennas. Additionally, or alternatively, the transmitter **1015** may support outputting information by transmitting signals via one or more wired (e.g., electrical, fiber optic) interfaces, wireless interfaces, or any combination thereof. In some examples, the transmitter **1015** and the receiver **1010** may be co-located in a transceiver, which may include or be coupled with a modem.

[0176] The device **1005**, or various components thereof, may be an example of means for performing various aspects of random access procedures with a virtual cell as described herein. For example, the communications manager **1020** may include a control message configuration component **1025**, a random access message manager **1030**, a random access response message configuration component **1035**, or any combination thereof. The communications manager **1020** may be an example of aspects of a communications manager **920** as described herein. In some examples, the communications manager **1020**, or various components thereof, may be configured to perform various operations (e.g., receiving, obtaining, monitoring, outputting, transmitting) using or otherwise in cooperation with the receiver **1010**, the transmitter **1015**, or both. For example, the communications manager **1020** may receive information from the receiver **1010**, send information to the transmitter **1015**, or be integrated in combination with the receiver **1010**, the transmitter **1015**, or both to obtain information, output information, or perform various other operations as described herein.

[0177] The communications manager **1020** may support wireless communications in accordance with examples as disclosed herein. The control message configuration component **1025** is capable of, configured to, or operable to support a means for outputting a control message that includes an index of a sub-band of a set of multiple sub-bands of a virtual cell and a quantity of random access occasions associated with the sub-band. The random access message manager **1030** is capable of, configured to, or operable to support a means for obtaining a random access message within a random access occasion of the quantity of random access occasions indicated by the control message. The random access response message configuration component **1035** is capable of, configured to, or operable to support a means for outputting, to a UE, a random access response message that is associated with the index of the sub-band, the random access occasion, or both after obtaining the random access message.

[0178] FIG. **11** shows a block diagram **1100** of a communications manager **1120** that supports random access procedures with a virtual cell in accordance with one or more aspects of the present disclosure. The communications manager **1120** may be an example of aspects of a communications manager **920**, a communications manager **1020**, or both, as described herein. The communications manager **1120**, or various components thereof, may be an example of means for performing various aspects of random access procedures with a virtual cell as described herein. For example, the communications manager **1120** may include a control message configuration component **1125**, a random access message manager **1130**, a random access response message configuration component **1135**, a message encoding component **1140**, or any combination thereof. Each of these components, or components or subcomponents thereof (e.g., one or more processors, one or more memories), may communicate, directly or indirectly, with one another (e.g., via one or more buses) which may include communications within a protocol layer of a protocol stack, communications associated with a logical channel of a protocol stack (e.g., between protocol layers of a protocol stack, within a device, component, or virtualized component associated with a network entity **105**, between devices, components, or virtualized components associated with a network entity **105**), or any combination thereof.

[0179] The communications manager **1120** may support wireless communications in accordance with examples as disclosed herein. The control message configuration component **1125** is capable of, configured to, or operable to support a means for outputting a control message that includes an index of a sub-band of a set of multiple sub-bands of a virtual cell and a quantity of random access occasions associated with the sub-band. The random access message manager **1130** is capable of, configured to, or operable to support a means for obtaining a random access message within a random access occasion of the quantity of random access occasions indicated by the control message. The random access response message configuration component **1135** is capable of, configured to, or operable to support a means for outputting, to a UE, a random access response message that is associated with the index of the sub-band, the random access occasion, or both after obtaining the random access message.

[0180] In some examples, to support obtaining the random access message, the random access message manager **1130** is capable of, configured to, or operable to support a means for obtaining the random access message in accordance with a first index, where the first index is based on a combination of the quantity of random access occasions with one or more second quantities of random access occasions associated with one or more second sub-bands.

[0181] In some examples, the first index is based on a combination of a second index of the random access occasion and the combined quantity of random access occasions, the second index based on the index of the sub-band and the quantity of random access occasions. In some examples, the second index is a sub-band specific index and the first index is a non-sub-band specific index.

[0182] In some examples, the random access message manager **1130** is capable of, configured to, or operable to support a means for obtaining the random access message in accordance with a temporary identifier, the temporary identifier being associated with a first type of random access procedure and the first index, where the temporary identifier is different than one or more second temporary identifiers associated with a second type of random access procedure based on the first index.

[0183] In some examples, to support outputting the random access response message, the control message configuration component **1125** is capable of, configured to, or operable to support a means for outputting a second control message associated with the random access response message based on obtaining the random access message, where the random access response message is associated with the index of the sub-band, the random access occasion, or both based on outputting the second control message.

[0184] In some examples, the second control message includes one or more fields that indicate the index of the sub-band, the random access occasion, or both.

[0185] In some examples, the message encoding component **1140** is capable of, configured to, or operable to support a means for encoding the second control message in accordance with the index of the sub-band, the random access occasion, or both based on one or more cyclic redundancy check bits of the second control message, a reference signal scrambling identifier of the second control message, a bit interleaving pattern of the second control message, or any combination thereof.

[0186] In some examples, to support outputting the random access response message, the random access response message configuration component **1135** is capable of, configured to, or operable to support a means for outputting, via the random access response message, an indication of the index of the sub-band, an indication of the random access occasion, or both.

[0187] In some examples, to support outputting the indication, the random access response message configuration component **1135** is capable of, configured to, or operable to support a means for outputting the indication of the index of the sub-band, the indication of the random access occasion of the random access response message, or both via a MAC header of the random access response message, a MAC payload, one or more padding bits of the random access response message, a reference signal scrambling identifier of the random access response message, or a combination thereof.

