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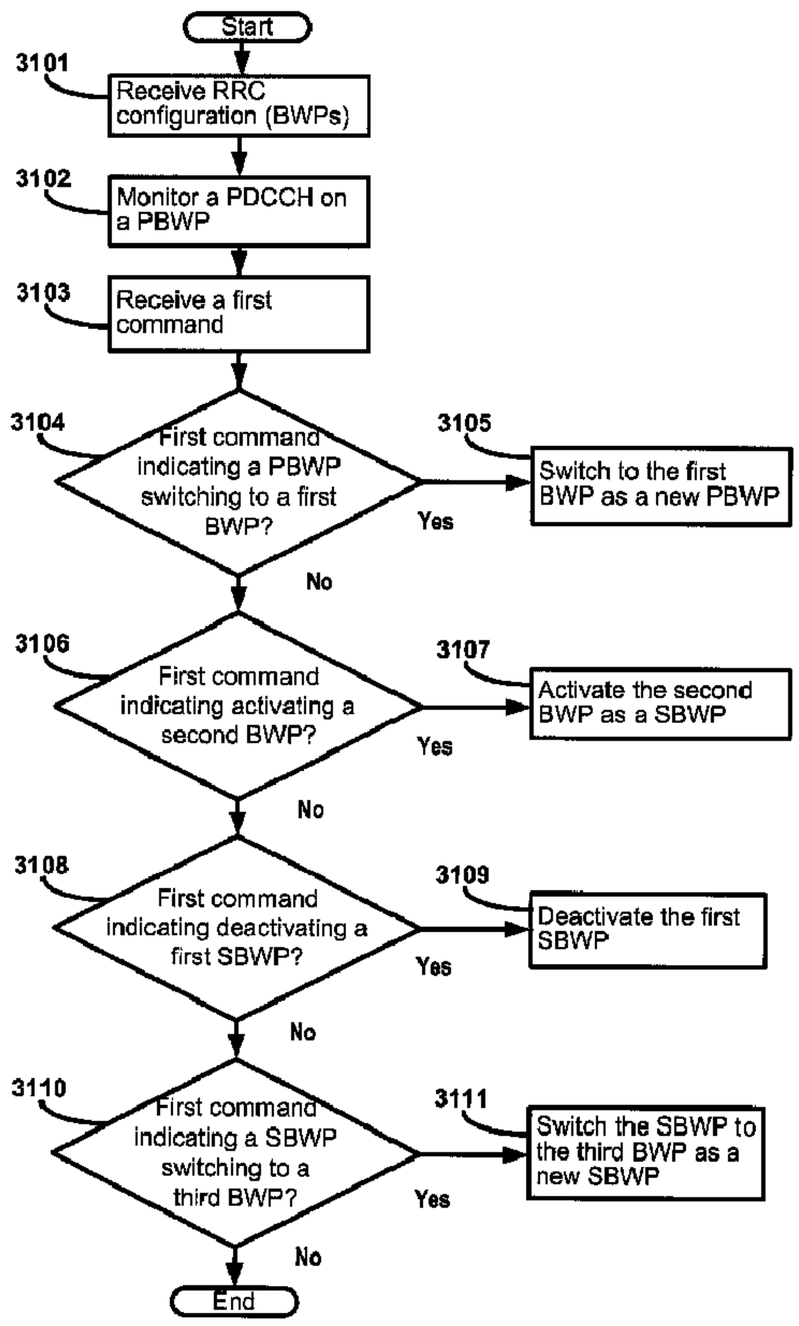
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(54) Title: MULTIPLE ACTIVE BANDWIDTH PARTS




(57) Abrégé/Abstract:
Bandwidth parts (BWPs) and other resources for wireless communications are described. A wireless device may use a BWP control procedure and/or a BWP timer management procedure for activating, deactivating, and/or switching BWPs, for example,

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(57) Abrégé(suite)/Abstract(continued):
using multiple active BWPs. A base station may send information comprising one or more fields indicating an action associated with a BWP, for example, if multiple active BWPs are supported. A wireless device may control a first BWP inactivity timer associated with a first active BWP, for example, based on activating, deactivating, and/or switching a second BWP.

## ABSTRACT

Bandwidth parts (BWPs) and other resources for wireless communications are described. A wireless device may use a BWP control procedure and/or a BWP timer management procedure for activating, deactivating, and/or switching BWPs, for example, using multiple active BWPs. A base station may send information comprising one or more fields indicating an action associated with a BWP, for example, if multiple active BWPs are supported. A wireless device may control a first BWP inactivity timer associated with a first active BWP, for example, based on activating, deactivating, and/or switching a second BWP.

# MULTIPLE ACTIVE BANDWIDTH PARTS

## CROSS-REFERENCE TO RELATED APPLICATIONS

[01] This application claims priority from and the benefit of U.S. Provisional Application No. 62/671,732, titled "Multiple Active Bandwidth Parts" and filed on May 15, 2018, and U.S. Provisional Application No. 62/672,096, titled "Bandwidth Part Inactivity Timer Management with Multiple Active Bandwidth Parts" and filed on May 16, 2018. Each of the above-referenced applications is hereby incorporated by reference in its entirety.

## BACKGROUND

[02] Wireless communications may use bandwidth parts (BWPs) and other wireless resources. A base station and/or a wireless device may activate, deactivate, and/or switch a BWP. A wireless device may not be able to determine whether downlink control information (DCI) is for switching a BWP, activating a new BWP, or deactivating an active BWP, for example, if multiple active BWPs are supported. Misalignment may occur between a base station and a wireless device, for example, based on BWP activation, deactivation, and/or switching. Signaling overhead may increase and/or spectral efficiency may decrease, for example, as a result of a misalignment between a base station and a wireless device.

## SUMMARY

[03] The following summary presents a simplified summary of certain features. The summary is not an extensive overview and is not intended to identify key or critical elements.

[04] BWP control procedures and BWP timer management procedures are described. A base station may send one or more messages to configure multiple BWPs. The base station may configure multiple BWPs as multiple active BWPs. The base station may send an indication of an action associated with a BWP. The indication may be included in DCI and/or a media access control control element (MAC CE) that may be configured to control changes for BWPs, for example, if multiple active BWPs are configured. A wireless device may deactivate a second active BWP, for example, based on a first active BWP switching to a default BWP. A wireless device may restart and/or start a first BWP

inactivity timer, for example, based on activating, deactivating, and/or switching a second BWP. By providing an indication of an action associated with a BWP, and/or by performing a predetermined action based on a BWP activation, deactivation, and/or switching, improved communications between devices may be achieved, such as reduced and/or avoided misalignment between a wireless device and a base station.

[05] These and other features and advantages are described in greater detail below.

## BRIEF DESCRIPTION OF THE DRAWINGS

[06] Some features are shown by way of example, and not by limitation, in the accompanying drawings. In the drawings, like numerals reference similar elements.

[07] FIG. 1 shows an example radio access network (RAN) architecture.

[08] FIG. 2A shows an example user plane protocol stack.

[09] FIG. 2B shows an example control plane protocol stack.

[10] FIG. 3 shows an example wireless device and two base stations.

[11] FIG. 4A, FIG. 4B, FIG. 4C, and FIG. 4D show examples of uplink and downlink signal transmission.

[12] FIG. 5A shows an example uplink channel mapping and example uplink physical signals.

[13] FIG. 5B shows an example downlink channel mapping and example downlink physical signals.

[14] FIG. 6 shows an example transmission time and/or reception time for a carrier.

[15] FIG. 7A and FIG. 7B show example sets of orthogonal frequency division multiplexing (OFDM) subcarriers.

[16] FIG. 8 shows example OFDM radio resources.

[17] FIG. 9A shows an example channel state information reference signal (CSI-RS) and/or synchronization signal (SS) block transmission in a multi-beam system.

[18] FIG. 9B shows an example downlink beam management procedure.

[19] FIG. 10 shows an example of configured bandwidth parts (BWPs).

[20] FIG. 11A and FIG. 11B show examples of multi connectivity.

[21] FIG. 12 shows an example of a random access procedure.

[22] FIG. 13 shows example medium access control (MAC) entities.

[23] FIG. 14 shows an example RAN architecture.

[24] FIG. 15 shows example radio resource control (RRC) states.

[25] FIG. 16A, FIG. 16B and FIG. 16C show examples of MAC subheaders.

[26] FIG. 17A and FIG. 17B show examples of MAC PDUs.

[27] FIG. 18 shows an example of LCIDs for DL-SCH.

[28] FIG. 19 shows an example of LCIDs for UL-SCH.

[29] FIG. 20A and FIG. 20B show examples of SCell Activation/Deactivation MAC CE.

[30] FIG. 21 shows an example of BWP operation.

[31] FIG. 22 shows an example of BWP operation in an SCell.

[32] FIG. 23A, FIG. 23B and FIG. 23C show examples of multiple active BWPs operation.

[33] FIG. 24A and FIG. 24B show examples of BWP scheduling.

[34] FIG. 25A, FIG. 25B, FIG. 25C and FIG. 25D show examples of multiple active BWPs operation.

[35] FIG. 26A, FIG. 26B, and FIG. 26C show examples of multiple active BWPs operation.

[36] FIG. 27A, FIG. 27B, FIG. 27C, and FIG. 27D show examples of a MAC CE and a corresponding MAC subheader for BWP activation/deactivation.

[37] FIG. 28A and FIG. 28B show examples of one or more fields of DCI for multiple active BWP operation indication.

[38] FIG. 29A and FIG. 29B show examples of one or more fields of DCI for multiple active BWP operation indication.

[39] FIG. 30A and FIG. 30B show examples of one or more fields of DCI for multiple active BWP operation indication.

[40] FIG. 31 shows an example of a flow chart of multiple active BWP operation.

[41] FIG. 32 shows an example of a procedure at a cell that may be configured with a plurality of BWPs.

[42] FIG. 33 shows an example method that may be performed by a wireless device to configure a plurality of BWPs.

[43] FIG. 34 shows an example method that may be performed by a base station to configure a plurality of BWPs.

[44] FIG. 35 shows an example of a procedure at a cell that may be configured with a plurality of BWPs.

[45] FIG. 36 shows an example of a procedure at a cell that may be configured with a plurality of BWPs.

[46] FIG. 37 shows an example method of configuring multiple active BWP operation.

[47] FIG. 38 shows an example of BWP management comprising BWP deactivation of a secondary BWP in a cell.

[48] FIG. 39 shows an example of BWP management using multiple BWPs in a cell.

[49] FIG. 40 shows an example of BWP management with multiple BWPs in a cell.

[50] FIG. 41 shows an example of BWP management with a primary BWP and multiple secondary BWPs in a cell.

[51] FIG. 42 shows an example of BWP management using cross-BWP scheduling for multiple BWPs in a cell.

[52] FIG. 43 shows an example of BWP management using cross-BWP scheduling for multiple BWPs in a cell.

[53] FIG. 44 shows an example of BWP management for multiple active BWPs in a cell using BWP switching.

[54] FIG. 45 shows an example of BWP management using a primary BWP, default BWP, and at least a secondary BWP in a cell.

[55] FIG. 46 shows an example of BWP management using a primary BWP, default BWP, and at least a secondary BWP in a cell.

[56] FIG. 47 shows an example of BWP management with multiple active BWPs in a cell.

[57] FIG. 48 shows an example of BWP management with multiple active BWPs in a cell.

[58] FIG. 49 shows an example method for BWP management by a wireless device.

[59] FIG. 50 shows example elements of a computing device that may be used to implement any of the various devices described herein.

DETAILED DESCRIPTION

[60] The accompanying drawings and descriptions provide examples. It is to be understood that the examples shown in the drawings and/or described are non-exclusive and that there are other examples of how features shown and described may be practiced.

[61] Examples are provided for operation of wireless communication systems which may be used in the technical field of multicarrier communication systems. More particularly, the technology described herein may relate to multiple active bandwidth parts in multicarrier communication systems.

