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(54) **USER EQUIPMENT (UE) CAPABILITY SIGNALING FOR PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) CELL SWITCHING**

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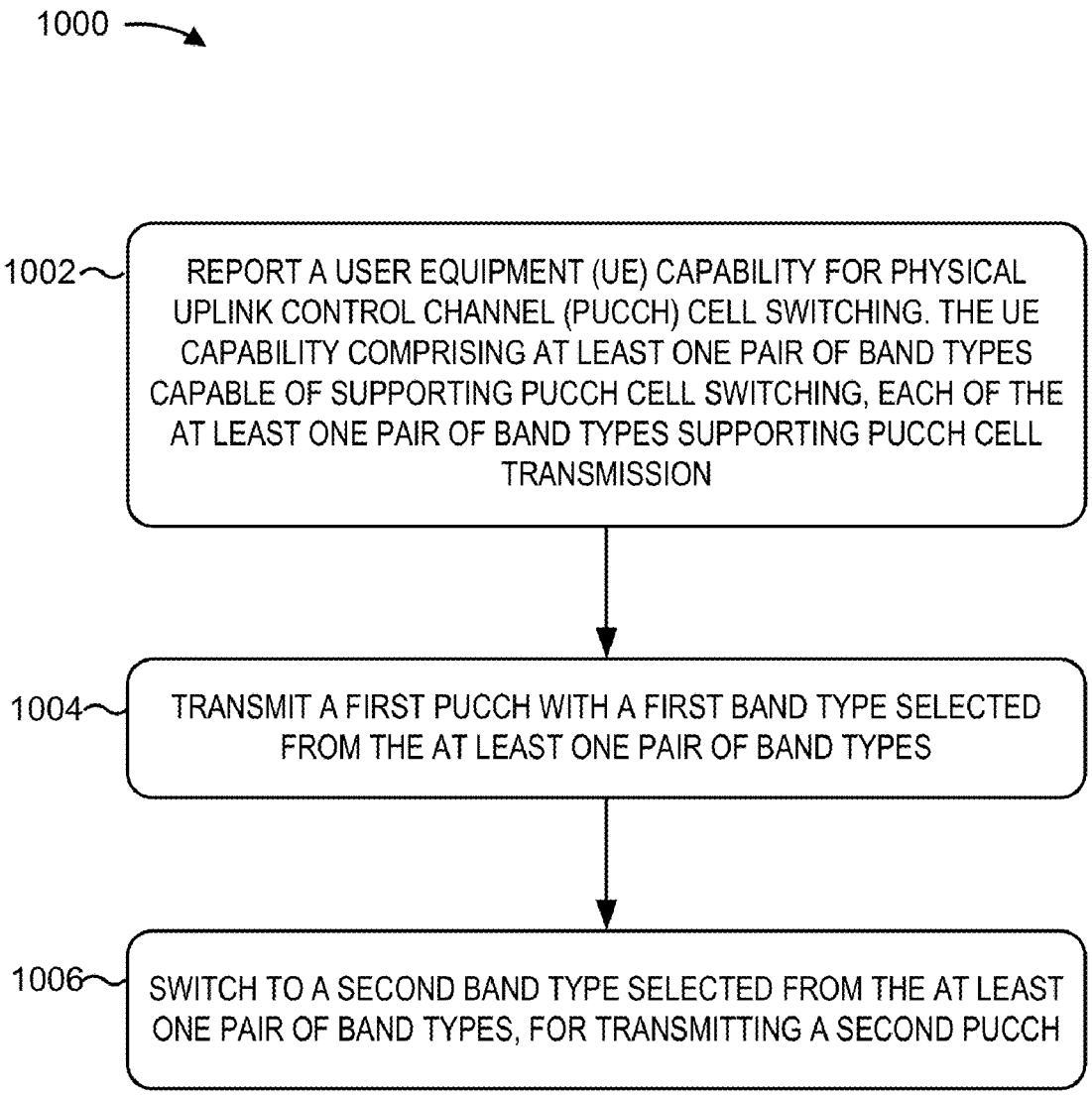
CPC ***H04W 36/06*** (2013.01); ***H04W 72/044*** (2013.01)

(57) **ABSTRACT**

A method of wireless communication, by a user equipment (UE), includes reporting a UE capability for physical uplink control channel (PUCCH) cell switching. The UE capability includes at least one pair of band types capable of supporting PUCCH cell switching. Each band type of the at least one pair of band types supports PUCCH cell transmission. The method also includes transmitting a first PUCCH with a first band type selected from the at least one pair of band types. The method further includes switching to a second band type selected from the at least one pair of band types, for transmitting a second PUCCH.



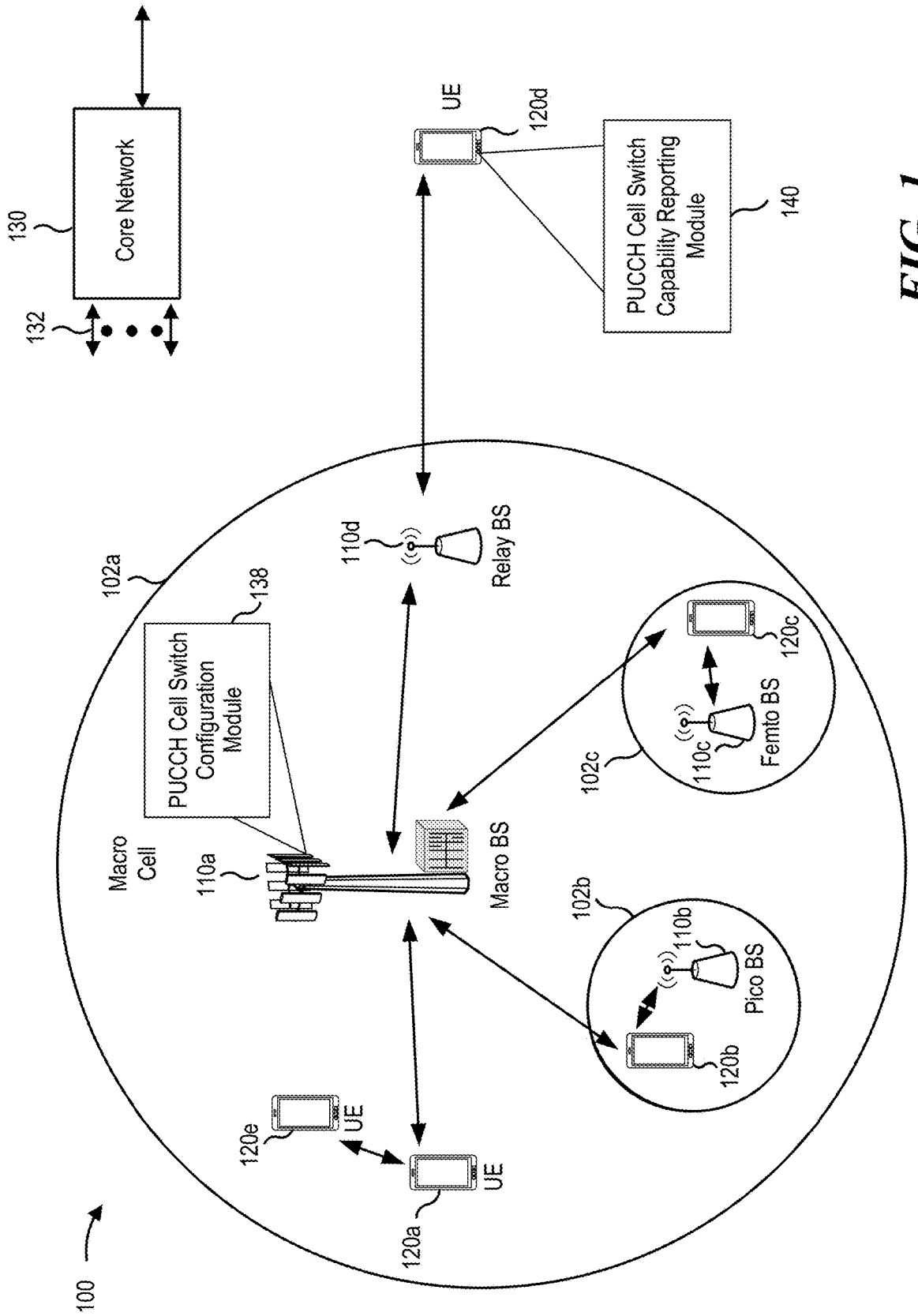

130
Core Network
132
UE
120d
PUCCH Cell Switch Capability Reporting Module
140
102a
138
PUCCH Cell Switch Configuration Module
110d
Relay BS
Macro Cell
110a
Macro BS
102c
120c
110c
Femto BS
102b
110b
Pico BS
120b
120e
UE
UE
120a
100

FIG. 1

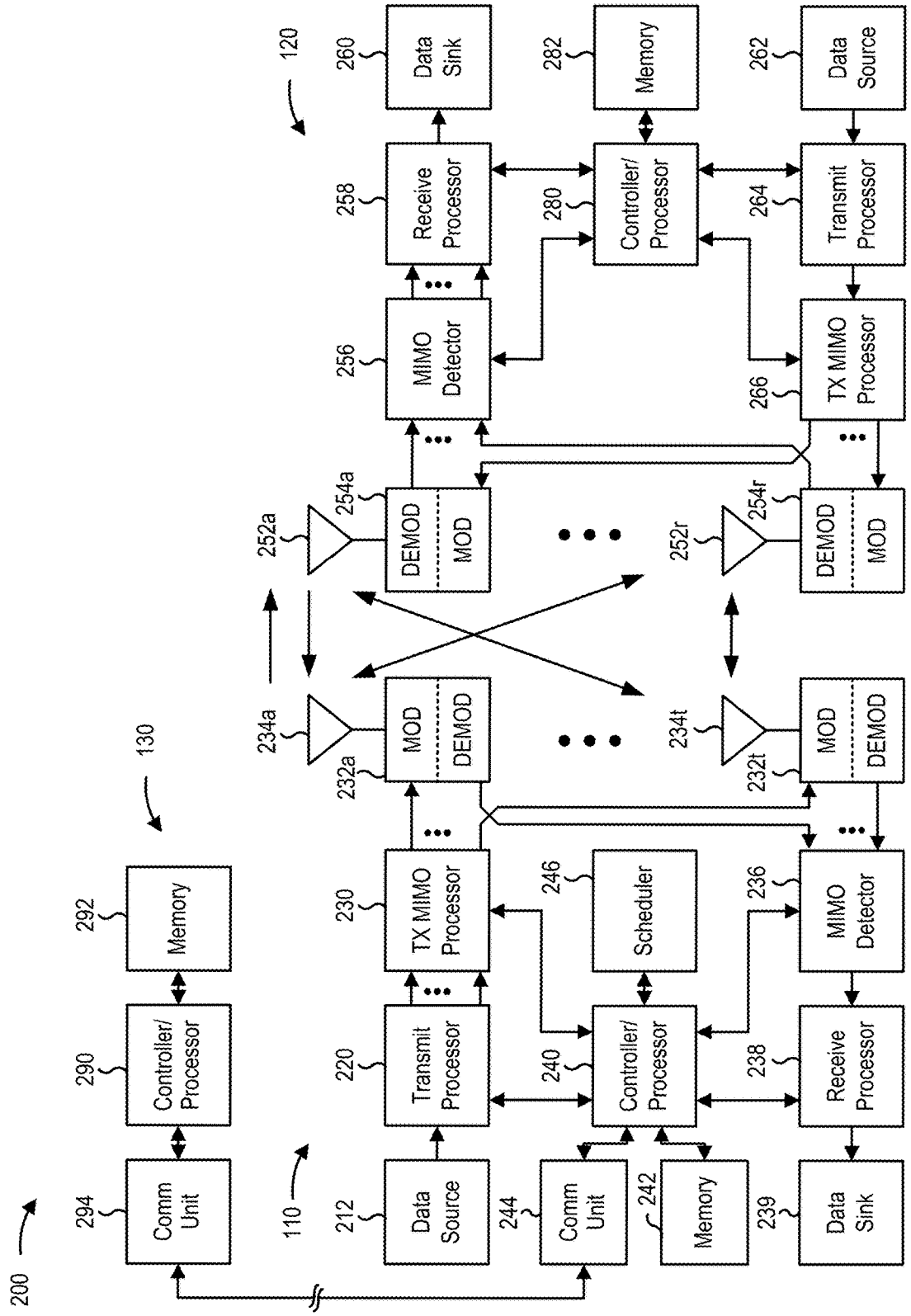

200
110
120
130
212
Data Source
220
Transmit Processor
230
TX MIMO Processor
232a
MOD
DEMOD
234a
252a
254a
DEMOD
MOD
256
MIMO Detector
258
Receive Processor
260
Data Sink
240
Controller/ Processor
242
Memory
244
Comm Unit
246
Scheduler
234t
232t
252r
254r
DEMOD
MOD
236
MIMO Detector
238
Receive Processor
239
Data Sink
280
Controller/ Processor
282
Memory
264
Transmit Processor
262
Data Source
266
TX MIMO Processor
290
Controller/ Processor
292
Memory
294
Comm Unit