[0188] In some examples, to support outputting the random access response message, the random access response message configuration component **1135** is capable of, configured to, or operable to support a means for outputting the random access response message in accordance with the index of the sub-band, the random access occasion, or both based on including first information in a second control message associated with the random access response message and second information in the random access response message.

[0189] In some examples, the quantity of random access occasions is based on a type of random access procedure.

[0190] In some examples, at least a first sub-band of the set of multiple sub-bands and a second sub-band of the set of multiple sub-bands are non-contiguous in a frequency domain.

[0191] FIG. **12** shows a diagram of a system **1200** including a device **1205** that supports random access procedures with a virtual cell in accordance with one or more aspects of the present disclosure. The device **1205** may be an example of or include the components of a device **905**, a device **1005**, or a network entity **105** as described herein. The device **1205** may communicate with one or more network entities **105**, one or more UEs **115**, or any combination thereof, which may include communications over one or more wired interfaces, over one or more wireless interfaces, or any combination thereof. The device **1205** may include components that support outputting and obtaining communications, such as a communications manager **1220**, a transceiver **1210**, an antenna **1215**, at least one memory **1225**, code **1230**, and at least one processor **1235**. These components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more buses (e.g., a bus **1240**).

[0192] The transceiver **1210** may support bi-directional communications via wired links, wireless links, or both as described herein. In some examples, the transceiver **1210** may include a wired transceiver and may communicate bi-directionally with another wired transceiver. Additionally, or alternatively, in some examples, the transceiver **1210** may include a wireless transceiver and may communicate bi-directionally with another wireless transceiver. In some examples, the device **1205** may include one or more antennas **1215**, which may be capable of transmitting or receiving wireless transmissions (e.g., concurrently). The transceiver **1210** may also include a modem to modulate signals, to provide the modulated signals for transmission (e.g., by one or more antennas **1215**, by a wired transmitter), to receive modulated signals (e.g., from one or more antennas **1215**, from a wired receiver), and to demodulate signals. In some implementations, the transceiver **1210** may include one or more interfaces, such as one or more interfaces coupled with the one or more antennas **1215** that are configured to support various receiving or obtaining operations, or one or more interfaces coupled with the one or more antennas **1215** that are configured to support various transmitting or outputting operations, or a combination thereof. In some implementations, the transceiver **1210** may include or be configured for coupling with one or more processors or one or more memory components that are operable to perform or support operations based on received or obtained information or signals, or to generate information or other signals for transmission or other outputting, or any combination thereof. In some implementations, the transceiver **1210**, or the transceiver **1210** and the one or more antennas **1215**, or the transceiver **1210** and the one or more antennas **1215** and one or more processors or one or more memory components (e.g., the at least one processor **1235**, the at least one memory **1225**, or both), may be included in a chip or chip assembly that is installed in the device **1205**. In some examples, the transceiver **1210** may be operable to support communications via one or more communications links (e.g., a communication link **125**, a backhaul communication link **120**, a midhaul communication link **162**, a fronthaul communication link **168**).

[0193] The at least one memory **1225** may include RAM, ROM, or any combination thereof. The at least one memory **1225** may store computer-readable, computer-executable code **1230** including instructions that, when executed by one or more of the at least one processor **1235**, cause the device **1205** to perform various functions described herein. The code **1230** may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. In some cases, the code **1230** may not be directly executable by a processor of the at least one processor **1235** but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some cases, the at least one memory **1225** may contain, among other things, a BIOS which may control basic hardware or software operation such as the interaction with peripheral components or devices. In some examples, the at least one processor **1235** may include multiple processors and the at least one memory **1225** 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 (for example, as part of a processing system).

[0194] The at least one processor **1235** may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, an ASIC, a CPU, an FPGA, a microcontroller, a programmable logic device, discrete gate or transistor logic, a discrete hardware component, or any combination thereof). In some cases, the at least one processor **1235** may be configured to operate a memory array using a memory controller. In some other cases, a memory controller may be integrated into one or more of the at least one processor **1235**. The at least one processor **1235** may be configured to execute computer-readable instructions stored in a memory (e.g., one or more of the at least one memory **1225**) to cause the device **1205** to perform various functions (e.g., functions or tasks supporting random access procedures with a virtual cell). For example, the device **1205** or a component of the device **1205** may include at least one processor **1235** and at least one memory **1225** coupled with one or more of the at least one processor **1235**, the at least one processor **1235** and the at least one memory **1225** configured to perform various functions described herein. The at least one processor **1235** may be an example of a cloud-computing platform (e.g., one or more physical nodes and supporting software such as operating systems, virtual machines, or container instances) that may host the functions (e.g., by executing code **1230**) to perform the functions of the device **1205**. The at least one processor **1235** may be any one or more suitable processors capable of executing scripts or instructions of one or more software programs stored in the device **1205** (such as within one or more of the at least one memory **1225**). In some examples, the at least one processor **1235** may include multiple processors and the at least one memory **1225** 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. In some examples, the at least one processor **1235** may be a component of a processing system, which may refer to a system (such as a series) of machines, circuitry (including, for example, one or both of processor circuitry (which may include the at least one processor **1235**) and memory circuitry (which may include the at least one memory **1225**)), or components, that receives or obtains inputs and processes the inputs to produce, generate, or obtain a set of outputs. The processing system may be configured to perform one or more of the functions described herein. For example, the at least one processor **1235** or a processing system including the at least one processor **1235** may be configured to, configurable to, or operable to cause the device **1205** to perform one or more of the functions described herein. Further, as described herein, being "configured to," being "configurable to," and being "operable to" may be used interchangeably and may be associated with a capability, when executing code stored in the at least one memory **1225** or otherwise, to perform one or more of the functions described herein.