[62] The following acronyms are used throughout the drawings and/or descriptions, and are provided below for convenience although other acronyms may be introduced in the detailed description:

| | |
|---|---|
| 3GPP | 3rd Generation Partnership Project |
| 5GC | 5G Core Network |
| ACK | Acknowledgement |
| AMF | Access and Mobility Management Function |
| ARQ | Automatic Repeat Request |
| AS | Access Stratum |
| ASIC | Application-Specific Integrated Circuit |
| BA | Bandwidth Adaptation |
| BCCH | Broadcast Control Channel |
| BCH | Broadcast Channel |
| BPSK | Binary Phase Shift Keying |
| BWP | Bandwidth Part |
| CA | Carrier Aggregation |
| CC | Component Carrier |
| CCCH | Common Control CHannel |
| CDMA | Code Division Multiple Access |
| CN | Core Network |
| CP | Cyclic Prefix |

| | |
|---|---|
| CP-OFDM | Cyclic Prefix- Orthogonal Frequency Division Multiplex |
| C-RNTI | Cell-Radio Network Temporary Identifier |
| CS | Configured Scheduling |
| CSI | Channel State Information |
| CSI-RS | Channel State Information-Reference Signal |
| CQI | Channel Quality Indicator |
| CSS | Common Search Space |
| CU | Central Unit |
| DC | Dual Connectivity |
| DCCH | Dedicated Control Channel |
| DCI | Downlink Control Information |
| DL | Downlink |
| DL-SCH | Downlink Shared CHannel |
| DM-RS | DeModulation Reference Signal |
| DRB | Data Radio Bearer |
| DRX | Discontinuous Reception |
| DTCH | Dedicated Traffic Channel |
| DU | Distributed Unit |
| EPC | Evolved Packet Core |
| E-UTRA | Evolved UMTS Terrestrial Radio Access |
| E-UTRAN | Evolved-Universal Terrestrial Radio Access Network |
| FDD | Frequency Division Duplex |
| FPGA | Field Programmable Gate Arrays |
| F1-C | F1-Control plane |
| F1-U | F1-User plane |
| gNB | next generation Node B |
| HARQ | Hybrid Automatic Repeat reQuest |
| HDL | Hardware Description Languages |
| IE | Information Element |
| IP | Internet Protocol |
| LCID | Logical Channel Identifier |

| | |
|---|---|
| LTE | Long Term Evolution |
| MAC | Media Access Control |
| MCG | Master Cell Group |
| MCS | Modulation and Coding Scheme |
| MeNB | Master evolved Node B |
| MIB | Master Information Block |
| MME | Mobility Management Entity |
| MN | Master Node |
| NACK | Negative Acknowledgement |
| NAS | Non-Access Stratum |
| NG CP | Next Generation Control Plane |
| NGC | Next Generation Core |
| NG-C | NG-Control plane |
| ng-eNB | next generation evolved Node B |
| NG-U | NG-User plane |
| NR | New Radio |
| NR MAC | New Radio MAC |
| NR PDCP | New Radio PDCP |
| NR PHY | New Radio PHYsical |
| NR RLC | New Radio RLC |
| NR RRC | New Radio RRC |
| NSSAI | Network Slice Selection Assistance Information |
| O&M | Operation and Maintenance |
| OFDM | Orthogonal Frequency Division Multiplexing |
| PBCH | Physical Broadcast CHannel |
| PCC | Primary Component Carrier |
| PCCH | Paging Control CHannel |
| PCell | Primary Cell |
| PCH | Paging CHannel |
| PDCCH | Physical Downlink Control CHannel |
| PDCP | Packet Data Convergence Protocol |

| | |
|---|---|
| PDSCH | Physical Downlink Shared CHannel |
| PDU | Protocol Data Unit |
| PHICH | Physical HARQ Indicator CHannel |
| PHY | PHYsical |
| PLMN | Public Land Mobile Network |
| PMI | Precoding Matrix Indicator |
| PRACH | Physical Random Access CHannel |
| PRB | Physical Resource Block |
| PSCell | Primary Secondary Cell |
| PSS | Primary Synchronization Signal |
| pTAG | primary Timing Advance Group |
| PT-RS | Phase Tracking Reference Signal |
| PUCCH | Physical Uplink Control CHannel |
| PUSCH | Physical Uplink Shared CHannel |
| QAM | Quadrature Amplitude Modulation |
| QFI | Quality of Service Indicator |
| QoS | Quality of Service |
| QPSK | Quadrature Phase Shift Keying |
| RA | Random Access |
| RACH | Random Access CHannel |
| RAN | Radio Access Network |
| RAT | Radio Access Technology |
| RA-RNTI | Random Access-Radio Network Temporary Identifier |
| RB | Resource Blocks |
| RBG | Resource Block Groups |
| RI | Rank indicator |
| RLC | Radio Link Control |
| RRC | Radio Resource Control |
| RS | Reference Signal |
| RSRP | Reference Signal Received Power |
| SCC | Secondary Component Carrier |

| | |
|---|---|
| SCell | Secondary Cell |
| SCG | Secondary Cell Group |
| SC-FDMA | Single Carrier-Frequency Division Multiple Access |
| SDAP | Service Data Adaptation Protocol |
| SDU | Service Data Unit |
| SeNB | Secondary evolved Node B |
| SFN | System Frame Number |
| S-GW | Serving GateWay |
| SI | System Information |
| SIB | System Information Block |
| SMF | Session Management Function |
| SN | Secondary Node |
| SpCell | Special Cell |
| SRB | Signaling Radio Bearer |
| SRS | Sounding Reference Signal |
| SS | Synchronization Signal |
| SSS | Secondary Synchronization Signal |
| sTAG | secondary Timing Advance Group |
| TA | Timing Advance |
| TAG | Timing Advance Group |
| TAI | Tracking Area Identifier |
| TAT | Time Alignment Timer |
| TB | Transport Block |
| TC-RNTI | Temporary Cell-Radio Network Temporary Identifier |
| TDD | Time Division Duplex |
| TDMA | Time Division Multiple Access |
| TTI | Transmission Time Interval |
| UCI | Uplink Control Information |
| UE | User Equipment |
| UL | Uplink |
| UL-SCH | Uplink Shared CHannel |

| | |
|---|---|
| UPF | User Plane Function |
| UPGW | User Plane Gateway |
| VHDL | VHSIC Hardware Description Language |
| Xn-C | Xn-Control plane |
| Xn-U | Xn-User plane |

[63] Examples described herein may be implemented using various physical layer modulation and transmission mechanisms. Example transmission mechanisms may include, but are not limited to: Code Division Multiple Access (CDMA), Orthogonal Frequency Division Multiple Access (OFDMA), Time Division Multiple Access (TDMA), Wavelet technologies, and/or the like. Hybrid transmission mechanisms such as TDMA/CDMA, and/or OFDM/CDMA may be used. Various modulation schemes may be used for signal transmission in the physical layer. Examples of modulation schemes include, but are not limited to: phase, amplitude, code, a combination of these, and/or the like. An example radio transmission method may implement Quadrature Amplitude Modulation (QAM) using Binary Phase Shift Keying (BPSK), Quadrature Phase Shift Keying (QPSK), 16-QAM, 64-QAM, 256-QAM, 1024-QAM and/or the like. Physical radio transmission may be enhanced by dynamically or semi-dynamically changing the modulation and coding scheme, for example, depending on transmission requirements and/or radio conditions.

[64] FIG. 1 shows an example Radio Access Network (RAN) architecture. A RAN node may comprise a next generation Node B (gNB) (e.g., 120A, 120B) providing New Radio (NR) user plane and control plane protocol terminations towards a first wireless device (e.g., 110A). A RAN node may comprise a base station such as a next generation evolved Node B (ng-eNB) (e.g., 120C, 120D), providing Evolved UMTS Terrestrial Radio Access (E-UTRA) user plane and control plane protocol terminations towards a second wireless device (e.g., 110B). A first wireless device 110A may communicate with a base station, such as a gNB 120A, over a Uu interface. A second wireless device 110B may communicate with a base station, such as an ng-eNB 120D, over a Uu interface. The wireless devices 110A and/or 110B may be structurally similar to wireless devices shown in and/or described in connection with other drawing figures. The Node B 120A, the Node B 120B, the Node B 120C, and/or the Node B 120D may be structurally similar to

Nodes B and/or base stations shown in and/or described in connection with other drawing figures.

[65] A base station, such as a gNB (e.g., 120A, 120B, etc.) and/or an ng-eNB (e.g., 120C, 120D, etc.) may host functions such as radio resource management and scheduling, IP header compression, encryption and integrity protection of data, selection of Access and Mobility Management Function (AMF) at wireless device (e.g., User Equipment (UE)) attachment, routing of user plane and control plane data, connection setup and release, scheduling and transmission of paging messages (e.g., originated from the AMF), scheduling and transmission of system broadcast information (e.g., originated from the AMF or Operation and Maintenance (O&M)), measurement and measurement reporting configuration, transport level packet marking in the uplink, session management, support of network slicing, Quality of Service (QoS) flow management and mapping to data radio bearers, support of wireless devices in an inactive state (e.g., RRC_INACTIVE state), distribution function for Non-Access Stratum (NAS) messages, RAN sharing, dual connectivity, and/or tight interworking between NR and E-UTRA.

[66] One or more first base stations (e.g., gNBs 120A and 120B) and/or one or more second base stations (e.g., ng-eNBs 120C and 120D) may be interconnected with each other via Xn interface. A first base station (e.g., gNB 120A, 120B, etc.) or a second base station (e.g., ng-eNB 120C, 120D, etc.) may be connected via NG interfaces to a network, such as a 5G Core Network (5GC). A 5GC may comprise one or more AMF/User Plan Function (UPF) functions (e.g., 130A and/or 130B). A base station (e.g., a gNB and/or an ng-eNB) may be connected to a UPF via an NG-User plane (NG-U) interface. The NG-U interface may provide delivery (e.g., non-guaranteed delivery) of user plane Protocol Data Units (PDUs) between a RAN node and the UPF. A base station (e.g., a gNB and/or an ng-eNB) may be connected to an AMF via an NG-Control plane (NG-C) interface. The NG-C interface may provide functions such as NG interface management, wireless device (e.g., UE) context management, wireless device (e.g., UE) mobility management, transport of NAS messages, paging, PDU session management, configuration transfer, and/or warning message transmission.

[67] A UPF may host functions such as anchor point for intra-/inter-Radio Access Technology (RAT) mobility (e.g., if applicable), external PDU session point of interconnect to data network, packet routing and forwarding, packet inspection and user plane part of policy rule enforcement, traffic usage reporting, uplink classifier to support routing traffic flows to a data network, branching point to support multi-homed PDU session, quality of service (QoS) handling for user plane, packet filtering, gating, Uplink (UL)/Downlink (DL) rate enforcement, uplink traffic verification (e.g., Service Data Flow (SDF) to QoS flow mapping), downlink packet buffering, and/or downlink data notification triggering.

[68] An AMF may host functions such as NAS signaling termination, NAS signaling security, Access Stratum (AS) security control, inter Core Network (CN) node signaling (e.g., for mobility between 3rd Generation Partnership Project (3GPP) access networks), idle mode wireless device reachability (e.g., control and execution of paging retransmission), registration area management, support of intra-system and inter-system mobility, access authentication, access authorization including check of roaming rights, mobility management control (e.g., subscription and/or policies), support of network slicing, and/or Session Management Function (SMF) selection.

[69] FIG. 2A shows an example user plane protocol stack. A Service Data Adaptation Protocol (SDAP) (e.g., 211 and 221), Packet Data Convergence Protocol (PDCP) (e.g., 212 and 222), Radio Link Control (RLC) (e.g., 213 and 223), and Media Access Control (MAC) (e.g., 214 and 224) sublayers, and a Physical (PHY) (e.g., 215 and 225) layer, may be terminated in a wireless device (e.g., 110) and in a base station (e.g., 120) on a network side. A PHY layer may provide transport services to higher layers (e.g., MAC, RRC, etc.). Services and/or functions of a MAC sublayer may comprise mapping between logical channels and transport channels, multiplexing and/or demultiplexing of MAC Service Data Units (SDUs) belonging to the same or different logical channels into and/or from Transport Blocks (TBs) delivered to and/or from the PHY layer, scheduling information reporting, error correction through Hybrid Automatic Repeat request (HARQ) (e.g., one HARQ entity per carrier for Carrier Aggregation (CA)), priority handling between wireless devices such as by using dynamic scheduling, priority handling between logical channels of a wireless device such as by using logical channel

prioritization, and/or padding. A MAC entity may support one or multiple numerologies and/or transmission timings. Mapping restrictions in a logical channel prioritization may control which numerology and/or transmission timing a logical channel may use. An RLC sublayer may support transparent mode (TM), unacknowledged mode (UM), and/or acknowledged mode (AM) transmission modes. The RLC configuration may be per logical channel with no dependency on numerologies and/or Transmission Time Interval (TTI) durations. Automatic Repeat Request (ARQ) may operate on any of the numerologies and/or TTI durations with which the logical channel is configured. Services and functions of the PDCP layer for the user plane may comprise, for example, sequence numbering, header compression and decompression, transfer of user data, reordering and duplicate detection, PDCP PDU routing (e.g., such as for split bearers), retransmission of PDCP SDUs, ciphering, deciphering and integrity protection, PDCP SDU discard, PDCP re-establishment and data recovery for RLC AM, and/or duplication of PDCP PDUs. Services and/or functions of SDAP may comprise, for example, mapping between a QoS flow and a data radio bearer. Services and/or functions of SDAP may comprise mapping a Quality of Service Indicator (QFI) in DL and UL packets. A protocol entity of SDAP may be configured for an individual PDU session.