FIG. 2

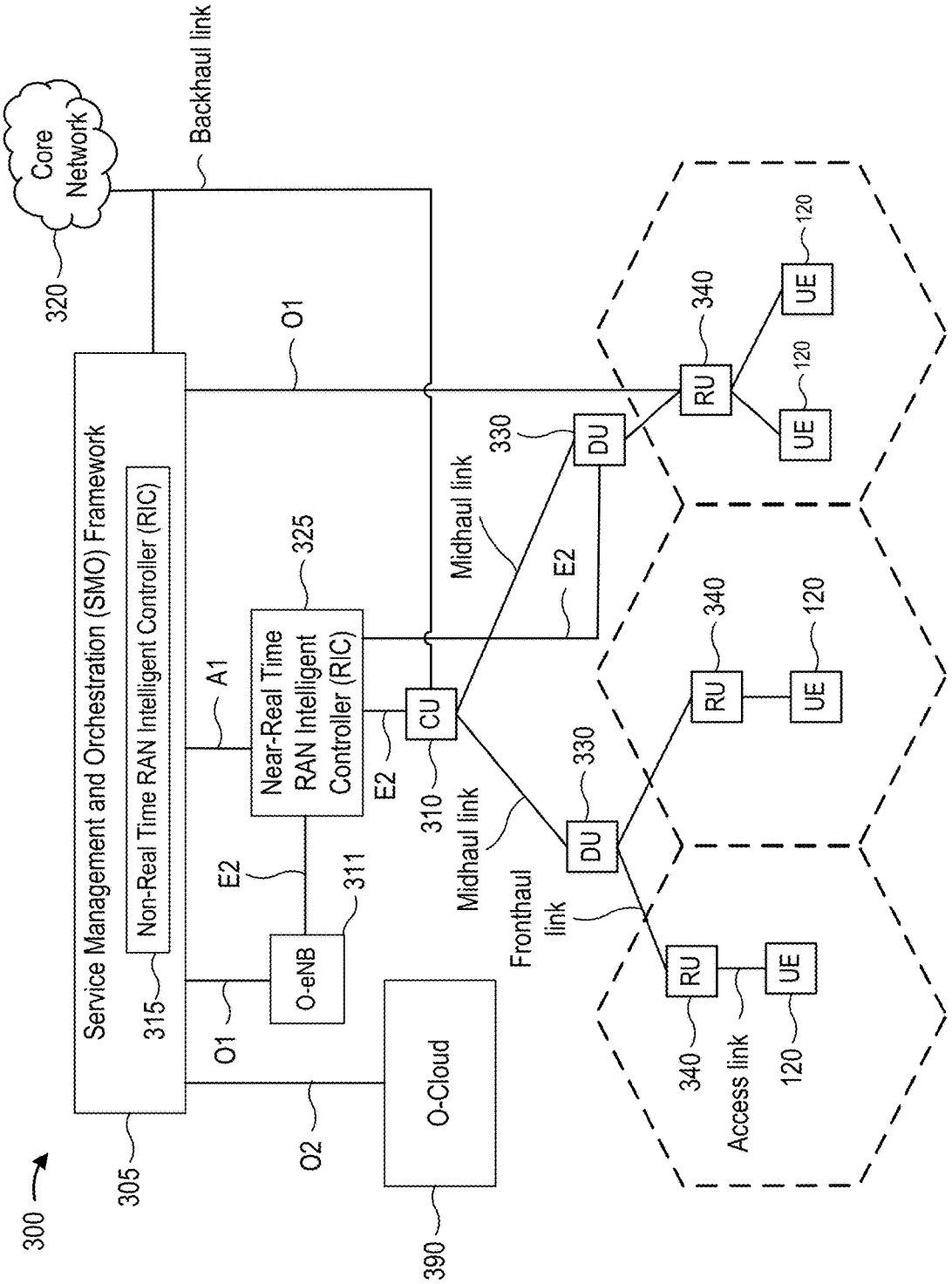

300
305
Service Management and Orchestration (SMO) Framework
Non-Real Time RAN Intelligent Controller (RIC)
315
O1
O2
A1
E2
O-eNB
311
Near-Real Time RAN Intelligent Controller (RIC)
325
E2
CU
310
Midhaul link
Midhaul link
Fronthaul link
DU
330
DU
330
RU
340
RU
340
RU
340
UE
120
UE
120
UE
120
UE
120
Access link
O-Cloud
390
Core Network
320
Backhaul link
O1

FIG. 3

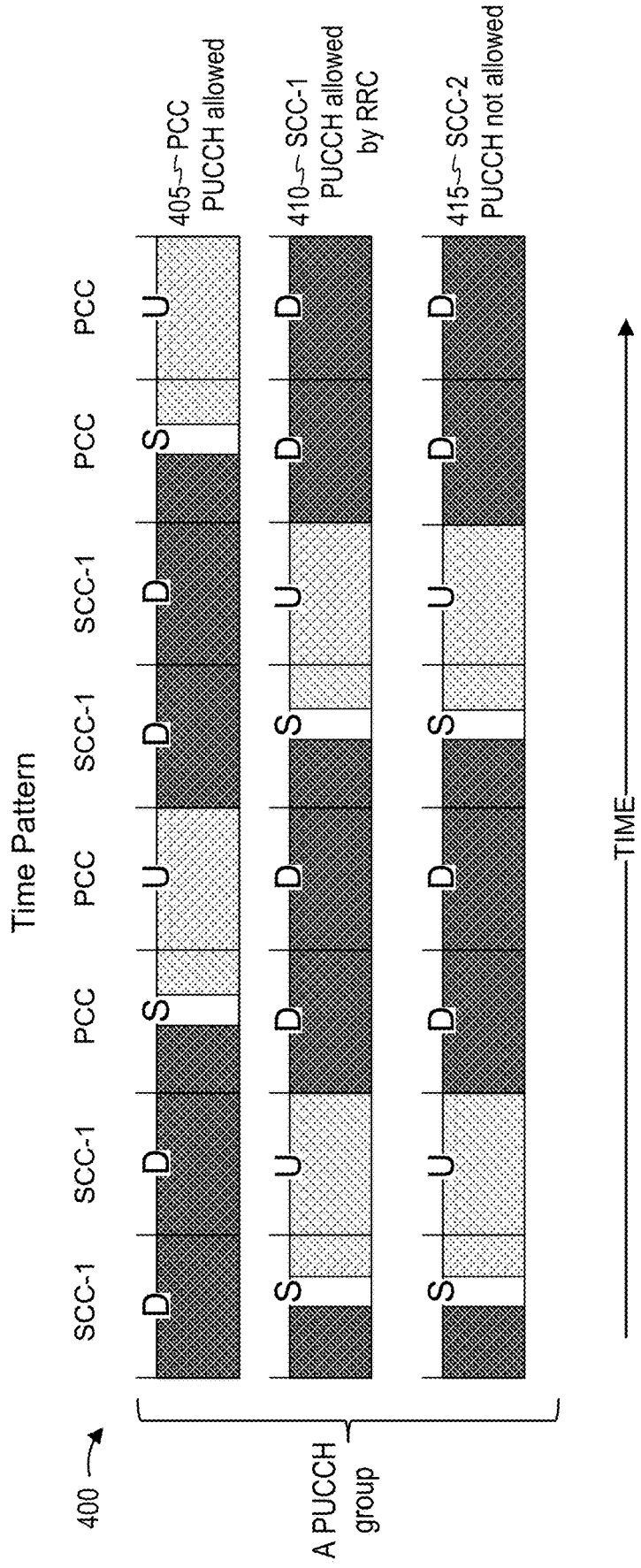

400
A PUCCH group
Time Pattern
SCC-1
SCC-1
PCC
PCC
SCC-1
SCC-1
PCC
PCC
405 PCC PUCCH allowed
410 SCC-1 PUCCH allowed by RRC
415 SCC-2 PUCCH not allowed
TIME

FIG. 4

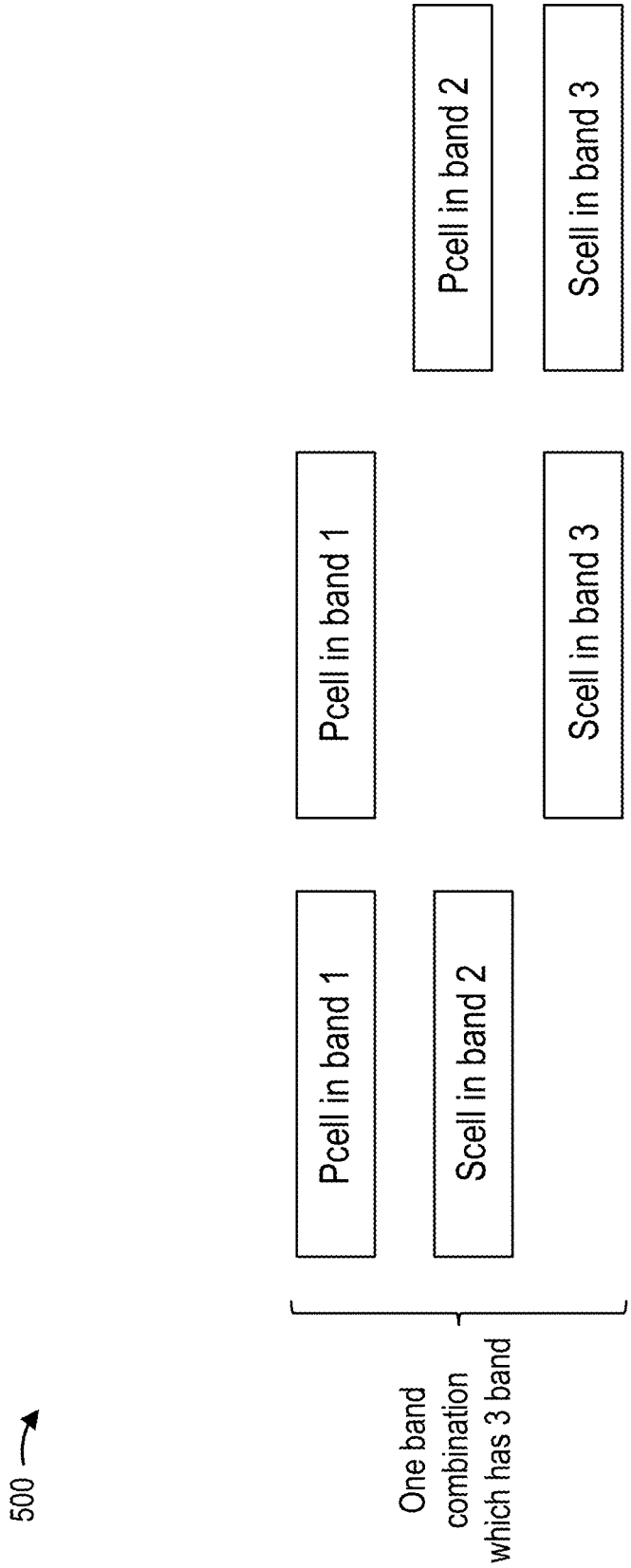

500
One band combination which has 3 band
Pcell in band 1
Scell in band 2
Pcell in band 1
Scell in band 3
Pcell in band 2
Scell in band 3

FIG. 5

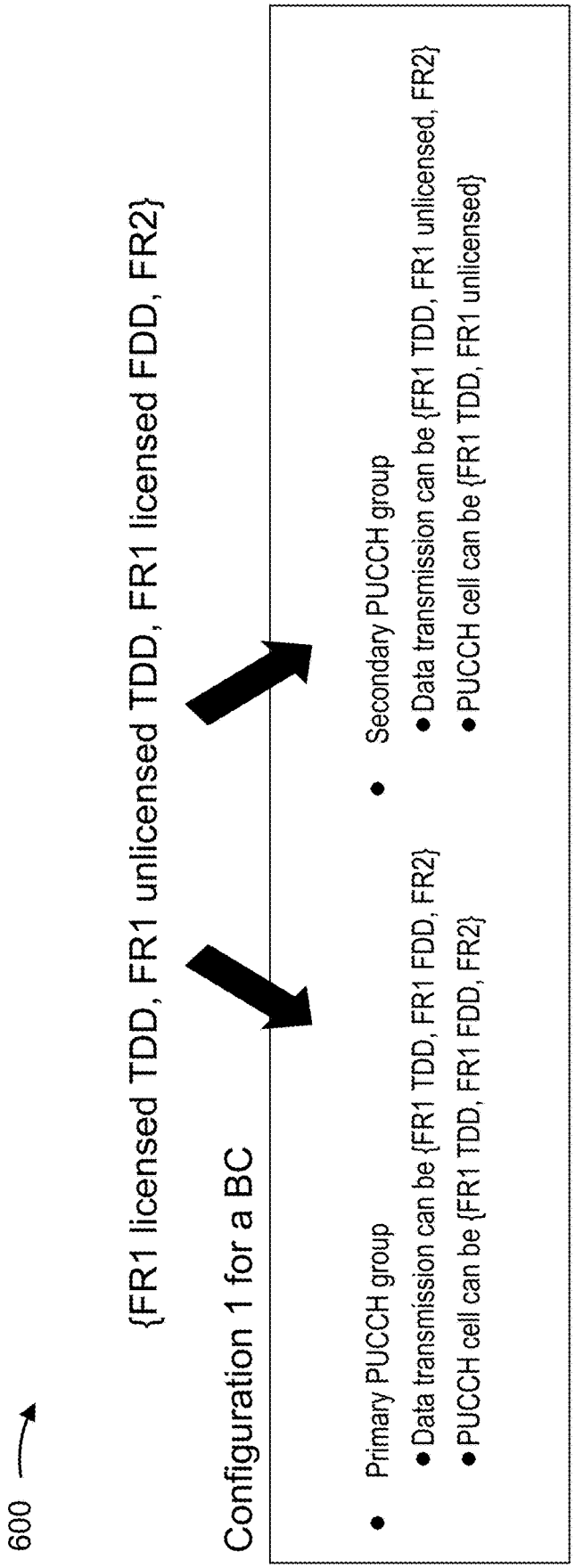

600
{FR1 licensed TDD, FR1 unlicensed TDD, FR1 licensed FDD, FR2}
Configuration 1 for a BC
Primary PUCCH group
Data transmission can be {FR1 TDD, FR1 FDD, FR2}
PUCCH cell can be {FR1 TDD, FR1 FDD, FR2}
Secondary PUCCH group
Data transmission can be {FR1 TDD, FR1 unlicensed, FR2}
PUCCH cell can be {FR1 TDD, FR1 unlicensed}

