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

(19) **World Intellectual Property Organization**
International Bureau

(43) **International Publication Date**
**11 November 2021 (11.11.2021)**

WIPO | PCT

(10) **International Publication Number**
**WO 2021/223216 A1**

(51) **International Patent Classification:**
*H04W 72/00* (2009.01)

(21) **International Application Number:** PCT/CN2020/089188

(22) **International Filing Date:** 08 May 2020 (08.05.2020)

(25) **Filing Language:** English

(26) **Publication Language:** English

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

(54) **Title:** SYSTEM AND METHOD FOR GROUP COMPONENT CARRIER-BASED BEAM UPDATE

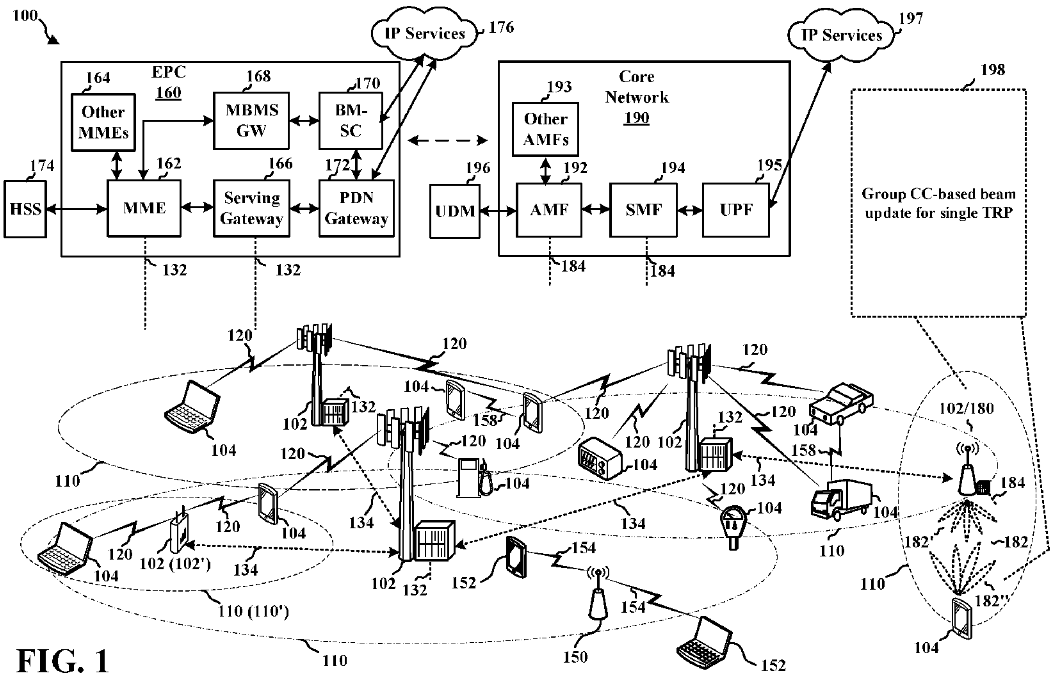


**FIG. 1**

(57) **Abstract:** A user equipment (UE) may be configured to receive information indicating a beam associated with communication on a plurality of component carriers (CCs); determine whether a single transmission-reception point (TRP) or multiple TRP (mTRP) is configured for the communication on the plurality of CCs; and apply the beam for the communication on the plurality of CCs when the single TRP is configured for the communication on the plurality of CCs. A base station may be configured to determine whether a single TRP or mTRP is configured for communication by a UE on a plurality of CCs; configure a beam for the communication by the UE on the plurality of CCs when the single TRP is configured for the communication by the UE on the plurality of CCs; and transmit information indicating the beam to the UE.

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*[Continued on next page]*

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

**Declarations under Rule 4.17:**
— *of inventorship (Rule 4.17(iv))*

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

# SYSTEM AND METHOD FOR GROUP COMPONENT CARRIER-BASED BEAM UPDATE

## BACKGROUND

### Technical Field

[0001] The present disclosure relates generally to communication systems, and more particularly, to updating a beam for communication by a user equipment on a group of component carriers.

### Introduction

[0002] Wireless communication systems are widely deployed to provide various telecommunication services such as telephony, video, data, messaging, and broadcasts. Typical wireless communication systems may employ multiple-access technologies capable of supporting communication with multiple users by sharing available system resources. 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, and time division synchronous code division multiple access (TD-SCDMA) systems.

[0003] These multiple access technologies have been adopted in various telecommunication standards to provide a common protocol that enables different wireless devices to communicate on a municipal, national, regional, and even global level. An example telecommunication standard is 5G New Radio (NR). 5G NR is part of a continuous mobile broadband evolution promulgated by Third Generation Partnership Project (3GPP) to meet new requirements associated with latency, reliability, security, scalability (e.g., with Internet of Things (IoT)), and other requirements. 5G NR includes services associated with enhanced mobile broadband (eMBB), massive machine type communications (mMTC), and ultra-reliable low latency communications (URLLC). Some aspects of 5G NR may be based on the 4G Long Term Evolution (LTE) standard. There exists a need for further improvements in 5G NR technology. These improvements may also be applicable to other multi-access technologies and the telecommunication standards that employ these technologies.

## SUMMARY

[0004] The following presents a simplified summary of one or more aspects in order to provide a basic understanding of such aspects. This summary is not an extensive overview of all contemplated aspects, and is intended to neither identify key or critical elements of all aspects nor delineate the scope of any or all aspects. Its sole purpose is to present some concepts of one or more aspects in a simplified form as a prelude to the more detailed description that is presented later.

[0005] According to an example radio access technology (RAT), such as 5G New Radio (NR), a user equipment (UE) and a base station (e.g., a gNB) may be able to communicate on more than one component carrier (CC). For example, the gNB may assign a group of CCs to the UE for carrier aggregation, which may increase the data rate for the UE. The gNB may configure the group of CCs to carry some downlink communication (e.g., downlink control information and/or downlink data) and/or some uplink communication.

[0006] Potentially, the example RAT may include more than one transmission-reception point (TRP). A TRP may be another cell, such as a secondary cell (SCell), that is different from the gNB-provided cell, which may be a primary cell (PCell). For example, a TRP may be a pico cell, femtocell, remote radio head, or cell connected to the radio access network (RAN) that includes the gNB. A group of CCs assigned to the UE may be configured through a single TRP or multiple TRPs (mTRP).

[0007] The UE and the gNB may communicate on CCs using directional beamforming. However, mTRP configured for the UE may affect directional beamforming for the UE. For example, the UE may use different beams for communicating with different TRPs. Accordingly, a need exists for determining how to apply a beam by a UE for communication on a group of CCs.

[0008] The present disclosure describes various techniques and solutions for applying (e.g., updating) a beam by a UE for communicating on at least one CC. In particular, the present disclosure describes various approaches to determining whether to apply one beam to a group of CCs. For example, the UE may determine whether communication on a group of CCs is configured through a single TRP or mTRP, and the UE may determine whether to apply the beam to a group of CCs based on whether the communication is configured through one TRP or mTRP.

[0009] In a first aspect of the disclosure, a first method, a first computer-readable medium, and a first apparatus are provided. The first apparatus may be implemented as a UE. The first apparatus may be configured to receive information indicating a beam associated with communication on a plurality of CCs; determine whether a single TRP or mTRP is configured for the communication on the plurality of CCs; and apply the beam for the communication on the plurality of CCs when the single TRP is configured for the communication on the plurality of CCs.

[0010] In a second aspect of the disclosure, a second method, a second computer-readable medium, and a second apparatus are provided. The second apparatus may be implemented as a base station (e.g., gNB). The second apparatus may be configured to determine whether a single TRP or mTRP is configured for communication by a UE on a plurality of CCs; configure a beam for the communication by the UE on the plurality of CCs when the single TRP is configured for the communication by the UE on the plurality of CCs; and transmit information indicating the beam to the UE.

[0011] To the accomplishment of the foregoing and related ends, the one or more aspects comprise the features hereinafter fully described and particularly pointed out in the claims. The following description and the annexed drawings set forth in detail certain illustrative features of the one or more aspects. These features are indicative, however, of but a few of the various ways in which the principles of various aspects may be employed, and this description is intended to include all such aspects and their equivalents.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. 1 is a diagram illustrating an example of a wireless communications system and an access network.

[0013] FIGs. 2A, 2B, 2C, and 2D are diagrams illustrating examples of a first 5G/NR frame, DL channels within a 5G/NR subframe, a second 5G/NR frame, and UL channels within a 5G/NR subframe, respectively.

[0014] FIG. 3 is a diagram illustrating an example of a base station and user equipment (UE) in an access network.

[0015] FIG. 4 is a call flow diagram illustrating example operations in a wireless communications system.

[0016] FIG. 5 is a flowchart of an example method of wireless communication by a UE.

[0017] FIG. 6 is a flowchart of an example method of wireless communication by a base station.

## DETAILED DESCRIPTION

[0018] The detailed description set forth below in connection with the appended drawings is intended as a description of various configurations and is not intended to represent the only configurations in which the concepts described herein may be practiced. The detailed description includes specific details for the purpose of providing a thorough understanding of various concepts. However, it will be apparent to those skilled in the art that these concepts may be practiced without these specific details. In some instances, well known structures and components are shown in block diagram form in order to avoid obscuring such concepts.

[0019] Several aspects of telecommunication systems will now be presented with reference to various apparatus and methods. These apparatus and methods will be described in the following detailed description and illustrated in the accompanying drawings by various blocks, components, circuits, processes, algorithms, etc. (collectively referred to as "elements"). These elements may be implemented using electronic hardware, computer software, or any combination thereof. Whether such elements are implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system.

[0020] By way of example, an element, or any portion of an element, or any combination of elements may be implemented as a "processing system" that includes one or more processors. Examples of processors include microprocessors, microcontrollers, graphics processing units (GPUs), central processing units (CPUs), application processors, digital signal processors (DSPs), reduced instruction set computing (RISC) processors, systems on a chip (SoC), baseband processors, field programmable gate arrays (FPGAs), programmable logic devices (PLDs), state machines, gated logic, discrete hardware circuits, and other suitable hardware configured to perform the various functionality described throughout this disclosure. One or more processors in the processing system may execute software. Software shall be construed broadly to mean instructions, instruction sets, code, code segments, program code, programs, subprograms, software components, applications, software applications, software packages, routines, subroutines, objects, executables, threads of execution, procedures, functions, etc., whether referred to as software, firmware, middleware, microcode, hardware description language, or otherwise.

[0021] Accordingly, in one or more example embodiments, the functions described may be implemented in hardware, software, or any combination thereof. If implemented in software, the functions may be stored on or encoded as one or more instructions or code on a computer-readable medium. Computer-readable media includes computer storage media. Storage media may be any available media that can be accessed by a computer. By way of example, and not limitation, such computer-readable media can comprise a random-access memory (RAM), a read-only memory (ROM), an electrically erasable programmable ROM (EEPROM), optical disk storage, magnetic disk storage, other magnetic storage devices, combinations of the aforementioned types of computer-readable media, or any other medium that can be used to store computer executable code in the form of instructions or data structures that can be accessed by a computer.

[0022] FIG. 1 is a diagram illustrating an example of a wireless communications system and an access network 100. The wireless communications system (also referred to as a wireless wide area network (WWAN)) includes base stations 102, UEs 104, an Evolved Packet Core (EPC) 160, and another core network 190 (e.g., a 5G Core (5GC)). The base stations 102 may include macrocells (high power cellular base station) and/or small cells (low power cellular base station). The macrocells include base stations. The small cells include femtocells, picocells, and microcells.

[0023] The base stations 102 configured for 4G LTE (collectively referred to as Evolved Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access Network (E-UTRAN)) may interface with the EPC 160 through first backhaul links 132 (e.g., S1 interface). The base stations 102 configured for 5G NR (collectively referred to as Next Generation RAN (NG-RAN)) may interface with core network 190 through second backhaul links 184. In addition to other functions, the base stations 102 may perform one or more of the following functions: transfer of user data, radio channel ciphering and deciphering, integrity protection, header compression, mobility control functions (e.g., handover, dual connectivity), inter-cell interference coordination, connection setup and release, load balancing, distribution for non-access stratum (NAS) messages, NAS node selection, synchronization, radio access network (RAN) sharing, multimedia broadcast multicast service (MBMS), subscriber and equipment trace, RAN information management (RIM), paging, positioning, and delivery of warning messages. The base stations 102 may communicate directly or indirectly (e.g., through the EPC 160 or core network 190) with each other over third backhaul links 134 (e.g., X2 interface). The first backhaul links 132, the second backhaul links 184, and the third backhaul links 134 may be wired or wireless.

[0024] The base stations 102 may wirelessly communicate with the UEs 104. Each of the base stations 102 may provide communication coverage for a respective geographic coverage area 110. There may be overlapping geographic coverage areas 110. For example, the small cell 102' may have a coverage area 110' that overlaps the coverage area 110 of one or more macro base stations 102. A network that includes both small cell and macrocells may be known as a heterogeneous network. A heterogeneous network may also include Home Evolved Node Bs (eNBs) (HeNBs), which may provide service to a restricted group known as a closed subscriber group (CSG). The communication links 120 between the base stations 102 and the UEs 104 may include uplink (UL) (also referred to as reverse link) transmissions from a UE 104 to a base station 102 and/or downlink (DL) (also referred to as forward link) transmissions from a base station 102 to a UE 104. The communication links 120 may use multiple-input and multiple-output (MIMO) antenna technology, including spatial multiplexing, beamforming, and/or transmit diversity. The communication links may be through one or more carriers. The base stations 102 / UEs 104 may use spectrum up to *Y* MHz (e.g., 5, 10, 15, 20, 100, 400, etc. MHz) bandwidth per carrier allocated in a carrier aggregation of up to a total of *Yx* MHz (*x* component carriers) used for transmission in each direction. The carriers may or may not be adjacent to each other. Allocation of carriers may be asymmetric with respect to DL and UL (e.g., more or fewer carriers may be allocated for DL than for UL). The component carriers may include a primary component carrier and one or more secondary component carriers. A primary component carrier may be referred to as a primary cell (PCell) and a secondary component carrier may be referred to as a secondary cell (SCell).