[70] FIG. 2B shows an example control plane protocol stack. A PDCP (e.g., 233 and 242), RLC (e.g., 234 and 243), and MAC (e.g., 235 and 244) sublayers, and a PHY (e.g., 236 and 245) layer, may be terminated in a wireless device (e.g., 110), and in a base station (e.g., 120) on a network side, and perform service and/or functions described above. RRC (e.g., 232 and 241) may be terminated in a wireless device and a base station on a network side. Services and/or functions of RRC may comprise broadcast of system information related to AS and/or NAS; paging (e.g., initiated by a 5GC or a RAN); establishment, maintenance, and/or release of an RRC connection between the wireless device and RAN; security functions such as key management, establishment, configuration, maintenance, and/or release of Signaling Radio Bearers (SRBs) and Data Radio Bearers (DRBs); mobility functions; QoS management functions; wireless device measurement reporting and control of the reporting; detection of and recovery from radio link failure; and/or NAS message transfer to/from NAS from/to a wireless device. NAS

control protocol (e.g., 231 and 251) may be terminated in the wireless device and AMF (e.g., 130) on a network side. NAS control protocol may perform functions such as authentication, mobility management between a wireless device and an AMF (e.g., for 3GPP access and non-3GPP access), and/or session management between a wireless device and an SMF (e.g., for 3GPP access and non-3GPP access).

[71] A base station may configure a plurality of logical channels for a wireless device. A logical channel of the plurality of logical channels may correspond to a radio bearer. The radio bearer may be associated with a QoS requirement. A base station may configure a logical channel to be mapped to one or more TTIs and/or numerologies in a plurality of TTIs and/or numerologies. The wireless device may receive Downlink Control Information (DCI) via a Physical Downlink Control CHannel (PDCCH) indicating an uplink grant. The uplink grant may be for a first TTI and/or a first numerology and may indicate uplink resources for transmission of a transport block. The base station may configure each logical channel in the plurality of logical channels with one or more parameters to be used by a logical channel prioritization procedure at the MAC layer of the wireless device. The one or more parameters may comprise, for example, priority, prioritized bit rate, etc. A logical channel in the plurality of logical channels may correspond to one or more buffers comprising data associated with the logical channel. The logical channel prioritization procedure may allocate the uplink resources to one or more first logical channels in the plurality of logical channels and/or to one or more MAC Control Elements (CEs). The one or more first logical channels may be mapped to the first TTI and/or the first numerology. The MAC layer at the wireless device may multiplex one or more MAC CEs and/or one or more MAC SDUs (e.g., logical channel) in a MAC PDU (e.g., transport block). The MAC PDU may comprise a MAC header comprising a plurality of MAC sub-headers. A MAC sub-header in the plurality of MAC sub-headers may correspond to a MAC CE or a MAC SUD (e.g., logical channel) in the one or more MAC CEs and/or in the one or more MAC SDUs. A MAC CE and/or a logical channel may be configured with a Logical Channel IDentifier (LCID). An LCID for a logical channel and/or a MAC CE may be fixed and/or pre-configured. An LCID for a logical channel and/or MAC CE may be configured for the wireless device by the base

station. The MAC sub-header corresponding to a MAC CE and/or a MAC SDU may comprise an LCID associated with the MAC CE and/or the MAC SDU.

[72] A base station may activate, deactivate, and/or impact one or more processes (e.g., set values of one or more parameters of the one or more processes or start and/or stop one or more timers of the one or more processes) at the wireless device, for example, by using one or more MAC commands. The one or more MAC commands may comprise one or more MAC control elements. The one or more processes may comprise activation and/or deactivation of PDCP packet duplication for one or more radio bearers. The base station may send (e.g., transmit) a MAC CE comprising one or more fields. The values of the fields may indicate activation and/or deactivation of PDCP duplication for the one or more radio bearers. The one or more processes may comprise Channel State Information (CSI) transmission of on one or more cells. The base station may send (e.g., transmit) one or more MAC CEs indicating activation and/or deactivation of the CSI transmission on the one or more cells. The one or more processes may comprise activation and/or deactivation of one or more secondary cells. The base station may send (e.g., transmit) a MAC CE indicating activation and/or deactivation of one or more secondary cells. The base station may send (e.g., transmit) one or more MAC CEs indicating starting and/or stopping of one or more Discontinuous Reception (DRX) timers at the wireless device. The base station may send (e.g., transmit) one or more MAC CEs indicating one or more timing advance values for one or more Timing Advance Groups (TAGs).

[73] FIG. 3 shows an example of base stations (base station 1, 120A, and base station 2, 120B) and a wireless device 110. The wireless device 110 may comprise a UE or any other wireless device. The base station (e.g., 120A, 120B) may comprise a Node B, eNB, gNB, ng-eNB, or any other base station. A wireless device and/or a base station may perform one or more functions of a relay node. The base station 1, 120A, may comprise at least one communication interface 320A (e.g., a wireless modem, an antenna, a wired modem, and/or the like), at least one processor 321A, and at least one set of program code instructions 323A that may be stored in non-transitory memory 322A and executable by the at least one processor 321A. The base station 2, 120B, may comprise at least one communication interface 320B, at least one processor 321B, and at least one set of

program code instructions 323B that may be stored in non-transitory memory 322B and executable by the at least one processor 321B.

[74] A base station may comprise any number of sectors, for example: 1, 2, 3, 4, or 6 sectors. A base station may comprise any number of cells, for example, ranging from 1 to 50 cells or more. A cell may be categorized, for example, as a primary cell or secondary cell. At Radio Resource Control (RRC) connection establishment, re-establishment, handover, etc., a serving cell may provide NAS (non-access stratum) mobility information (e.g., Tracking Area Identifier (TAI)). At RRC connection re-establishment and/or handover, a serving cell may provide security input. This serving cell may be referred to as the Primary Cell (PCell). In the downlink, a carrier corresponding to the PCell may be a DL Primary Component Carrier (PCC). In the uplink, a carrier may be an UL PCC. Secondary Cells (SCells) may be configured to form together with a PCell a set of serving cells, for example, depending on wireless device capabilities. In a downlink, a carrier corresponding to an SCell may be a downlink secondary component carrier (DL SCC). In an uplink, a carrier may be an uplink secondary component carrier (UL SCC). An SCell may or may not have an uplink carrier.

[75] A cell, comprising a downlink carrier and optionally an uplink carrier, may be assigned a physical cell ID and/or a cell index. A carrier (downlink and/or uplink) may belong to one cell. The cell ID and/or cell index may identify the downlink carrier and/or uplink carrier of the cell (e.g., depending on the context it is used). A cell ID may be equally referred to as a carrier ID, and a cell index may be referred to as a carrier index. A physical cell ID and/or a cell index may be assigned to a cell. A cell ID may be determined using a synchronization signal transmitted via a downlink carrier. A cell index may be determined using RRC messages. A first physical cell ID for a first downlink carrier may indicate that the first physical cell ID is for a cell comprising the first downlink carrier. The same concept may be used, for example, with carrier activation and/or deactivation (e.g., secondary cell activation and/or deactivation). A first carrier that is activated may indicate that a cell comprising the first carrier is activated.

[76] A base station may send (e.g., transmit) to a wireless device one or more messages (e.g., RRC messages) comprising a plurality of configuration parameters for one or more cells. One or more cells may comprise at least one primary cell and at least one secondary cell. An RRC message may be broadcasted and/or unicasted to the wireless device. Configuration parameters may comprise common parameters and dedicated parameters.

[77] Services and/or functions of an RRC sublayer may comprise at least one of: broadcast of system information related to AS and/or NAS; paging initiated by a 5GC and/or an NG-RAN; establishment, maintenance, and/or release of an RRC connection between a wireless device and an NG-RAN, which may comprise at least one of addition, modification, and/or release of carrier aggregation; and/or addition, modification, and/or release of dual connectivity in NR or between E-UTRA and NR. Services and/or functions of an RRC sublayer may comprise at least one of security functions comprising key management; establishment, configuration, maintenance, and/or release of Signaling Radio Bearers (SRBs) and/or Data Radio Bearers (DRBs); mobility functions which may comprise at least one of a handover (e.g., intra NR mobility or inter-RAT mobility) and/or a context transfer; and/or a wireless device cell selection and/or reselection and/or control of cell selection and reselection. Services and/or functions of an RRC sublayer may comprise at least one of QoS management functions; a wireless device measurement configuration/reporting; detection of and/or recovery from radio link failure; and/or NAS message transfer to and/or from a core network entity (e.g., AMF, Mobility Management Entity (MME)) from and/or to the wireless device.

[78] An RRC sublayer may support an RRC_Idle state, an RRC_Inactive state, and/or an RRC_Connected state for a wireless device. In an RRC_Idle state, a wireless device may perform at least one of: Public Land Mobile Network (PLMN) selection; receiving broadcasted system information; cell selection and/or re-selection; monitoring and/or receiving a paging for mobile terminated data initiated by 5GC; paging for mobile terminated data area managed by 5GC; and/or DRX for CN paging configured via NAS. In an RRC_Inactive state, a wireless device may perform at least one of: receiving broadcasted system information; cell selection and/or re-selection; monitoring and/or receiving a RAN and/or CN paging initiated by an NG-RAN and/or a 5GC; RAN-based

notification area (RNA) managed by an NG- RAN; and/or DRX for a RAN and/or CN paging configured by NG-RAN/NAS. In an RRC_Idle state of a wireless device, a base station (e.g., NG-RAN) may keep a 5GC-NG-RAN connection (e.g., both C/U-planes) for the wireless device; and/or store a wireless device AS context for the wireless device. In an RRC_Connected state of a wireless device, a base station (e.g., NG-RAN) may perform at least one of: establishment of 5GC-NG-RAN connection (both C/U-planes) for the wireless device; storing a UE AS context for the wireless device; send (e.g., transmit) and/or receive of unicast data to and/or from the wireless device; and/or network-controlled mobility based on measurement results received from the wireless device. In an RRC_Connected state of a wireless device, an NG-RAN may know a cell to which the wireless device belongs.

[79] System information (SI) may be divided into minimum SI and other SI. The minimum SI may be periodically broadcast. The minimum SI may comprise basic information required for initial access and/or information for acquiring any other SI broadcast periodically and/or provisioned on-demand (e.g., scheduling information). The other SI may either be broadcast, and/or be provisioned in a dedicated manner, such as either triggered by a network and/or upon request from a wireless device. A minimum SI may be transmitted via two different downlink channels using different messages (e.g., MasterInformationBlock and SystemInformationBlockType1). Another SI may be transmitted via SystemInformationBlockType2. For a wireless device in an RRC_Connected state, dedicated RRC signalling may be used for the request and delivery of the other SI. For the wireless device in the RRC_Idle state and/or in the RRC_Inactive state, the request may trigger a random access procedure.

[80] A wireless device may report its radio access capability information, which may be static. A base station may request one or more indications of capabilities for a wireless device to report based on band information. A temporary capability restriction request may be sent by the wireless device (e.g., if allowed by a network) to signal the limited availability of some capabilities (e.g., due to hardware sharing, interference, and/or overheating) to the base station. The base station may confirm or reject the request. The temporary capability restriction may be transparent to 5GC (e.g., static capabilities may be stored in 5GC).

[81] A wireless device may have an RRC connection with a network, for example, if CA is configured. At RRC connection establishment, re-establishment, and/or handover procedures, a serving cell may provide NAS mobility information. At RRC connection re-establishment and/or handover, a serving cell may provide a security input. This serving cell may be referred to as the PCell. SCells may be configured to form together with the PCell a set of serving cells, for example, depending on the capabilities of the wireless device. The configured set of serving cells for the wireless device may comprise a PCell and one or more SCells.

[82] The reconfiguration, addition, and/or removal of SCells may be performed by RRC messaging. At intra-NR handover, RRC may add, remove, and/or reconfigure SCells for usage with the target PCell. Dedicated RRC signaling may be used (e.g., if adding a new SCell) to send all required system information of the SCell (e.g., if in connected mode, wireless devices may not acquire broadcasted system information directly from the SCells).