[0195] In some examples, a bus **1240** may support communications of (e.g., within) a protocol layer of a protocol stack. In some examples, a bus **1240** may support communications associated with a logical channel of a protocol stack (e.g., between protocol layers of a protocol stack), which may include communications performed within a component of the device **1205**, or between different components of the device **1205** that may be co-located or located in different locations (e.g., where the device **1205** may refer to a system in which one or more of the communications manager **1220**, the transceiver **1210**, the at least one memory **1225**, the code **1230**, and the at least one processor **1235** may be located in one of the different components or divided between different components).

[0196] In some examples, the communications manager **1220** may manage aspects of communications with a core network **130** (e.g., via one or more wired or wireless backhaul links). For example, the communications manager **1220** may manage the transfer of data communications for client devices, such as one or more UEs **115**. In some examples, the communications manager **1220** may manage communications with other network entities **105**, and may include a controller or scheduler for controlling communications with UEs **115** in cooperation with other network entities **105**. In some examples, the communications manager **1220** may support an X2 interface within an LTE/LTE-A wireless communications network technology to provide communication between network entities **105**.

[0197] The communications manager **1220** may support wireless communications in accordance with examples as disclosed herein. For example, the communications manager **1220** is capable of, configured to, or operable to support a means for outputting a control message that includes an index of a sub-band of a set of multiple sub-bands of a virtual cell and a quantity of random access occasions associated with the sub-band. The communications manager **1220** is capable of, configured to, or operable to support a means for obtaining a random access message within a random access occasion of the quantity of random access occasions indicated by the control message. The communications manager **1220** is capable of, configured to, or operable to support a means for outputting, to a UE, a random access response message that is associated with the index of the sub-band, the random access occasion, or both after obtaining the random access message.

[0198] By including or configuring the communications manager **1220** in accordance with examples as described herein, the device **1205** may support techniques for improved communication reliability, reduced latency, and improved coordination between devices, among other benefits.

[0199] In some examples, the communications manager **1220** may be configured to perform various operations (e.g., receiving, obtaining, monitoring, outputting, transmitting) using or otherwise in cooperation with the transceiver **1210**, the one or more antennas **1215** (e.g., where applicable), or any combination thereof. Although the communications manager **1220** is illustrated as a separate component, in some examples, one or more functions described with reference to the communications manager **1220** may be supported by or performed by the transceiver **1210**, one or more of the at least one processor **1235**, one or more of the at least one memory **1225**, the code **1230**, or any combination thereof (for example, by a processing system including at least a portion of the at least one processor **1235**, the at least one memory **1225**, the code **1230**, or any combination thereof). For example, the code **1230** may include instructions executable by one or more of the at least one processor **1235** to cause the device **1205** to perform various aspects of random access procedures with a virtual cell as described herein, or the at least one processor **1235** and the at least one memory **1225** may be otherwise configured to, individually or collectively, perform or support such operations.

[0200] FIG. **13** shows a flowchart illustrating a method **1300** that supports random access procedures with a virtual cell in accordance with one or more aspects of the present disclosure. The operations of the method **1300** may be implemented by a UE or its components as described herein. For example, the operations of the method **1300** may be performed by a UE **115** as described with reference to FIGS. **1** through **8**. In some examples, a UE may execute a set of instructions to control the functional elements of the UE to perform the described functions. Additionally, or alternatively, the UE may perform aspects of the described functions using special-purpose hardware.

[0201] At **1305**, the method may include receiving a control message that includes an index of a sub-band of a set of multiple sub-bands of a virtual cell and a quantity of random access occasions associated with the sub-band. The operations of block **1305** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1305** may be performed by a control message component **725** as described with reference to FIG. **7**.

[0202] At **1310**, the method may include transmitting a random access message within a random access occasion of the quantity of random access occasions indicated by the control message. The operations of block **1310** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1310** may be performed by a random access message component **730** as described with reference to FIG. **7**.

[0203] At **1315**, the method may include receiving a random access response message that is associated with the index of the sub-band, the random access occasion, or both after transmitting the random access message. The operations of block **1315** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1315** may be performed by a random access response message component **735** as described with reference to FIG. **7**.

[0204] FIG. **14** shows a flowchart illustrating a method **1400** that supports random access procedures with a virtual cell in accordance with one or more aspects of the present disclosure. The operations of the method **1400** may be implemented by a UE or its components as described herein. For example, the operations of the method **1400** may be performed by a UE **115** as described with reference to FIGS. **1** through **8**. In some examples, a UE may execute a set of instructions to control the functional elements of the UE to perform the described functions. Additionally, or alternatively, the UE may perform aspects of the described functions using special-purpose hardware.

[0205] At **1405**, the method may include receiving a control message that includes an index of a sub-band of a set of multiple sub-bands of a virtual cell and a quantity of random access occasions associated with the sub-band. The operations of block **1405** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1405** may be performed by a control message component **725** as described with reference to FIG. **7**.

[0206] At **1410**, the method may include transmitting a random access message within a random access occasion of the quantity of random access occasions indicated by the control message. The operations of block **1410** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1410** may be performed by a random access message component **730** as described with reference to FIG. **7**.