[0025] Certain UEs 104 may communicate with each other using device-to-device (D2D) communication link 158. The D2D communication link 158 may use the DL/UL WWAN spectrum. The D2D communication link 158 may use one or more sidelink channels, such as a physical sidelink broadcast channel (PSBCH), a physical sidelink discovery channel (PSDCH), a physical sidelink shared channel (PSSCH), and a physical sidelink control channel (PSCCH). D2D communication may be through a variety of wireless D2D communications systems, such as for example, WiMedia, Bluetooth, ZigBee, Wi-Fi based on the Institute of Electrical and Electronics Engineers (IEEE) 802.11 standard, LTE, or NR.

[0026] The wireless communications system may further include a Wi-Fi access point (AP) 150 in communication with Wi-Fi stations (STAs) 152 via communication links 154 in a 5 GHz unlicensed frequency spectrum. When communicating in an unlicensed frequency spectrum, the STAs 152 / AP 150 may perform a clear channel assessment (CCA) prior to communicating in order to determine whether the channel is available.

[0027] The small cell 102' may operate in a licensed and/or an unlicensed frequency spectrum. When operating in an unlicensed frequency spectrum, the small cell 102' may employ NR and use the same 5 GHz unlicensed frequency spectrum as used by the Wi-Fi AP 150. The small cell 102', employing NR in an unlicensed frequency spectrum, may boost coverage to and/or increase capacity of the access network.

[0028] A base station 102, whether a small cell 102' or a large cell (e.g., macro base station), may include and/or be referred to as an eNB, gNodeB (gNB), or another type of base station. Some base stations, such as gNB 180 may operate in a traditional sub 6 GHz spectrum, in millimeter wave (mmW) frequencies, and/or near mmW frequencies in communication with the UE 104. When the gNB 180 operates in mmW or near mmW frequencies, the gNB 180 may be referred to as an mmW base station. Extremely high frequency (EHF) is part of the RF in the electromagnetic spectrum. EHF has a range of 30 GHz to 300 GHz and a wavelength between 1 millimeter and 10 millimeters. Radio waves in the band may be referred to as a millimeter wave. Near mmW may extend down to a frequency of 3 GHz with a wavelength of 100 millimeters. The super high frequency (SHF) band extends between 3 GHz and 30 GHz, also referred to as centimeter wave. Communications using the mmW / near mmW radio frequency (RF) band (e.g., 3 GHz – 300 GHz) has extremely high path loss and a short range. The mmW base station 180 may utilize beamforming 182 with the UE 104 to compensate for the extremely high path loss and short range. The base station 180 and the UE 104 may each include a plurality of antennas, such as antenna elements, antenna panels, and/or antenna arrays to facilitate the beamforming.

[0029] The base station 180 may transmit a beamformed signal to the UE 104 in one or more transmit directions 182'. The UE 104 may receive the beamformed signal from the base station 180 in one or more receive directions 182''. The UE 104 may also transmit a beamformed signal to the base station 180 in one or more transmit directions. The base station 180 may receive the beamformed signal from the UE 104 in one or more receive directions. The base station 180 / UE 104 may perform beam training to determine the best receive and transmit directions for each of the base station 180 / UE 104. The transmit and receive directions for the base station 180 may or may not be the same. The transmit and receive directions for the UE 104 may or may not be the same.

[0030] The EPC 160 may include a Mobility Management Entity (MME) 162, other MMEs 164, a Serving Gateway 166, a Multimedia Broadcast Multicast Service (MBMS) Gateway 168, a Broadcast Multicast Service Center (BM-SC) 170, and a Packet Data Network (PDN) Gateway 172. The MME 162 may be in communication with a Home Subscriber Server (HSS) 174. The MME 162 is the control node that processes the signaling between the UEs 104 and the EPC 160. Generally, the MME 162 provides bearer and connection management. All user Internet protocol (IP) packets are transferred through the Serving Gateway 166, which itself is connected to the PDN Gateway 172. The PDN Gateway 172 provides UE IP address allocation as well as other functions. The PDN Gateway 172 and the BM-SC 170 are connected to the IP Services 176. The IP Services 176 may include the Internet, an intranet, an IP Multimedia Subsystem (IMS), a PS Streaming Service, and/or other IP services. The BM-SC 170 may provide functions for MBMS user service provisioning and delivery. The BM-SC 170 may serve as an entry point for content provider MBMS transmission, may be used to authorize and initiate MBMS Bearer Services within a public land mobile network (PLMN), and may be used to schedule MBMS transmissions. The MBMS Gateway 168 may be used to distribute MBMS traffic to the base stations 102 belonging to a Multicast Broadcast Single Frequency Network (MBSFN) area broadcasting a particular service, and may be responsible for session management (start/stop) and for collecting eMBMS related charging information.

[0031] The core network 190 may include a Access and Mobility Management Function (AMF) 192, other AMFs 193, a Session Management Function (SMF) 194, and a User Plane Function (UPF) 195. The AMF 192 may be in communication with a Unified Data Management (UDM) 196. The AMF 192 is the control node that processes the signaling between the UEs 104 and the core network 190. Generally, the AMF 192 provides QoS flow and session management. All user Internet protocol (IP) packets are transferred through the UPF 195. The UPF 195 provides UE IP address allocation as well as other functions. The UPF 195 is connected to the IP Services 197. The IP

Services 197 may include the Internet, an intranet, an IP Multimedia Subsystem (IMS), a Packet Switch (PS) Streaming (PSS) Service, and/or other IP services.

[0032] The base station may include and/or be referred to as a gNB, Node B, eNB, an access point, a base transceiver station, a radio base station, a radio transceiver, a transceiver function, a basic service set (BSS), an extended service set (ESS), a transmit reception point (TRP), or some other suitable terminology. The base station 102 provides an access point to the EPC 160 or core network 190 for a UE 104. Examples of UEs 104 include a cellular phone, a smart phone, a session initiation protocol (SIP) phone, a laptop, a personal digital assistant (PDA), a satellite radio, a global positioning system, a multimedia device, a video device, a digital audio player (e.g., MP3 player), a camera, a game console, a tablet, a smart device, a wearable device, a vehicle, an electric meter, a gas pump, a large or small kitchen appliance, a healthcare device, an implant, a sensor/actuator, a display, or any other similar functioning device. Some of the UEs 104 may be referred to as IoT devices (e.g., parking meter, gas pump, toaster, vehicles, heart monitor, etc.). The UE 104 may also be referred to as a station, a mobile station, a subscriber station, a mobile unit, a subscriber unit, a wireless unit, a remote unit, a mobile device, a wireless device, a wireless communications device, a remote device, a mobile subscriber station, an access terminal, a mobile terminal, a wireless terminal, a remote terminal, a handset, a user agent, a mobile client, a client, or some other suitable terminology.

[0033] Although the present disclosure may focus on 5G NR, the concepts and various aspects described herein may be applicable to other similar areas, such as LTE, LTE-Advanced (LTE-A), Code Division Multiple Access (CDMA), Global System for Mobile communications (GSM), or other wireless/radio access technologies.

[0034] Referring again to FIG. 1, in certain aspects, the base station 102/180 may be configured to determine whether a single TRP or multiple TRPs (mTRP) is configured for communication by the UE 104 on a plurality of component carriers (CCs). The base station 102/180 may configure a beam for the communication by the UE 104 on the plurality of CCs when the single TRP is configured for the communication by the UE 104 on the plurality of CCs. The base station 102/180 may then transmit information indicating the beam to the UE, which may be a group-based beam update for a single TRP (198).

[0035] Correspondingly, the UE 104 may be configured to receive, from the base station 102/180, the information indicating the beam, which may be a group-based beam update for a single TRP (198). The UE 104 may determine whether a single TRP or mTRP is configured for the communication on a plurality of CCs assigned to the UE 104. The UE 104 may then apply the beam for the communication on the plurality of CCs when the single TRP is configured for the communication on the plurality of CCs.

**[0036]** FIG. 2A is a diagram 200 illustrating an example of a first subframe within a 5G/NR frame structure. FIG. 2B is a diagram 230 illustrating an example of DL channels within a 5G/NR subframe. FIG. 2C is a diagram 250 illustrating an example of a second subframe within a 5G/NR frame structure. FIG. 2D is a diagram 280 illustrating an example of UL channels within a 5G/NR subframe. The 5G/NR frame structure may be frequency division duplexed (FDD) in which for a particular set of subcarriers (carrier system bandwidth), subframes within the set of subcarriers are dedicated for either DL or UL, or may be time division duplexed (TDD) in which for a particular set of subcarriers (carrier system bandwidth), subframes within the set of subcarriers are dedicated for both DL and UL. In the examples provided by FIGs. 2A, 2C, the 5G/NR frame structure is assumed to be TDD, with subframe 4 being configured with slot format 28 (with mostly DL), where D is DL, U is UL, and F is flexible for use between DL/UL, and subframe 3 being configured with slot format 34 (with mostly UL). While subframes 3, 4 are shown with slot formats 34, 28, respectively, any particular subframe may be configured with any of the various available slot formats 0-61. Slot formats 0, 1 are all DL, UL, respectively. Other slot formats 2-61 include a mix of DL, UL, and flexible symbols. UEs are configured with the slot format (dynamically through DL control information (DCI), or semi-statically/statically through radio resource control (RRC) signaling) through a received slot format indicator (SFI). Note that the description *infra* applies also to a 5G/NR frame structure that is TDD.

**[0037]** Other wireless communication technologies may have a different frame structure and/or different channels. A frame (10 ms) may be divided into 10 equally sized subframes (1 ms). Each subframe may include one or more time slots. Subframes may also include mini-slots, which may include 7, 4, or 2 symbols. Each slot may include 7 or 14 symbols, depending on the slot configuration. For slot configuration 0, each slot may include 14 symbols, and for slot configuration 1, each slot may include 7 symbols. The symbols on DL may be cyclic prefix (CP) OFDM (CP-OFDM) symbols. The symbols on UL may be CP-OFDM symbols (for high throughput scenarios) or discrete Fourier transform (DFT) spread OFDM (DFT-s-OFDM) symbols (also referred to as single carrier frequency-division multiple access (SC-FDMA) symbols) (for power limited scenarios; limited to a single stream transmission). The number of slots within a subframe is based on the slot configuration and the numerology. For slot configuration 0, different numerologies μ 0 to 4 allow for 1, 2, 4, 8, and 16 slots, respectively, per subframe. For slot configuration 1, different numerologies 0 to 2 allow for 2, 4, and 8 slots, respectively, per subframe. Accordingly, for slot configuration 0 and numerology μ, there are 14 symbols/slot and $2^{\mu}$ slots/subframe. The subcarrier spacing and symbol length/duration are a function of the numerology. The subcarrier spacing may be equal to $2^{\mu} * 15$ kHz, where $\mu$ is the numerology 0 to 4. As such, the numerology μ=0 has a subcarrier spacing of 15 kHz and the numerology μ=4 has a subcarrier spacing of 240 kHz. The symbol length/duration is inversely related to the subcarrier spacing. FIGs. 2A-2D provide an example of slot configuration 0 with 14 symbols per slot and numerology μ=2 with 4 slots per subframe. The slot duration is 0.25 ms, the subcarrier spacing is 60 kHz, and the symbol duration is approximately 16.67 μs. Within a set of frames, there may be one or more different bandwidth parts (BWPs) (see FIG. 2B) that are frequency division multiplexed. Each BWP may have a particular numerology.

[0038] A resource grid may be used to represent the frame structure. Each time slot includes a resource block (RB) (also referred to as physical RBs (PRBs)) that extends 12 consecutive subcarriers. The resource grid is divided into multiple resource elements (REs). The number of bits carried by each RE depends on the modulation scheme.

[0039] As illustrated in FIG. 2A, some of the REs carry reference (pilot) signals (RS) for the UE. The RS may include demodulation RS (DM-RS) (indicated as $R_x$ for one particular configuration, where 100x is the port number, but other DM-RS configurations are possible) and channel state information reference signals (CSI-RS) for channel estimation at the UE. The RS may also include beam measurement RS (BRS), beam refinement RS (BRRS), and phase tracking RS (PT-RS).

[0040] FIG. 2B illustrates an example of various DL channels within a subframe of a frame. The physical downlink control channel (PDCCH) carries DCI within one or more control channel elements (CCEs), each CCE including nine RE groups (REGs), each REG including four consecutive REs in an OFDM symbol. A PDCCH within one BWP may be referred to as a control resource set (CORESET). Additional BWPs may be located at greater and/or lower frequencies across the channel bandwidth. A primary synchronization signal (PSS) may be within symbol 2 of particular subframes of a frame. The PSS is used by a UE 104 to determine subframe/symbol timing and a physical layer identity. A secondary synchronization signal (SSS) may be within symbol 4 of particular subframes of a frame. The SSS is used by a UE to determine a physical layer cell identity group number and radio frame timing. Based on the physical layer identity and the physical layer cell identity group number, the UE can determine a physical cell identifier (PCI). Based on the PCI, the UE can determine the locations of the aforementioned DM-RS. The physical broadcast channel (PBCH), which carries a master information block (MIB), may be logically grouped with the PSS and SSS to form a synchronization signal (SS)/PBCH block (also referred to as SS block (SSB)). The MIB provides a number of RBs in the system bandwidth and a system frame number (SFN). The physical downlink shared channel (PDSCH) carries user data, broadcast system information not transmitted through the PBCH such as system information blocks (SIBs), and paging messages.