FIG. 6

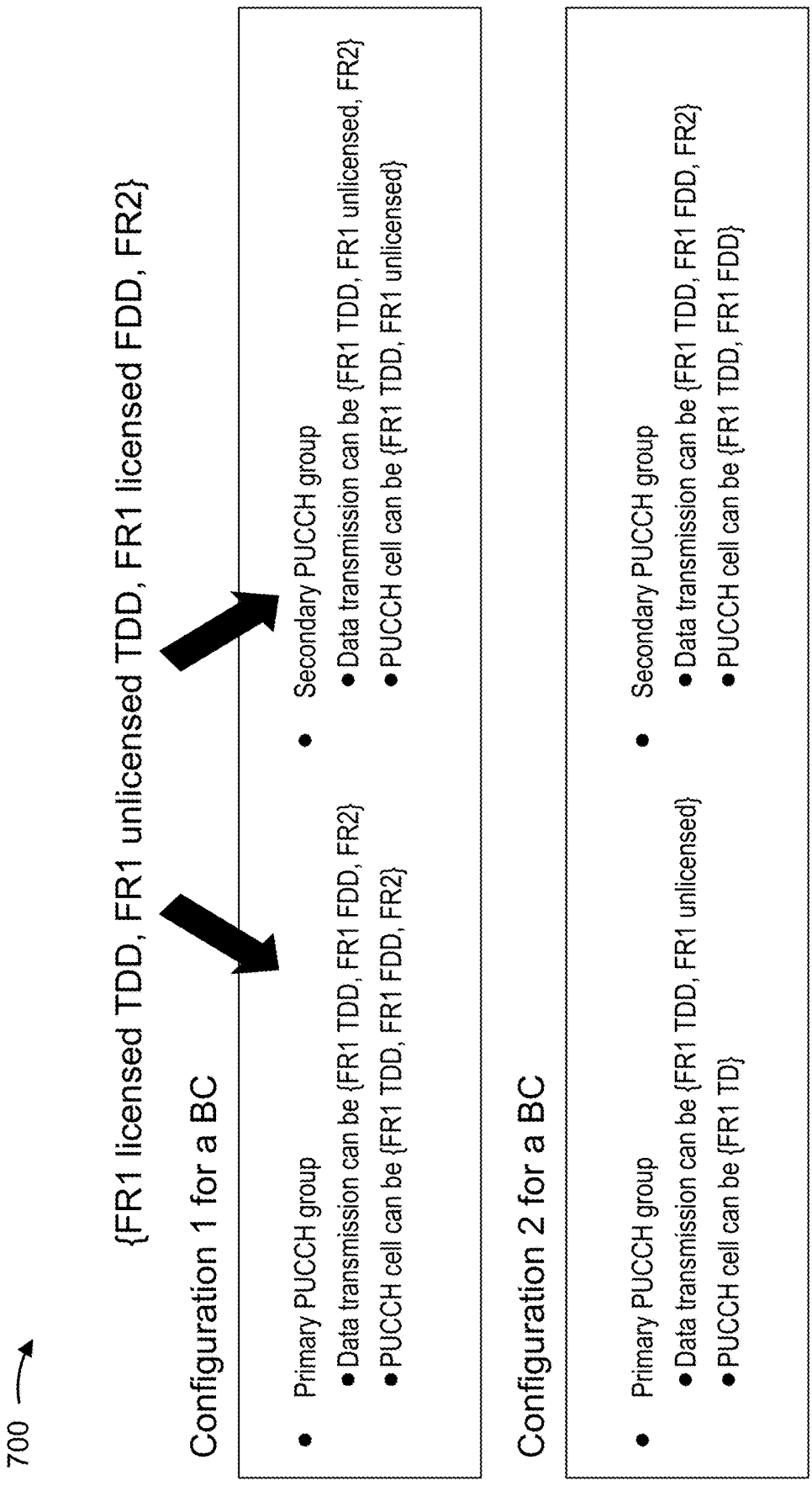

700
{FR1 licensed TDD, FR1 unlicensed TDD, FR1 licensed FDD, FR2}
Configuration 1 for a BC
Primary PUCCH group
Data transmission can be {FR1 TDD, FR1 FDD, FR2}
PUCCH cell can be {FR1 TDD, FR1 FDD, FR2}
Secondary PUCCH group
Data transmission can be {FR1 TDD, FR1 unlicensed, FR2}
PUCCH cell can be {FR1 TDD, FR1 unlicensed}
Configuration 2 for a BC
Primary PUCCH group
Data transmission can be {FR1 TDD, FR1 unlicensed}
PUCCH cell can be {FR1 TD}
Secondary PUCCH group
Data transmission can be {FR1 TDD, FR1 FDD, FR2}
PUCCH cell can be {FR1 TDD, FR1 FDD}

FIG. 7

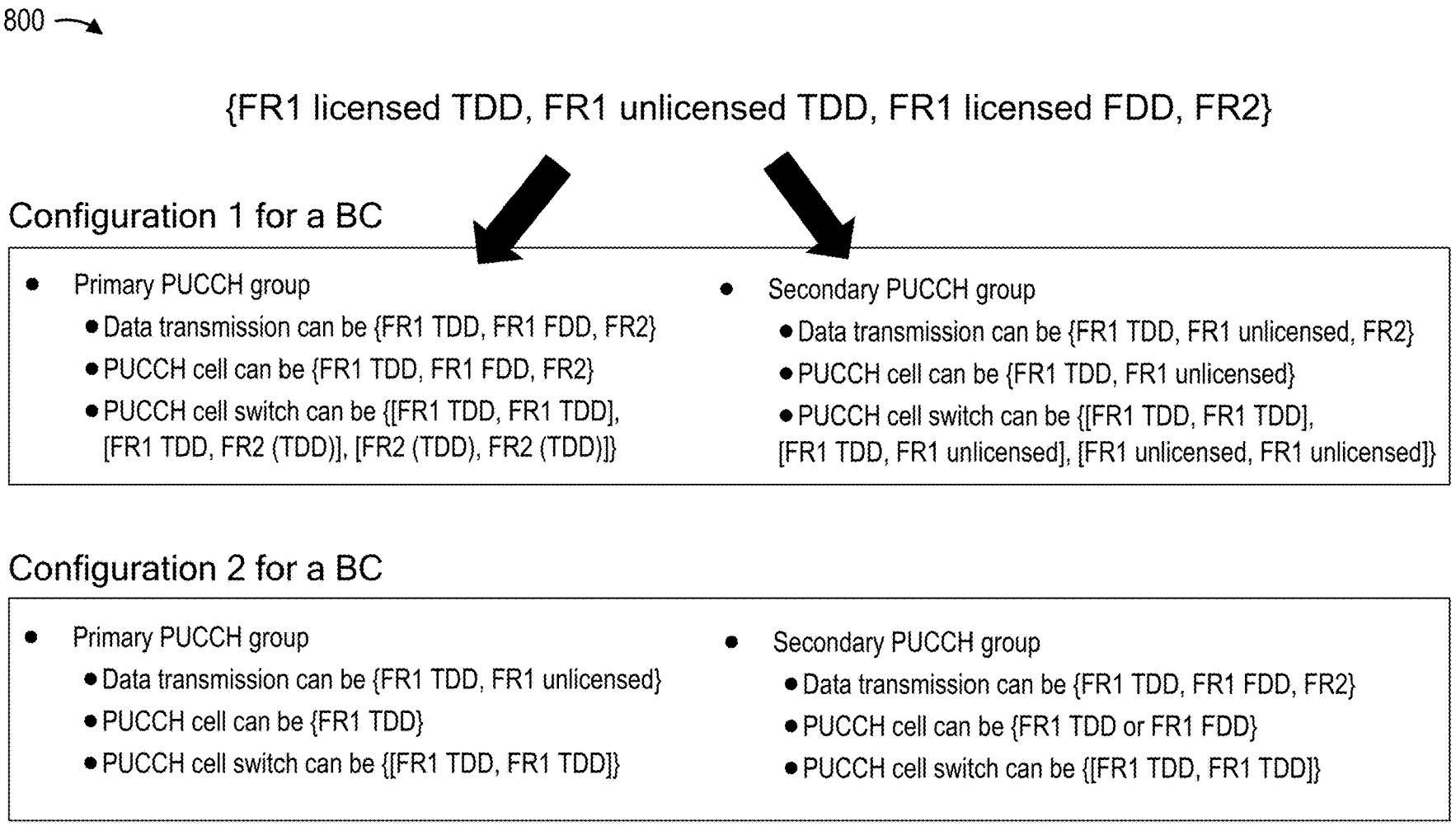

800
{FR1 licensed TDD, FR1 unlicensed TDD, FR1 licensed FDD, FR2}
Configuration 1 for a BC
Primary PUCCH group
Data transmission can be {FR1 TDD, FR1 FDD, FR2}
PUCCH cell can be {FR1 TDD, FR1 FDD, FR2}
PUCCH cell switch can be {[FR1 TDD, FR1 TDD], [FR1 TDD, FR2 (TDD)], [FR2 (TDD), FR2 (TDD)]}
Secondary PUCCH group
Data transmission can be {FR1 TDD, FR1 unlicensed, FR2}
PUCCH cell can be {FR1 TDD, FR1 unlicensed}
PUCCH cell switch can be {[FR1 TDD, FR1 TDD], [FR1 TDD, FR1 unlicensed], [FR1 unlicensed, FR1 unlicensed]}
Configuration 2 for a BC
Primary PUCCH group
Data transmission can be {FR1 TDD, FR1 unlicensed}
PUCCH cell can be {FR1 TDD}
PUCCH cell switch can be {[FR1 TDD, FR1 TDD]}
Secondary PUCCH group
Data transmission can be {FR1 TDD, FR1 FDD, FR2}
PUCCH cell can be {FR1 TDD or FR1 FDD}
PUCCH cell switch can be {[FR1 TDD, FR1 TDD]}

FIG. 8

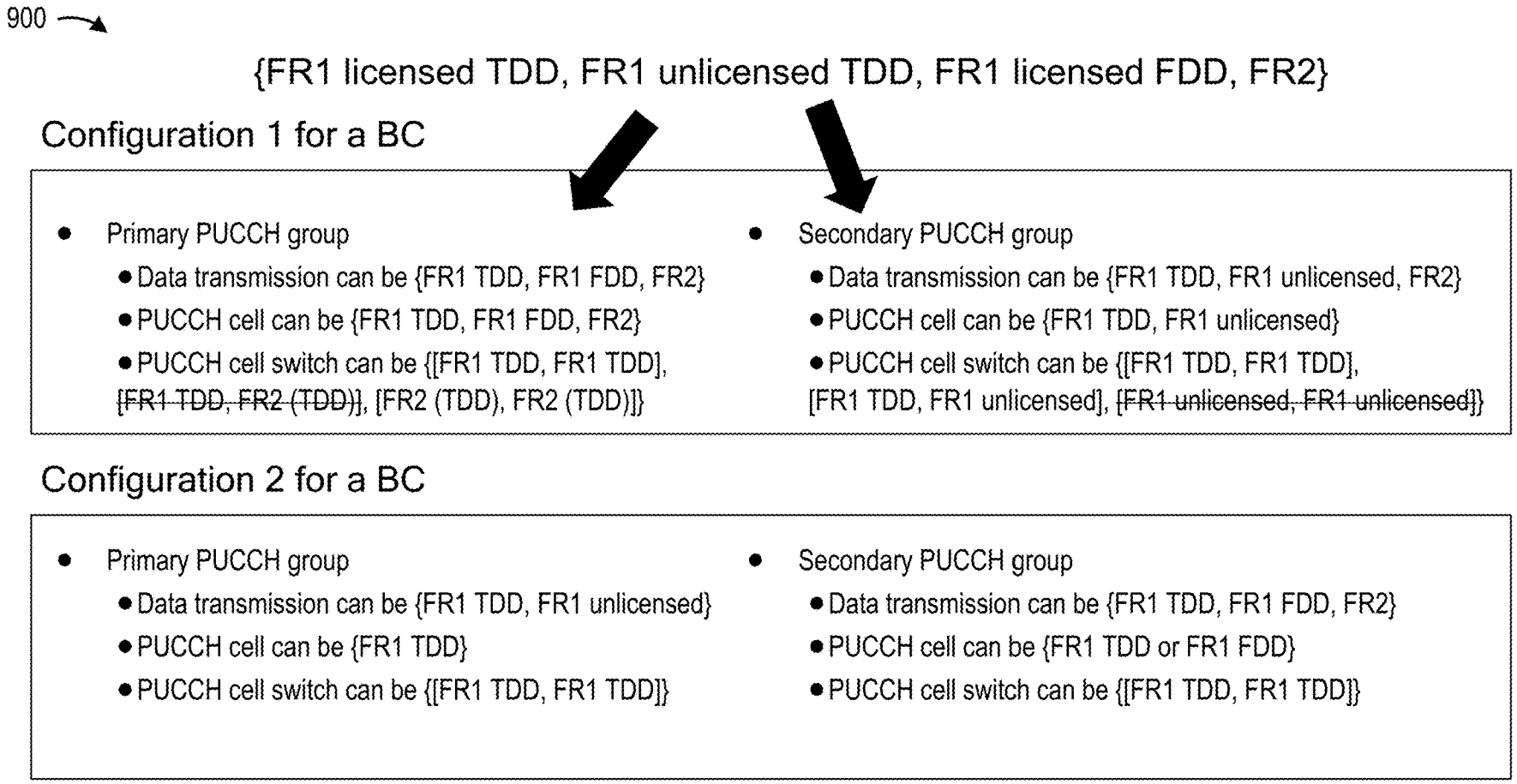

900
{FR1 licensed TDD, FR1 unlicensed TDD, FR1 licensed FDD, FR2}
Configuration 1 for a BC
Primary PUCCH group
Data transmission can be {FR1 TDD, FR1 FDD, FR2}
PUCCH cell can be {FR1 TDD, FR1 FDD, FR2}
PUCCH cell switch can be {[FR1 TDD, FR1 TDD], [FR1 TDD, FR2 (TDD)], [FR2 (TDD), FR2 (TDD)]}
Secondary PUCCH group
Data transmission can be {FR1 TDD, FR1 unlicensed, FR2}
PUCCH cell can be {FR1 TDD, FR1 unlicensed}
PUCCH cell switch can be {[FR1 TDD, FR1 TDD], [FR1 TDD, FR1 unlicensed], [FR1 unlicensed, FR1 unlicensed]}
Configuration 2 for a BC
Primary PUCCH group
Data transmission can be {FR1 TDD, FR1 unlicensed}
PUCCH cell can be {FR1 TDD}
PUCCH cell switch can be {[FR1 TDD, FR1 TDD]}
Secondary PUCCH group
Data transmission can be {FR1 TDD, FR1 FDD, FR2}
PUCCH cell can be {FR1 TDD or FR1 FDD}
PUCCH cell switch can be {[FR1 TDD, FR1 TDD]}