[0207] At **1415**, the method may include transmitting the random access message in accordance with a first index, where the first index is based on combining the quantity of random access occasions with one or more second quantities of random access occasions associated with one or more second sub-bands. The operations of block **1415** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1415** may be performed by a random access response message component **735** as described with reference to FIG. **7**.

[0208] At **1420**, the method may include receiving a random access response message that is associated with the index of the sub-band, the random access occasion, or both after transmitting the random access message. The operations of block **1420** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1420** may be performed by a random access response message component **735** as described with reference to FIG. **7**.

[0209] FIG. **15** shows a flowchart illustrating a method **1500** that supports random access procedures with a virtual cell in accordance with one or more aspects of the present disclosure. The operations of the method **1500** may be implemented by a UE or its components as described herein. For example, the operations of the method **1500** may be performed by a UE **115** as described with reference to FIGS. **1** through **8**. In some examples, a UE may execute a set of instructions to control the functional elements of the UE to perform the described functions. Additionally, or alternatively, the UE may perform aspects of the described functions using special-purpose hardware.

[0210] At **1505**, the method may include receiving a control message that includes an index of a sub-band of a set of multiple sub-bands of a virtual cell and a quantity of random access occasions associated with the sub-band. The operations of block **1505** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1505** may be performed by a control message component **725** as described with reference to FIG. **7**.

[0211] At **1510**, the method may include transmitting a random access message within a random access occasion of the quantity of random access occasions indicated by the control message. The operations of block **1510** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1510** may be performed by a random access message component **730** as described with reference to FIG. **7**.

[0212] At **1515**, the method may include receiving a second control message associated with the random access response message based on transmitting the random access message, where a random access response message is associated with the index of the sub-band, the random access occasion, or both based on receiving the second control message. The operations of block **1515** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1515** may be performed by a control message component **725** as described with reference to FIG. **7**.

[0213] At **1520**, the method may include receiving the random access response message that is associated with the index of the sub-band, the random access occasion, or both after transmitting the random access message. The operations of block **1520** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1520** may be performed by a random access response message component **735** as described with reference to FIG. **7**.

[0214] FIG. **16** shows a flowchart illustrating a method **1600** that supports random access procedures with a virtual cell in accordance with one or more aspects of the present disclosure. The operations of the method **1600** may be implemented by a network entity or its components as described herein. For example, the operations of the method **1600** may be performed by a network entity as described with reference to FIGS. **1** through **4** and **9** through **12**. In some examples, a network entity may execute a set of instructions to control the functional elements of the network entity to perform the described functions. Additionally, or alternatively, the network entity may perform aspects of the described functions using special-purpose hardware.

[0215] At **1605**, the method may include outputting a control message that includes an index of a sub-band of a set of multiple sub-bands of a virtual cell and a quantity of random access occasions associated with the sub-band. The operations of block **1605** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1605** may be performed by a control message configuration component **1125** as described with reference to FIG. **11**.

[0216] At **1610**, the method may include obtaining a random access message within a random access occasion of the quantity of random access occasions indicated by the control message. The operations of block **1610** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1610** may be performed by a random access message manager **1130** as described with reference to FIG. **11**.

[0217] At **1615**, the method may include outputting, to a UE, a random access response message that is associated with the index of the sub-band, the random access occasion, or both after obtaining the random access message. The operations of block **1615** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1615** may be performed by a random access response message configuration component **1135** as described with reference to FIG. **11**.

[0218] FIG. **17** shows a flowchart illustrating a method **1700** that supports random access procedures with a virtual cell in accordance with one or more aspects of the present disclosure. The operations of the method **1700** may be implemented by a network entity or its components as described herein. For example, the operations of the method **1700** may be performed by a network entity as described with reference to FIGS. **1** through **4** and **9** through **12**. In some examples, a network entity may execute a set of instructions to control the functional elements of the network entity to perform the described functions. Additionally, or alternatively, the network entity may perform aspects of the described functions using special-purpose hardware.

[0219] At **1705**, the method may include outputting a control message that includes an index of a sub-band of a set of multiple sub-bands of a virtual cell and a quantity of random access occasions associated with the sub-band. The operations of block **1705** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1705** may be performed by a control message configuration component **1125** as described with reference to FIG. **11**.

[0220] At **1710**, the method may include obtaining a random access message within a random access occasion of the quantity of random access occasions indicated by the control message. The operations of block **1710** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1710** may be performed by a random access message manager **1130** as described with reference to FIG. **11**.

[0221] At **1715**, the method may include obtaining the random access message in accordance with a first index, where the first index is based on a combination of the quantity of random access occasions with one or more second quantities of random access occasions associated with one or more second sub-bands. The operations of block

1715 may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1715** may be performed by a random access message manager **1130** as described with reference to FIG. **11**.

[0222] At **1720**, the method may include outputting, to a UE, a random access response message that is associated with the index of the sub-band, the random access occasion, or both after obtaining the random access message. The operations of block **1720** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1720** may be performed by a random access response message configuration component **1135** as described with reference to FIG. **11**.

[0223] FIG. **18** shows a flowchart illustrating a method **1800** that supports random access procedures with a virtual cell in accordance with one or more aspects of the present disclosure. The operations of the method **1800** may be implemented by a network entity or its components as described herein. For example, the operations of the method **1800** may be performed by a network entity as described with reference to FIGS. **1** through **4** and **9** through **12**. In some examples, a network entity may execute a set of instructions to control the functional elements of the network entity to perform the described functions. Additionally, or alternatively, the network entity may perform aspects of the described functions using special-purpose hardware.