[83] The purpose of an RRC connection reconfiguration procedure may be to modify an RRC connection, (e.g., to establish, modify, and/or release RBs; to perform handover; to setup, modify, and/or release measurements, for example, to add, modify, and/or release SCells and cell groups). NAS dedicated information may be transferred from the network to the wireless device, for example, as part of the RRC connection reconfiguration procedure. The RRCConnectionReconfiguration message may be a command to modify an RRC connection. One or more RRC messages may convey information for measurement configuration, mobility control, and/or radio resource configuration (e.g., RBs, MAC main configuration, and/or physical channel configuration), which may comprise any associated dedicated NAS information and/or security configuration. The wireless device may perform an SCell release, for example, if the received RRC Connection Reconfiguration message includes the sCellToReleaseList. The wireless device may perform SCell additions or modification, for example, if the received RRC Connection Reconfiguration message includes the sCellToAddModList.

[84] An RRC connection establishment, reestablishment, and/or resume procedure may be to establish, reestablish, and/or resume an RRC connection, respectively. An RRC connection establishment procedure may comprise SRB1 establishment. The RRC connection establishment procedure may be used to transfer the initial NAS dedicated information and/or message from a wireless device to an E-UTRAN. The RRCConnectionReestablishment message may be used to re-establish SRB1.

[85] A measurement report procedure may be used to transfer measurement results from a wireless device to an NG-RAN. The wireless device may initiate a measurement report procedure, for example, after successful security activation. A measurement report message may be used to send (e.g., transmit) measurement results.

[86] The wireless device 110 may comprise at least one communication interface 310 (e.g., a wireless modem, an antenna, and/or the like), at least one processor 314, and at least one set of program code instructions 316 that may be stored in non-transitory memory 315 and executable by the at least one processor 314. The wireless device 110 may further comprise at least one of at least one speaker and/or microphone 311, at least one keypad 312, at least one display and/or touchpad 313, at least one power source 317, at least one global positioning system (GPS) chipset 318, and/or other peripherals 319.

[87] The processor 314 of the wireless device 110, the processor 321A of the base station 1 120A, and/or the processor 321B of the base station 2 120B may comprise at least one of a general-purpose processor, a digital signal processor (DSP), a controller, a microcontroller, an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) and/or other programmable logic device, discrete gate and/or transistor logic, discrete hardware components, and/or the like. The processor 314 of the wireless device 110, the processor 321A in base station 1 120A, and/or the processor 321B in base station 2 120B may perform at least one of signal coding and/or processing, data processing, power control, input/output processing, and/or any other functionality that may enable the wireless device 110, the base station 1 120A and/or the base station 2 120B to operate in a wireless environment.

[88] The processor 314 of the wireless device 110 may be connected to and/or in communication with the speaker and/or microphone 311, the keypad 312, and/or the display and/or touchpad 313. The processor 314 may receive user input data from and/or provide user output data to the speaker and/or microphone 311, the keypad 312, and/or the display and/or touchpad 313. The processor 314 in the wireless device 110 may receive power from the power source 317 and/or may be configured to distribute the power to the other components in the wireless device 110. The power source 317 may comprise at least one of one or more dry cell batteries, solar cells, fuel cells, and/or the like. The processor 314 may be connected to the GPS chipset 318. The GPS chipset 318 may be configured to provide geographic location information of the wireless device 110.

[89] The processor 314 of the wireless device 110 may further be connected to and/or in communication with other peripherals 319, which may comprise one or more software and/or hardware modules that may provide additional features and/or functionalities. For example, the peripherals 319 may comprise at least one of an accelerometer, a satellite transceiver, a digital camera, a universal serial bus (USB) port, a hands-free headset, a frequency modulated (FM) radio unit, a media player, an Internet browser, and/or the like.

[90] The communication interface 320A of the base station 1, 120A, and/or the communication interface 320B of the base station 2, 120B, may be configured to communicate with the communication interface 310 of the wireless device 110, for example, via a wireless link 330A and/or via a wireless link 330B, respectively. The communication interface 320A of the base station 1, 120A, may communicate with the communication interface 320B of the base station 2 and/or other RAN and/or core network nodes.

[91] The wireless link 330A and/or the wireless link 330B may comprise at least one of a bi-directional link and/or a directional link. The communication interface 310 of the wireless device 110 may be configured to communicate with the communication interface 320A of the base station 1 120A and/or with the communication interface 320B of the base station 2 120B. The base station 1 120A and the wireless device 110, and/or

the base station 2 120B and the wireless device 110, may be configured to send and receive transport blocks, for example, via the wireless link 330A and/or via the wireless link 330B, respectively. The wireless link 330A and/or the wireless link 330B may use at least one frequency carrier. Transceiver(s) may be used. A transceiver may be a device that comprises both a transmitter and a receiver. Transceivers may be used in devices such as wireless devices, base stations, relay nodes, computing devices, and/or the like. Radio technology may be implemented in the communication interface 310, 320A, and/or 320B, and the wireless link 330A and/or 330B. The radio technology may comprise one or more elements shown in FIG. 4A, FIG. 4B, FIG. 4C, FIG. 4D, FIG. 6, FIG. 7A, FIG. 7B, FIG. 8, and associated text, described below.

[92] Other nodes in a wireless network (e.g. AMF, UPF, SMF, etc.) may comprise one or more communication interfaces, one or more processors, and memory storing instructions. A node (e.g., wireless device, base station, AMF, SMF, UPF, servers, switches, antennas, and/or the like) may comprise one or more processors, and memory storing instructions that when executed by the one or more processors causes the node to perform certain processes and/or functions. Single-carrier and/or multi-carrier communication operation may be performed. A non-transitory tangible computer readable media may comprise instructions executable by one or more processors to cause operation of single-carrier and/or multi-carrier communications. An article of manufacture may comprise a non-transitory tangible computer readable machine-accessible medium having instructions encoded thereon for enabling programmable hardware to cause a node to enable operation of single-carrier and/or multi-carrier communications. The node may include processors, memory, interfaces, and/or the like.

[93] An interface may comprise at least one of a hardware interface, a firmware interface, a software interface, and/or a combination thereof. The hardware interface may comprise connectors, wires, and/or electronic devices such as drivers, amplifiers, and/or the like. The software interface may comprise code stored in a memory device to implement protocol(s), protocol layers, communication drivers, device drivers, combinations thereof, and/or the like. The firmware interface may comprise a combination of embedded hardware and/or code stored in (and/or in communication with) a memory device to

implement connections, electronic device operations, protocol(s), protocol layers, communication drivers, device drivers, hardware operations, combinations thereof, and/or the like.

[94] A communication network may comprise the wireless device 110, the base station 1, 120A, the base station 2, 120B, and/or any other device. The communication network may comprise any number and/or type of devices, such as, for example, computing devices, wireless devices, mobile devices, handsets, tablets, laptops, internet of things (IoT) devices, hotspots, cellular repeaters, computing devices, and/or, more generally, user equipment (e.g., UE). Although one or more of the above types of devices may be referenced herein (e.g., UE, wireless device, computing device, etc.), it should be understood that any device herein may comprise any one or more of the above types of devices or similar devices. The communication network, and any other network referenced herein, may comprise an LTE network, a 5G network, or any other network for wireless communications. Apparatuses, systems, and/or methods described herein may generally be described as implemented on one or more devices (e.g., wireless device, base station, eNB, gNB, computing device, etc.), in one or more networks, but it will be understood that one or more features and steps may be implemented on any device and/or in any network. As used throughout, the term "base station" may comprise one or more of: a base station, a node, a Node B, a gNB, an eNB, an ng-eNB, a relay node (e.g., an integrated access and backhaul (IAB) node), a donor node (e.g., a donor eNB, a donor gNB, etc.), an access point (e.g., a WiFi access point), a computing device, a device capable of wirelessly communicating, or any other device capable of sending and/or receiving signals. As used throughout, the term "wireless device" may comprise one or more of: a UE, a handset, a mobile device, a computing device, a node, a device capable of wirelessly communicating, or any other device capable of sending and/or receiving signals. Any reference to one or more of these terms/devices also considers use of any other term/device mentioned above.

[95] FIG. 4A, FIG. 4B, FIG. 4C and FIG. 4D show examples of uplink and downlink signal transmission. FIG. 4A shows an example uplink transmitter for at least one physical channel. A baseband signal representing a physical uplink shared channel may perform

one or more functions. The one or more functions may comprise at least one of: scrambling (e.g., by Scrambling); modulation of scrambled bits to generate complex-valued symbols (e.g., by a Modulation mapper); mapping of the complex-valued modulation symbols onto one or several transmission layers (e.g., by a Layer mapper); transform precoding to generate complex-valued symbols (e.g., by a Transform precoder); precoding of the complex-valued symbols (e.g., by a Precoder); mapping of precoded complex-valued symbols to resource elements (e.g., by a Resource element mapper); generation of complex-valued time-domain Single Carrier-Frequency Division Multiple Access (SC-FDMA) or CP-OFDM signal for an antenna port (e.g., by a signal gen.); and/or the like. A SC-FDMA signal for uplink transmission may be generated, for example, if transform precoding is enabled. A CP-OFDM signal for uplink transmission may be generated by FIG. 4A, for example, if transform precoding is not enabled. These functions are shown as examples and other mechanisms may be implemented.

[96] FIG. 4B shows an example of modulation and up-conversion to the carrier frequency of a complex-valued SC-FDMA or CP-OFDM baseband signal for an antenna port and/or for the complex-valued Physical Random Access CHannel (PRACH) baseband signal. Filtering may be performed prior to transmission.

[97] FIG. 4C shows an example of downlink transmissions. The baseband signal representing a downlink physical channel may perform one or more functions. The one or more functions may comprise: scrambling of coded bits in a codeword to be transmitted on a physical channel (e.g., by Scrambling); modulation of scrambled bits to generate complex-valued modulation symbols (e.g., by a Modulation mapper); mapping of the complex-valued modulation symbols onto one or several transmission layers (e.g., by a Layer mapper); precoding of the complex-valued modulation symbols on a layer for transmission on the antenna ports (e.g., by Precoding); mapping of complex-valued modulation symbols for an antenna port to resource elements (e.g., by a Resource element mapper); generation of complex-valued time-domain OFDM signal for an antenna port (e.g., by an OFDM signal gen.); and/or the like. These functions are shown as examples and other mechanisms may be implemented.

[98] A base station may send (e.g., transmit) a first symbol and a second symbol on an antenna port, to a wireless device. The wireless device may infer the channel (e.g., fading gain, multipath delay, etc.) for conveying the second symbol on the antenna port, from the channel for conveying the first symbol on the antenna port. A first antenna port and a second antenna port may be quasi co-located, for example, if one or more large-scale properties of the channel over which a first symbol on the first antenna port is conveyed may be inferred from the channel over which a second symbol on a second antenna port is conveyed. The one or more large-scale properties may comprise at least one of: delay spread; Doppler spread; Doppler shift; average gain; average delay; and/or spatial receiving (Rx) parameters.

[99] FIG. 4D shows an example modulation and up-conversion to the carrier frequency of the complex-valued OFDM baseband signal for an antenna port. Filtering may be performed prior to transmission.

[100] FIG. 5A shows example uplink channel mapping and example uplink physical signals. A physical layer may provide one or more information transfer services to a MAC and/or one or more higher layers. The physical layer may provide the one or more information transfer services to the MAC via one or more transport channels. An information transfer service may indicate how and/or with what characteristics data is transferred over the radio interface.

[101] Uplink transport channels may comprise an Uplink-Shared CHannel (UL-SCH) 501 and/or a Random Access CHannel (RACH) 502. A wireless device may send (e.g., transmit) one or more uplink DM-RSs 506 to a base station for channel estimation, for example, for coherent demodulation of one or more uplink physical channels (e.g., PUSCH 503 and/or PUCCH 504). The wireless device may send (e.g., transmit) to a base station at least one uplink DM-RS 506 with PUSCH 503 and/or PUCCH 504, wherein the at least one uplink DM-RS 506 may be spanning a same frequency range as a corresponding physical channel. The base station may configure the wireless device with one or more uplink DM-RS configurations. At least one DM-RS configuration may support a front-loaded DM-RS pattern. A front-loaded DM-RS may be mapped over one

or more OFDM symbols (e.g., 1 or 2 adjacent OFDM symbols). One or more additional uplink DM-RS may be configured to send (e.g., transmit) at one or more symbols of a PUSCH and/or PUCCH. The base station may semi-statically configure the wireless device with a maximum number of front-loaded DM-RS symbols for PUSCH and/or PUCCH. The wireless device may schedule a single-symbol DM-RS and/or double symbol DM-RS based on a maximum number of front-loaded DM-RS symbols, wherein the base station may configure the wireless device with one or more additional uplink DM-RS for PUSCH and/or PUCCH. A new radio network may support, for example, at least for CP-OFDM, a common DM-RS structure for DL and UL, wherein a DM-RS location, DM-RS pattern, and/or scrambling sequence may be same or different.