FIG. 9

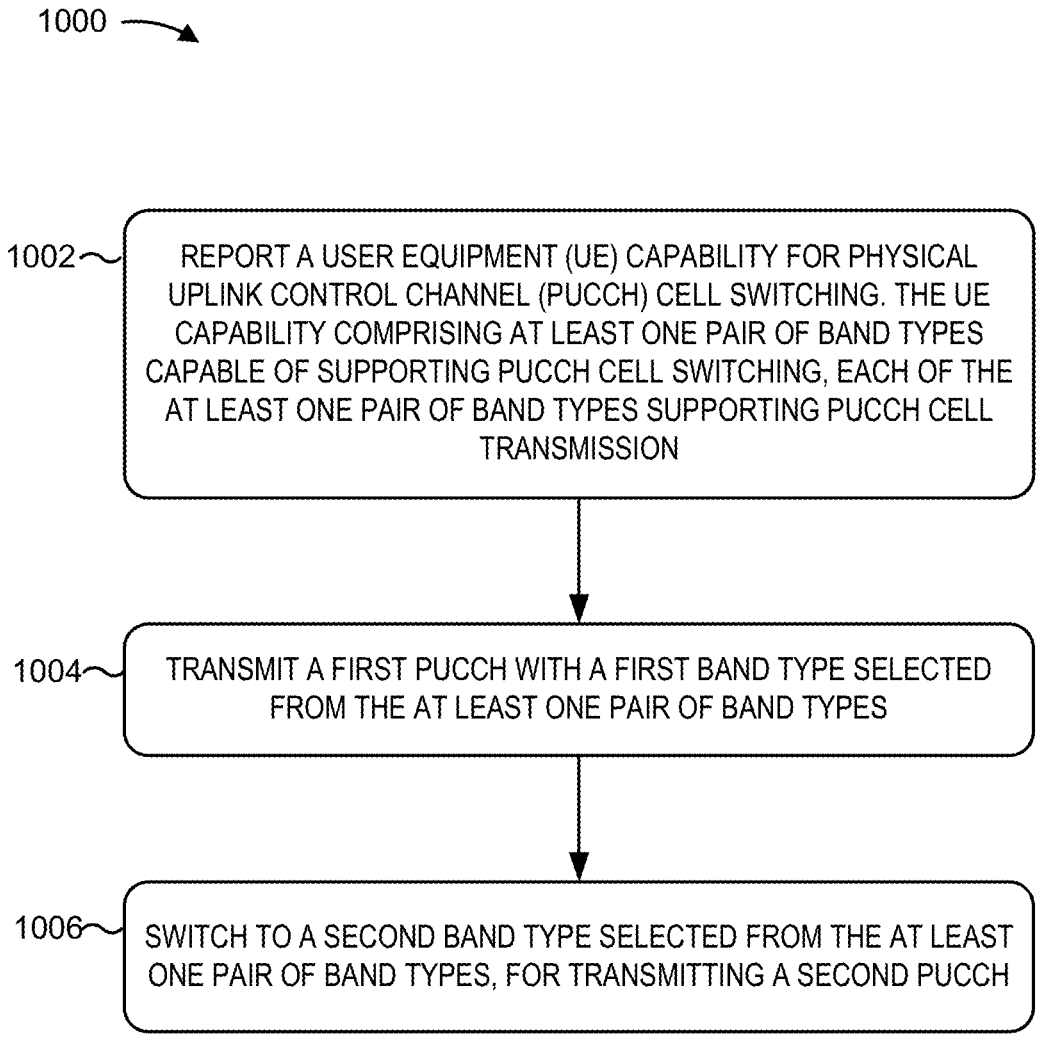

1000
1002
REPORT A USER EQUIPMENT (UE) CAPABILITY FOR PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) CELL SWITCHING. THE UE CAPABILITY COMPRISING AT LEAST ONE PAIR OF BAND TYPES CAPABLE OF SUPPORTING PUCCH CELL SWITCHING, EACH OF THE AT LEAST ONE PAIR OF BAND TYPES SUPPORTING PUCCH CELL TRANSMISSION
1004
TRANSMIT A FIRST PUCCH WITH A FIRST BAND TYPE SELECTED FROM THE AT LEAST ONE PAIR OF BAND TYPES
1006
SWITCH TO A SECOND BAND TYPE SELECTED FROM THE AT LEAST ONE PAIR OF BAND TYPES, FOR TRANSMITTING A SECOND PUCCH

FIG. 10

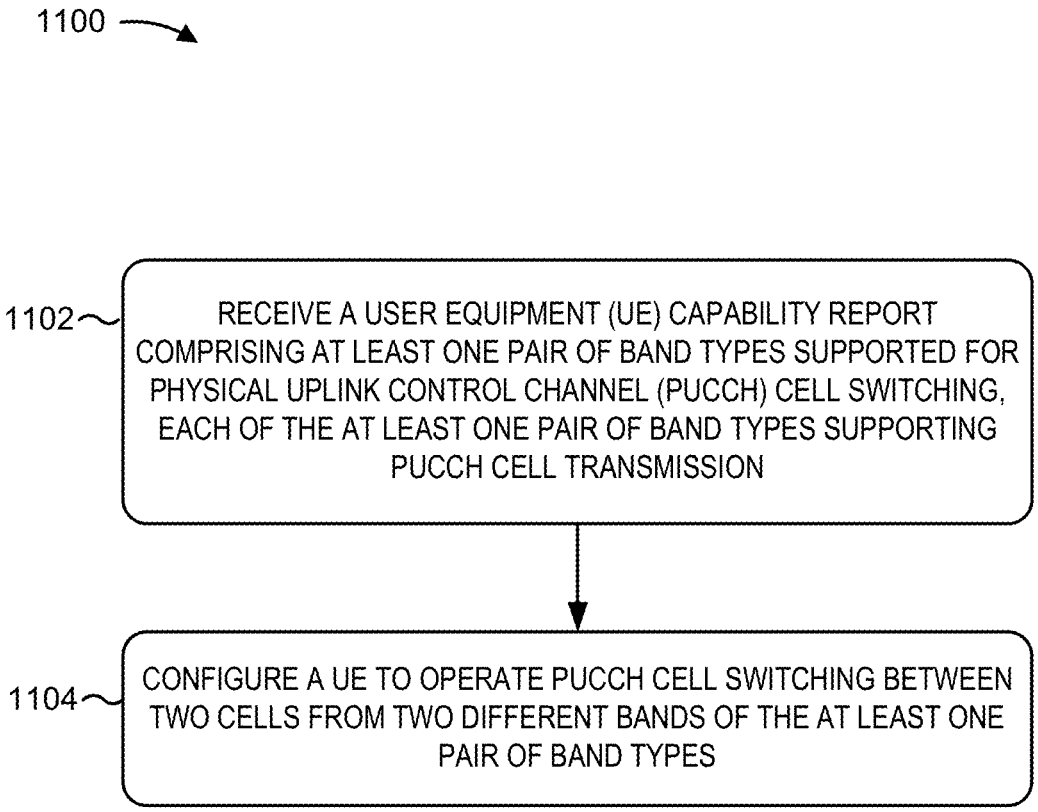

1100
1102
RECEIVE A USER EQUIPMENT (UE) CAPABILITY REPORT COMPRISING AT LEAST ONE PAIR OF BAND TYPES SUPPORTED FOR PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) CELL SWITCHING, EACH OF THE AT LEAST ONE PAIR OF BAND TYPES SUPPORTING PUCCH CELL TRANSMISSION
1104
CONFIGURE A UE TO OPERATE PUCCH CELL SWITCHING BETWEEN TWO CELLS FROM TWO DIFFERENT BANDS OF THE AT LEAST ONE PAIR OF BAND TYPES

FIG. 11

USER EQUIPMENT (UE) CAPABILITY SIGNALING FOR PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) CELL SWITCHING

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present application claims the benefit of U.S. Provisional Patent Application No. 63/333,957, filed on Apr. 22, 2022, and titled "USER EQUIPMENT (UE) CAPABILITY SIGNALING FOR PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) CELL SWITCHING," the disclosure of which is expressly incorporated by reference in its entirety.

FIELD OF THE DISCLOSURE

[0002] The present disclosure relates generally to wireless communications, and more specifically to user equipment (UE) capability signaling for physical uplink control channel (PUCCH) cell switching.

BACKGROUND

[0003] Wireless communications systems are widely deployed to provide various telecommunications services such as telephony, video, data, messaging, and broadcasts. Typical wireless communications systems may employ multiple-access technologies capable of supporting communications with multiple users by sharing available system resources (e.g., bandwidth, transmit power, and/or the like). Examples of such multiple-access technologies include code division multiple access (CDMA) systems, time division multiple access (TDMA) systems, frequency-division multiple access (FDMA) systems, orthogonal frequency-division multiple access (OFDMA) systems, single-carrier frequency-division multiple access (SC-FDMA) systems, time division synchronous code division multiple access (TD-SCDMA) systems, and long term evolution (LTE). LTE/LTE-Advanced is a set of enhancements to the universal mobile telecommunications system (UMTS) mobile standard promulgated by the Third Generation Partnership Project (3GPP). Narrowband (NB)-Internet of things (IoT) and enhanced machine-type communications (eMTC) are a set of enhancements to LTE for machine type communications.

[0004] A wireless communications network may include a number of base stations (BSs) that can support communications for a number of user equipment (UEs). A UE may communicate with a base station (BS) via the downlink and uplink. The downlink (or forward link) refers to the communications link from the BS to the UE, and the uplink (or reverse link) refers to the communications link from the UE to the BS. As will be described in more detail, a BS may be referred to as a Node B, an evolved Node B (eNB), a gNB, an access point (AP), a radio head, a transmit and receive point (TRP), a new radio (NR) BS, a 5G Node B, and/or the like.

[0005] The above multiple access technologies have been adopted in various telecommunications standards to provide a common protocol that enables different UEs to communicate on a municipal, national, regional, and even global level. New radio (NR), which may also be referred to as 5G, is a set of enhancements to the LTE mobile standard promulgated by the Third Generation Partnership Project (3GPP). NR is designed to better support mobile broadband Internet access by improving spectral efficiency, lowering costs, improving services, making use of new spectrum, and better integrating with other open standards using orthogonal frequency division multiplexing (OFDM) with a cyclic prefix (CP) (CP-OFDM) on the downlink (DL), using CP-OFDM and/or SC-FDM (e.g., also known as discrete Fourier transform spread OFDM (DFT-s-OFDM)) on the uplink (UL), as well as supporting beamforming, multiple-input multiple-output (MIMO) antenna technology, and carrier aggregation.

SUMMARY

[0006] In aspects of the present disclosure, a method of wireless communication, by a user equipment (UE), includes reporting a UE capability for physical uplink control channel (PUCCH) cell switching. The UE capability includes at least one pair of band types capable of supporting PUCCH cell switching, each band type of the at least one pair of band types supporting PUCCH cell transmission. The method also includes transmitting a first PUCCH with a first band type selected from the at least one pair of band types. The method further includes switching to a second band type selected from the at least one pair of band types, for transmitting a second PUCCH.

[0007] In other aspects of the present disclosure, a method of wireless communication by a network device includes receiving a user equipment (UE) capability report. The UE capability report includes at least one pair of band types supported for PUCCH cell switching. Each band type of the at least one pair of band types supports PUCCH cell transmission. The method also includes configuring a UE to operate PUCCH cell switching between two cells from two different bands of the at least one pair of band types.

[0008] Other aspects of the present disclosure are directed to an apparatus for wireless communication. The apparatus has a memory and one or more processor(s) coupled to the memory. The processor(s) is configured to report a UE capability for PUCCH cell switching. The UE capability has at least one pair of band types capable of supporting PUCCH cell switching. Each band type of the at least one pair of band types supports PUCCH cell transmission. The processor(s) is also configured to transmit a first PUCCH with a first band type selected from the at least one pair of band types. The processor(s) is further configured to switch to a second band type selected from the at least one pair of band types, for transmitting a second PUCCH.

[0009] Other aspects of the present disclosure are directed to an apparatus for wireless communication. The apparatus has a memory and one or more processor(s) coupled to the memory. The processor(s) is configured to receive a UE capability report. The UE capability report has at least one pair of band types supported for PUCCH cell switching. Each band type of the at least one pair of band types supports PUCCH cell transmission. The processor(s) is also configured a UE to operate PUCCH cell switching between two cells from two different bands of the at least one pair of band types.

[0010] Other aspects of the present disclosure are directed to an apparatus for wireless communication. The apparatus includes means for reporting a UE capability for PUCCH cell switching. The UE capability has at least one pair of band types capable of supporting PUCCH cell switching. Each band type of the at least one pair of band types supports PUCCH cell transmission. The apparatus also includes

means for transmitting a first PUCCH with a first band type selected from the at least one pair of band types. The apparatus further includes means for switching to a second band type selected from the at least one pair of band types, for transmitting a second PUCCH.

[0011] Other aspects of the present disclosure are directed to an apparatus for wireless communication. The apparatus includes means for receiving a UE capability report comprising at least one pair of band types supported for PUCCH cell switching, each band type of the at least one pair of band types supporting PUCCH cell transmission. The apparatus also includes means for configuring a UE to operate PUCCH cell switching between two cells from two different bands of the at least one pair of band types.