[0224] At **1805**, the method may include outputting a control message that includes an index of a sub-band of a set of multiple sub-bands of a virtual cell and a quantity of random access occasions associated with the sub-band. The operations of block **1805** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1805** may be performed by a control message configuration component **1125** as described with reference to FIG. **11**.

[0225] At **1810**, the method may include obtaining a random access message within a random access occasion of the quantity of random access occasions indicated by the control message. The operations of block **1810** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1810** may be performed by a random access message manager **1130** as described with reference to FIG. **11**.

[0226] At **1815**, the method may include outputting a second control message associated with a random access response message based on obtaining the random access message, where the random access response message is associated with the index of the sub-band, the random access occasion, or both based on outputting the second control message. The operations of block **1815** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1815** may be performed by a control message configuration component **1125** as described with reference to FIG. **11**.

[0227] At **1820**, the method may include outputting, to a UE, the random access response message that is associated with the index of the sub-band, the random access occasion, or both after obtaining the random access message. The operations of block **1820** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1820** may be performed by a random access response message configuration component **1135** as described with reference to FIG. **11**.

[0228] The following provides an overview of aspects of the present disclosure:

[0229] Aspect 1: A method for wireless communications by a UE, comprising: receiving a control message that comprises an index of a sub-band of a plurality of sub-bands of a virtual cell and a quantity of random access occasions associated with the sub-band; transmitting a random access message within a random access occasion of the quantity of random access occasions indicated by the control message; and receiving a random access response message that is associated with the index of the sub-band, the random access occasion, or both after transmitting the random access message.

[0230] Aspect 2: The method of aspect 1, wherein transmitting the random access message comprises: transmitting the random access message in accordance with a first index, wherein the first index is based at least in part on combining the quantity of random access occasions with one or more second quantities of random access occasions associated with one or more second sub-bands.

[0231] Aspect 3: The method of aspect 2, further comprising: selecting a second index of the random access occasion based at least in part on the index of the sub-band and the quantity of random access occasions, wherein the first index is based at least in part on combining the second index with the combined quantity of random access occasions, and wherein the second index is a sub-band specific index and the first index is a non-sub-band specific index.

[0232] Aspect 4: The method of any of aspects 2 through 3, further comprising: transmitting the random access message in accordance with a temporary identifier, the temporary identifier being associated with a first type of random access procedure and the first index, wherein the temporary identifier is different than one or more second temporary identifiers associated with a second type of random access procedure based at least in part on the first index.

[0233] Aspect 5: The method of any of aspects 1 through 4, wherein receiving the random access response message comprises: receiving a second control message associated with the random access response message based at least in part on transmitting the random access message, wherein the random access response message is associated with the index of the sub-band, the random access occasion, or both based at least in part on receiving the second control message.

[0234] Aspect 6: The method of aspect 5, wherein the second control message comprises one or more fields that indicate the index of the sub-band, the random access occasion, or both.

[0235] Aspect 7: The method of any of aspects 5 through 6, further comprising: decoding the second control message in accordance with the index of the sub-band, the random access occasion, or both based at least in part on one or more cyclic redundancy check bits of the second control message, a reference signal scrambling identifier of the second control message, a bit interleaving pattern of the second control message, or any combination thereof, wherein receiving the random access response message is based at least in part on decoding the second control message.

[0236] Aspect 8: The method of any of aspects 1 through 7, wherein receiving the random access response message comprises: receiving, via the random access response message, an indication of the index of the sub-band, an indication of the random access occasion, or both.

[0237] Aspect 9: The method of aspect 8, wherein receiving the indication comprises: receiving the indication of the index of the sub-band, the indication of the random access occasion of the random access response message, or both via a medium access control header of the random access response message, a medium access control payload, one or more padding bits of the random access response message, a reference signal scrambling identifier of the random access response message, or a combination thereof.

[0238] Aspect 10: The method of any of aspects 1 through 9, wherein receiving the random access response message comprises: receiving the random access response message in accordance with the index of the sub-band, the random access occasion, or both based at least in part on first information included in a second control message associated with the random access response message and second information included in the random access response message.

[0239] Aspect 11: The method of any of aspects 1 through 10, wherein the quantity of random access occasions is based at least in part on a type of random access procedure.

[0240] Aspect 12: The method of any of aspects 1 through 11, wherein at least a first sub-band of the plurality of sub-bands and a second sub-band of the plurality of sub-bands are non-contiguous in a frequency domain.

[0241] Aspect 13: A method for wireless communications by a network entity, comprising: outputting a control message that comprises an index of a sub-band of a plurality of sub-bands of a virtual cell and a quantity of random access occasions associated with the sub-band; obtaining a random access message within a random access occasion of the quantity of random access occasions indicated by the control message; and outputting, to a UE, a random access response message that is associated with the index of the sub-band, the random access occasion, or both after obtaining the random access message.

[0242] Aspect 14: The method of aspect 13, wherein obtaining the random access message comprises: obtaining the random access message in accordance with a first index, wherein the first index is based at least in part on a combination of the quantity of random access occasions with one or more second quantities of random access occasions associated with one or more second sub-bands.

[0243] Aspect 15: The method of aspect 14, wherein the first index is based at least in part on a combination of a second index of the random access occasion and the combined quantity of random access occasions, the second index based at least in part on the index of the sub-band and the quantity of random access occasions, and the second index is a sub-band specific index and the first index is a non-sub-band specific index.