[102] Whether or not an uplink PT-RS 507 is present may depend on an RRC configuration. A presence of the uplink PT-RS may be wireless device-specifically configured. A presence and/or a pattern of the uplink PT-RS 507 in a scheduled resource may be wireless device-specifically configured by a combination of RRC signaling and/or association with one or more parameters used for other purposes (e.g., Modulation and Coding Scheme (MCS)) which may be indicated by DCI. If configured, a dynamic presence of uplink PT-RS 507 may be associated with one or more DCI parameters comprising at least a MCS. A radio network may support a plurality of uplink PT-RS densities defined in time/frequency domain. If present, a frequency domain density may be associated with at least one configuration of a scheduled bandwidth. A wireless device may assume a same precoding for a DMRS port and a PT-RS port. A number of PT-RS ports may be less than a number of DM-RS ports in a scheduled resource. The uplink PT-RS 507 may be confined in the scheduled time/frequency duration for a wireless device.

[103] A wireless device may send (e.g., transmit) an SRS 508 to a base station for channel state estimation, for example, to support uplink channel dependent scheduling and/or link adaptation. The SRS 508 sent (e.g., transmitted) by the wireless device may allow for the base station to estimate an uplink channel state at one or more different frequencies. A base station scheduler may use an uplink channel state to assign one or more resource blocks of a certain quality (e.g., above a quality threshold) for an uplink PUSCH transmission from the wireless device. The base station may semi-statically configure the

wireless device with one or more SRS resource sets. For an SRS resource set, the base station may configure the wireless device with one or more SRS resources. An SRS resource set applicability may be configured by a higher layer (e.g., RRC) parameter. An SRS resource in each of one or more SRS resource sets may be sent (e.g., transmitted) at a time instant, for example, if a higher layer parameter indicates beam management. The wireless device may send (e.g., transmit) one or more SRS resources in different SRS resource sets simultaneously. A new radio network may support aperiodic, periodic, and/or semi-persistent SRS transmissions. The wireless device may send (e.g., transmit) SRS resources, for example, based on one or more trigger types. The one or more trigger types may comprise higher layer signaling (e.g., RRC) and/or one or more DCI formats (e.g., at least one DCI format may be used for a wireless device to select at least one of one or more configured SRS resource sets). An SRS trigger type 0 may refer to an SRS triggered based on a higher layer signaling. An SRS trigger type 1 may refer to an SRS triggered based on one or more DCI formats. The wireless device may be configured to send (e.g., transmit) the SRS 508 after a transmission of PUSCH 503 and corresponding uplink DM-RS 506, for example, if PUSCH 503 and the SRS 508 are transmitted in a same slot.

[104] A base station may semi-statically configure a wireless device with one or more SRS configuration parameters indicating at least one of following: an SRS resource configuration identifier, a number of SRS ports, time domain behavior of SRS resource configuration (e.g., an indication of periodic, semi-persistent, or aperiodic SRS), slot (mini-slot, and/or subframe) level periodicity and/or offset for a periodic and/or aperiodic SRS resource, a number of OFDM symbols in a SRS resource, starting OFDM symbol of a SRS resource, an SRS bandwidth, a frequency hopping bandwidth, a cyclic shift, and/or an SRS sequence ID.

[105] FIG. 5B shows an example downlink channel mapping and downlink physical signals. Downlink transport channels may comprise a Downlink-Shared CHannel (DL-SCH) 511, a Paging CHannel (PCH) 512, and/or a Broadcast CHannel (BCH) 513. A transport channel may be mapped to one or more corresponding physical channels. A UL-SCH 501 may be mapped to a Physical Uplink Shared CHannel (PUSCH) 503. A RACH 502 may

be mapped to a PRACH 505. A DL-SCH 511 and a PCH 512 may be mapped to a Physical Downlink Shared CHannel (PDSCH) 514. A BCH 513 may be mapped to a Physical Broadcast CHannel (PBCH) 516.

[106] A radio network may comprise one or more downlink and/or uplink transport channels. The radio network may comprise one or more physical channels without a corresponding transport channel. The one or more physical channels may be used for an Uplink Control Information (UCI) 509 and/or a Downlink Control Information (DCI) 517. A Physical Uplink Control CHannel (PUCCH) 504 may carry UCI 509 from a wireless device to a base station. A Physical Downlink Control CHannel (PDCCH) 515 may carry the DCI 517 from a base station to a wireless device. The radio network (e.g., NR) may support the UCI 509 multiplexing in the PUSCH 503, for example, if the UCI 509 and the PUSCH 503 transmissions may coincide in a slot (e.g., at least in part). The UCI 509 may comprise at least one of a CSI, an Acknowledgement (ACK)/Negative Acknowledgement (NACK), and/or a scheduling request. The DCI 517 via the PDCCH 515 may indicate at least one of following: one or more downlink assignments and/or one or more uplink scheduling grants.

[107] In uplink, a wireless device may send (e.g., transmit) one or more Reference Signals (RSs) to a base station. The one or more RSs may comprise at least one of a Demodulation-RS (DM-RS) 506, a Phase Tracking-RS (PT-RS) 507, and/or a Sounding RS (SRS) 508. In downlink, a base station may send (e.g., transmit, unicast, multicast, and/or broadcast) one or more RSs to a wireless device. The one or more RSs may comprise at least one of a Primary Synchronization Signal (PSS)/Secondary Synchronization Signal (SSS) 521, a CSI-RS 522, a DM-RS 523, and/or a PT-RS 524.

[108] In a time domain, an SS/PBCH block may comprise one or more OFDM symbols (e.g., 4 OFDM symbols numbered in increasing order from 0 to 3) within the SS/PBCH block. An SS/PBCH block may comprise the PSS/SSS 521 and/or the PBCH 516. In the frequency domain, an SS/PBCH block may comprise one or more contiguous subcarriers (e.g., 240 contiguous subcarriers with the subcarriers numbered in increasing order from 0 to 239) within the SS/PBCH block. The PSS/SSS 521 may occupy, for example, 1

OFDM symbol and 127 subcarriers. The PBCH 516 may span across, for example, 3 OFDM symbols and 240 subcarriers. A wireless device may assume that one or more SS/PBCH blocks transmitted with a same block index may be quasi co-located, for example, with respect to Doppler spread, Doppler shift, average gain, average delay, and/or spatial Rx parameters. A wireless device may not assume quasi co-location for other SS/PBCH block transmissions. A periodicity of an SS/PBCH block may be configured by a radio network (e.g., by an RRC signaling). One or more time locations in which the SS/PBCH block may be sent may be determined by sub-carrier spacing. A wireless device may assume a band-specific sub-carrier spacing for an SS/PBCH block, for example, unless a radio network has configured the wireless device to assume a different sub-carrier spacing.

[109] The downlink CSI-RS 522 may be used for a wireless device to acquire channel state information. A radio network may support periodic, aperiodic, and/or semi-persistent transmission of the downlink CSI-RS 522. A base station may semi-statically configure and/or reconfigure a wireless device with periodic transmission of the downlink CSI-RS 522. A configured CSI-RS resources may be activated and/or deactivated. For semi-persistent transmission, an activation and/or deactivation of a CSI-RS resource may be triggered dynamically. A CSI-RS configuration may comprise one or more parameters indicating at least a number of antenna ports. A base station may configure a wireless device with 32 ports, or any other number of ports. A base station may semi-statically configure a wireless device with one or more CSI-RS resource sets. One or more CSI-RS resources may be allocated from one or more CSI-RS resource sets to one or more wireless devices. A base station may semi-statically configure one or more parameters indicating CSI RS resource mapping, for example, time-domain location of one or more CSI-RS resources, a bandwidth of a CSI-RS resource, and/or a periodicity. A wireless device may be configured to use the same OFDM symbols for the downlink CSI-RS 522 and the Control Resource Set (CORESET), for example, if the downlink CSI-RS 522 and the CORESET are spatially quasi co-located and resource elements associated with the downlink CSI-RS 522 are the outside of PRBs configured for the CORESET. A wireless device may be configured to use the same OFDM symbols for downlink CSI-RS 522 and

SS/PBCH blocks, for example, if the downlink CSI-RS 522 and SS/PBCH blocks are spatially quasi co-located and resource elements associated with the downlink CSI-RS 522 are outside of the PRBs configured for the SS/PBCH blocks.

[110] A wireless device may send (e.g., transmit) one or more downlink DM-RSs 523 to a base station for channel estimation, for example, for coherent demodulation of one or more downlink physical channels (e.g., PDSCH 514). A radio network may support one or more variable and/or configurable DM-RS patterns for data demodulation. At least one downlink DM-RS configuration may support a front-loaded DM-RS pattern. A front-loaded DM-RS may be mapped over one or more OFDM symbols (e.g., 1 or 2 adjacent OFDM symbols). A base station may semi-statically configure a wireless device with a maximum number of front-loaded DM-RS symbols for PDSCH 514. A DM-RS configuration may support one or more DM-RS ports. A DM-RS configuration may support at least 8 orthogonal downlink DM-RS ports, for example, for single user-MIMO. ADM-RS configuration may support 12 orthogonal downlink DM-RS ports, for example, for multiuser-MIMO. A radio network may support, for example, at least for CP-OFDM, a common DM-RS structure for DL and UL, wherein a DM-RS location, DM-RS pattern, and/or scrambling sequence may be the same or different.

[111] Whether or not the downlink PT-RS 524 is present may depend on an RRC configuration. A presence of the downlink PT-RS 524 may be wireless device-specifically configured. A presence and/or a pattern of the downlink PT-RS 524 in a scheduled resource may be wireless device-specifically configured, for example, by a combination of RRC signaling and/or an association with one or more parameters used for other purposes (e.g., MCS) which may be indicated by the DCI. If configured, a dynamic presence of the downlink PT-RS 524 may be associated with one or more DCI parameters comprising at least MCS. A radio network may support a plurality of PT-RS densities in a time/frequency domain. If present, a frequency domain density may be associated with at least one configuration of a scheduled bandwidth. A wireless device may assume the same precoding for a DMRS port and a PT-RS port. A number of PT-RS ports may be less than a number of DM-RS ports in a scheduled resource. The downlink

PT-RS 524 may be confined in the scheduled time/frequency duration for a wireless device.

[112] FIG. 6 shows an example transmission time and reception time for a carrier. A multicarrier OFDM communication system may include one or more carriers, for example, ranging from 1 to 32 carriers (such as for carrier aggregation) or ranging from 1 to 64 carriers (such as for dual connectivity). Different radio frame structures may be supported (e.g., for FDD and/or for TDD duplex mechanisms). FIG. 6 shows an example frame timing. Downlink and uplink transmissions may be organized into radio frames 601. Radio frame duration may be 10 milliseconds (ms). A 10 ms radio frame 601 may be divided into ten equally sized subframes 602, each with a 1 ms duration. Subframe(s) may comprise one or more slots (e.g., slots 603 and 605) depending on subcarrier spacing and/or CP length. For example, a subframe with 15 kHz, 30 kHz, 60 kHz, 120 kHz, 240 kHz and 480 kHz subcarrier spacing may comprise one, two, four, eight, sixteen and thirty-two slots, respectively. In FIG. 6, a subframe may be divided into two equally sized slots 603 with 0.5 ms duration. For example, 10 subframes may be available for downlink transmission and 10 subframes may be available for uplink transmissions in a 10 ms interval. Other subframe durations such as, for example, 0.5 ms, 1 ms, 2 ms, and 5 ms may be supported. Uplink and downlink transmissions may be separated in the frequency domain. Slot(s) may include a plurality of OFDM symbols 604. The number of OFDM symbols 604 in a slot 605 may depend on the cyclic prefix length. A slot may be 14 OFDM symbols for the same subcarrier spacing of up to 480 kHz with normal CP. A slot may be 12 OFDM symbols for the same subcarrier spacing of 60 kHz with extended CP. A slot may comprise downlink, uplink, and/or a downlink part and an uplink part, and/or alike.