[0041] As illustrated in FIG. 2C, some of the REs carry DM-RS (indicated as R for one particular configuration, but other DM-RS configurations are possible) for channel estimation at the base station. The UE may transmit DM-RS for the physical uplink control channel (PUCCH) and DM-RS for the physical uplink shared channel (PUSCH). The PUSCH DM-RS may be transmitted in the first one or two symbols of the PUSCH. The PUCCH DM-RS may be transmitted in different configurations depending on whether short or long PUCCHs are transmitted and depending on the particular PUCCH format used. The UE may transmit sounding reference signals (SRS). The SRS may be transmitted in the last symbol of a subframe. The SRS may have a comb structure, and a UE may transmit SRS on one of the combs. The SRS may be used by a base station for channel quality estimation to enable frequency-dependent scheduling on the UL.

[0042] FIG. 2D illustrates an example of various UL channels within a subframe of a frame. The PUCCH may be located as indicated in one configuration. The PUCCH carries uplink control information (UCI), such as scheduling requests, a channel quality indicator (CQI), a precoding matrix indicator (PMI), a rank indicator (RI), and hybrid automatic repeat request (HARQ) ACK/NACK feedback. The PUSCH carries data, and may additionally be used to carry a buffer status report (BSR), a power headroom report (PHR), and/or UCI.

[0043] FIG. 3 is a block diagram of a base station 310 in communication with a UE 350 in an access network. In the DL, IP packets from the EPC 160 may be provided to a controller/processor 375. The controller/processor 375 implements layer 3 and layer 2 functionality. Layer 3 includes a radio resource control (RRC) layer, and layer 2 includes a service data adaptation protocol (SDAP) layer, a packet data convergence protocol (PDCP) layer, a radio link control (RLC) layer, and a medium access control (MAC) layer. The controller/processor 375 provides RRC layer functionality associated with broadcasting of system information (e.g., MIB, SIBs), RRC connection control (e.g., RRC connection paging, RRC connection establishment, RRC connection modification, and RRC connection release), inter radio access technology (RAT) mobility, and measurement configuration for UE measurement reporting; PDCP layer functionality associated with header compression / decompression, security (ciphering, deciphering, integrity protection, integrity verification), and handover support functions; RLC layer functionality associated with the transfer of upper layer packet data units (PDUs), error correction through ARQ, concatenation, segmentation, and reassembly of RLC service data units (SDUs), re-segmentation of RLC data PDUs, and reordering of RLC data PDUs; and MAC layer functionality associated with mapping between logical channels and transport channels, multiplexing of MAC SDUs onto transport blocks (TBs), demultiplexing of MAC SDUs from TBs, scheduling information reporting, error correction through HARQ, priority handling, and logical channel prioritization.

[0044] The transmit (TX) processor 316 and the receive (RX) processor 370 implement layer 1 functionality associated with various signal processing functions. Layer 1, which includes a physical (PHY) layer, may include error detection on the transport channels, forward error correction (FEC) coding/decoding of the transport channels, interleaving, rate matching, mapping onto physical channels, modulation/demodulation of physical channels, and MIMO antenna processing. The TX processor 316 handles mapping to signal constellations based on various modulation schemes (e.g., binary phase-shift keying (BPSK), quadrature phase-shift keying (QPSK), M-phase-shift keying (M-PSK), M-quadrature amplitude modulation (M-QAM)). The coded and modulated symbols may then be split into parallel streams. Each stream may then be mapped to an OFDM subcarrier, multiplexed with a reference signal (e.g., pilot) in the time and/or frequency domain, and then combined together using an Inverse Fast Fourier Transform (IFFT) to produce a physical channel carrying a time domain OFDM symbol stream. The OFDM stream is spatially precoded to produce multiple spatial streams. Channel estimates from a channel estimator 374 may be used to determine the coding and modulation scheme, as well as for spatial processing. The channel estimate may be derived from a reference signal and/or channel condition feedback transmitted by the UE 350. Each spatial stream may then be provided to a different antenna 320 via a separate transmitter 318TX. Each transmitter 318TX may modulate an RF carrier with a respective spatial stream for transmission.

**[0045]** At the UE 350, each receiver 354RX receives a signal through its respective antenna 352. Each receiver 354RX recovers information modulated onto an RF carrier and provides the information to the receive (RX) processor 356. The TX processor 368 and the RX processor 356 implement layer 1 functionality associated with various signal processing functions. The RX processor 356 may perform spatial processing on the information to recover any spatial streams destined for the UE 350. If multiple spatial streams are destined for the UE 350, they may be combined by the RX processor 356 into a single OFDM symbol stream. The RX processor 356 then converts the OFDM symbol stream from the time-domain to the frequency domain using a Fast Fourier Transform (FFT). The frequency domain signal comprises a separate OFDM symbol stream for each subcarrier of the OFDM signal. The symbols on each subcarrier, and the reference signal, are recovered and demodulated by determining the most likely signal constellation points transmitted by the base station 310. These soft decisions may be based on channel estimates computed by the channel estimator 358. The soft decisions are then decoded and deinterleaved to recover the data and control signals that were originally transmitted by the base station 310 on the physical channel. The data and control signals are then provided to the controller/processor 359, which implements layer 3 and layer 2 functionality.

**[0046]** The controller/processor 359 can be associated with a memory 360 that stores program codes and data. The memory 360 may be referred to as a computer-readable medium. In the UL, the controller/processor 359 provides demultiplexing between transport and logical channels, packet reassembly, deciphering, header decompression, and control signal processing to recover IP packets from the EPC 160. The controller/processor 359 is also responsible for error detection using an ACK and/or NACK protocol to support HARQ operations.

[0047] Similar to the functionality described in connection with the DL transmission by the base station 310, the controller/processor 359 provides RRC layer functionality associated with system information (e.g., MIB, SIBs) acquisition, RRC connections, and measurement reporting; PDCP layer functionality associated with header compression / decompression, and security (ciphering, deciphering, integrity protection, integrity verification); RLC layer functionality associated with the transfer of upper layer PDUs, error correction through ARQ, concatenation, segmentation, and reassembly of RLC SDUs, re-segmentation of RLC data PDUs, and reordering of RLC data PDUs; and MAC layer functionality associated with mapping between logical channels and transport channels, multiplexing of MAC SDUs onto TBs, demultiplexing of MAC SDUs from TBs, scheduling information reporting, error correction through HARQ, priority handling, and logical channel prioritization.

[0048] Channel estimates derived by a channel estimator 358 from a reference signal or feedback transmitted by the base station 310 may be used by the TX processor 368 to select the appropriate coding and modulation schemes, and to facilitate spatial processing. The spatial streams generated by the TX processor 368 may be provided to different antenna 352 via separate transmitters 354TX. Each transmitter 354TX may modulate an RF carrier with a respective spatial stream for transmission.

[0049] The UL transmission is processed at the base station 310 in a manner similar to that described in connection with the receiver function at the UE 350. Each receiver 318RX receives a signal through its respective antenna 320. Each receiver 318RX recovers information modulated onto an RF carrier and provides the information to a RX processor 370.

[0050] The controller/processor 375 can be associated with a memory 376 that stores program codes and data. The memory 376 may be referred to as a computer-readable medium. In the UL, the controller/processor 375 provides demultiplexing between transport and logical channels, packet reassembly, deciphering, header decompression, control signal processing to recover IP packets from the UE 350. IP packets from the controller/processor 375 may be provided to the EPC 160. The controller/processor 375 is also responsible for error detection using an ACK and/or NACK protocol to support HARQ operations.

[0051] In some aspects, at least one of the TX processor 368, the RX processor 356, and the controller/processor 359 may be configured to perform aspects in connection with (198) of FIG. 1.

[0052] In some other aspects, at least one of the TX processor 316, the RX processor 370, and the controller/processor 375 may be configured to perform aspects in connection with (198) of FIG. 1.

[0053] According to various aspects of the present disclosure, a UE and a base station (e.g., a gNB) may be able to communicate on more than one CC in an example RAN, such as a 5G NR RAN. For example, the base station may assign a group of CCs to the UE for carrier aggregation, which may increase the data rate for the UE. The base station may configure the group of CCs to carry some downlink communication (e.g., downlink control information and/or downlink data) and/or some uplink communication.

[0054] Potentially, the example RAN may include more than one TRP. A TRP may be another cell, such as an SCell, that is different from the base station-provided cell, which may be a PCell and/or serving cell. For example, a TRP may be a pico cell, femtocell, remote radio head, or other cell connected to the RAN that includes the base station. A group of CCs assigned to the UE may be configured through a single TRP or mTRP.

[0055] The UE and the gNB may communicate on CCs using directional beamforming. However, mTRP configured for the UE may affect directional beamforming for the UE. For example, the UE may use a respective directional beam for each TRP because each TRP may include a respective antenna array for beamforming. Accordingly, a need exists for determining how to apply a beam by a UE for communication on a group of CCs.

[0056] The present disclosure describes various techniques and solutions for applying (e.g., updating) a beam by a UE for communicating on at least one CC. In particular, the present disclosure describes various approaches to determining whether to apply one beam to a group of CCs. For example, the UE may determine whether communication on a group of CCs is configured through a single TRP or mTRP, and the UE may determine whether to apply the beam to a group of CCs based on whether the communication is configured through one TRP or mTRP.

[0057] Correspondingly, the base station may configure a beam to be applied (e.g., updated) by the UE on at least one of the CCs. Potentially, the base station may configure a beam to be applied by the UE on all of the CCs of the group. For example, the gNB may transmit a group CC-based beam update to the UE, which may indicate a single beam to be applied for communication on all CCs of the group.

[0058] As the base station may configure the beam to be used by the UE, the base station may determine whether communication on a group of CCs assigned to the UE is configured through a single TRP or mTRP, and the base station may determine whether to transmit the group CC-based beam update to the UE based on whether the group of CCs assigned to the UE are configured through one TRP or mTRP

[0059] FIG. 4 is a call flow diagram illustrating example operations in an example access network 400. The example access network 400 may include a base station 402 (e.g., gNB) and a UE 404. The base station 402 may provide a serving cell and/or PCell on which the UE 404 operates. According to various aspects, the base station 402 may assign a group of CCs to the UE 404. For example, the base station 402 may assign a group of CCs to the UE 404 by transmitting an applicable list of CCs to the UE 404 via RRC signaling.

[0060] In some aspects, each CC in the group of CCs may include BWPs, such as downlink BWPs. Each of the CCs may be configured with a corresponding CORESET. The CCs may be assigned for carrier aggregation, which may be intra-band carrier aggregation and/or, if supported, inter-band carrier aggregation.

[0061] In some other aspects, the base station 402 may assign the group of CCs to the UE 404 for uplink communication. Accordingly, the UE 404 may transmit SRSs on the group of CCs (see, e.g., FIG. 2C). The UE 404 may transmit SRSs aperiodically and/or semi-periodically.

[0062] The UE 404 and the base station 402 may communicate on CCs using directional beamforming – e.g., the UE 404 may generate beams 414a-d that may be paired with beams 412a-d generated by the base station 402. The base station 402 may configure the beams used by the UE 404. For example, the base station 402 may transmit information to the UE 404 that indicates a beam (e.g., beam identifier and/or beam index) to be applied (e.g., activated, updated, etc.) by the UE 404.

[0063] In some aspects, the base station 402 may indicate one of the beams 414a-d to be applied by the UE 404 for downlink communication by indicating a transmission configuration indication (TCI) state identifier (ID). The base station 402 may configure different TCI state IDs for the UE 404 for different types of communication. For example, the base station 402 may configure a respective TCI state ID for each CORESET corresponding to each CC/BWP configured for the UE 404. The base station 402 may indicate a TCI state ID in a MAC control element (CE) and/or in at least one RRC message.

[0064] In some other aspects, the base station 402 may indicate one of the beams 414a-d to be applied by the UE 404 for uplink communication by setting a value of a Spatial Relation Info field (e.g., an information element labeled “spatialRelationInfo”). The UE 404 may use the value of the Spatial Relation Info field to determine a corresponding one of the beams 414a-d, such as by determining an index or ID corresponding to the indicated one of the beams 414a-d.

[0065] In some aspects, the base station 402 may configure one beam for all of the group of CCs assigned to the UE 404, which may be referred to as a group CC-based beam update. For example, the base station 402 may set a value in a MAC CE or information element that indicates a TCI state ID or Spatial Relation Info for a first CC, and the base station 402 may indicate that value of the TCI state ID or Spatial Relation Info is further applicable to each of the other CCs in the group of CCs.

[0066] For example, when a TCI state ID is activated for a CORESET by a MAC CE for a set of CCs/BWPs at least for the same band (the applicable list of CCs being indicated by RRC signaling), the TCI state ID may be applied for the CORESET(s) with the same CORESET ID for all BWPs in the indicated CCs on the list. In another example, the base station 402 potentially may use a single MAC CE to activate the same TCI state IDs of a downlink control channel (e.g., PDCCH) for multiple CCs/BWPs. In a further example, when a Spatial Relation Info is activated for a semi-periodic/aperiodic SRS resource by a MAC CE for a set of CCs/BWPs at least for the same band (the applicable list of CCs being indicated by RRC signaling), the Spatial Relation Info may be applied for the semi-periodic/aperiodic resource(s) with the same SRS resource ID for all BWPs in the indicated CCs on the list.

[0067] In some aspects, the base station 402 may indicate to the UE 404 using one MAC CE to map at least one TCI state ID to a set of codepoints in DCI. For example, the number of TCI state IDs configurable for the UE 404 (e.g., 128 TCI state IDs to receive PDSCH) may exceed the capacity of DCI, and therefore, the base station 402 may indicate using one MAC CE that each codepoint in DCI corresponds to at least one respective TCI state ID. Each codepoint, however, may be capable of being mapped to two TCI state IDs, e.g., when a group of CCs are configured on mTRP.