[0244] Aspect 16: The method of any of aspects 14 through 15, further comprising: obtaining the random access message in accordance with a temporary identifier, the temporary identifier being associated with a first type of random access procedure and the first index, wherein the temporary identifier is different than one or more second temporary identifiers associated with a second type of random access procedure based at least in part on the first index.

[0245] Aspect 17: The method of any of aspects 13 through 16, wherein outputting the random access response message comprises: outputting a second control message associated with the random access response message based at least in part on obtaining the random access message, wherein the random access response message is associated with the index of the sub-band, the random access occasion, or both based at least in part on outputting the second control message.

[0246] Aspect 18: The method of aspect 17, wherein the second control message comprises one or more fields that indicate the index of the sub-band, the random access occasion, or both.

[0247] Aspect 19: The method of any of aspects 17 through 18, further comprising: encoding the second control message in accordance with the index of the sub-band, the random access occasion, or both based at least in part on one or more cyclic redundancy check bits of the second control message, a reference signal scrambling identifier of the second control message, a bit interleaving pattern of the second control message, or any combination thereof.

[0248] Aspect 20: The method of any of aspects 13 through 19, wherein outputting the random access response message comprises: outputting, via the random access response message, an indication of the index of the sub-band, an indication of the random access occasion, or both.

[0249] Aspect 21: The method of aspect 20, wherein outputting the indication comprises: outputting the indication of the index of the sub-band, the indication of the random access occasion of the random access response message, or both via a medium access control header of the random access response message, a medium access control payload, one or more padding bits of the random access response message, a reference signal scrambling identifier of the random access response message, or a combination thereof.

[0250] Aspect 22: The method of any of aspects 13 through 21, wherein outputting the random access response message comprises: outputting the random access response message in accordance with the index of the sub-band, the random access occasion, or both based at least in part on including first information in a second control message associated with the random access response message and second information in the random access response message.

[0251] Aspect 23: The method of any of aspects 13 through 22, wherein the quantity of random access occasions is based at least in part on a type of random access procedure.

[0252] Aspect 24: The method of any of aspects 13 through 23, wherein at least a first sub-band of the plurality of sub-bands and a second sub-band of the plurality of sub-bands are non-contiguous in a frequency domain.

[0253] Aspect 25: A UE for wireless communications, comprising one or more memories storing processor-executable code, and one or more processors coupled with the one or more memories and individually or collectively operable to execute the code to cause the UE to perform a method of any of aspects 1 through 12.

[0254] Aspect 26: A UE for wireless communications, comprising at least one means for performing a method of any of aspects 1 through 12.

[0255] Aspect 27: A non-transitory computer-readable medium storing code for wireless communications, the code comprising instructions executable by one or more processors to perform a method of any of aspects 1 through 12.

[0256] Aspect 28: A network entity for wireless communications, comprising one or more memories storing processor-executable code, and one or more processors coupled with the one or more memories and individually or collectively operable to execute the code to cause the network entity to perform a method of any of aspects 13 through 24.

[0257] Aspect 29: A network entity for wireless communications, comprising at least one means for performing a method of any of aspects 13 through 24.

[0258] Aspect 30: A non-transitory computer-readable medium storing code for wireless communications, the code comprising instructions executable by one or more processors to perform a method of any of aspects 13 through 24.

[0259] It should be noted that the methods described herein describe 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.

[0260] Although aspects of an LTE, LTE-A, LTE-A Pro, or NR system may be described for purposes of example, and LTE, LTE-A, LTE-A Pro, or NR terminology may be used in much of the description, the techniques described herein are applicable beyond LTE, LTE-A, LTE-A Pro, or NR networks. For example, the described techniques may be applicable to various other wireless communications systems such as Ultra Mobile Broadband (UMB), Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20, Flash-OFDM, as well as other systems and radio technologies not explicitly mentioned herein.

[0261] 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.

[0262] The various illustrative blocks and components described in connection with the disclosure herein may be implemented or performed using 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). Any functions or operations described herein as being capable of being performed by a processor may be performed by multiple processors that, individually or collectively, are capable of performing the described functions or operations.

[0263] The functions described herein may be implemented using hardware, software executed by a processor, firmware, or any combination thereof. If implemented using software executed by a processor, the functions may be stored as or transmitted using one or more instructions or code of 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.

[0264] 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 location 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, and not limitation, 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. Also, any connection is properly termed a computer-readable medium. For example, if the software is transmitted from a website, server, or other remote source using a coaxial cable, fiber optic cable, twisted pair, digital subscriber line (DSL), or wireless technologies such as infrared, radio, and microwave, then the coaxial cable, fiber optic cable, twisted pair, DSL, or wireless technologies such as infrared, radio, and microwave are included in the definition of computer-readable medium. Disk and disc, as used herein, include CD, laser disc, optical disc, digital versatile disc (DVD), floppy disk and Blu-ray disc. Disks may reproduce data magnetically, and discs may reproduce data optically using lasers. Combinations of the above are also included within the scope of computer-readable media. Any functions or operations described herein as being capable of being performed by a memory may be performed by multiple memories that, individually or collectively, are capable of performing the described functions or operations.

[0265] 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") 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."