[113] FIG. 7A shows example sets of OFDM subcarriers. A base station may communicate with a wireless device using a carrier having an example channel bandwidth 700. Arrow(s) in the example may depict a subcarrier in a multicarrier OFDM system. The OFDM system may use technology such as OFDM technology, SC-FDMA technology, and/or the like. An arrow 701 shows a subcarrier transmitting information symbols. A subcarrier spacing 702, between two contiguous subcarriers in a carrier, may be any one

of 15 kHz, 30 kHz, 60 kHz, 120 kHz, 240 kHz, or any other frequency. Different subcarrier spacing may correspond to different transmission numerologies. A transmission numerology may comprise at least: a numerology index; a value of subcarrier spacing; and/or a type of cyclic prefix (CP). A base station may send (e.g., transmit) to and/or receive from a wireless device via a number of subcarriers 703 in a carrier. A bandwidth occupied by a number of subcarriers 703 (e.g., transmission bandwidth) may be smaller than the channel bandwidth 700 of a carrier, for example, due to guard bands 704 and 705. Guard bands 704 and 705 may be used to reduce interference to and from one or more neighbor carriers. A number of subcarriers (e.g., transmission bandwidth) in a carrier may depend on the channel bandwidth of the carrier and/or the subcarrier spacing. A transmission bandwidth, for a carrier with a 20 MHz channel bandwidth and a 15 kHz subcarrier spacing, may be in number of 1024 subcarriers.

[114] A base station and a wireless device may communicate with multiple component carriers (CCs), for example, if configured with CA. Different component carriers may have different bandwidth and/or different subcarrier spacing, for example, if CA is supported. A base station may send (e.g., transmit) a first type of service to a wireless device via a first component carrier. The base station may send (e.g., transmit) a second type of service to the wireless device via a second component carrier. Different types of services may have different service requirements (e.g., data rate, latency, reliability), which may be suitable for transmission via different component carriers having different subcarrier spacing and/or different bandwidth.

[115] FIG. 7B shows examples of component carriers. A first component carrier may comprise a first number of subcarriers 706 having a first subcarrier spacing 709. A second component carrier may comprise a second number of subcarriers 707 having a second subcarrier spacing 710. A third component carrier may comprise a third number of subcarriers 708 having a third subcarrier spacing 711. Carriers in a multicarrier OFDM communication system may be contiguous carriers, non-contiguous carriers, or a combination of both contiguous and non-contiguous carriers.

[116] FIG. 8 shows an example of OFDM radio resources. A carrier may have a transmission bandwidth 801. A resource grid may be in a structure of frequency domain 802 and time domain 803. A resource grid may comprise a first number of OFDM symbols in a subframe and a second number of resource blocks, starting from a common resource block indicated by higher-layer signaling (e.g., RRC signaling), for a transmission numerology and a carrier. In a resource grid, a resource element 805 may comprise a resource unit that may be identified by a subcarrier index and a symbol index. A subframe may comprise a first number of OFDM symbols 807 that may depend on a numerology associated with a carrier. A subframe may have 14 OFDM symbols for a carrier, for example, if a subcarrier spacing of a numerology of a carrier is 15 kHz. A subframe may have 28 OFDM symbols, for example, if a subcarrier spacing of a numerology is 30 kHz. A subframe may have 56 OFDM symbols, for example, if a subcarrier spacing of a numerology is 60 kHz. A subcarrier spacing of a numerology may comprise any other frequency. A second number of resource blocks comprised in a resource grid of a carrier may depend on a bandwidth and a numerology of the carrier.

[117] A resource block 806 may comprise 12 subcarriers. Multiple resource blocks may be grouped into a Resource Block Group (RBG) 804. A size of a RBG may depend on at least one of: a RRC message indicating a RBG size configuration; a size of a carrier bandwidth; and/or a size of a bandwidth part of a carrier. A carrier may comprise multiple bandwidth parts. A first bandwidth part of a carrier may have a different frequency location and/or a different bandwidth from a second bandwidth part of the carrier.

[118] A base station may send (e.g., transmit), to a wireless device, a downlink control information comprising a downlink or uplink resource block assignment. A base station may send (e.g., transmit) to and/or receive from, a wireless device, data packets (e.g., transport blocks). The data packets may be scheduled on and transmitted via one or more resource blocks and one or more slots indicated by parameters in downlink control information and/or RRC message(s). A starting symbol relative to a first slot of the one or more slots may be indicated to the wireless device. A base station may send (e.g.,

transmit) to and/or receive from, a wireless device, data packets. The data packets may be scheduled for transmission on one or more RBGs and in one or more slots.

[119] A base station may send (e.g., transmit), to a wireless device, downlink control information comprising a downlink assignment. The base station may send (e.g., transmit) the DCI via one or more PDCCHs. The downlink assignment may comprise parameters indicating at least one of a modulation and coding format; resource allocation; and/or HARQ information related to the DL-SCH. The resource allocation may comprise parameters of resource block allocation; and/or slot allocation. A base station may allocate (e.g., dynamically) resources to a wireless device, for example, via a Cell-Radio Network Temporary Identifier (C-RNTI) on one or more PDCCHs. The wireless device may monitor the one or more PDCCHs, for example, in order to find possible allocation if its downlink reception is enabled. The wireless device may receive one or more downlink data packets on one or more PDSCH scheduled by the one or more PDCCHs, for example, if the wireless device successfully detects the one or more PDCCHs.

[120] A base station may allocate Configured Scheduling (CS) resources for down link transmission to a wireless device. The base station may send (e.g., transmit) one or more RRC messages indicating a periodicity of the CS grant. The base station may send (e.g., transmit) DCI via a PDCCH addressed to a Configured Scheduling-RNTI (CS-RNTI) activating the CS resources. The DCI may comprise parameters indicating that the downlink grant is a CS grant. The CS grant may be implicitly reused according to the periodicity defined by the one or more RRC messages. The CS grant may be implicitly reused, for example, until deactivated.

[121] A base station may send (e.g., transmit), to a wireless device via one or more PDCCHs, downlink control information comprising an uplink grant. The uplink grant may comprise parameters indicating at least one of a modulation and coding format; a resource allocation; and/or HARQ information related to the UL-SCH. The resource allocation may comprise parameters of resource block allocation; and/or slot allocation. The base station may dynamically allocate resources to the wireless device via a C-RNTI on one or more PDCCHs. The wireless device may monitor the one or more PDCCHs, for example,

in order to find possible resource allocation. The wireless device may send (e.g., transmit) one or more uplink data packets via one or more PUSCH scheduled by the one or more PDCCHs, for example, if the wireless device successfully detects the one or more PDCCHs.

[122] The base station may allocate CS resources for uplink data transmission to a wireless device. The base station may transmit one or more RRC messages indicating a periodicity of the CS grant. The base station may send (e.g., transmit) DCI via a PDCCH addressed to a CS-RNTI to activate the CS resources. The DCI may comprise parameters indicating that the uplink grant is a CS grant. The CS grant may be implicitly reused according to the periodicity defined by the one or more RRC message, The CS grant may be implicitly reused, for example, until deactivated.

[123] A base station may send (e.g., transmit) DCI and/or control signaling via a PDCCH. The DCI may comprise a format of a plurality of formats. The DCI may comprise downlink and/or uplink scheduling information (e.g., resource allocation information, HARQ related parameters, MCS), request(s) for CSI (e.g., aperiodic CQI reports), request(s) for an SRS, uplink power control commands for one or more cells, one or more timing information (e.g., TB transmission/reception timing, HARQ feedback timing, etc.), and/or the like. The DCI may indicate an uplink grant comprising transmission parameters for one or more transport blocks. The DCI may indicate a downlink assignment indicating parameters for receiving one or more transport blocks. The DCI may be used by the base station to initiate a contention-free random access at the wireless device. The base station may send (e.g., transmit) DCI comprising a slot format indicator (SFI) indicating a slot format. The base station may send (e.g., transmit) DCI comprising a preemption indication indicating the PRB(s) and/or OFDM symbol(s) in which a wireless device may assume no transmission is intended for the wireless device. The base station may send (e.g., transmit) DCI for group power control of the PUCCH, the PUSCH, and/or an SRS. DCI may correspond to an RNTI. The wireless device may obtain an RNTI after or in response to completing the initial access (e.g., C-RNTI). The base station may configure an RNTI for the wireless (e.g., CS-RNTI, TPC-CS-RNTI, TPC-PUCCH-RNTI, TPC-PUSCH-RNTI, TPC-SRS-RNTI, etc.). The wireless device

may determine (e.g., compute) an RNTI (e.g., the wireless device may determine the RA-RNTI based on resources used for transmission of a preamble). An RNTI may have a pre-configured value (e.g., P-RNTI or SI-RNTI). The wireless device may monitor a group common search space which may be used by the base station for sending (e.g., transmitting) DCIs that are intended for a group of wireless devices. A group common DCI may correspond to an RNTI which is commonly configured for a group of wireless devices. The wireless device may monitor a wireless device-specific search space. A wireless device specific DCI may correspond to an RNTI configured for the wireless device.

[124] A communications system (e.g., an NR system) may support a single beam operation and/or a multi-beam operation. In a multi-beam operation, a base station may perform a downlink beam sweeping to provide coverage for common control channels and/or downlink SS blocks, which may comprise at least a PSS, a SSS, and/or PBCH. A wireless device may measure quality of a beam pair link using one or more RSs. One or more SS blocks, or one or more CSI-RS resources (e.g., which may be associated with a CSI-RS resource index (CRI)), and/or one or more DM-RSs of a PBCH, may be used as an RS for measuring a quality of a beam pair link. The quality of a beam pair link may be based on a reference signal received power (RSRP) value, a reference signal received quality (RSRQ) value, and/or a CSI value measured on RS resources. The base station may indicate whether an RS resource, used for measuring a beam pair link quality, is quasi-co-located (QCLed) with DM-RSs of a control channel. An RS resource and DM-RSs of a control channel may be called QCLed, for example, if channel characteristics from a transmission on an RS to a wireless device, and that from a transmission on a control channel to a wireless device, are similar or the same under a configured criterion. In a multi-beam operation, a wireless device may perform an uplink beam sweeping to access a cell.

[125] A wireless device may be configured to monitor a PDCCH on one or more beam pair links simultaneously, for example, depending on a capability of the wireless device. This monitoring may increase robustness against beam pair link blocking. A base station may send (e.g., transmit) one or more messages to configure the wireless device to monitor the

PDCCH on one or more beam pair links in different PDCCH OFDM symbols. A base station may send (e.g., transmit) higher layer signaling (e.g., RRC signaling) and/or a MAC CE comprising parameters related to the Rx beam setting of the wireless device for monitoring the PDCCH on one or more beam pair links. The base station may send (e.g., transmit) an indication of a spatial QCL assumption between an DL RS antenna port(s) (e.g., a cell-specific CSI-RS, a wireless device-specific CSI-RS, an SS block, and/or a PBCH with or without DM-RSs of the PBCH) and/or DL RS antenna port(s) for demodulation of a DL control channel. Signaling for beam indication for a PDCCH may comprise MAC CE signaling, RRC signaling, DCI signaling, and/or specification-transparent and/or implicit method, and/or any combination of signaling methods.

[126] A base station may indicate spatial QCL parameters between DL RS antenna port(s) and DM-RS antenna port(s) of a DL data channel, for example, for reception of a unicast DL data channel. The base station may send (e.g., transmit) DCI (e.g., downlink grants) comprising information indicating the RS antenna port(s). The information may indicate RS antenna port(s) that may be QCL-ed with the DM-RS antenna port(s). A different set of DM-RS antenna port(s) for a DL data channel may be indicated as QCL with a different set of the RS antenna port(s).

[127] FIG. 9A shows an example of beam sweeping in a DL channel. In an RRC_INACTIVE state or RRC_IDLE state, a wireless device may assume that SS blocks form an SS burst 940, and an SS burst set 950. The SS burst set 950 may have a given periodicity. A base station 120 may send (e.g., transmit) SS blocks in multiple beams, together forming a SS burst 940, for example, in a multi-beam operation. One or more SS blocks may be sent (e.g., transmitted) on one beam. If multiple SS bursts 940 are transmitted with multiple beams, SS bursts together may form SS burst set 950.