[0012] Other aspects relate to a non-transitory computer-readable medium having program code recorded thereon. The program code is executed by a processor and comprises program code to report a UE capability for PUCCH cell switching, the UE capability comprising at least one pair of band types capable of supporting PUCCH cell switching, each band type of the at least one pair of band types supporting PUCCH cell transmission. The program code also comprises program code to transmit a first PUCCH with a first band type selected from the at least one pair of band types; and program code to switch to a second band type selected from the at least one pair of band types, for transmitting a second PUCCH.

[0013] In still other aspects, a non-transitory computer-readable medium has program code recorded thereon. The program code is executed by a processor and comprises program code to receive a UE capability report comprising at least one pair of band types supported for PUCCH cell switching, each band type of the at least one pair of band types supporting PUCCH cell transmission. The program code also includes program code to configure a UE to operate PUCCH cell switching between two cells from two different bands of the at least one pair of band types.

[0014] Aspects generally include a method, apparatus, system, computer program product, non-transitory computer-readable medium, user equipment, base station, wireless communications device, and processing system as substantially described with reference to and as illustrated by the accompanying drawings and specification.

[0015] The foregoing has outlined rather broadly the features and technical advantages of examples according to the disclosure in order that the detailed description that follows may be better understood. Additional features and advantages will be described. The conception and specific examples disclosed may be readily utilized as a basis for modifying or designing other structures for carrying out the same purposes of the present disclosure. Such equivalent constructions do not depart from the scope of the appended claims. Characteristics of the concepts disclosed, both their organization and method of operation, together with associated advantages will be better understood from the following description when considered in connection with the accompanying figures. Each of the figures is provided for the purposes of illustration and description, and not as a definition of the limits of the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] So that features of the present disclosure can be understood in detail, a particular description may be had by reference to aspects, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only certain aspects of this disclosure and are therefore not to be considered limiting of its scope, for the description may admit to other equally effective aspects. The same reference numbers in different drawings may identify the same or similar elements.

[0017] FIG. **1** is a block diagram conceptually illustrating an example of a wireless communications network, in accordance with various aspects of the present disclosure.

[0018] FIG. **2** is a block diagram conceptually illustrating an example of a base station in communication with a user equipment (UE) in a wireless communications network, in accordance with various aspects of the present disclosure.

[0019] FIG. **3** is a block diagram illustrating an example disaggregated base station.

[0020] FIG. **4** is a timing diagram illustrating a physical uplink control channel (PUCCH) group, in accordance with various aspects of the present disclosure.

[0021] FIG. **5** is a block diagram illustrating band combinations, in accordance with various aspects of the present disclosure.

[0022] FIG. **6** is a diagram illustrating an exemplary physical uplink control channel (PUCCH) capability report structure, in accordance with various aspects of the present disclosure.

[0023] FIG. **7** is a diagram illustrating an exemplary PUCCH capability report structure for multiple configurations, in accordance with various aspects of the present disclosure.

[0024] FIG. **8** is a diagram illustrating an exemplary PUCCH capability report structure for PUCCH cell switching, in accordance with various aspects of the present disclosure.

[0025] FIG. **9** is a diagram illustrating an exemplary PUCCH capability report structure for when all band type pair combinations are not supported, in accordance with various aspects of the present disclosure.

[0026] FIG. **10** is a flow diagram illustrating an example process performed, for example, by a user equipment (UE), in accordance with various aspects of the present disclosure.

[0027] FIG. **11** is a flow diagram illustrating an example process performed, for example, by a network device, in accordance with various aspects of the present disclosure.

DETAILED DESCRIPTION

[0028] Various aspects of the disclosure are described more fully below with reference to the accompanying drawings. This disclosure may, however, be embodied in many different forms and should not be construed as limited to any specific structure or function presented throughout this disclosure. Rather, these aspects are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the disclosure to those skilled in the art. Based on the teachings, one skilled in the art should appreciate that the scope of the disclosure is intended to cover any aspect of the disclosure, whether implemented independently of or combined with any other aspect of the disclosure. For example, an apparatus may be implemented or a method may be practiced using any number of the aspects set forth. In addition, the scope of the disclosure is intended to cover such an apparatus or method, which is practiced using other structure, functionality, or structure and functionality in addition to or other than the various aspects of

the disclosure set forth. It should be understood that any aspect of the disclosure disclosed may be embodied by one or more elements of a claim.

[0029] Several aspects of telecommunications systems will now be presented with reference to various apparatuses and techniques. These apparatuses and techniques will be described in the following detailed description and illustrated in the accompanying drawings by various blocks, modules, components, circuits, steps, processes, algorithms, and/or the like (collectively referred to as "elements"). These elements may be implemented using hardware, software, or combinations thereof. Whether such elements are implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system.

[0030] It should be noted that while aspects may be described using terminology commonly associated with 5G and later wireless technologies, aspects of the present disclosure can be applied in other generation-based communications systems, such as and including 3G and/or 4G technologies.

[0031] A physical uplink control channel (PUCCH) group is a group of cells for uplink transmissions in a carrier aggregation configuration. Previously, a PUCCH was only permitted to be transmitted on a primary cell (Pcell) of the carrier aggregation configuration. PUCCH cell switching has since been introduced to allow PUCCH switching between a primary cell and a single additional secondary cell (Scell). One reason for allowing the PUCCH cell switch is to reduce PUCCH feedback latency and improve PUCCH reliability. The PUCCH cell switching applies to all PUCCH types.

[0032] It would be beneficial to define a user equipment (UE) capability report structure to enable a UE to indicate support of PUCCH cell switching. If the feature is supported, the structure should provide details for supporting the PUCCH cell switch feature.

[0033] In some aspects of the present disclosure, a UE reports at least one pair of band types that can support a PUCCH cell switch. Each of these reported band types is selected from band types supporting PUCCH cell transmission. That is, the UE may select each band type from a list of supported band types for PUCCH transmission in a PUCCH group of a configuration of a band combination in carrier aggregation.

[0034] If multiple PUCCH grouping configurations are available for a particular band combination, the UE may report the PUCCH cell switch capability for each PUCCH grouping configuration of the band combination. If multiple PUCCH groups are available for a PUCCH grouping configuration of the band combination, the UE may report the PUCCH cell switch capability for each PUCCH group of each PUCCH grouping configuration for the band combination. In some aspects, the UE does not report all combinations of band type pairs.

[0035] Once a base station receives the UE capability report (including at least one pair of band types), the base station may configure the UE to operate PUCCH cell switching between two cells from two different bands of the at least one pair of band types. The configuration may be a per band combination, a per PUCCH group, and/or a per PUCCH grouping configuration of each band combination.

[0036] Reporting the PUCCH cell switch capability in accordance with the described structure reduces report signaling overhead.

[0037] FIG. **1** is a diagram illustrating a network **100** in which aspects of the present disclosure may be practiced. The network **100** may be a 5G or NR network or some other wireless network, such as an LTE network. The wireless network **100** may include a number of BSs **110** (shown as BS **110***a*, BS **110***b*, BS **110***c*, and BS **110***d*) and other network entities. A BS is an entity that communicates with user equipment (UEs) and may also be referred to as a base station, an NR BS, a Node B, a gNB, a 5G Node B, an access point, a transmit and receive point (TRP), a network node, a network entity, and/or the like. A base station can be implemented as an aggregated base station, as a disaggregated base station, an integrated access and backhaul (IAB) node, a relay node, a sidelink node, etc. The base station can be implemented in an aggregated or monolithic base station architecture, or alternatively, in a disaggregated base station architecture, and may include one or more of a central unit (CU), a distributed unit (DU), a radio unit (RU), a near-real time (near-RT) RAN intelligent controller (RIC), or a non-real time (non-RT) RIC.

[0038] Each BS may provide communications coverage for a particular geographic area. In 3GPP, the term "cell" can refer to a coverage area of a BS and/or a BS subsystem serving this coverage area, depending on the context in which the term is used.

[0039] A BS may provide communications coverage for a macro cell, a pico cell, a femto cell, and/or another type of cell. A macro cell may cover a relatively large geographic area (e.g., several kilometers in radius) and may allow unrestricted access by UEs with service subscription. A pico cell may cover a relatively small geographic area and may allow unrestricted access by UEs with service subscription. A femto cell may cover a relatively small geographic area (e.g., a home) and may allow restricted access by UEs having association with the femto cell (e.g., UEs in a closed subscriber group (CSG)). A BS for a macro cell may be referred to as a macro BS. A BS for a pico cell may be referred to as a pico BS. A BS for a femto cell may be referred to as a femto BS or a home BS. In the example shown in FIG. **1**, a BS **110***a* may be a macro BS for a macro cell **102***a*, a BS **110***b* may be a pico BS for a pico cell **102***b*, and a BS **110***c* may be a femto BS for a femto cell **102***c*. ABS may support one or multiple (e.g., three) cells. The terms "eNB," "base station," "NR BS," "gNB," "AP," "Node B," "5G NB," "TRP," and "cell" may be used interchangeably.

[0040] In some aspects, a cell may not necessarily be stationary, and the geographic area of the cell may move according to the location of a mobile BS. In some aspects, the BSs may be interconnected to one another and/or to one or more other BSs or network nodes (not shown) in the wireless network **100** through various types of backhaul interfaces such as a direct physical connection, a virtual network, and/or the like using any suitable transport network.

[0041] The wireless network **100** may also include relay stations. A relay station is an entity that can receive a transmission of data from an upstream station (e.g., a BS or a UE) and send a transmission of the data to a downstream station (e.g., a UE or a BS). A relay station may also be a UE that can relay transmissions for other UEs. In the example shown in FIG. **1**, a relay station **110***d* may communicate with

macro BS **110***a* and a UE **120***d* in order to facilitate communications between the BS **110***a* and UE **120***d*. A relay station may also be referred to as a relay BS, a relay base station, a relay, and/or the like.

[0042] The wireless network **100** may be a heterogeneous network that includes BSs of different types (e.g., macro BSs, pico BSs, femto BSs, relay BSs, and/or the like). These different types of BSs may have different transmit power levels, different coverage areas, and different impact on interference in the wireless network **100**. For example, macro BSs may have a high transmit power level (e.g., 5 to 40 watts) whereas pico BSs, femto BSs, and relay BSs may have lower transmit power levels (e.g., 0.1 to 2 watts).

[0043] As an example, the BSs **110** (shown as BS **110***a*, BS **110***b*, BS **110***c*, and BS **110***d*) and the core network **130** may exchange communications via backhaul links **132** (e.g., S1, etc.). Base stations **110** may communicate with one another over other backhaul links (e.g., X2, etc.) either directly or indirectly (e.g., through core network **130**).

[0044] The core network **130** may be an evolved packet core (EPC), which may include at least one mobility management entity (MME), at least one serving gateway (S-GW), and at least one packet data network (PDN) gateway (P-GW). The MME may be the control node that processes the signaling between the UEs **120** and the EPC. All user IP packets may be transferred through the S-GW, which itself may be connected to the P-GW. The P-GW may provide IP address allocation as well as other functions. The P-GW may be connected to the network operator's IP services. The operator's IP services may include the Internet, the Intranet, an IP multimedia subsystem (IMS), and a packet-switched (PS) streaming service.

[0045] The core network **130** may provide user authentication, access authorization, tracking, IP connectivity, and other access, routing, or mobility functions. One or more of the base stations **110** or access node controllers (ANCs) may interface with the core network **130** through backhaul links **132** (e.g., S1, S2, etc.) and may perform radio configuration and scheduling for communications with the UEs **120**. In some configurations, various functions of each access network entity or base station **110** may be distributed across various network devices (e.g., radio heads and access network controllers) or consolidated into a single network device (e.g., a base station **110**).

[0046] UEs **120** (e.g., **120***a*, **120***b*, **120***c*) may be dispersed throughout the wireless network **100**, and each UE may be stationary or mobile. A UE may also be referred to as an access terminal, a terminal, a mobile station, a subscriber unit, a station, and/or the like. A UE may be a cellular phone (e.g., a smart phone), a personal digital assistant (PDA), a wireless modem, a wireless communications device, a handheld device, a laptop computer, a cordless phone, a wireless local loop (WLL) station, a tablet, a camera, a gaming device, a netbook, a smartbook, an ultrabook, a medical device or equipment, biometric sensors/devices, wearable devices (smart watches, smart clothing, smart glasses, smart wrist bands, smart jewelry (e.g., smart ring, smart bracelet)), an entertainment device (e.g., a music or video device, or a satellite radio), a vehicular component or sensor, smart meters/sensors, industrial manufacturing equipment, a global positioning system device, or any other suitable device that is configured to communicate via a wireless or wired medium.

[0047] One or more UEs **120** may establish a protocol data unit (PDU) session for a network slice. In some cases, the UE **120** may select a network slice based on an application or subscription service. By having different network slices serving different applications or subscriptions, the UE **120** may improve its resource utilization in the wireless network **100**, while also satisfying performance specifications of individual applications of the UE **120**. In some cases, the network slices used by UE **120** may be served by an AMF (not shown in FIG. **1**) associated with one or both of the base station **110** or core network **130**. In addition, session management of the network slices may be performed by an access and mobility management function (AMF).

[0048] The UEs **120** may include a PUCCH cell switch configuration module **140**. For brevity, only one UE **120***d* is shown as including the PUCCH cell switch configuration module **140**. The PUCCH cell switch configuration module **140** may report a UE capability for physical uplink control channel (PUCCH) cell switching. The UE capability includes at least one pair of band types capable of supporting PUCCH cell switching, each band type of the at least one pair of band types supporting PUCCH cell transmission. The PUCCH cell switch configuration module **140** may also transmit a first PUCCH with a first band type selected from the at least one pair of band types. The PUCCH cell switch configuration module **140** may further switch to a second band type selected from the at least one pair of band types, for transmitting a second PUCCH.