[0068] The access network 400 may further include a set of TRPs 406, 408, each of which may be a pico cell, femtocell, remote radio head, or other cell connected to the access network 400. While the base station 402 may itself be a TRP, the base station 402 may provide a PCell and/or serving cell, whereas each of the TRPs 406, 408 may be configurable as an SCell for the UE 404. For example, the base station 402 may be capable of configuring one or more of the group of CCs assigned to the UE 404 through one or more of the TRPs 406, 408.

[0069] As each of the TRPs 406, 408 may include a respective antenna array for beamforming, the UE 404 may apply different beams for communicating with different ones of the TRPs 406, 408, as well as the base station 402. In other words, the UE 404 may use different ones of the beams 414a-d in order to steer communication in a direction suitable for the one of the TRPs 406, 408 or base station 402 that the UE 404 is communicating.

[0070] As the UE 404 may apply different beams for communicating with the different ones of the TRPs 406, 408, the UE 404 may be unable to apply the same beam for all CCs in a group assigned to the UE 404 when one or more of those CCs are configured through the TRPs 406, 408 different from the base station 402. In other words, the UE 404 may be configured to update a beam for a group of assigned CCs when that group of assigned CCs is configured on a single TRP (e.g., the base station 402). However, the UE 404 may not be configured to update a beam for a group of assigned CCs when that group of CCs is configured on mTRP (e.g., on TRPs 406, 408).

[0071] When the base station 402 is configuring a beam for the UE 404, the base station 402 may determine whether a single TRP or mTRP is configured for the UE 404 on the group of assigned CCs (420). The base station 402 may only transmit a group CC-based beam update to the UE 404 for all assigned CCs when all assigned CCs are configured on a single TRP. If, however, the assigned CCs are configured on mTRP, the base station 402 may configure a respective beam for each of the CCs.

[0072] In the illustrated aspect, the base station 402 may configure group CC-based beam update for the UE 404 (422). That is, the base station 402 may configure a beam for one CC of the group of assigned CCs, and the base station 402 may configure communication on all other CCs of the group to use the same beam.

[0073] In some aspects, the base station 402 may configure the group CC-based beam update for downlink data on a downlink data channel (e.g., PDSCH). In some other aspects, the base station 402 may configure the group CC-based beam update for downlink control information on a downlink control channel (e.g., PDCCH). In still other aspects, the base station 402 may configure the group CC-based beam update for semi-periodic/aperiodic SRS transmitted by the UE 404.

[0074] In order for the group of CCs to be configured on a single TRP, a CORESET pool for each of the set of CORESET should be configured with only one index or no indexes, and additionally, each of a set of codepoints in DCI should correspond to only a single respective TCI state ID by the mapping of MAC CE. Thus, the base station 402 may configure a set of CORESET for the UE 404. For example, the base station 402 may configure each CC/BWP in the assigned group with a plurality of respective CORESETs. A CORESET may be a frequency resource where a downlink control channel (e.g., PDCCH) is located. The base station 402 may configure a CORESET pool index for each CORESET. The CORESET is not associated with any CORESET pool if no CORESET pool index is configured for it.

[0075] Further, the base station 402 may configure, for the UE 404, each of a set of codepoints that map to a respective TCI state ID in DCI. As the base station 402 may configure a group CC-based beam update for the UE 404, the base station 402 may configure each codepoint to map to only a single TCI state ID.

[0076] The base station 402 may transmit first control information 424 indicating the set of CORESET, and further, may transmit second control information 426 indicating the set of codepoints in DCI respectively associated with a single TCI state ID. In some aspects, the base station 402 may transmit the first control information 424 via RRC signaling and may transmit the second control information 426 in at least one MAC CE.

[0077] Further, the base station 402 may transmit the group CC-based beam update 428 to the UE 404. In some aspects, the group CC-based beam update 428 may be included in at least one MAC CE and/or in an RRC message.

[0078] The UE 404 may receive the first control information 424 (e.g., via RRC signaling) and the second control information 426 (e.g., in at least one MAC CE). Based thereon, the UE 404 may determine whether a single TRP or mTRP is configured for the communication on the group of assigned CCs (430). First, the UE 404 may determine that the first control information 424 indicates less than two indexes (i.e., zero or one indexes) associated with a CORESET pool for all of the set of CORESET configured in the CCs/BWPs assigned to the UE 404. For example, all of CORESETs to the UE 404 can be configured with a same value of CORESET pool index. In a further example, all of CORESETs to the UE 404 can be configured with no value of CORESET pool. Second, the UE 404 may determine that the second control information 426 indicates each of the set of codepoints in DCI maps to a respective single TCI state ID.

[0079] If either of the two aforementioned conditions fail, then the UE 404 may determine that the group of CCs is configured on mTRP. That is, the UE 404 may determine that the group of CCs is configured on mTRP when the first control information 424 indicates two or more indexes associated with the CORESET pool of the set of CORESET and/or the second control information 426 indicates at least one of the set of codepoints is mapped with more than one (e.g., two) TCI state IDs included in DCI.

[0080] The UE 404 may further receive the group CC-based beam update 428. The UE 404 may determine that the group of CCs is assigned on the single TRP, and therefore, the UE 404 may apply the beam for each CC of the group of assigned CCs (432).

[0081] In a first aspect, the group CC-based beam update 428 may configure a beam for downlink control information on a downlink control channel (e.g., PDCCH). In such aspects, if the UE 404 is provided by simultaneousTCI-CellList a number of up to two lists of cells for simultaneous TCI state activation by simultaneousTCI-UpdateList-r16 and/or simultaneousTCI-UpdateListSecond-r16, the UE 404 applies the antenna port quasi co-location provided by TCI-States with same activated tci-StateID value to CORESETs with index *p* in all configured DL BWPs of all configured cells in a list determined from a serving cell index provided by a MAC CE command. The simultaneousTCI-CellList can be provided for simultaneous TCI state activation only if the UE 404 is not provided different values of CORESETPoolIndex in ControlResourceSets, and is not provided at least one TCI codepoint mapped with two TCI states.

[0082] Further to the first aspect, when the UE 404 has applied the beam for the group of assigned CCs on the downlink control channel (e.g., PDCCH), the UE 404 may receive downlink control information 434 on the downlink control channel via the one of the beams 414a-d activated by the group CC-based beam update 428.

[0083] In a second aspect, the group CC-based beam update 428 may configure a beam for downlink data on a downlink data channel (e.g., PDSCH). In such aspects, the UE 404 may receive the group CC-based beam update 428 as an activation command used to map up to eight TCI states to the codepoints of the DCI field "Transmission Configuration Indication" in one CC/DL BWP or in a set of CCs/DL BWPs, respectively. When a set of TCI state IDs are activated for a set of CCs/DL BWPs, where the applicable list of CCs is determined by indicated CC in the activation command, the same set of TCI state IDs are applied for all DL BWPs in the indicated CCs. A set of TCI state IDs can be activated for a set of CCs/DL BWPs only if the UE 404 is not provided different values of CORESETPoolIndex in ControlResourceSets, and is not provided at least one TCI codepoint mapped with two TCI states.

**[0084]** Further to the second aspect, when the UE 404 has applied the beam for the group of assigned CCs on the downlink data channel (e.g., PDSCH), the UE 404 may receive downlink data 436 on the downlink data channel via the one of the beams 414a-d activated by the group CC-based beam update 428.

**[0085]** In a third aspect, the group CC-based beam update 428 may configure a beam for semi-periodic/aperiodic SRS. In such aspects, when a spatialRelationInfo is activated/updated for a semi-persistent or aperiodic SRS resource configured by the higher layer parameter SRS-Resource by a MAC CE for a set of CCs/BWPs, where the applicable list of CCs is indicated by higher layer parameter simultaneousSpatial-UpdatedList-r16 or simultaneousSpatial-UpdatedListSecond-r16, the spatialRelationInfo is applied for the semi-persistent or aperiodic SRS resource(s) with the same SRS resource ID for all the BWPs in the indicated CCs. A spatialRelationInfo can be activated/updated for a semi-persistent or aperiodic SRS resource configured by the higher layer parameter SRS-Resource by a MAC CE for a set of CCs/BWPs only if the UE 404 is not provided different values of CORESETPoolIndex in ControlResourceSets, and is not provided at least one TCI codepoint mapped with two TCI states.

**[0086]** Further to the third aspect, when the UE 404 has applied the beam for the group of assigned CCs, the UE 404 may transmit semi-periodic/aperiodic SRS(s) on SRS resource(s) via the one of the beams 414a-d activated by the group CC-based beam update 428.

**[0087]** FIG. 5 is a flowchart of an example method 500 of wireless communication. The method may be performed by a UE (e.g., the UE 104, 350, 404). According to different aspects, one or more of the illustrated operations may be transposed, omitted, and/or contemporaneously performed.

**[0088]** At 502, the UE may receive first control information associated with a set of CORESET. The UE may receive the first control information via RRC signaling. The information associated with the set of CORESET may indicate zero, one, or more than one indexes associated with a CORESET pool of each CORESET of the set. For example, referring to FIG. 4, the UE 404 may receive the first control information 424 from the base station 402.

[0089] At 504, the UE may receive second control information indicating a set of codepoints associated with at least one respective TCI state ID included in third control information. The second control information may be received in at least one MAC CE, and the third control information may be at least one DCI message. For example, referring to FIG. 4, the UE 404 may receive the second control information 426 from the base station 402.

[0090] At 506, the UE may receive information indicating a beam associated with communication on a plurality of CCs. In one aspect, the information indicating the beam associated with the communication on the plurality of CCs may be received in at least one MAC CE. For example, referring to FIG. 4, the UE 404 may receive the group CC-based beam update 428 from the base station 402.

[0091] At 508, the UE may determine whether a single TRP or mTRP is configured for the communication on the plurality of CCs. For example, referring to FIG. 4, the UE 404 may determine whether a single TRP or mTRP 406, 408 is configured for communication on a group of CCs (430).

[0092] In order to determine whether the single TRP or mTRP is configured for the communication on the plurality of CCs, at 510, the UE may determine whether less than two (i.e., zero or one) indexes associated with a CORESET pool are configured for each of the set of CORESET. For example, the UE may identify from the first control information whether zero or one indexes associated with a CORESET pool are configured for each of the set of CORESET. Referring to FIG. 4, the UE 404 may determine whether the first control information 424 indicates less than two indexes associated with a CORESET pool are configured for each of the set of CORESET of the CC/BWPs.

[0093] At 512, the UE may determine whether each codepoint in the second control information is associated with a single TCI state ID of third control information. For example, the UE may identify whether each codepoint in the second control information maps to one TCI state ID in DCI or two TCI state IDs in DCI. Referring to FIG. 4, the UE 404 may determine whether the second control information 426 indicates each codepoint maps to a single TCI state ID in DCI or maps to two TCI state IDs in DCI.

[0094] If the UE determines, at 510, that less than two (i.e., zero or one) indexes associated with a CORESET pool are configured for each of the set of CORESET and, at 512, that each codepoint in the second control information maps to a single TCI state ID of third control information, then the UE may determine that a single TRP is configured for the communication on the plurality of CCs. At 514, the UE may apply the beam for the communication on the plurality of CCs. The communication on the plurality of CCs may include semi-periodic/aperiodic SRS(s), downlink data on a downlink data channel (e.g., PDSCH), or downlink control information on a downlink control channel (e.g., PDCCH). For example, referring to FIG. 4, the UE 404 may apply one of the beams 414a-d corresponding to the beam update 428 for receiving the downlink control information 434 on the downlink control channel, receiving the downlink data 436 on the downlink data channel, or transmitting the semi-periodic/aperiodic SRS(s) 438.

[0095] If the UE determines, at 510, that two or more indexes associated with a CORESET pool are configured for each of the set of CORESET and/or, at 512, that at least one codepoint in the second control information maps to more than one TCI state ID of third control information, then the UE may determine that mTRP is configured for the communication on the plurality of CCs. At 516, the UE may apply the beam for the communication on only one CC of the plurality of CCs.

[0096] FIG. 6 is a flowchart of an example method 600 of wireless communication. The method may be performed by a base station (e.g., the base station 102/180, 310, 402). According to different aspects, one or more of the illustrated operations may be transposed, omitted, and/or contemporaneously performed.

[0097] At 602, the base station may configure a set of CORESET for a UE. For example, the base station may configure a respective CORESET for each CC/BWP assigned to the UE in a group of CCs. For example, referring to FIG. 4, the base station 402 may configure a set of CORESET for the UE 404.

[0098] At 604, the base station may configure a set of codepoints associated with at least one respective TCI state ID included in other control information for the UE. For example, referring to FIG. 4, the base station 402 may configure a set of codepoints associated with at least one respective TCI state ID included in DCI for the UE 404.

[0099] At 606, the base station may transmit, to the UE, first control information indicating the set of CORESET. The base station may transmit the first control information via

RRC signaling. For example, referring to FIG. 4, the base station 402 may transmit the first control information 424 to the UE 404.

[00100] At 608, the base station may transmit, to the UE, second control information indicating the set of codepoints associated with the at least one respective TCI state ID included in the other control information. The base station may transmit the second control information in at least one MAC CE, and the other control information may be DCI. For example, referring to FIG. 4, the base station 402 may transmit the second control information 426 to the UE 404.