[128] A wireless device may use CSI-RS for estimating a beam quality of a link between a wireless device and a base station, for example, in the multi beam operation. A beam may be associated with a CSI-RS. A wireless device may (e.g., based on a RSRP measurement on CSI-RS) report a beam index, which may be indicated in a CRI for downlink beam selection and/or associated with an RSRP value of a beam. A CSI-RS may be sent (e.g.,

transmitted) on a CSI-RS resource, which may comprise at least one of: one or more antenna ports and/or one or more time and/or frequency radio resources. A CSI-RS resource may be configured in a cell-specific way such as by common RRC signaling, or in a wireless device-specific way such as by dedicated RRC signaling and/or L1/L2 signaling. Multiple wireless devices covered by a cell may measure a cell-specific CSI-RS resource. A dedicated subset of wireless devices covered by a cell may measure a wireless device-specific CSI-RS resource.

[129] A CSI-RS resource may be sent (e.g., transmitted) periodically, using aperiodic transmission, or using a multi-shot or semi-persistent transmission. In a periodic transmission in FIG. 9A, a base station 120 may send (e.g., transmit) configured CSI-RS resources 940 periodically using a configured periodicity in a time domain. In an aperiodic transmission, a configured CSI-RS resource may be sent (e.g., transmitted) in a dedicated time slot. In a multi-shot and/or semi-persistent transmission, a configured CSI-RS resource may be sent (e.g., transmitted) within a configured period. Beams used for CSI-RS transmission may have a different beam width than beams used for SS-blocks transmission.

[130] FIG. 9B shows an example of a beam management procedure, such as in an example new radio network. The base station 120 and/or the wireless device 110 may perform a downlink L1/L2 beam management procedure. One or more of the following downlink L1/L2 beam management procedures may be performed within one or more wireless devices 110 and one or more base stations 120. A P1 procedure 910 may be used to enable the wireless device 110 to measure one or more Transmission (Tx) beams associated with the base station 120, for example, to support a selection of a first set of Tx beams associated with the base station 120 and a first set of Rx beam(s) associated with the wireless device 110. A base station 120 may sweep a set of different Tx beams, for example, for beamforming at a base station 120 (such as shown in the top row, in a counter-clockwise direction). A wireless device 110 may sweep a set of different Rx beams, for example, for beamforming at a wireless device 110 (such as shown in the bottom row, in a clockwise direction). A P2 procedure 920 may be used to enable a wireless device 110 to measure one or more Tx beams associated with a base station 120,

for example, to possibly change a first set of Tx beams associated with a base station 120. A P2 procedure 920 may be performed on a possibly smaller set of beams (e.g., for beam refinement) than in the P1 procedure 910. A P2 procedure 920 may be a special example of a P1 procedure 910. A P3 procedure 930 may be used to enable a wireless device 110 to measure at least one Tx beam associated with a base station 120, for example, to change a first set of Rx beams associated with a wireless device 110.

[131] A wireless device 110 may send (e.g., transmit) one or more beam management reports to a base station 120. In one or more beam management reports, a wireless device 110 may indicate one or more beam pair quality parameters comprising one or more of: a beam identification; an RSRP; a Precoding Matrix Indicator (PMI), Channel Quality Indicator (CQI), and/or Rank Indicator (RI) of a subset of configured beams. Based on one or more beam management reports, the base station 120 may send (e.g., transmit) to a wireless device 110 a signal indicating that one or more beam pair links are one or more serving beams. The base station 120 may send (e.g., transmit) the PDCCH and the PDSCH for a wireless device 110 using one or more serving beams.

[132] A communications network (e.g., a new radio network) may support a Bandwidth Adaptation (BA). Receive and/or transmit bandwidths that may be configured for a wireless device using a BA may not be large. Receive and/or transmit bandwidth may not be as large as a bandwidth of a cell. Receive and/or transmit bandwidths may be adjustable. A wireless device may change receive and/or transmit bandwidths, for example, to reduce (e.g., shrink) the bandwidth(s) at (e.g., during) a period of low activity such as to save power. A wireless device may change a location of receive and/or transmit bandwidths in a frequency domain, for example, to increase scheduling flexibility. A wireless device may change a subcarrier spacing, for example, to allow different services.

[133] A Bandwidth Part (BWP) may comprise a subset of a total cell bandwidth of a cell. A base station may configure a wireless device with one or more BWPs, for example, to achieve a BA. A base station may indicate, to a wireless device, which of the one or more (configured) BWPs is an active BWP.

[134] FIG. 10 shows an example of BWP configurations. BWPs may be configured as follows: BWP1 (1010 and 1050) with a width of 40 MHz and subcarrier spacing of 15 kHz; BWP2 (1020 and 1040) with a width of 10 MHz and subcarrier spacing of 15 kHz; BWP3 1030 with a width of 20 MHz and subcarrier spacing of 60 kHz. Any number of BWP configurations may comprise any other width and subcarrier spacing combination.

[135] A wireless device, configured for operation in one or more BWPs of a cell, may be configured by one or more higher layers (e.g., RRC layer). The wireless device may be configured for a cell with: a set of one or more BWPs (e.g., at most four BWPs) for reception (e.g., a DL BWP set) in a DL bandwidth by at least one parameter DL-BWP; and a set of one or more BWPs (e.g., at most four BWPs) for transmissions (e.g., UL BWP set) in an UL bandwidth by at least one parameter UL-BWP. BWPs are described as example resources. Any wireless resource may be applicable to one or more procedures described herein.

[136] A base station may configure a wireless device with one or more UL and DL BWP pairs, for example, to enable BA on the PCell. To enable BA on SCells (e.g., for CA), a base station may configure a wireless device at least with one or more DL BWPs (e.g., there may be none in an UL).

[137] An initial active DL BWP may comprise at least one of a location and number of contiguous PRBs, a subcarrier spacing, or a cyclic prefix, for example, for a control resource set for at least one common search space. For operation on the PCell, one or more higher layer parameters may indicate at least one initial UL BWP for a random access procedure. If a wireless device is configured with a secondary carrier on a primary cell, the wireless device may be configured with an initial BWP for random access procedure on a secondary carrier.

[138] A wireless device may expect that a center frequency for a DL BWP may be same as a center frequency for a UL BWP, for example, for unpaired spectrum operation. A base station may semi-statically configure a wireless device for a cell with one or more parameters, for example, for a DL BWP or an UL BWP in a set of one or more DL BWPs

or one or more UL BWPs, respectively. The one or more parameters may indicate one or more of following: a subcarrier spacing; a cyclic prefix; a number of contiguous PRBs; an index in the set of one or more DL BWPs and/or one or more UL BWPs; a link between a DL BWP and an UL BWP from a set of configured DL BWPs and UL BWPs; a DCI detection to a PDSCH reception timing; a PDSCH reception to a HARQ-ACK transmission timing value; a DCI detection to a PUSCH transmission timing value; and/or an offset of a first PRB of a DL bandwidth or an UL bandwidth, respectively, relative to a first PRB of a bandwidth.

[139] For a DL BWP in a set of one or more DL BWPs on a PCell, a base station may configure a wireless device with one or more control resource sets for at least one type of common search space and/or one wireless device-specific search space. A base station may not configure a wireless device without a common search space on a PCell, or on a PSCell, in an active DL BWP. For an UL BWP in a set of one or more UL BWPs, a base station may configure a wireless device with one or more resource sets for one or more PUCCH transmissions.

[140] DCI may comprise a BWP indicator field. The BWP indicator field value may indicate an active DL BWP, from a configured DL BWP set, for one or more DL receptions. The BWP indicator field value may indicate an active UL BWP, from a configured UL BWP set, for one or more UL transmissions.

[141] For a PCell, a base station may semi-statically configure a wireless device with a default DL BWP among configured DL BWPs. If a wireless device is not provided with a default DL BWP, a default BWP may be an initial active DL BWP. A default BWP may not be configured for one or more wireless devices. A first (or initial) BWP may serve as a default BWP, for example, if a default BWP is not configured.

[142] A base station may configure a wireless device with a timer value for a PCell. A wireless device may start a timer (e.g., a BWP inactivity timer), for example, if a wireless device detects DCI indicating an active DL BWP, other than a default DL BWP, for a paired spectrum operation, and/or if a wireless device detects DCI indicating an active DL BWP

or UL BWP, other than a default DL BWP or UL BWP, for an unpaired spectrum operation. The wireless device may increment the timer by an interval of a first value (e.g., the first value may be 1 millisecond, 0.5 milliseconds, or any other time duration), for example, if the wireless device does not detect DCI at (e.g., during) the interval for a paired spectrum operation or for an unpaired spectrum operation. The timer may expire at a time that the timer is equal to the timer value. A wireless device may switch to the default DL BWP from an active DL BWP, for example, if the timer expires.

[143] A base station may semi-statically configure a wireless device with one or more BWPs. A wireless device may switch an active BWP from a first BWP to a second BWP, for example, after or in response to receiving DCI indicating the second BWP as an active BWP, and/or after or in response to an expiry of BWP inactivity timer (e.g., the second BWP may be a default BWP). FIG. 10 shows an example of three BWPs configured, BWP1 (1010 and 1050), BWP2 (1020 and 1040), and BWP3 (1030). BWP2 (1020 and 1040) may be a default BWP. BWP1 (1010) may be an initial active BWP. A wireless device may switch an active BWP from BWP1 1010 to BWP2 1020, for example, after or in response to an expiry of the BWP inactivity timer. A wireless device may switch an active BWP from BWP2 1020 to BWP3 1030, for example, after or in response to receiving DCI indicating BWP3 1030 as an active BWP. Switching an active BWP from BWP3 1030 to BWP2 1040 and/or from BWP2 1040 to BWP1 1050 may be after or in response to receiving DCI indicating an active BWP, and/or after or in response to an expiry of BWP inactivity timer.

[144] Wireless device procedures on a secondary cell may be same as on a primary cell using the timer value for the secondary cell and the default DL BWP for the secondary cell, for example, if a wireless device is configured for a secondary cell with a default DL BWP among configured DL BWPs and a timer value. A wireless device may use an indicated DL BWP and an indicated UL BWP on a secondary cell as a respective first active DL BWP and first active UL BWP on a secondary cell or carrier, for example, if a base station configures a wireless device with a first active DL BWP and a first active UL BWP on a secondary cell or carrier.

[145] FIG. 11A and FIG. 11B show packet flows using a multi connectivity (e.g., dual connectivity, multi connectivity, tight interworking, and/or the like). FIG. 11A shows an example of a protocol structure of a wireless device 110 (e.g., UE) with CA and/or multi connectivity. FIG. 11B shows an example of a protocol structure of multiple base stations with CA and/or multi connectivity. The multiple base stations may comprise a master node, MN 1130 (e.g., a master node, a master base station, a master gNB, a master eNB, and/or the like) and a secondary node, SN 1150 (e.g., a secondary node, a secondary base station, a secondary gNB, a secondary eNB, and/or the like). A master node 1130 and a secondary node 1150 may co-work to communicate with a wireless device 110.

[146] If multi connectivity is configured for a wireless device 110, the wireless device 110, which may support multiple reception and/or transmission functions in an RRC connected state, may be configured to utilize radio resources provided by multiple schedulers of a multiple base stations. Multiple base stations may be inter-connected via a non-ideal or ideal backhaul (e.g., Xn interface, X2 interface, and/or the like). A base station involved in multi connectivity for a certain wireless device may perform at least one of two different roles: a base station may act as a master base station or act as a secondary base station. In multi connectivity, a wireless device may be connected to one master base station and one or more secondary base stations. A master base station (e.g., the MN 1130) may provide a master cell group (MCG) comprising a primary cell and/or one or more secondary cells for a wireless device (e.g., the wireless device 110). A secondary base station (e.g., the SN 1150) may provide a secondary cell group (SCG) comprising a primary secondary cell (PSCell) and/or one or more secondary cells for a wireless device (e.g., the wireless device 110).

[147] In multi connectivity, a radio protocol architecture that a bearer uses may depend on how a bearer is setup. Three different types of bearer setup options may be supported: an MCG bearer, an SCG bearer, and/or a split bearer. A wireless device may receive and/or send (e.g., transmit) packets of an MCG bearer via one or more cells of the MCG. A wireless device may receive and/or send (e.g., transmit) packets of an SCG bearer via one or more cells of an SCG. Multi-connectivity may indicate having at least one bearer



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configured to use radio resources provided by the secondary base station. Multi-connectivity may or may not be configured and/or implemented.

[148] A wireless device (e.g., wireless device 110) may send (e.g., transmit) and/or receive: packets of an MCG bearer via an SDAP layer (e.g., SDAP 1110), a PDCP layer (e.g., NR PDCP 1111), an RLC layer (e.g., MN RLC 1114), and a MAC layer (e.g., MN MAC 1118); packets of a split bearer via an SDAP layer (e.g., SDAP 1110), a PDCP layer (e.g., NR PDCP 1112), one of a master or secondary RLC layer (e.g., MN RLC 1115, SN RLC 1116), and one of a master or secondary MAC layer (e.g., MN MAC 1118, SN MAC 1119); and/or packets of an SCG bearer via an SDAP layer (e.g., SDAP 1110), a PDCP layer (e.g., NR PDCP 1113), an RLC layer (e.g., SN RLC 1117), and a MAC layer (e.g., MN MAC 1119).