[0049] The core network **130** or the base stations **110** may include a PUCCH cell switch configuration module **138**. For brevity, only one base station **110***a* is shown as including the PUCCH cell switch configuration module **138**. The PUCCH cell switch configuration module **138** may receive a user equipment (UE) capability report. The UE capability report includes at least one pair of band types supported for physical uplink control channel (PUCCH) cell switching. Each band type of the at least one pair of band types supports PUCCH cell transmission. The PUCCH cell switch configuration module **138** may also configure a UE to operate PUCCH cell switching between two cells from two different bands of the at least one pair of band types.

[0050] Some UEs may be considered machine-type communications (MTC) or evolved or enhanced machine-type communications (eMTC) UEs. MTC and eMTC UEs include, for example, robots, drones, remote devices, sensors, meters, monitors, location tags, and/or the like, that may communicate with a base station, another device (e.g., remote device), or some other entity. A wireless node may provide, for example, connectivity for or to a network (e.g., a wide area network such as Internet or a cellular network) via a wired or wireless communications link. Some UEs may be considered Internet-of-Things (IoT) devices, and/or may be implemented as NB-IoT (narrowband internet of things) devices. Some UEs may be considered a customer premises equipment (CPE). UE **120** may be included inside a housing that houses components of UE **120**, such as processor components, memory components, and/or the like.

[0051] In general, any number of wireless networks may be deployed in a given geographic area. Each wireless network may support a particular radio access technology (RAT) and may operate on one or more frequencies. A RAT may also be referred to as a radio technology, an air interface, and/or the like. A frequency may also be referred to as a carrier, a frequency channel, and/or the like. Each

frequency may support a single RAT in a given geographic area in order to avoid interference between wireless networks of different RATs. In some cases, NR or 5G RAT networks may be deployed.

[0052] In some aspects, two or more UEs **120** (e.g., shown as UE **120***a* and UE **120***e*) may communicate directly using one or more sidelink channels (e.g., without using a base station **110** as an intermediary to communicate with one another). For example, the UEs **120** may communicate using peer-to-peer (P2P) communications, device-to-device (D2D) communications, a vehicle-to-everything (V2X) protocol (e.g., which may include a vehicle-to-vehicle (V2V) protocol, a vehicle-to-infrastructure (V2I) protocol, and/or the like), a mesh network, and/or the like. In this case, the UE **120** may perform scheduling operations, resource selection operations, and/or other operations described elsewhere as being performed by the base station **110**. For example, the base station **110** may configure a UE **120** via downlink control information (DCI), radio resource control (RRC) signaling, a media access control-control element (MAC-CE) or via system information (e.g., a system information block (SIB).

[0053] As indicated above, FIG. **1** is provided merely as an example. Other examples may differ from what is described with regard to FIG. **1**.

[0054] FIG. **2** shows a block diagram of a design **200** of the base station **110** and UE **120**, which may be one of the base stations and one of the UEs in FIG. **1**. The base station **110** may be equipped with T antennas **234***a* through **234***t*, and UE **120** may be equipped with R antennas **252***a* through **252***r*, where in general T≥1 and R≥1.

[0055] At the base station **110**, a transmit processor **220** may receive data from a data source **212** for one or more UEs, select one or more modulation and coding schemes (MCS) for each UE based at least in part on channel quality indicators (CQIs) received from the UE, process (e.g., encode and modulate) the data for each UE based at least in part on the MCS(s) selected for the UE, and provide data symbols for all UEs. Decreasing the MCS lowers throughput but increases reliability of the transmission. The transmit processor **220** may also process system information (e.g., for semi-static resource partitioning information (SRPI) and/or the like) and control information (e.g., CQI requests, grants, upper layer signaling, and/or the like) and provide overhead symbols and control symbols. The transmit processor **220** may also generate reference symbols for reference signals (e.g., the cell-specific reference signal (CRS)) and synchronization signals (e.g., the primary synchronization signal (PSS) and secondary synchronization signal (SSS)). A transmit (TX) multiple-input multiple-output (MIMO) processor **230** may perform spatial processing (e.g., precoding) on the data symbols, the control symbols, the overhead symbols, and/or the reference symbols, if applicable, and may provide T output symbol streams to T modulators (MODs) **232***a* through **232***t*. Each modulator **232** may process a respective output symbol stream (e.g., for orthogonal frequency division multiplexing (OFDM) and/or the like) to obtain an output sample stream. Each modulator **232** may further process (e.g., convert to analog, amplify, filter, and upconvert) the output sample stream to obtain a downlink signal. T downlink signals from modulators **232***a* through **232***t* may be transmitted via T antennas **234***a* through **234***t*, respectively. According to various aspects described in more detail below, the synchronization signals can be generated with location encoding to convey additional information.

[0056] At the UE **120**, antennas **252***a* through **252***r* may receive the downlink signals from the base station **110** and/or other base stations and may provide received signals to demodulators (DEMODs) **254***a* through **254***r*, respectively. Each demodulator **254** may condition (e.g., filter, amplify, downconvert, and digitize) a received signal to obtain input samples. Each demodulator **254** may further process the input samples (e.g., for OFDM and/or the like) to obtain received symbols. A MIMO detector **256** may obtain received symbols from all R demodulators **254***a* through **254***r*, perform MIMO detection on the received symbols if applicable, and provide detected symbols. A receive processor **258** may process (e.g., demodulate and decode) the detected symbols, provide decoded data for the UE **120** to a data sink **260**, and provide decoded control information and system information to a controller/processor **280**. A channel processor may determine reference signal received power (RSRP), received signal strength indicator (RSSI), reference signal received quality (RSRQ), channel quality indicator (CQI), and/or the like. In some aspects, one or more components of the UE **120** may be included in a housing.

[0057] On the uplink, at the UE **120**, a transmit processor **264** may receive and process data from a data source **262** and control information (e.g., for reports comprising RSRP, RSSI, RSRQ, CQI, and/or the like) from the controller/processor **280**. Transmit processor **264** may also generate reference symbols for one or more reference signals. The symbols from the transmit processor **264** may be precoded by a TX MIMO processor **266** if applicable, further processed by modulators **254***a* through **254***r* (e.g., for DFT-s-OFDM, CP-OFDM, and/or the like), and transmitted to the base station **110**. At the base station **110**, the uplink signals from the UE **120** and other UEs may be received by the antennas **234**, processed by the demodulators **254**, detected by a MIMO detector **236** if applicable, and further processed by a receive processor **238** to obtain decoded data and control information sent by the UE **120**. The receive processor **238** may provide the decoded data to a data sink **239** and the decoded control information to a controller/processor **240**. The base station **110** may include communications unit **244** and communicate to the core network **130** via the communications unit **244**. The core network **130** may include a communications unit **294**, a controller/processor **290**, and a memory **292**.

[0058] The controller/processor **240** of the base station **110**, the controller/processor **280** of the UE **120**, and/or any other component(s) of FIG. **2** may perform one or more techniques associated with PUCCH cell switching, as described in more detail elsewhere. For example, the controller/processor **240** of the base station **110**, the controller/processor **280** of the UE **120**, and/or any other component(s) of FIG. **2** may perform or direct operations of, for example, the processes of FIGS. **4** and **5** and/or other processes as described. Memories **242** and **282** may store data and program codes for the base station **110** and UE **120**, respectively. A scheduler **246** may schedule UEs for data transmission on the downlink and/or uplink.

[0059] In some aspects, the UE **120** may include means for reporting, means for transmitting, means for switching, and/or means for selecting. Such means may include one or

more components of the UE **120** or base station **110** described in connection with FIG. **2**.

[0060] In some aspects, the base station **110** may include means for receiving, and/or means for configuring. Such means may include one or more components of the UE **120** or base station **110** described in connection with FIG. **2**.

[0061] As indicated above, FIG. **2** is provided merely as an example. Other examples may differ from what is described with regard to FIG. **2**.

[0062] Deployment of communication systems, such as 5G new radio (NR) systems, may be arranged in multiple manners with various components or constituent parts. In a 5G NR system, or network, a network node, a network entity, a mobility element of a network, a radio access network (RAN) node, a core network node, a network element, or a network equipment, such as a base station (BS), or one or more units (or one or more components) performing base station functionality, may be implemented in an aggregated or disaggregated architecture. For example, a BS (such as a Node B (NB), an evolved NB (eNB), an NR BS, 5G NB, an access point (AP), a transmit and receive point (TRP), or a cell, etc.) may be implemented as an aggregated base station (also known as a standalone BS or a monolithic BS) or a disaggregated base station.

[0063] An aggregated base station may be configured to utilize a radio protocol stack that is physically or logically integrated within a single RAN node. A disaggregated base station may be configured to utilize a protocol stack that is physically or logically distributed among two or more units (such as one or more central or centralized units (CUs), one or more distributed units (DUs), or one or more radio units (RUs)). In some aspects, a CU may be implemented within a RAN node, and one or more DUs may be co-located with the CU, or alternatively, may be geographically or virtually distributed throughout one or multiple other RAN nodes. The DUs may be implemented to communicate with one or more RUs. Each of the CU, DU, and RU also can be implemented as virtual units (e.g., a virtual central unit (VCU), a virtual distributed unit (VDU), or a virtual radio unit (VRU)).

[0064] Base station-type operations or network designs may consider aggregation characteristics of base station functionality. For example, disaggregated base stations may be utilized in an integrated access backhaul (IAB) network, an open radio access network (O-RAN (such as the network configuration sponsored by the O-RAN Alliance)), or a virtualized radio access network (vRAN, also known as a cloud radio access network (C-RAN)). Disaggregation may include distributing functionality across two or more units at various physical locations, as well as distributing functionality for at least one unit virtually, which can enable flexibility in network design. The various units of the disaggregated base station, or disaggregated RAN architecture, can be configured for wired or wireless communication with at least one other unit.

[0065] FIG. **3** shows a diagram illustrating an example disaggregated base station **300** architecture. The disaggregated base station **300** architecture may include one or more central units (CUs) **310** that can communicate directly with a core network **320** via a backhaul link, or indirectly with the core network **320** through one or more disaggregated base station units (such as a near-real time (near-RT) RAN intelligent controller (RIC) **325** via an E2 link, or a non-real time (non-RT) RIC **315** associated with a service management and orchestration (SMO) framework **305**, or both). A CU **310** may communicate with one or more distributed units (DUs) **330** via respective midhaul links, such as an F1 interface. The DUs **330** may communicate with one or more radio units (RUs) **340** via respective fronthaul links. The RUs **340** may communicate with respective UEs **120** via one or more radio frequency (RF) access links. In some implementations, the UE **120** may be simultaneously served by multiple RUs **340**.

[0066] Each of the units (e.g., the CUs **310**, the DUs **330**, the RUs **340**, as well as the near-RT RICs **325**, the non-RT RICs **315**, and the SMO framework **305**) may include one or more interfaces or be coupled to one or more interfaces configured to receive or transmit signals, data, or information (collectively, signals) via a wired or wireless transmission medium. Each of the units, or an associated processor or controller providing instructions to the communication interfaces of the units, can be configured to communicate with one or more of the other units via the transmission medium. For example, the units can include a wired interface configured to receive or transmit signals over a wired transmission medium to one or more of the other units. Additionally, the units can include a wireless interface, which may include a receiver, a transmitter or transceiver (such as a radio frequency (RF) transceiver), configured to receive or transmit signals, or both, over a wireless transmission medium to one or more of the other units.

[0067] In some aspects, the CU **310** may host one or more higher layer control functions. Such control functions can include radio resource control (RRC), packet data convergence protocol (PDCP), service data adaptation protocol (SDAP), or the like. Each control function can be implemented with an interface configured to communicate signals with other control functions hosted by the CU **310**. The CU **310** may be configured to handle user plane functionality (e.g., central unit-user plane (CU-UP)), control plane functionality (e.g., central unit-control plane (CU-CP)), or a combination thereof. In some implementations, the CU **310** can be logically split into one or more CU-UP units and one or more CU-CP units. The CU-UP unit can communicate bi-directionally with the CU-CP unit via an interface, such as the E1 interface when implemented in an O-RAN configuration. The CU **310** can be implemented to communicate with the DU **330**, as necessary, for network control and signaling.

[0068] The DU **330** may correspond to a logical unit that includes one or more base station functions to control the operation of one or more RUs **340**. In some aspects, the DU **330** may host one or more of a radio link control (RLC) layer, a medium access control (MAC) layer, and one or more high physical (PHY) layers (such as modules for forward error correction (FEC) encoding and decoding, scrambling, modulation and demodulation, or the like) depending, at least in part, on a functional split, such as those defined by the Third Generation Partnership Project (3GPP). In some aspects, the DU **330** may further host one or more low PHY layers. Each layer (or module) can be implemented with an interface configured to communicate signals with other layers (and modules) hosted by the DU **330**, or with the control functions hosted by the CU **310**.

[0069] Lower-layer functionality can be implemented by one or more RUs **340**. In some deployments, an RU **340**, controlled by a DU **330**, may correspond to a logical node that hosts RF processing functions, or low-PHY layer func-

tions (such as performing fast Fourier transform (FFT), inverse FFT (iFFT), digital beamforming, physical random access channel (PRACH) extraction and filtering, or the like), or both, based at least in part on the functional split, such as a lower layer functional split. In such an architecture, the RU(s) **340** can be implemented to handle over the air (OTA) communication with one or more UEs **120**. In some implementations, real-time and non-real-time aspects of control and user plane communication with the RU(s) **340** can be controlled by the corresponding DU **330**. In some scenarios, this configuration can enable the DU(s) **330** and the CU **310** to be implemented in a cloud-based RAN architecture, such as a vRAN architecture.