[00101] At 610, the base station may determine whether a single TRP or mTRP is configured for communication by the UE on a plurality of CCs assigned to the UE. If a single TRP is configured, then the base station may configure less than two (i.e., zero or one) indexes associated with a CORESET pool for each of the set of CORESET indicated in the first control information and, further, may configure each codepoint in the second control information to map to a single TCI state ID of the other control information. At 612, if the single TRP is configured, the base station may configure a beam for the communication by the UE on the plurality of CCs. For example, the base station may configure a group CC-based beam update. Referring to FIG. 4, the base station 402 may configure a beam for the UE 404 (422).

[00102] If mTRP is configured, then the base station may configure two or more indexes associated with a CORESET pool for at least one of the set of CORESET, and/or may configure at least one codepoint in the second control information to map to more than one TCI state ID of the other control information. At 614, if mTRP is configured, the base station may configure a beam for communication by the UE on one of the plurality of CCs.

[00103] At 616, the base station may transmit information indicating the beam to the UE. The information indicating the beam may be included in at least one MAC CE. For example, referring to FIG. 4, the base station 402 may transmit the beam update 428 to the UE 404.

[00104] Further disclosure is included in the Appendix.

[00105] It is understood that the specific order or hierarchy of blocks in the processes / flowcharts disclosed is an illustration of example approaches. Based upon design preferences, it is understood that the specific order or hierarchy of blocks in the processes / flowcharts may be rearranged. Further, some blocks may be combined or omitted. The accompanying method claims present elements of the various blocks in

a sample order, and are not meant to be limited to the specific order or hierarchy presented.

**[00106]** The previous description is provided to enable any person skilled in the art to practice the various aspects described herein. Various modifications to these aspects will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other aspects. Thus, the claims are not intended to be limited to the aspects shown herein, but is to be accorded the full scope consistent with the language claims, wherein reference to an element in the singular is not intended to mean "one and only one" unless specifically so stated, but rather "one or more." Terms such as "if," "when," and "while" should be interpreted to mean "under the condition that" rather than imply an immediate temporal relationship or reaction. That is, these phrases, e.g., "when," do not imply an immediate action in response to or during the occurrence of an action, but simply imply that if a condition is met then an action will occur, but without requiring a specific or immediate time constraint for the action to occur. The word "exemplary" is used herein to mean "serving as an example, instance, or illustration." Any aspect described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other aspects. Unless specifically stated otherwise, the term "some" refers to one or more. Combinations such as "at least one of A, B, or C," "one or more of A, B, or C," "at least one of A, B, and C," "one or more of A, B, and C," and "A, B, C, or any combination thereof" include any combination of A, B, and/or C, and may include multiples of A, multiples of B, or multiples of C. Specifically, combinations such as "at least one of A, B, or C," "one or more of A, B, or C," "at least one of A, B, and C," "one or more of A, B, and C," and "A, B, C, or any combination thereof" may be A only, B only, C only, A and B, A and C, B and C, or A and B and C, where any such combinations may contain one or more member or members of A, B, or C. All structural and functional equivalents to the elements of the various aspects described throughout this disclosure that are known or later come to be known to those of ordinary skill in the art are expressly incorporated herein by reference and are intended to be encompassed by the claims. Moreover, nothing disclosed herein is intended to be dedicated to the public regardless of whether such disclosure is explicitly recited in the claims. The words "module," "mechanism," "element," "device," and the like may not be a substitute for the word "means." As such, no claim element is to be construed as a means plus function unless the element is expressly recited using the phrase "means for."

# Group CC based beam update for Single TRP

# Group CC Based Beam Update for Single TRP

- group CC based beam update for PDSCH, PDCCH, and SP/AP SRS should be restricted to a single TRP.
- When a set of TCI-state IDs for PDSCH are activated by a MAC CE for a set of CCs/BWPs at least for the same band, where the applicable list of CCs is indicated by RRC signalling, the same set of TCI-state IDs are applied for the all BWPs in the indicated CCs.
- Further signaling details are up to RAN2.
- Whether to support the inter-band CA for this feature will be decided, e.g., by RAN1.
- Whether to indicate the applicable list of bands for the feature of single MAC-CE to activate the same set of PDSCH TCI state IDs for multiple CCs/BWPs is possible.
- UE capability signaling for group CCs, single TRP, mTRP, etc.
- How many combinations of CCs can be configured by RRC and relevant UE capability

# Group CC Based Beam Update for Single TRP

- When a TCI-state ID is activated for a CORESET by a MAC CE for a set of CCs/BWPs at least for the same band, where the applicable list of CCs is indicated by RRC signalling, the TCI-state ID is applied for the CORESET(s) with the same CORESET ID for all the BWPs in the indicated CCs.
- Further signaling details are up to RAN2.
- Whether to support the inter-band CA for this feature will be decided, e.g., by RAN1.
- Whether to indicate the applicable list of bands for the feature of single MAC-CE to activate the same PDCCH TCI state IDs for multiple CCs/BWPs is up to capability discussion.
- UE capability signaling details
- Note: This at least applies to single TRP case.
- When a Spatial Relation Info is activated for a SP/AP SRS resource by a MAC CE for a set of CCs/BWPs at least for the same band, where the applicable list of CCs is indicated by RRC signalling, the Spatial Relation Info is applied for the SP/AP SRS resource(s) with the same SRS resource ID for all the BWPs in the indicated CCs.

# Group CC Based Beam Update for Single TRP

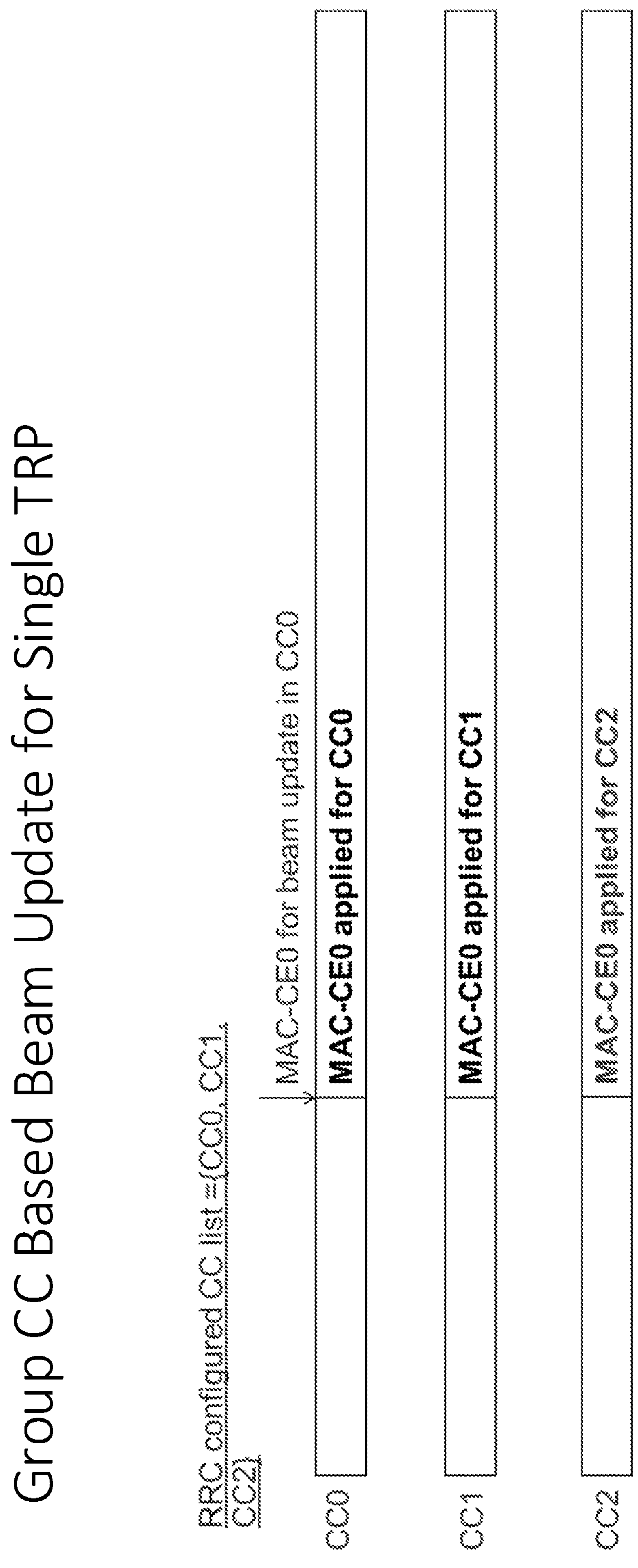
- Proposal: Group CC based beam update for SP/AP SRS is only applicable when UE is not in mTRP, i.e. not configured with different values of CORESETPoolIndex and not provided any TCI codepoint mapped with two TCI states
- When a spatialRelationInfo is activated/updated for a semi-persistent or aperiodic SRS resource configured by the higher layer parameter SRS-Resource by a MAC CE for a set of CCs/BWPs, where the applicable list of CCs is indicated by higher layer parameter simultaneousSpatial-UpdatedList-r16 or simultaneousSpatial-UpdatedListSecond-r16, the spatialRelationInfo is applied for the semi-persistent or aperiodic SRS resource(s) with the same SRS resource ID for all the BWPs in the indicated CCs. A spatialRelationInfo can be activated/updated for a semi-persistent or aperiodic SRS resource configured by the higher layer parameter SRS-Resource by a MAC CE for a set of CCs/BWPs only if UE is not provided different values of CORESETPoolIndex in ControlResourceSets, and is not provided at least one TCI codepoint mapped with two TCI states.

# Group CC Based Beam Update for Single TRP

- Proposal: Group CC based beam update for PDSCH is only applicable when UE is not in mTRP, i.e. not configured with different values of CORESETPoolIndex and not provided any TCI codepoint mapped with two TCI states
- The UE receives an activation command, used to map up to 8 TCI states to the codepoints of the DCI field 'Transmission Configuration Indication' in one CC/DL BWP or in a set of CCs/DL BWPs, respectively. When a set of TCI state IDs are activated for a set of CCs/DL BWPs, where the applicable list of CCs is determined by indicated CC in the activation command, the same set of TCI state IDs are applied for all DL BWPs in the indicated CCs. A set of TCI state IDs can be activated for a set of CCs/DL BWPs only if UE is not provided different values of CORESETPoolIndex in ControlResourceSets, and is not provided at least one TCI codepoint mapped with two TCI states.

# Group CC Based Beam Update for Single TRP

- Proposal: Group CC based beam update for PDCCH is only applicable when UE is not in mTRP, i.e. not configured with different values of CORESETPoolIndex and not provided any TCI codepoint mapped with two TCI states
- if the UE is provided by simultaneousTCI-CellList a number of up to two lists of cells for simultaneous TCI state activation by simultaneousTCI-UpdateList-r16 and/or simultaneousTCI-UpdateListSecond-r16, the UE applies the antenna port quasi co-location provided by TCI-States with same activated tci-StateID value to CORESETs with index $p$ in all configured DL BWPs of all configured cells in a list determined from a serving cell index provided by a MAC CE command. The simultaneousTCI-CellList can be provided for simultaneous TCI state activation only if UE is not provided different values of CORESETPoolIndex in ControlResourceSets, and is not provided at least one TCI codepoint mapped with two TCI states.


Group CC Based Beam Update for Single TRP
RRC configured CC list ={CC0, CC1, CC2}
MAC-CE0 for beam update in CC0
CC0
MAC-CE0 applied for CC0
CC1
MAC-CE0 applied for CC1
CC2
MAC-CE0 applied for CC2

# new MIMO DL MAC CE -
# TCI States Activation/Deactivation for UE-specific PDSCH MAC CE for Multiple CCs

The MAC CE activates and deactivates the configured TCI states for PDSCH of a serving cell or multiple cells from a cell list.

This MAC CE activates and deactivates the TCI states for PDSCH in multiple PDCCHs multiple TRPs case.

- If the indicated serving cell is configured as part of a cell list, this MAC CE applies to all the cells in the cell list, and the BWP ID field is ignored.
- CORESET Pool ID indicates that this MAC CE shall be applied for the DL transmission scheduled by CORESET with which CORESET pool ID.
- The codepoint of the DCI *Transmission Configuration Indication* field to which the TCI state is mapped is determined by its ordinal position among all the TCI States with $T_i$ field set to 1.
- The maximum number of activated TCI states is 8.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CORSET Pool ID | Serving Cell ID | | | | | BWP ID | | Oct 1 |
| $T_7$ | $T_6$ | $T_5$ | $T_4$ | $T_3$ | $T_2$ | $T_1$ | $T_0$ | Oct 2 |
| $T_{15}$ | $T_{14}$ | $T_{13}$ | $T_{12}$ | $T_{11}$ | $T_{10}$ | $T_9$ | $T_8$ | Oct 3 |
| ... | | | | | | | | |
| $T_{(N-2)\times 8+7}$ | $T_{(N-2)\times 8+6}$ | $T_{(N-2)\times 8+5}$ | $T_{(N-2)\times 8+4}$ | $T_{(N-2)\times 8+3}$ | $T_{(N-2)\times 8+2}$ | $T_{(N-2)\times 8+1}$ | $T_{(N-2)\times 8}$ | Oct N |

# new MIMO DL MAC CE -
# Enhanced TCI States Activation/Deactivation for UE-specific PDSCH MAC CE

This MAC CE activates and deactivates the TCI states for PDSCH in single PDCCH multiple TRPs case.

The MAC CE updates the configured one or two TCI states for the codepoint of the DCI *Transmission configuration indication* field for PDSCH of a serving cell.