[0266] As used herein, including in the claims, the article "a" before a noun is open-ended and understood to refer to "at least one" of those nouns or "one or more" of those nouns. Thus, the terms "a," "at least one," "one or more," "at least one of one or more" may be interchangeable. For example, if a claim recites "a component" that performs one or more functions, each of the individual functions may be performed by a single component or by any combination of multiple components. Thus, the term "a component" having characteristics or performing functions may refer to "at least one of one or more components" having a particular characteristic or performing a particular function. Subsequent reference to a component introduced with the article "a" using the terms "the" or "said" may refer to any or all of the one or more components. For example, a component introduced with the article "a" may be understood to mean "one or more components," and referring to "the component" subsequently in the claims may be understood to be equivalent to referring to "at least one of the one or more components." Similarly, subsequent reference to a component introduced as "one or more components" using the terms "the" or "said" may refer to any or all of the one or more components. For example, referring to "the one or more components" subsequently in the claims may be understood to be equivalent to referring to "at least one of the one or more components."

[0267] The term "determine" or "determining" encompasses a variety of actions and, therefore, "determining" can include calculating, computing, processing, deriving, investigating, looking up (such as via looking up in a table, a database or another data structure), ascertaining and the like. Also, "determining" can include receiving (e.g., receiving information), accessing (e.g., accessing data stored in memory) and the like. Also, "determining" can include resolving, obtaining, selecting, choosing, establishing, and other such similar actions.

[0268] In the appended figures, similar components or features may have the same reference label. Further, various components of the same type may be distinguished by following the reference label by a dash and a second label that distinguishes among the similar components. If just the first reference label is used in the specification, the description is applicable to any one of the similar components having the same first reference label irrespective of the second reference label, or other subsequent reference label.

[0269] The description set forth herein, in connection with the appended drawings, describes example configurations and does not represent all the examples that may be implemented or that are within the scope of the claims. The term "example" used herein means "serving as an example, instance, or illustration," and not "preferred" or "advantageous over other examples." The detailed description includes specific details for the purpose of providing an understanding of the described techniques. These techniques, however, may be practiced without these specific details. In some instances, known structures and devices are shown in block diagram form in order to avoid obscuring the concepts of the described examples.

[0270] 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.

What is claimed is:

1. A user equipment (UE), comprising:

one or more memories storing processor-executable code; and

one or more processors coupled with the one or more memories and individually or collectively operable to execute the code to cause the UE to:

receive a control message that comprises an index of a sub-band of a plurality of sub-bands of a virtual cell and a quantity of random access occasions associated with the sub-band;

transmit a random access message within a random access occasion of the quantity of random access occasions indicated by the control message; and

receive a random access response message that is associated with the index of the sub-band, the random access occasion, or both after transmitting the random access message.

2. The UE of claim **1**, wherein, to transmit the random access message, the one or more processors are individually or collectively operable to execute the code to cause the UE to:

transmit the random access message in accordance with a first index, wherein the first index is based at least in part on combining the quantity of random access occasions with one or more second quantities of random access occasions associated with one or more second sub-bands.

3. The UE of claim **2**, wherein the one or more processors are individually or collectively further operable to execute the code to cause the UE to:

select a second index of the random access occasion based at least in part on the index of the sub-band and the quantity of random access occasions, wherein the first index is based at least in part on combining the second index with the combined quantity of random access occasions, and wherein the second index is a sub-band specific index and the first index is a non-sub-band specific index.

4. The UE of claim **2**, wherein the one or more processors are individually or collectively further operable to execute the code to cause the UE to:

transmit the random access message in accordance with a temporary identifier, the temporary identifier being associated with a first type of random access procedure and the first index, wherein the temporary identifier is different than one or more second temporary identifiers associated with a second type of random access procedure based at least in part on the first index.

5. The UE of claim **1**, wherein, to receive the random access response message, the one or more processors are individually or collectively operable to execute the code to cause the UE to:

receive a second control message associated with the random access response message based at least in part on transmitting the random access message, wherein the random access response message is associated with the index of the sub-band, the random access occasion, or both based at least in part on receiving the second control message.

6. The UE of claim **5**, wherein the second control message comprises one or more fields that indicate the index of the sub-band, the random access occasion, or both.

7. The UE of claim **5**, wherein the one or more processors are individually or collectively further operable to execute the code to cause the UE to:

decode the second control message in accordance with the index of the sub-band, the random access occasion, or both based at least in part on one or more cyclic redundancy check bits of the second control message, a reference signal scrambling identifier of the second control message, a bit interleaving pattern of the second control message, or any combination thereof, wherein receiving the random access response message is based at least in part on decoding the second control message.

8. The UE of claim **1**, wherein, to receive the random access response message, the one or more processors are individually or collectively operable to execute the code to cause the UE to:

receive, via the random access response message, an indication of the index of the sub-band, an indication of the random access occasion, or both.

9. The UE of claim **8**, wherein, to receive the indication, the one or more processors are individually or collectively operable to execute the code to cause the UE to:

receive the indication of the index of the sub-band, the indication of the random access occasion of the random access response message, or both via a medium access control header of the random access response message, a medium access control payload, one or more padding bits of the random access response message, a reference signal scrambling identifier of the random access response message, or a combination thereof.

10. The UE of claim **1**, wherein, to receive the random access response message, the one or more processors are individually or collectively operable to execute the code to cause the UE to:

receive the random access response message in accordance with the index of the sub-band, the random access occasion, or both based at least in part on first information included in a second control message associated with the random access response message and second information included in the random access response message.

11. The UE of claim **1**, wherein the quantity of random access occasions is based at least in part on a type of random access procedure.