[0070] The SMO Framework **305** may be configured to support RAN deployment and provisioning of non-virtualized and virtualized network elements. For non-virtualized network elements, the SMO Framework **305** may be configured to support the deployment of dedicated physical resources for RAN coverage requirements, which may be managed via an operations and maintenance interface (such as an O1 interface). For virtualized network elements, the SMO Framework **305** may be configured to interact with a cloud computing platform (such as an open cloud (O-cloud) **390**) to perform network element life cycle management (such as to instantiate virtualized network elements) via a cloud computing platform interface (such as an O2 interface). Such virtualized network elements can include, but are not limited to, CUs **310**, DUs **330**, RUs **340**, and near-RT RICs **325**. In some implementations, the SMO Framework **305** can communicate with a hardware aspect of a 4G RAN, such as an open eNB (O-eNB) **311**, via an O1 interface. Additionally, in some implementations, the SMO Framework **305** can communicate directly with one or more RUs **340** via an O1 interface. The SMO Framework **305** also may include a non-RT RIC **315** configured to support functionality of the SMO Framework **305**.

[0071] The non-RT RIC **315** may be configured to include a logical function that enables non-real-time control and optimization of RAN elements and resources, artificial intelligence/machine learning (AI/ML) workflows including model training and updates, or policy-based guidance of applications/features in the near-RT RIC **325**. The non-RT RIC **315** may be coupled to or communicate with (such as via an A1 interface) the near-RT RIC **325**. The near-RT RIC **325** may be configured to include a logical function that enables near-real-time control and optimization of RAN elements and resources via data collection and actions over an interface (such as via an E2 interface) connecting one or more CUs **310**, one or more DUs **330**, or both, as well as the O-eNB **311**, with the near-RT RIC **325**.

[0072] In some implementations, to generate AI/ML models to be deployed in the near-RT RIC **325**, the non-RT RIC **315** may receive parameters or external enrichment information from external servers. Such information may be utilized by the near-RT RIC **325** and may be received at the SMO Framework **305** or the non-RT RIC **315** from non-network data sources or from network functions. In some examples, the non-RT RIC **315** or the near-RT RIC **325** may be configured to tune RAN behavior or performance. For example, the non-RT RIC **315** may monitor long-term trends and patterns for performance and employ AI/ML models to perform corrective actions through the SMO Framework **305** (such as reconfiguration via O1) or via creation of RAN management policies (such as A1 policies).

[0073] A physical uplink control channel (PUCCH) group is a group of cells for uplink transmissions in a carrier aggregation configuration. Previously, a PUCCH was only permitted to be transmitted on a primary cell (Pcell) of the carrier aggregation configuration. PUCCH cell switching has since been introduced to allow PUCCH switching between a primary cell and a single additional secondary cell (Scell). That is, one additional Scell can transmit PUCCH besides the Pcell in a PUCCH group. A reason for allowing the PUCCH cell switch is to reduce PUCCH feedback latency and improve PUCCH reliability. The PUCCH cell switching applies to all PUCCH types, including hybrid automatic repeat request (HARQ) acknowledgment (ACK), channel state information (CSI), and scheduling requests (SR) on the PUCCH.

[0074] FIG. **4** is a timing diagram illustrating a physical uplink control channel (PUCCH) group **400**, in accordance with various aspects of the present disclosure. In the example of FIG. **4**, the PUCCH group **400** includes a primary component carrier (PCC) **405**, a first secondary component carrier (SCC) **410**, and a second SCC **415**. The PCC **405** has first and second slots for downlink transmission (D), and a special slot (S), followed by an uplink slot (U). The pattern repeats. For the first SCC **410**, a special slot (S) is followed by an uplink slot (U) and then two downlink slots (D). The pattern repeats. The second SCC **415** has the same uplink downlink pattern as the first SCC **410**. In the example of FIG. **4**, PUCCH transmission is supported on the PCC **405** and the first SCC **410**. PUCCH transmission is not permitted on the second SCC **415**. Radio resource control (RRC) signaling configures the first SCC **410** for PUCCH transmission.

[0075] Both dynamic and semi-static cell switch modes are available. With dynamic cell switching, a downlink control information (DCI) field may indicate a target PUCCH cell for transmitting the PUCCH. The target PUCCH cell may be a Pcell or an Scell configured by RRC signaling. For semi-static cell switching, a cell switch time pattern may be configured by RRC signaling. This may occur without a dynamic scheduling DCI message. In the example of FIG. **4**, a cell switch time pattern starts with the first SCC **410** for two slots, and then switches to the PCC **405** for the next two slots. The pattern repeats. The PUCCH resource to transmit uplink control information (UCI) may be interpreted based on PUCCH resources configured on the target PUCCH cell.

[0076] It would be beneficial to define a UE capability report structure to enable a UE to indicate support of PUCCH cell switching. If the feature is supported, the structure should provide details for supporting the cell switch feature. UE capability reports are defined on a per band combination (BC) basis. Details of per band combination reporting are currently undefined.

[0077] Ideally, per band combination reports are exhaustive. That is, for each combination of {band X, band Y}, the UE reports whether it supports semi-static and dynamic PUCCH cell switching between one cell in band X and one cell in band Y. Given a total of N bands, a total number of bits for a per band combination report is C(N,2), where C(N,2) denotes the number of combinations for choosing two from N (e.g., N choose two).

[0078] FIG. **5** is a block diagram **500** illustrating band combinations, in accordance with various aspects of the present disclosure. In the example block diagram **500** shown

FIG. **5**, three bands are available: band 1, band 2, and band 3. In this example, three different band combinations are possible: {Pcell in band 1, Scell in band 2}, {Pcell in band 1, Scell in band 3}, and {Pcell in band 2, Scell in band 3}. If many bands are available, however, an exhaustive report may be large, incurring significant signaling overhead. According to aspects of the present disclosure, a UE capability report structure is presented that can reduce the report signaling overhead.

[0079] In some aspects of the present disclosure, a UE reports at least one pair of band types that can support a PUCCH cell switch. Each of these reported band types is selected from band types supporting PUCCH cell transmission. That is, the UE may select each band type from a list of supported band types for PUCCH transmission in a carrier aggregation configuration. For example, if a PUCCH cell includes a frequency range one (FR1) licensed time division duplexed (TDD) band type, an FR1 unlicensed TDD band type, an FR1 licensed frequency division duplexed (FDD) band type, and a frequency range two (FR2) band type, the PUCCH cell switch band pair may be: {[FR1 TDD, FR1 TDD], [FR1 TDD, FR2], [FR2, FR2]}. In other words, the switching may occur between FR1 TDD and FR1 TDD or between FR1 TDD and FR2, or between FR2 and FR2.

[0080] An FR1 licensed TDD band type is a PUCCH cell that includes FR1 in a licensed spectrum and supports TDD operation. Similarly, an FR1 licensed FDD band type is a PUCCH cell that includes FR1 in a licensed spectrum and supports FDD operation. An FR1 unlicensed TDD band type is a PUCCH cell that includes FR1 in an unlicensed spectrum and supports TDD operation. An FR2 band type is a PUCCH cell that includes FR2. Although these four band types are described, the present disclosure is not so limited, as other supported band types, including those that may be available in the future, are also contemplated for the reporting structure.

[0081] FIG. **6** is a diagram illustrating an exemplary PUCCH capability report structure, in accordance with various aspects of the present disclosure. In the example of FIG. **6**, a report **600** includes a first PUCCH grouping configuration (e.g., configuration 1) for a band combination (BC), which comprises a primary PUCCH group and a secondary PUCCH group. The primary PUCCH group band types for data transmission (e.g., uplink or downlink) in this example include {FR1 TDD, FR1 FDD, FR2}. The secondary PUCCH group band types for data transmission include {FR1 TDD, FR1 unlicensed, FR2}. The primary PUCCH group also lists band types supported for a PUCCH cell, including {FR1 TDD, FR1 FDD, FR2}. The secondary PUCCH group also includes band types for a PUCCH cell, including {FR1 TDD, FR1 unlicensed}. In configuration 1 for the band combination, the report **600** lists band types for PUCCH cell switching, including {[FR1 TDD, FR1 TDD], [FR1 TDD, FR2 (TDD only)], [FR2 (TDD), FR2 (TDD)}. For the secondary PUCCH group, the report **600** lists band types for PUCCH cell switching, including {[FR1 TDD, FR1 TDD], [FR1 TDD, FR1 unlicensed], [FR1 unlicensed, FR1 unlicensed]}.

[0082] If multiple PUCCH grouping configurations are available for a particular band combination, the UE may report the PUCCH cell switch capability for each PUCCH grouping configuration of the band combination. FIG. **7** is a diagram illustrating an exemplary physical uplink control channel (PUCCH) capability report structure for multiple configurations, in accordance with various aspects of the present disclosure. In the example shown in FIG. **7**, a report **700** includes a second PUCCH grouping configuration (e.g., configuration 2) for the particular band combination. This second configuration comprises primary and secondary PUCCH groups. The primary PUCCH group band types for data transmission in the second configuration include {FR1 TDD, FR1 unlicensed}. The secondary PUCCH group band types for data transmission include {FR1 TDD, FR1 FDD, FR2}. The primary PUCCH group also includes band types for a PUCCH cell, including {FR1 TDD}. The secondary PUCCH group includes band types for a PUCCH cell, including {FR1 TDD, FR1 FDD}. In configuration 2, the report **700** lists band types available for PUCCH cell switching for the primary PUCCH group, including {[FR1 TDD, FR1 TDD]}. For the secondary PUCCH group, the report **700** lists band types available for PUCCH cell switching, including {[FR1 TDD, FR1 TDD]}.

[0083] According to aspects of the present disclosure, if multiple PUCCH groups are available for a configuration of the band combination, the UE may report the PUCCH cell switch capability for each PUCCH group of each PUCCH grouping configuration for the band combination. FIG. **8** is a diagram illustrating an exemplary physical uplink control channel (PUCCH) capability report structure for PUCCH cell switching, in accordance with various aspects of the present disclosure. In the example of FIG. **8**, a report **800** is provided for the primary and secondary PUCCH groups of each PUCCH grouping configuration. For the first configuration (configuration 1), PUCCH cell switching for the primary PUCCH group is supported for the following band combinations: {[FR1 TDD, FR1 TDD], [FR1 TDD, FR2] (TDD), [FR2 (TDD), FR2 (TDD)]}. For the secondary PUCCH group in the first configuration (configuration 1), PUCCH cell switching is supported for the following band combinations: {[FR1 TDD, FR1 TDD], [FR1 TDD, FR1 unlicensed], [FR1 unlicensed, FR1 unlicensed]}. For the second configuration (configuration 2), PUCCH cell switching for the primary PUCCH group is supported for the following band combinations: {[FR1 TDD, FR1 TDD]}. For the secondary PUCCH group of the second configuration (configuration 2), PUCCH cell switching is supported for the following band combinations: {[FR1 TDD, FR1 TDD]}.

[0084] In some aspects, the UE does not report all combinations of band type pairs. FIG. **9** is a diagram illustrating an exemplary physical uplink control channel (PUCCH) capability report structure for when all band type pair combinations are not supported, in accordance with various aspects of the present disclosure. In the example of FIG. **9**, the supported PUCCH band types include FR1 TDD, FR1 FDD, and FR2. The UE may generate a report **900** listing a PUCCH cell switch capability for the primary PUCCH group in configuration 1 as: {[FR1 TDD, FR1 TDD], [FR2 (TDD), FR2 (TDD)]}. In the example of FIG. **9**, the UE omits [FR1 TDD, FR2 (TDD)] from the primary PUCCH group, as seen by the strikethrough. The report **900** also omits [FR1 unlicensed, FR1 unlicensed]} from the secondary PUCCH group, as seen by the strikethrough.

[0085] Once a base station receives the UE capability report (including at least one pair of band types), the base station may configure the UE to operate PUCCH cell switching between two cells from two different bands of the at least one pair of band types. The configuration may be a

per band combination, a per PUCCH group, and/or a per PUCCH grouping configuration of each band combination. While some specific band combinations have been discussed, other configurations of band combinations are possible with the disclosed reporting structure, but are not described for the sake of conciseness.

[0086] By reporting PUCCH cell switch capability in accordance with the described structure, report signaling overhead is reduced.

[0087] FIG. **10** is a flow diagram illustrating an example process **1000** performed, for example, by a user equipment (UE), in accordance with various aspects of the present disclosure. The example process **1000** is an example of user equipment (UE) capability signaling for physical uplink control channel (PUCCH) cell switching. The operations of the process **1000** may be implemented by a UE **120**.

[0088] At block **1002**, the user equipment (UE) reports a UE capability for physical uplink control channel (PUCCH) cell switching. The UE capability includes at least one pair of band types capable of supporting PUCCH cell switching, each band type of the at least one pair of band types supporting PUCCH cell transmission. For example, the UE (e.g., using the controller/processor **280**, and/or memory **282**) may report the UE capability for PUCCH cell switching. The report may be per band combination, per PUCCH group per PUCCH grouping configuration of a band combination, and/or per PUCCH grouping configuration of a band combination.

[0089] At block **1004**, the user equipment (UE) transmits a first PUCCH with a first band type selected from the at least one pair of band types. For example, the UE (e.g., using the antenna **252**, DEMOD/MOD **254**, TX MIMO processor **266**, transmit processor **264**, controller/processor **280**, and/or memory **282**) may transmit the first PUCCH. At block **406**, the user equipment (UE) switches to a second band type selected from the at least one pair of band types, for transmitting a second PUCCH. For example, the UE (e.g., using the controller/processor **280**, and/or memory **282**) may switch to the second band type.

[0090] FIG. **11** is a flow diagram illustrating an example process **1100** performed, for example, by a network device, in accordance with various aspects of the present disclosure. The example process **1100** is an example of configuring for physical uplink control channel (PUCCH) cell switching. The operations of the process **1100** may be implemented by a base station **110**.

[0091] At block **1102**, the network device receives a user equipment (UE) capability report. The UE capability report includes at least one pair of band types supported for physical uplink control channel (PUCCH) cell switching. Each band type of the at least one pair of band types supports PUCCH cell transmission. For example, the network device (e.g., using the antenna **234**, MOD/DEMOD **232**, MIMO detector **236**, receive processor **238**, controller/processor **240**, and/or memory **242**) may receive the UE capability report. The report may be per band combination, per PUCCH group per PUCCH grouping configuration of a band combination, and/or per PUCCH grouping configuration of a band combination.