- TCI state $ID_{i,j}$ denotes the $j^{th}$ TCI state indicated for the $i^{th}$ codepoint in the DCI *Transmission Configuration Indication* field.
- The TCI codepoint to which the TCI States are mapped is determined by its ordinal position among all the TCI codepoints with sets of TCI state $ID_{i,j}$ fields.
- The maximum number of activated TCI codepoint is 8 and the maximum number of TCI states mapped to a TCI codepoint is 2.

| | | | |
|---|---|---|---|
| R | Serving Cell ID | BWP ID | Oct 1 |
| $C_0$ | TCI state $ID_{0,1}$ | | Oct 2 |
| R | TCI state $ID_{0,2}$ | | Oct 3 (Optional) |
| | ... | | |
| $C_N$ | TCI state $ID_{N,1}$ | | Oct M-1 |
| R | TCI state $ID_{N,2}$ | | Oct M (Optional) |

## CLAIMS

**WHAT IS CLAIMED IS:**

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

receiving information indicating a beam associated with communication on a plurality of component carriers (CCs);

determining whether a single transmission-reception point (TRP) or multiple TRPs (mTRP) is configured for the communication on the plurality of CCs; and

applying the beam for the communication on the plurality of CCs when the single TRP is configured for the communication on the plurality of CCs.

2. The method of claim 1, further comprising:

applying the beam for communication on one of the plurality of CCs when mTRP is configured for the communication on the plurality of CCs.

3. The method of claim 1, further comprising:

receiving first control information associated with a set of control resource set (CORESET);

receiving second control information indicating a set of codepoints associated with at least one respective transmission configuration indication (TCI) state identifier (ID) included in third control information;

determining the single TRP is configured for the communication on the plurality of CCs when the first control information indicates less than two indexes associated with a CORESET pool of each of the set of CORESET and the second control information indicates each of the set of codepoints is associated with a single respective TCI state ID; and

determining mTRP are configured for the communication on the plurality of CCs when the first control information indicates two or more indexes associated with the CORESET pool of the set of CORESET or the second control information indicates one of the set of codepoints is associated with more than one respective TCI state ID.

4. The method of claim 3, wherein the first control information comprises radio resource control (RRC) signaling, the second control information comprises at least one

medium access control (MAC) control element (CE), and the third control information comprises at least one downlink control information (DCI) message.

5. The method of claim 1, wherein the communication on the plurality of CCs comprises a sounding reference signal (SRS) that is aperiodic or semi-periodic.

6. The method of claim 1, wherein the communication on the plurality of CCs comprises downlink data on a downlink data channel.

7. The method of claim 1, wherein the communication on the plurality of CCs comprises control information on a downlink control channel.

8. The method of claim 1, wherein the information indicating the beam comprises a medium access control (MAC) control element (CE).

9. A method of wireless communication by a base station, the method comprising:

determining whether a single transmission-reception point (TRP) or multiple TRPs (mTRP) is configured for communication by a user equipment (UE) on a plurality of component carriers (CCs);

configuring a beam for the communication by the UE on the plurality of CCs when the single TRP is configured for the communication by the UE on the plurality of CCs; and

transmitting information indicating the beam to the UE.

10. The method of claim 9, further comprising:

configuring the beam for communication by the UE on one of the plurality of CCs when mTRP is configured for the communication by the UE on the plurality of CCs.

11. The method of claim 9, further comprising:

configuring a set of control resource set (CORESET) for the UE;

configuring a set of codepoints associated with at least one respective transmission configuration indication (TCI) state identifier (ID) included in other control information for the UE;

transmitting, to the UE, first control information indicating the set of CORESET; and

transmitting, to the UE, second control information indicating the set of codepoints associated with the at least one respective TCI state ID included in the other control information.

12. The method of claim 11, wherein, when the single TRP is configured for the communication by the UE on the plurality of CCs:

the first control information indicates less than two indexes associated with a CORESET pool of each of the set of CORESET, and

the second control information indicates that each of the set of codepoints is associated with a single respective TCI state ID included in the other control information.

13. The method of claim 11, wherein, when the mTRP is configured for the communication by the UE on the plurality of CCs, at least one of:

the first control information indicates two or more indexes associated with a CORESET pool of each of the set of CORESET, or

the second control information indicates that at least one of the set of codepoints is associated with two TCI state IDs included in the other control information.

14. The method of claim 11, wherein the first control information comprises radio resource control (RRC) signaling, the second control information comprises at least one medium access control (MAC) control element (CE), and the other control information comprises at least one downlink control information (DCI) message.

15. The method of claim 9, wherein the communication by the UE on the plurality of CCs comprises a sounding reference signal (SRS) that is aperiodic or semi-periodic.

16. The method of claim 9, wherein the communication by the UE on the plurality of CCs comprises downlink data on a downlink data channel.

17. The method of claim 9, wherein the communication by the UE on the plurality of CCs comprises control information on a downlink control channel.

18. The method of claim 9, wherein the information indicating the beam comprises a medium access control (MAC) control element (CE).

19. An apparatus for wireless communication by a user equipment (UE), the apparatus comprising:

a memory; and

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

receive information indicating a beam associated with communication on a plurality of component carriers (CCs);

determine whether a single transmission-reception point (TRP) or multiple TRPs (mTRP) is configured for the communication on the plurality of CCs; and

apply the beam for the communication on the plurality of CCs when the single TRP is configured for the communication on the plurality of CCs.

20. The apparatus of claim 19, wherein the at least one processor is further configured to:

apply the beam for communication on one of the plurality of CCs when mTRP is configured for the communication on the plurality of CCs.

21. The apparatus of claim 19, wherein the at least one processor is further configured to:

receive first control information associated with a set of control resource set (CORESET);

receive second control information indicating a set of codepoints associated with at least one respective transmission configuration indication (TCI) state identifier (ID) included in third control information;

determine the single TRP is configured for the communication on the plurality of CCs when the first control information indicates less than two indexes associated with a CORESET pool of each of the set of CORESET and the second control information indicates each of the set of codepoints is associated with a single respective TCI state ID; and determine mTRP are configured for the communication on the plurality of CCs when the first control information indicates two or more indexes associated with the CORESET pool of the set of CORESET or the second control information indicates one of the set of codepoints is associated with more than one respective TCI state ID.

22. The apparatus of claim 21, wherein the first control information comprises radio resource control (RRC) signaling, the second control information comprises at least one medium access control (MAC) control element (CE), and the third control information comprises at least one downlink control information (DCI) message.

23. The apparatus of claim 19, wherein the communication on the plurality of CCs comprises a sounding reference signal (SRS) that is aperiodic or semi-periodic.

24. The apparatus of claim 19, wherein the communication on the plurality of CCs comprises downlink data on a downlink data channel.

25. The apparatus of claim 19, wherein the communication on the plurality of CCs comprises control information on a downlink control channel.

26. The apparatus of claim 19, wherein the information indicating the beam comprises a medium access control (MAC) control element (CE).

27. An apparatus for wireless communication by a base station, the apparatus comprising:

a memory; and

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

determine whether a single transmission-reception point (TRP) or multiple TRPs (mTRP) is configured for communication by a user equipment (UE) on a plurality of component carriers (CCs);

configure a beam for the communication by the UE on the plurality of CCs when the single TRP is configured for the communication by the UE on the plurality of CCs; and

transmit information indicating the beam to the UE.

28. The apparatus of claim 27, wherein the at least one processor is further configured to:

configure the beam for communication by the UE on one of the plurality of CCs when mTRP is configured for the communication by the UE on the plurality of CCs.

29. The apparatus of claim 27, wherein the at least one processor is further configured to:

configure a set of control resource set (CORESET) for the UE;

configure a set of codepoints associated with at least one respective transmission configuration indication (TCI) state identifier (ID) included in other control information for the UE;

transmit, to the UE, first control information indicating the set of CORESET; and

transmit, to the UE, second control information indicating the set of codepoints associated with the at least one respective TCI state ID included in the other control information.

30. The apparatus of claim 29, wherein, when the single TRP is configured for the communication by the UE on the plurality of CCs:

the first control information indicates less than two indexes associated with a CORESET pool of each of the set of CORESET, and

the second control information indicates that each of the set of codepoints is associated with a single respective TCI state ID included in the other control information.

31. The apparatus of claim 29, wherein, when the mTRP is configured for the communication by the UE on the plurality of CCs, at least one of:

the first control information indicates two or more indexes associated with a CORESET pool of each of the set of CORESET, or

the second control information indicates that at least one of the set of codepoints is associated with two TCI state IDs included in the other control information.

32. The apparatus of claim 29, wherein the first control information comprises radio resource control (RRC) signaling, the second control information comprises at least one medium access control (MAC) control element (CE), and the other control information comprises at least one downlink control information (DCI) message.

33. The apparatus of claim 27, wherein the communication by the UE on the plurality of CCs comprises a sounding reference signal (SRS) that is aperiodic or semi-periodic.

34. The apparatus of claim 27, wherein the communication by the UE on the plurality of CCs comprises downlink data on a downlink data channel.

35. The apparatus of claim 27, wherein the communication by the UE on the plurality of CCs comprises control information on a downlink control channel.

36. The apparatus of claim 27, wherein the information indicating the beam comprises a medium access control (MAC) control element (CE).

37. An apparatus for wireless communication by a user equipment (UE), the apparatus comprising:

means for receiving information indicating a beam associated with communication on a plurality of component carriers (CCs);

means for determining whether a single transmission-reception point (TRP) or multiple TRPs (mTRP) is configured for the communication on the plurality of CCs; and

means for applying the beam for the communication on the plurality of CCs when the single TRP is configured for the communication on the plurality of CCs.

38. The apparatus of claim 37, further comprising:

means for applying the beam for communication on one of the plurality of CCs when mTRP is configured for the communication on the plurality of CCs.

39. The apparatus of claim 37, further comprising:

means for receiving first control information associated with a set of control resource set (CORESET);

means for receiving second control information indicating a set of codepoints associated with at least one respective transmission configuration indication (TCI) state identifier (ID) included in third control information;

means for determining the single TRP is configured for the communication on the plurality of CCs when the first control information indicates less than two indexes associated with a CORESET pool of each of the set of CORESET and the second control information indicates each of the set of codepoints is associated with a single respective TCI state ID; and

means for determining mTRP are configured for the communication on the plurality of CCs when the first control information indicates two or more indexes associated with the CORESET pool of the set of CORESET or the second control information indicates one of the set of codepoints is associated with more than one respective TCI state ID.

40. The apparatus of claim 39, wherein the first control information comprises radio resource control (RRC) signaling, the second control information comprises at least one medium access control (MAC) control element (CE), and the third control information comprises at least one downlink control information (DCI) message.

41. The apparatus of claim 37, wherein the communication on the plurality of CCs comprises a sounding reference signal (SRS) that is aperiodic or semi-periodic.

42. The apparatus of claim 37, wherein the communication on the plurality of CCs comprises downlink data on a downlink data channel.

43. The apparatus of claim 37, wherein the communication on the plurality of CCs comprises control information on a downlink control channel.

44. The apparatus of claim 37, wherein the information indicating the beam comprises a medium access control (MAC) control element (CE).

45. An apparatus for wireless communication by a base station, the apparatus comprising:

means for determining whether a single transmission-reception point (TRP) or multiple TRPs (mTRP) is configured for communication by a user equipment (UE) on a plurality of component carriers (CCs);

means for configuring a beam for the communication by the UE on the plurality of CCs when the single TRP is configured for the communication by the UE on the plurality of CCs; and

means for transmitting information indicating the beam to the UE.

46. The apparatus of claim 45, further comprising:

configuring the beam for communication by the UE on one of the plurality of CCs when mTRP is configured for the communication by the UE on the plurality of CCs.

47. The apparatus of claim 45, further comprising:

configuring a set of control resource set (CORESET) for the UE;

configuring a set of codepoints associated with at least one respective transmission configuration indication (TCI) state identifier (ID) included in other control information for the UE;

transmitting, to the UE, first control information indicating the set of CORESET; and

transmitting, to the UE, second control information indicating the set of codepoints associated with the at least one respective TCI state ID included in the other control information.

48. The apparatus of claim 47, wherein, when the single TRP is configured for the communication by the UE on the plurality of CCs:

the first control information indicates less than two indexes associated with a CORESET pool of each of the set of CORESET, and

the second control information indicates that each of the set of codepoints is associated with a single respective TCI state ID included in the other control information.

49. The apparatus of claim 47, wherein, when the mTRP is configured for the communication by the UE on the plurality of CCs, at least one of:

the first control information indicates two or more indexes associated with a CORESET pool of each of the set of CORESET, or

the second control information indicates that at least one of the set of codepoints is associated with two TCI state IDs included in the other control information.

50. The apparatus of claim 47, wherein the first control information comprises radio resource control (RRC) signaling, the second control information comprises at least one medium access control (MAC) control element (CE), and the other control information comprises at least one downlink control information (DCI) message.

51. The apparatus of claim 45, wherein the communication by the UE on the plurality of CCs comprises a sounding reference signal (SRS) that is aperiodic or semi-periodic.

52. The apparatus of claim 45, wherein the communication by the UE on the plurality of CCs comprises downlink data on a downlink data channel.

53. The apparatus of claim 45, wherein the communication by the UE on the plurality of CCs comprises control information on a downlink control channel.

54. The apparatus of claim 45, wherein the information indicating the beam comprises a medium access control (MAC) control element (CE).

55. A computer-readable medium storing computer-executable code for wireless communication by a user equipment (UE), the code when executed by a processor cause the processor to:

receive information indicating a beam associated with communication on a plurality of component carriers (CCs);

determine whether a single transmission-reception point (TRP) or multiple TRPs (mTRP) is configured for the communication on the plurality of CCs; and

apply the beam for the communication on the plurality of CCs when the single TRP is configured for the communication on the plurality of CCs.

56. A computer-readable medium storing computer-executable code for wireless communication by a base station, the code when executed by a processor cause the processor to:

determine whether a single transmission-reception point (TRP) or multiple TRPs (mTRP) is configured for communication by a user equipment (UE) on a plurality of component carriers (CCs);

configure a beam for the communication by the UE on the plurality of CCs when the single TRP is configured for the communication by the UE on the plurality of CCs; and

transmit information indicating the beam to the UE.