12. The UE of claim **1**, wherein at least a first sub-band of the plurality of sub-bands and a second sub-band of the plurality of sub-bands are non-contiguous in a frequency domain.

13. A network entity, comprising:

one or more memories storing processor-executable code; and

one or more processors coupled with the one or more memories and individually or collectively operable to execute the code to cause the network entity to:

output a control message that comprises an index of a sub-band of a plurality of sub-bands of a virtual cell and a quantity of random access occasions associated with the sub-band;

obtain a random access message within a random access occasion of the quantity of random access occasions indicated by the control message; and

output, to a user equipment (UE), a random access response message that is associated with the index of the sub-band, the random access occasion, or both after obtaining the random access message.

14. The network entity of claim **13**, wherein, to obtain the random access message, the one or more processors are individually or collectively operable to execute the code to cause the network entity to:

obtain the random access message in accordance with a first index, wherein the first index is based at least in part on a combination of the quantity of random access occasions with one or more second quantities of random access occasions associated with one or more second sub-bands.

15. The network entity of claim **14**, wherein:

the first index is based at least in part on a combination of a second index of the random access occasion and the combined quantity of random access occasions, the second index based at least in part on the index of the sub-band and the quantity of random access occasions, and

the second index is a sub-band specific index and the first index is a non-sub-band specific index.

16. The network entity of claim **14**, wherein the one or more processors are individually or collectively further operable to execute the code to cause the network entity to:

obtain the random access message in accordance with a temporary identifier, the temporary identifier being associated with a first type of random access procedure and the first index, wherein the temporary identifier is different than one or more second temporary identifiers associated with a second type of random access procedure based at least in part on the first index.

17. The network entity of claim **13**, wherein, to output the random access response message, the one or more processors are individually or collectively operable to execute the code to cause the network entity to:

output a second control message associated with the random access response message based at least in part on obtaining the random access message, wherein the random access response message is associated with the index of the sub-band, the random access occasion, or both based at least in part on outputting the second control message.

18. The network entity of claim **17**, wherein the second control message comprises one or more fields that indicate the index of the sub-band, the random access occasion, or both.

19. The network entity of claim **17**, wherein the one or more processors are individually or collectively further operable to execute the code to cause the network entity to:

encode the second control message in accordance with the index of the sub-band, the random access occasion, or both based at least in part on one or more cyclic redundancy check bits of the second control message, a reference signal scrambling identifier of the second control message, a bit interleaving pattern of the second control message, or any combination thereof.

20. The network entity of claim **13**, wherein, to output the random access response message, the one or more processors are individually or collectively operable to execute the code to cause the network entity to:

output, via the random access response message, an indication of the index of the sub-band, an indication of the random access occasion, or both.

21. The network entity of claim **20**, wherein, to output the indication, the one or more processors are individually or collectively operable to execute the code to cause the network entity to:

output the indication of the index of the sub-band, the indication of the random access occasion of the random access response message, or both via a medium access control header of the random access response message, a medium access control payload, one or more padding bits of the random access response message, a reference signal scrambling identifier of the random access response message, or a combination thereof.

22. The network entity of claim **13**, wherein, to output the random access response message, the one or more processors are individually or collectively operable to execute the code to cause the network entity to:

output the random access response message in accordance with the index of the sub-band, the random access occasion, or both based at least in part on including first information in a second control message associated with the random access response message and second information in the random access response message.

23. The network entity of claim **13**, wherein the quantity of random access occasions is based at least in part on a type of random access procedure.

24. The network entity of claim **13**, wherein at least a first sub-band of the plurality of sub-bands and a second sub-band of the plurality of sub-bands are non-contiguous in a frequency domain.

25. A method for wireless communications by a user equipment (UE), comprising:

receiving a control message that comprises an index of a sub-band of a plurality of sub-bands of a virtual cell and a quantity of random access occasions associated with the sub-band;

transmitting a random access message within a random access occasion of the quantity of random access occasions indicated by the control message; and

receiving a random access response message that is associated with the index of the sub-band, the random access occasion, or both after transmitting the random access message.

26. The method of claim **25**, wherein transmitting the random access message comprises:

transmitting the random access message in accordance with a first index, wherein the first index is based at least in part on combining the quantity of random access occasions with one or more second quantities of random access occasions associated with one or more second sub-bands.

27. The method of claim **26**, further comprising:

selecting a second index of the random access occasion based at least in part on the index of the sub-band and the quantity of random access occasions, wherein the first index is based at least in part on combining the second index with the combined quantity of random access occasions, and wherein the second index is a sub-band specific index and the first index is a non-sub-band specific index.

28. A method for wireless communications by a network entity, comprising:

outputting a control message that comprises an index of a sub-band of a plurality of sub-bands of a virtual cell and a quantity of random access occasions associated with the sub-band;

obtaining a random access message within a random access occasion of the quantity of random access occasions indicated by the control message; and

outputting, to a user equipment (UE), a random access response message that is associated with the index of the sub-band, the random access occasion, or both after obtaining the random access message.

29. The method of claim **28**, wherein obtaining the random access message comprises:

obtaining the random access message in accordance with a first index, wherein the first index is based at least in part on a combination of the quantity of random access occasions with one or more second quantities of random access occasions associated with one or more second sub-bands.

30. The method of claim **29**, wherein the first index is based at least in part on a combination of a second index of the random access occasion and the combined quantity of random access occasions, the second index based at least in part on the index of the sub-band and the quantity of random access occasions, and the second index is a sub-band specific index and the first index is a non-sub-band specific index.

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