[0092] At block **1104**, the network device configures a UE to operate PUCCH cell switching between two cells from two different bands of the at least one pair of band types. For example, the network device (e.g., using the antenna **234**, MOD/DEMOD **232**, TX MIMO processor **230**, transmit processor **220**, controller/processor **240**, and/or memory **242**) may configure the UE.

Example Aspects

[0093] Aspect 1: A method of wireless communication, by a user equipment (UE), comprising: reporting a UE capability for physical uplink control channel (PUCCH) cell switching, the UE capability comprising at least one pair of band types capable of supporting PUCCH cell switching, each band type of the at least one pair of band types supporting PUCCH cell transmission; transmitting a first PUCCH with a first band type selected from the at least one pair of band types; and switching to a second band type selected from the at least one pair of band types, for transmitting a second PUCCH.

[0094] Aspect 2: The method of Aspect 1, in which the switching is based on semi-static indication of cell switching.

[0095] Aspect 3: The method of Aspect 1, in which the switching is based on dynamic indication of cell switching.

[0096] Aspect 4: The method of any of the preceding Aspects, in which the at least one pair of band types comprises one of: {frequency range one (FR1) time division duplexed (TDD), FR1 TDD)}, {FR1 TDD, frequency range two (FR2) TDD}, or {FR2 TDD, FR2 TDD}.

[0097] Aspect 5: The method of any of the preceding Aspects, in which the reporting is per band combination.

[0098] Aspect 6: The method of any of the preceding Aspects, in which the reporting is for a primary PUCCH group and a secondary PUCCH group per PUCCH grouping configuration of a band combination.

[0099] Aspect 7: The method of any of the Aspects 1-4, in which the reporting is per PUCCH grouping configuration of a band combination.

[0100] Aspect 8: The method of any of the preceding Aspects, in which the reporting is limited to a subset of combinations of band types supporting PUCCH cell transmission in a PUCCH group.

[0101] Aspect 9: The method of any of the preceding Aspects, further comprising selecting each band type from a list of supported band types for PUCCH transmission in a PUCCH group of a configuration of a band combination in carrier aggregation.

[0102] Aspect 10: A method of wireless communication by a network device, comprising: receiving a user equipment (UE) capability report comprising at least one pair of band types supported for physical uplink control channel (PUCCH) cell switching, each band type of the at least one pair of band types supporting PUCCH cell transmission; and configuring a UE to operate PUCCH cell switching between two cells from two different bands of the at least one pair of band types.

[0103] Aspect 11: The method of Aspect 10, in which the configuring is semi-static indication of cell switching.

[0104] Aspect 12: The method of Aspect 10, in which the configuring is dynamic indication of cell switching.

[0105] Aspect 13: The method of any of the Aspects 10-12, in which the at least one pair of band types comprises one of: {frequency range one (FR1) time division duplexed (TDD), FR1 TDD)}, {FR1 TDD, frequency range two (FR2) TDD}, or {FR2 TDD, FR2 TDD}.

[0106] Aspect 14: The method of any of the Aspects 10-13, in which the configuring is per band combination.

[0107] Aspect 15: The method of any of the Aspects 10-13, in which the configuring is per PUCCH group per PUCCH grouping of a band combination.

[0108] Aspect 16: The method of any of the Aspects 10-13, in which the configuring is per PUCCH grouping configuration of a band combination.

[0109] Aspect 17: An apparatus for wireless communication, comprising: a memory; and at least one processor coupled to the memory, the at least one processor configured: to report a UE capability for physical uplink control channel (PUCCH) cell switching, the UE capability comprising at least one pair of band types capable of supporting PUCCH cell switching, each band type of the at least one pair of band types supporting PUCCH cell transmission; to transmit a first PUCCH with a first band type selected from the at least one pair of band types; and to switch to a second band type selected from the at least one pair of band types, for transmitting a second PUCCH.

[0110] Aspect 18: The apparatus of Aspect 17, in which the at least one processor is further configured to switch based on semi-static indication of cell switching.

[0111] Aspect 19: The apparatus of Aspect 17, in which the at least one processor is further configured to switch based on dynamic indication of cell switching.

[0112] Aspect 20: The apparatus of any of the Aspects 17-19, in which the at least one pair of band types comprises one of: {frequency range one (FR1) time division duplexed (TDD), FR1 TDD)}, {FR1 TDD, frequency range two (FR2) TDD}, or {FR2 TDD, FR2 TDD}.

[0113] Aspect 21: The apparatus of any of the Aspects 17-20, in which the at least one processor is further configured to report per band combination.

[0114] Aspect 22: The apparatus of any of the Aspects 17-21, in which the at least one processor is further configured to report for a primary PUCCH group and a secondary PUCCH group per PUCCH grouping configuration of a band combination.

[0115] Aspect 23: The apparatus of any of the Aspects 17-20, in which the at least one processor is further configured to report is per PUCCH grouping configuration of a band combination.

[0116] Aspect 24: The apparatus of any of the Aspects 17-23, in which the at least one processor is further configured to report limited to a subset of combinations of band types supporting PUCCH cell transmission in a PUCCH group.

[0117] Aspect 25: The apparatus of any of the Aspects 17-24, in which the at least one processor is further configured to select each band type from a list of supported band types for PUCCH transmission in a PUCCH group of a configuration of a band combination in carrier aggregation.

[0118] Aspect 26: An apparatus for wireless communication, comprising: a memory; and at least one processor coupled to the memory, the at least one processor configured: to receive a user equipment (UE) capability report comprising at least one pair of band types supported for physical uplink control channel (PUCCH) cell switching, each band type of the at least one pair of band types supporting PUCCH cell transmission; and to configure a UE to operate PUCCH cell switching between two cells from two different bands of the at least one pair of band types.

[0119] Aspect 27: The apparatus of Aspect 26, in which the at least one processor is further configured to configure semi-static indication of cell switching.

[0120] Aspect 28: The apparatus of Aspect 26, in which the at least one processor is further configured to configure dynamic indication of cell switching.

[0121] Aspect 29: The apparatus of any of the Aspects 26-28, in which the at least one pair of band types comprises one of: {frequency range one (FR1) time division duplexed (TDD), FR1 TDD)}, {FR1 TDD, frequency range two (FR2) TDD}, or {FR2 TDD, FR2 TDD}.

[0122] Aspect 30: The apparatus of any of the Aspects 26-29, in which the at least one processor is further configured to configure per band combination.

[0123] The foregoing disclosure provides illustration and description, but is not intended to be exhaustive or to limit the aspects to the precise form disclosed. Modifications and variations may be made in light of the above disclosure or may be acquired from practice of the aspects.

[0124] As used, the term "component" is intended to be broadly construed as hardware, firmware, and/or a combination of hardware and software. As used, a processor is implemented in hardware, firmware, and/or a combination of hardware and software.

[0125] Some aspects are described in connection with thresholds. As used, satisfying a threshold may, depending on the context, refer to a value being greater than the threshold, greater than or equal to the threshold, less than the threshold, less than or equal to the threshold, equal to the threshold, not equal to the threshold, and/or the like.

[0126] It will be apparent that systems and/or methods described may be implemented in different forms of hardware, firmware, and/or a combination of hardware and software. The actual specialized control hardware or software code used to implement these systems and/or methods is not limiting of the aspects. Thus, the operation and behavior of the systems and/or methods were described without reference to specific software code—it being understood that software and hardware can be designed to implement the systems and/or methods based, at least in part, on the description.

[0127] Even though particular combinations of features are recited in the claims and/or disclosed in the specification, these combinations are not intended to limit the disclosure of various aspects. In fact, many of these features may be combined in ways not specifically recited in the claims and/or disclosed in the specification. Although each dependent claim listed below may directly depend on only one claim, the disclosure of various aspects includes each dependent claim in combination with every other claim in the claim set. A phrase referring to "at least one of" a list of items refers to any combination of those items, including single members. As an example, "at least one of: a, b, or c" is intended to cover a, b, c, a-b, a-c, b-c, and a-b-c, as well as any combination with multiples of the same element (e.g., a-a, a-a-a, a-a-b, a-a-c, a-b-b, a-c-c, b-b, b-b-b, b-b-c, c-c, and c-c-c or any other ordering of a, b, and c).

[0128] No element, act, or instruction used should be construed as critical or essential unless explicitly described as such. Also, as used, the articles "a" and "an" are intended to include one or more items, and may be used interchangeably with "one or more." Furthermore, as used, the terms "set" and "group" are intended to include one or more items (e.g., related items, unrelated items, a combination of related and unrelated items, and/or the like), and may be used interchangeably with "one or more." Where only one item is intended, the phrase "only one" or similar language is used.

Also, as used, the terms "has," "have," "having," and/or the like are intended to be open-ended terms. Further, the phrase "based on" is intended to mean "based, at least in part, on" unless explicitly stated otherwise.

What is claimed is:

1. A method of wireless communication, by a user equipment (UE), comprising:

reporting a UE capability for physical uplink control channel (PUCCH) cell switching, the UE capability comprising at least one pair of band types capable of supporting PUCCH cell switching, each band type of the at least one pair of band types supporting PUCCH cell transmission;

transmitting a first PUCCH with a first band type selected from the at least one pair of band types; and

switching to a second band type selected from the at least one pair of band types, for transmitting a second PUCCH.

2. The method of claim **1**, in which the switching is based on semi-static indication of cell switching.

3. The method of claim **1**, in which the switching is based on dynamic indication of cell switching.

4. The method of claim **1**, in which the at least one pair of band types comprises one of: {frequency range one (FR1) time division duplexed (TDD), FR1 TDD)}, {FR1 TDD, frequency range two (FR2) TDD}, or {FR2 TDD, FR2 TDD}.

5. The method of claim **1**, in which the reporting is per band combination.

6. The method of claim **1**, in which the reporting is for a primary PUCCH group and a secondary PUCCH group per PUCCH grouping configuration of a band combination.

7. The method of claim **1**, in which the reporting is per PUCCH grouping configuration of a band combination.

8. The method of claim **1**, in which the reporting is limited to a subset of combinations of band types supporting PUCCH cell transmission in a PUCCH group.

9. The method of claim **1**, further comprising selecting each band type from a list of supported band types for PUCCH transmission in a PUCCH group of a configuration of a band combination in carrier aggregation.

10. A method of wireless communication by a network device, comprising:

receiving a user equipment (UE) capability report comprising at least one pair of band types supported for physical uplink control channel (PUCCH) cell switching, each band type of the at least one pair of band types supporting PUCCH cell transmission; and

configuring a UE to operate PUCCH cell switching between two cells from two different bands of the at least one pair of band types.

11. The method of claim **10**, in which the configuring is semi-static indication of cell switching.

12. The method of claim **10**, in which the configuring is dynamic indication of cell switching.

13. The method of claim **10**, in which the at least one pair of band types comprises one of: {frequency range one (FR1) time division duplexed (TDD), FR1 TDD)}, {FR1 TDD, frequency range two (FR2) TDD}, or {FR2 TDD, FR2 TDD}.

14. The method of claim **10**, in which the configuring is per band combination.

15. The method of claim **10**, in which the configuring is per PUCCH group per PUCCH grouping of a band combination.

16. The method of claim **10**, in which the configuring is per PUCCH grouping configuration of a band combination.

17. An apparatus for wireless communication, comprising:

a memory; and

at least one processor coupled to the memory, the at least one processor configured:

to report a UE capability for physical uplink control channel (PUCCH) cell switching, the UE capability comprising at least one pair of band types capable of supporting PUCCH cell switching, each band type of the at least one pair of band types supporting PUCCH cell transmission;

to transmit a first PUCCH with a first band type selected from the at least one pair of band types; and

to switch to a second band type selected from the at least one pair of band types, for transmitting a second PUCCH.

18. The apparatus of claim **17**, in which the at least one processor is further configured to switch based on semi-static indication of cell switching.

19. The apparatus of claim **17**, in which the at least one processor is further configured to switch based on dynamic indication of cell switching.

20. The apparatus of claim **17**, in which the at least one pair of band types comprises one of: {frequency range one (FR1) time division duplexed (TDD), FR1 TDD)}, {FR1 TDD, frequency range two (FR2) TDD}, or {FR2 TDD, FR2 TDD}.

21. The apparatus of claim **17**, in which the at least one processor is further configured to report per band combination.

22. The apparatus of claim **17**, in which the at least one processor is further configured to report for a primary PUCCH group and a secondary PUCCH group per PUCCH grouping configuration of a band combination.

23. The apparatus of claim **17**, in which the at least one processor is further configured to report per PUCCH grouping configuration of a band combination.

24. The apparatus of claim **17**, in which the at least one processor is further configured to report a subset of combinations of band types supporting PUCCH cell transmission in a PUCCH group.

25. The apparatus of claim **17**, in which the at least one processor is further configured to select each band type from a list of supported band types for PUCCH transmission in a PUCCH group of a configuration of a band combination in carrier aggregation.

26. An apparatus for wireless communication, comprising:

a memory; and

at least one processor coupled to the memory, the at least one processor configured:

to receive a user equipment (UE) capability report comprising at least one pair of band types supported for physical uplink control channel (PUCCH) cell switching, each band type of the at least one pair of band types supporting PUCCH cell transmission; and

to configure a UE to operate PUCCH cell switching between two cells from two different bands of the at least one pair of band types.

27. The apparatus of claim **26**, in which the at least one processor is further configured to configure semi-static indication of cell switching.

28. The apparatus of claim **26**, in which the at least one processor is further configured to configure dynamic indication of cell switching.

29. The apparatus of claim **26**, in which the at least one pair of band types comprises one of: {frequency range one (FR1) time division duplexed (TDD), FR1 TDD)}, {FR1 TDD, frequency range two (FR2) TDD}, or {FR2 TDD, FR2 TDD}.

30. The apparatus of claim **26**, in which the at least one processor is further configured to configure per band combination.

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