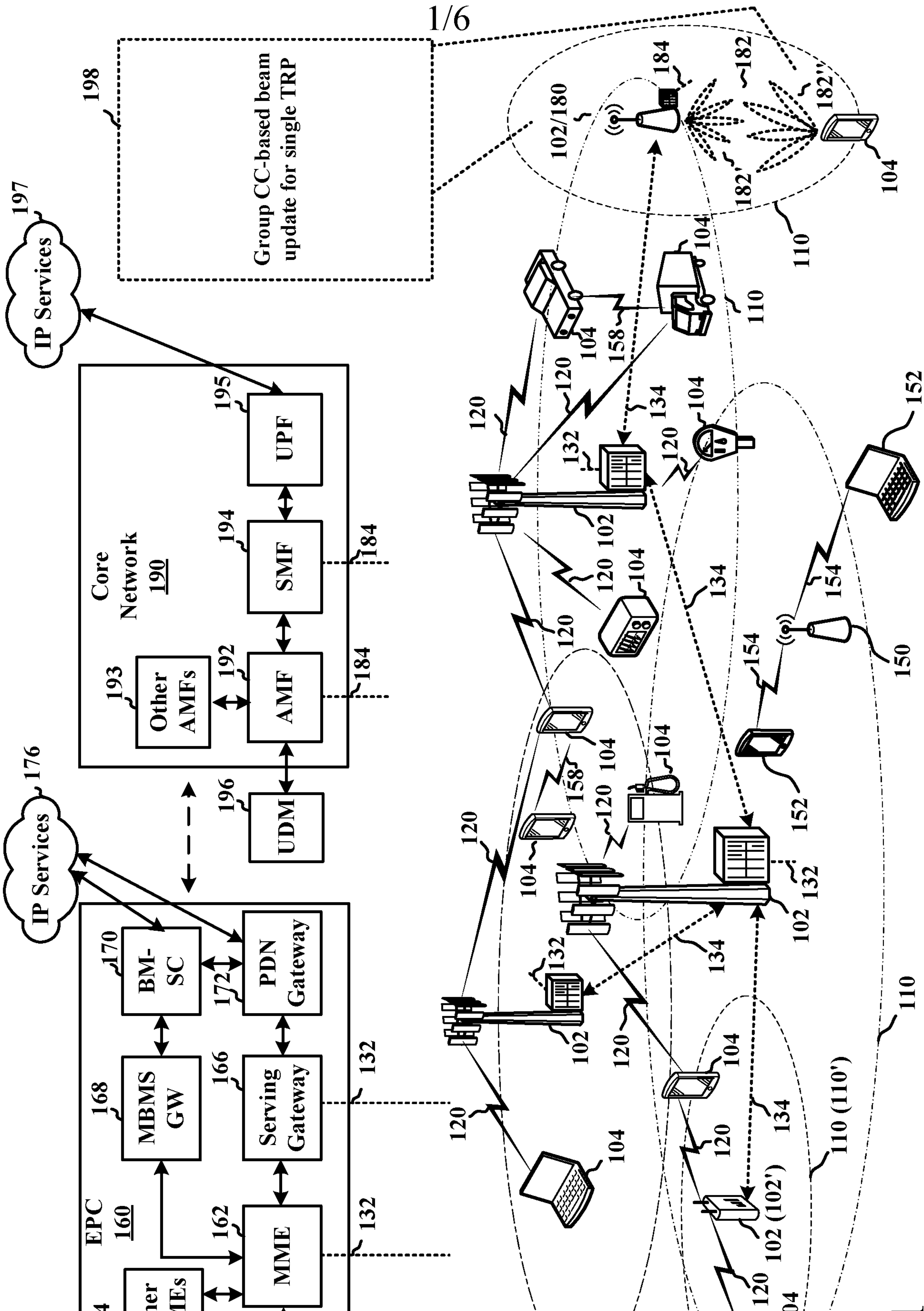

100
EPC
160
HSS
174
Other MMEs
164
MME
162
MBMS GW
168
Serving Gateway
166
BM-SC
170
PDN Gateway
172
IP Services
176
UDM
196
Core Network
190
Other AMFs
193
AMF
192
SMF
194
UPF
195
IP Services
197
198
Group CC-based beam update for single TRP
132
184
102
102 (102')
102/180
104
110
110 (110')
120
134
150
152
154
158
182
182'
182''

FIG. 1

2/6

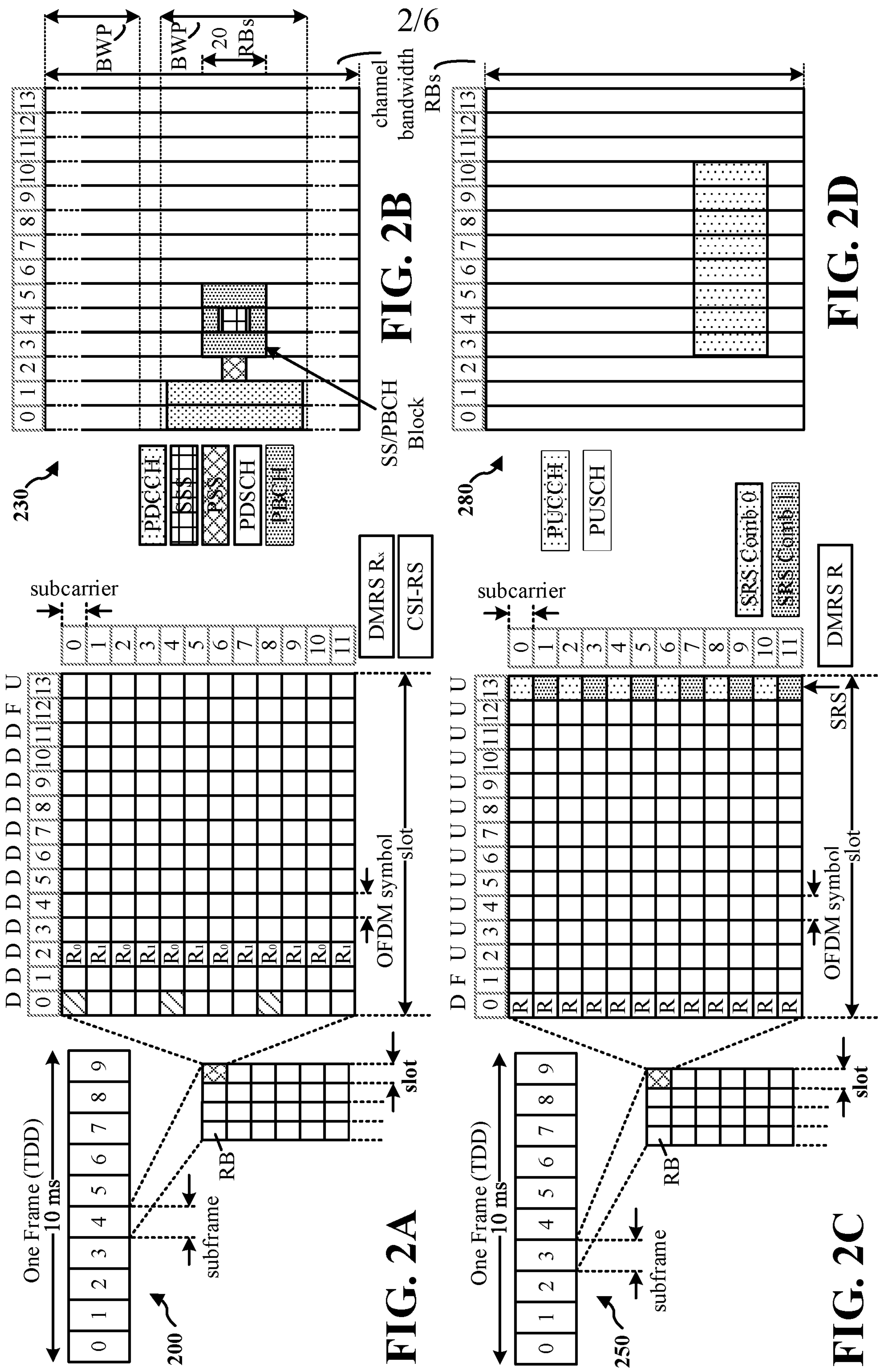



FIG. 2A

FIG. 2B

FIG. 2C

FIG. 2D

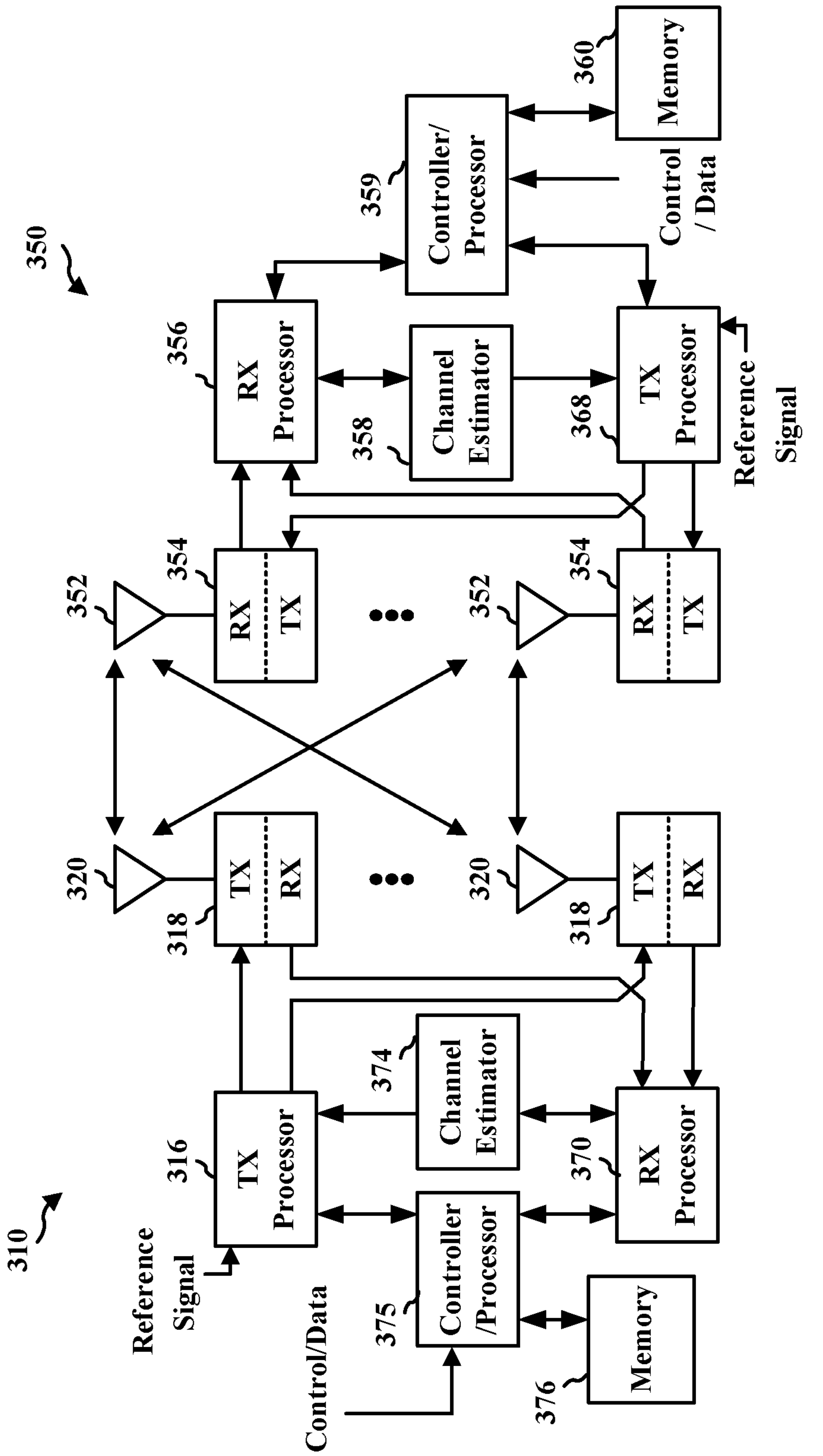

350
359
Controller/ Processor
360
Memory
Control / Data
356
RX Processor
358
Channel Estimator
368
TX Processor
Reference Signal
352
354
RX
TX
320
318
TX
RX
310
316
TX Processor
374
Channel Estimator
370
RX Processor
Reference Signal
375
Controller /Processor
Control/Data
376
Memory

FIG. 3

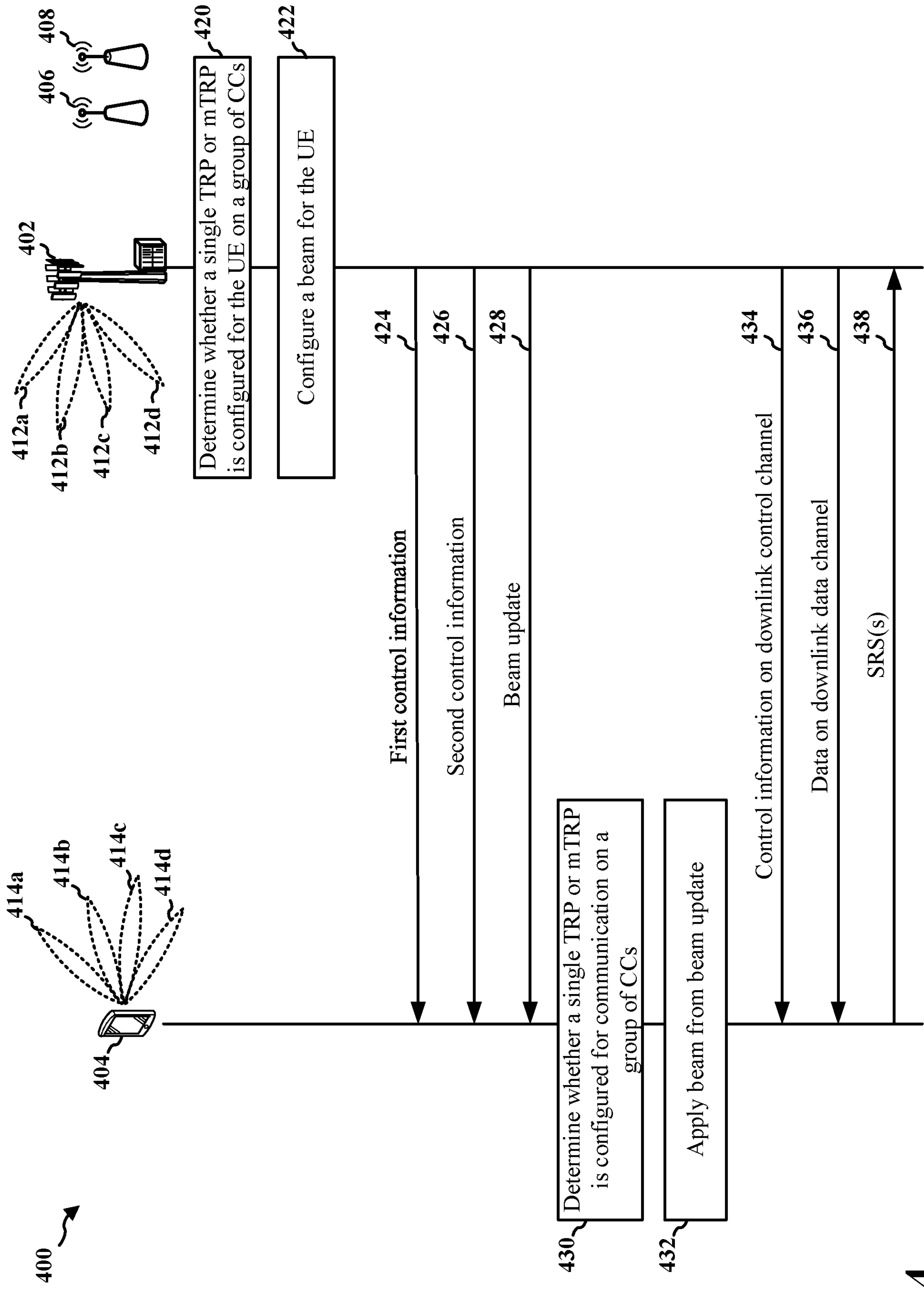

400
402
404
406
408
412a
412b
412c
412d
414a
414b
414c
414d
420
Determine whether a single TRP or mTRP is configured for the UE on a group of CCs
422
Configure a beam for the UE
424
First control information
426
Second control information
428
Beam update
430
Determine whether a single TRP or mTRP is configured for communication on a group of CCs
432
Apply beam from beam update
434
Control information on downlink control channel
436
Data on downlink data channel
438
SRS(s)

FIG. 4

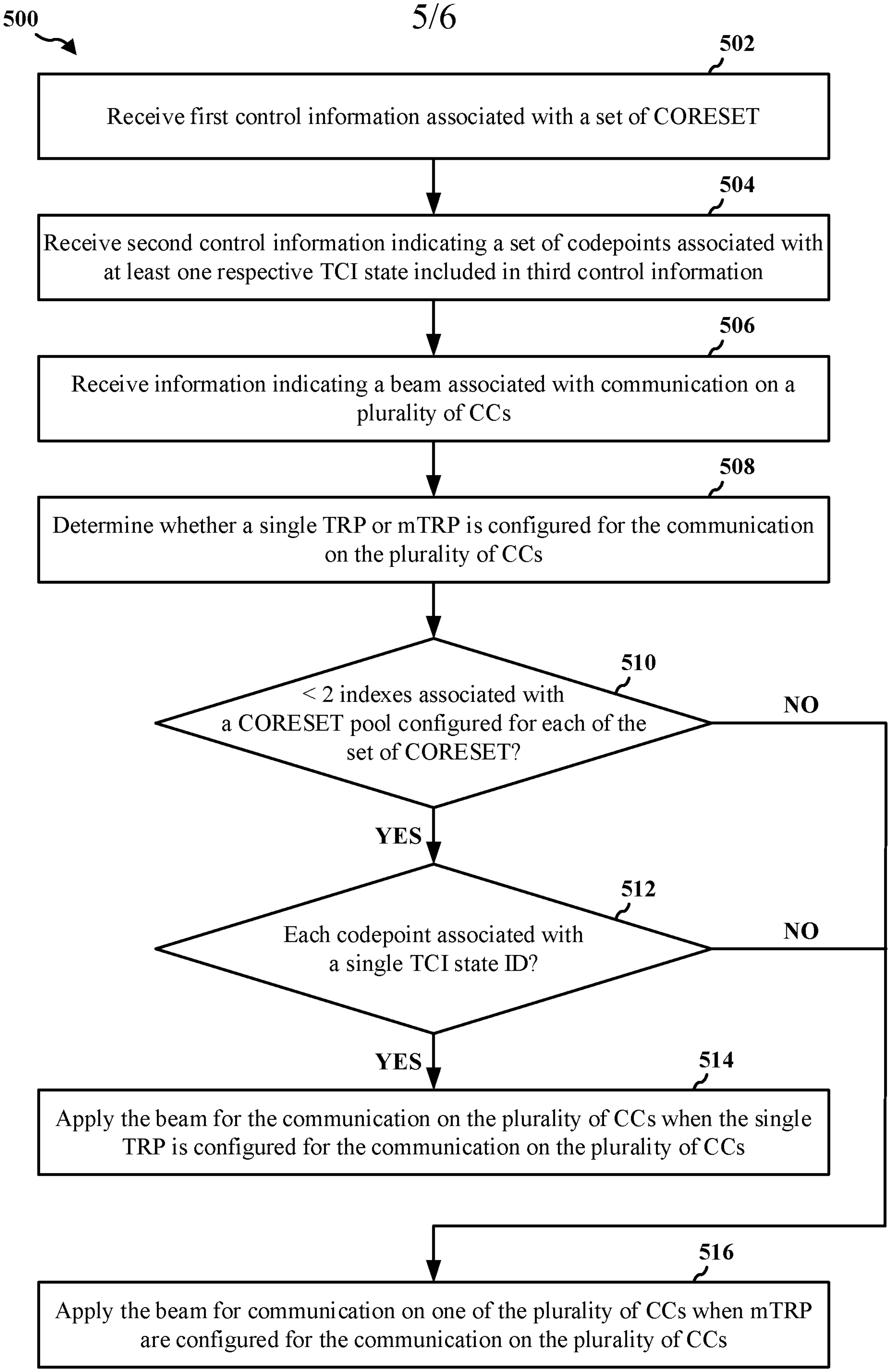

500
502
Receive first control information associated with a set of CORESET
504
Receive second control information indicating a set of codepoints associated with at least one respective TCI state included in third control information
506
Receive information indicating a beam associated with communication on a plurality of CCs
508
Determine whether a single TRP or mTRP is configured for the communication on the plurality of CCs
510
< 2 indexes associated with a CORESET pool configured for each of the set of CORESET?
NO
YES
512
Each codepoint associated with a single TCI state ID?
NO
YES
514
Apply the beam for the communication on the plurality of CCs when the single TRP is configured for the communication on the plurality of CCs
516
Apply the beam for communication on one of the plurality of CCs when mTRP are configured for the communication on the plurality of CCs

FIG. 5

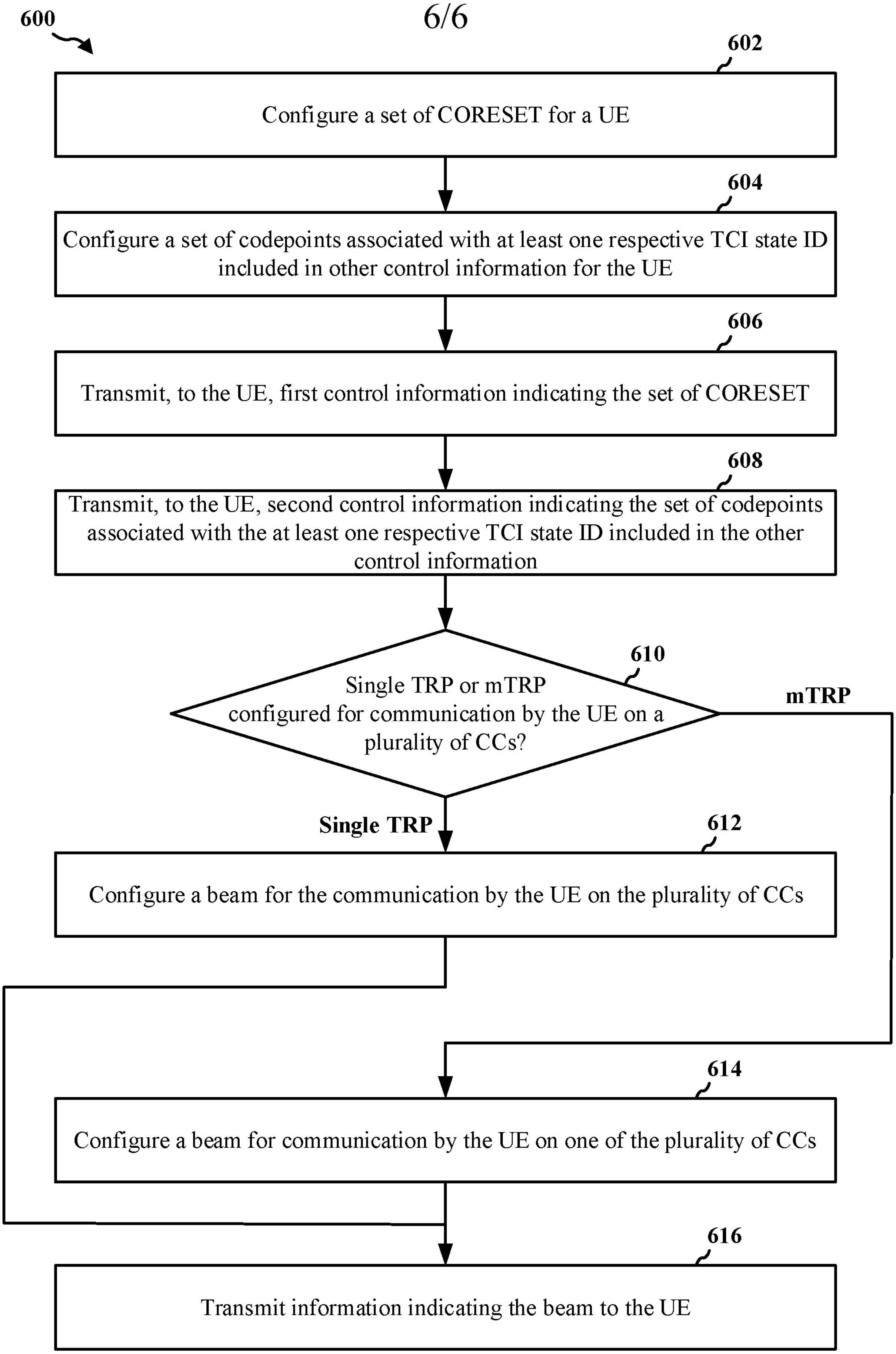

600
602
Configure a set of CORESET for a UE
604
Configure a set of codepoints associated with at least one respective TCI state ID included in other control information for the UE
606
Transmit, to the UE, first control information indicating the set of CORESET
608
Transmit, to the UE, second control information indicating the set of codepoints associated with the at least one respective TCI state ID included in the other control information
610
Single TRP or mTRP configured for communication by the UE on a plurality of CCs?
mTRP
Single TRP
612
Configure a beam for the communication by the UE on the plurality of CCs
614
Configure a beam for communication by the UE on one of the plurality of CCs
616
Transmit information indicating the beam to the UE

**FIG. 6**

# INTERNATIONAL SEARCH REPORT

International application No.
**PCT/CN2020/089188**

**A. CLASSIFICATION OF SUBJECT MATTER**

H04W 72/00(2009.01)i

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

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

H04W; H04Q

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

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

CNPAT,CNKI,WPI,EPODOC,3GPP:single TRP, multiple TRP, mTRP, component carrier, CC,group, plurality, beam update, CORESET, TCI, MAC CE

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | ZTE. "3GPP TSG RAN WG1 Meeting #99 R1-1911933" *Further details on multi-beam/TRP operation,* 22 November 2019 (2019-11-22), section 2 | 1-56 |
| A | APPLE INC. "3GPP TSG RAN WG1 #99 R1-1912824" *Remaining Issues on Multi-beam operation,* 22 November 2019 (2019-11-22), the whole document | 1-56 |
| A | US 2020113010 A1 (QUALCOMM INC.) 09 April 2020 (2020-04-09) the whole document | 1-56 |
| A | CN 110536423 A (ZTE CORP.) 03 December 2019 (2019-12-03) the whole document | 1-56 |

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| **26 January 2021** | **08 February 2021** |

| Name and mailing address of the ISA/CN | Authorized officer |
|---|---|
| **National Intellectual Property Administration, PRC**<br>**6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088**<br>**China** | **YAN,Sai** |
| Facsimile No. **(86-10)62019451** | Telephone No. **86-(10)-53961605** |

| Patent document cited in search report | | | Publication date (day/month/year) | Patent family member(s) | | | Publication date (day/month/year) |
|---|---|---|---|---|---|---|---|
| US | 2020113010 | A1 | 09 April 2020 | WO | 2020076462 | A1 | 16 April 2020 |
| CN | 110536423 | A | 03 December 2019 | WO | 2020030064 | A1 | 13 February 2020 |