[149] A master base station (e.g., MN 1130) and/or a secondary base station (e.g., SN 1150) may send (e.g., transmit) and/or receive: packets of an MCG bearer via a master or secondary node SDAP layer (e.g., SDAP 1120, SDAP 1140), a master or secondary node PDCP layer (e.g., NR PDCP 1121, NR PDCP 1142), a master node RLC layer (e.g., MN RLC 1124, MN RLC 1125), and a master node MAC layer (e.g., MN MAC 1128); packets of an SCG bearer via a master or secondary node SDAP layer (e.g., SDAP 1120, SDAP 1140), a master or secondary node PDCP layer (e.g., NR PDCP 1122, NR PDCP 1143), a secondary node RLC layer (e.g., SN RLC 1146, SN RLC 1147), and a secondary node MAC layer (e.g., SN MAC 1148); packets of a split bearer via a master or secondary node SDAP layer (e.g., SDAP 1120, SDAP 1140), a master or secondary node PDCP layer (e.g., NR PDCP 1123, NR PDCP 1141), a master or secondary node RLC layer (e.g., MN RLC 1126, SN RLC 1144, SN RLC 1145, MN RLC 1127), and a master or secondary node MAC layer (e.g., MN MAC 1128, SN MAC 1148).

[150] In multi connectivity, a wireless device may configure multiple MAC entities, such as one MAC entity (e.g., MN MAC 1118) for a master base station, and other MAC entities (e.g., SN MAC 1119) for a secondary base station. In multi-connectivity, a configured set of serving cells for a wireless device may comprise two subsets: an MCG comprising serving cells of a master base station, and SCGs comprising serving cells of a secondary

base station. For an SCG, one or more of following configurations may be used. At least one cell of an SCG may have a configured UL CC and at least one cell of a SCG, named as primary secondary cell (e.g., PSCell, PCell of SCG, PCell), and may be configured with PUCCH resources. If an SCG is configured, there may be at least one SCG bearer or one split bearer. After or upon detection of a physical layer problem or a random access problem on a PSCell, or a number of NR RLC retransmissions has been reached associated with the SCG, or after or upon detection of an access problem on a PSCell associated with (e.g., during) a SCG addition or an SCG change: an RRC connection re-establishment procedure may not be triggered, UL transmissions towards cells of an SCG may be stopped, a master base station may be informed by a wireless device of a SCG failure type, a DL data transfer over a master base station may be maintained (e.g., for a split bearer). An NR RLC acknowledged mode (AM) bearer may be configured for a split bearer. A PCell and/or a PSCell may not be de-activated. A PSCell may be changed with a SCG change procedure (e.g., with security key change and a RACH procedure). A bearer type change between a split bearer and a SCG bearer, and/or simultaneous configuration of a SCG and a split bearer, may or may not be supported.

[151] With respect to interactions between a master base station and a secondary base stations for multi-connectivity, one or more of the following may be used. A master base station and/or a secondary base station may maintain RRM measurement configurations of a wireless device. A master base station may determine (e.g., based on received measurement reports, traffic conditions, and/or bearer types) to request a secondary base station to provide additional resources (e.g., serving cells) for a wireless device. After or upon receiving a request from a master base station, a secondary base station may create and/or modify a container that may result in a configuration of additional serving cells for a wireless device (or decide that the secondary base station has no resource available to do so). For a wireless device capability coordination, a master base station may provide (e.g., all or a part of) an AS configuration and wireless device capabilities to a secondary base station. A master base station and a secondary base station may exchange information about a wireless device configuration such as by using RRC containers (e.g., inter-node messages) carried via Xn messages. A secondary base station may initiate a

reconfiguration of the secondary base station existing serving cells (e.g., PUCCH towards the secondary base station). A secondary base station may decide which cell is a PSCell within a SCG. A master base station may or may not change content of RRC configurations provided by a secondary base station. A master base station may provide recent (and/or the latest) measurement results for SCG cell(s), for example, if an SCG addition and/or an SCG SCell addition occurs. A master base station and secondary base stations may receive information of SFN and/or subframe offset of each other from an OAM and/or via an Xn interface (e.g., for a purpose of DRX alignment and/or identification of a measurement gap). Dedicated RRC signaling may be used for sending required system information of a cell as for CA, for example, if adding a new SCG SCell, except for an SFN acquired from an MIB of a PSCell of a SCG.

[152] FIG. 12 shows an example of a random access procedure. One or more events may trigger a random access procedure. For example, one or more events may be at least one of following: initial access from RRC_IDLE, RRC connection re-establishment procedure, handover, DL or UL data arrival in (e.g., during) a state of RRC_CONNECTED (e.g., if UL synchronization status is non-synchronized), transition from RRC_Inactive, and/or request for other system information. A PDCCH order, a MAC entity, and/or a beam failure indication may initiate a random access procedure.

[153] A random access procedure may comprise or be one of at least a contention based random access procedure and/or a contention free random access procedure. A contention based random access procedure may comprise one or more Msg 1 1220 transmissions, one or more Msg2 1230 transmissions, one or more Msg3 1240 transmissions, and contention resolution 1250. A contention free random access procedure may comprise one or more Msg 1 1220 transmissions and one or more Msg2 1230 transmissions. One or more of Msg 1 1220, Msg 2 1230, Msg 3 1240, and/or contention resolution 1250 may be transmitted in the same step. A two-step random access procedure, for example, may comprise a first transmission (e.g., Msg A) and a second transmission (e.g., Msg B). The first transmission (e.g., Msg A) may comprise transmitting, by a wireless device (e.g., wireless device 110) to a base station (e.g., base station 120), one or more messages indicating an equivalent and/or similar contents of Msg1 1220 and Msg3 1240 of a four-

step random access procedure. The second transmission (e.g., Msg B) may comprise transmitting, by the base station (e.g., base station 120) to a wireless device (e.g., wireless device 110) after or in response to the first message, one or more messages indicating an equivalent and/or similar content of Msg2 1230 and contention resolution 1250 of a four-step random access procedure.

[154] A base station may send (e.g., transmit, unicast, multicast, broadcast, etc.), to a wireless device, a RACH configuration 1210 via one or more beams. The RACH configuration 1210 may comprise one or more parameters indicating at least one of following: an available set of PRACH resources for a transmission of a random access preamble, initial preamble power (e.g., random access preamble initial received target power), an RSRP threshold for a selection of a SS block and corresponding PRACH resource, a power-ramping factor (e.g., random access preamble power ramping step), a random access preamble index, a maximum number of preamble transmissions, preamble group A and group B, a threshold (e.g., message size) to determine the groups of random access preambles, a set of one or more random access preambles for a system information request and corresponding PRACH resource(s) (e.g., if any), a set of one or more random access preambles for a beam failure recovery procedure and corresponding PRACH resource(s) (e.g., if any), a time window to monitor RA response(s), a time window to monitor response(s) on a beam failure recovery procedure, and/or a contention resolution timer.

[155] The Msg1 1220 may comprise one or more transmissions of a random access preamble. For a contention based random access procedure, a wireless device may select an SS block with an RSRP above the RSRP threshold. If random access preambles group B exists, a wireless device may select one or more random access preambles from a group A or a group B, for example, depending on a potential Msg3 1240 size. If a random access preambles group B does not exist, a wireless device may select the one or more random access preambles from a group A. A wireless device may select a random access preamble index randomly (e.g., with equal probability or a normal distribution) from one or more random access preambles associated with a selected group. If a base station semi-statically configures a wireless device with an association between random access

preambles and SS blocks, the wireless device may select a random access preamble index randomly with equal probability from one or more random access preambles associated with a selected SS block and a selected group.

[156] A wireless device may initiate a contention free random access procedure, for example, based on a beam failure indication from a lower layer. A base station may semi-statically configure a wireless device with one or more contention free PRACH resources for a beam failure recovery procedure associated with at least one of SS blocks and/or CSI-RSs. A wireless device may select a random access preamble index corresponding to a selected SS block or a CSI-RS from a set of one or more random access preambles for a beam failure recovery procedure, for example, if at least one of the SS blocks with an RSRP above a first RSRP threshold amongst associated SS blocks is available, and/or if at least one of CSI-RSs with a RSRP above a second RSRP threshold amongst associated CSI-RSs is available.

[157] A wireless device may receive, from a base station, a random access preamble index via PDCCH or RRC for a contention free random access procedure. The wireless device may select a random access preamble index, for example, if a base station does not configure a wireless device with at least one contention free PRACH resource associated with SS blocks or CSI-RS. The wireless device may select the at least one SS block and/or select a random access preamble corresponding to the at least one SS block, for example, if a base station configures the wireless device with one or more contention free PRACH resources associated with SS blocks and/or if at least one SS block with a RSRP above a first RSRP threshold amongst associated SS blocks is available. The wireless device may select the at least one CSI-RS and/or select a random access preamble corresponding to the at least one CSI-RS, for example, if a base station configures a wireless device with one or more contention free PRACH resources associated with CSI-RSs and/or if at least one CSI-RS with a RSRP above a second RSPR threshold amongst the associated CSI-RSs is available.

[158] A wireless device may perform one or more Msg1 1220 transmissions, for example, by sending (e.g., transmitting) the selected random access preamble. The wireless device

may determine a PRACH occasion from one or more PRACH occasions corresponding to a selected SS block, for example, if the wireless device selects an SS block and is configured with an association between one or more PRACH occasions and/or one or more SS blocks. The wireless device may determine a PRACH occasion from one or more PRACH occasions corresponding to a selected CSI-RS, for example, if the wireless device selects a CSI-RS and is configured with an association between one or more PRACH occasions and one or more CSI-RSs. The wireless device may send (e.g., transmit), to a base station, a selected random access preamble via a selected PRACH occasions. The wireless device may determine a transmit power for a transmission of a selected random access preamble at least based on an initial preamble power and a power-ramping factor. The wireless device may determine an RA-RNTI associated with a selected PRACH occasion in which a selected random access preamble is sent (e.g., transmitted). The wireless device may not determine an RA-RNTI for a beam failure recovery procedure. The wireless device may determine an RA-RNTI at least based on an index of a first OFDM symbol, an index of a first slot of a selected PRACH occasions, and/or an uplink carrier index for a transmission of Msg1 1220.

[159] A wireless device may receive, from a base station, a random access response, Msg 2 1230. The wireless device may start a time window (e.g., ra-ResponseWindow) to monitor a random access response. For a beam failure recovery procedure, the base station may configure the wireless device with a different time window (e.g., bfr-ResponseWindow) to monitor response to on a beam failure recovery request. The wireless device may start a time window (e.g., ra-ResponseWindow or bfr-ResponseWindow) at a start of a first PDCCH occasion, for example, after a fixed duration of one or more symbols from an end of a preamble transmission. If the wireless device sends (e.g., transmits) multiple preambles, the wireless device may start a time window at a start of a first PDCCH occasion after a fixed duration of one or more symbols from an end of a first preamble transmission. The wireless device may monitor a PDCCH of a cell for at least one random access response identified by a RA-RNTI, or for at least one response to a beam failure recovery request identified by a C-RNTI, at a time that a timer for a time window is running.

[160] A wireless device may determine that a reception of random access response is successful, for example, if at least one random access response comprises a random access preamble identifier corresponding to a random access preamble sent (e.g., transmitted) by the wireless device. The wireless device may determine that the contention free random access procedure is successfully completed, for example, if a reception of a random access response is successful. The wireless device may determine that a contention free random access procedure is successfully complete, for example, if a contention free random access procedure is triggered for a beam failure recovery request and if a PDCCH transmission is addressed to a C-RNTI. The wireless device may determine that the random access procedure is successfully completed, and may indicate a reception of an acknowledgement for a system information request to upper layers, for example, if at least one random access response comprises a random access preamble identifier. The wireless device may stop sending (e.g., transmitting) remaining preambles (if any) after or in response to a successful reception of a corresponding random access response, for example, if the wireless device has signaled multiple preamble transmissions.

[161] The wireless device may perform one or more Msg 3 1240 transmissions, for example, after or in response to a successful reception of random access response (e.g., for a contention based random access procedure). The wireless device may adjust an uplink transmission timing, for example, based on a timing advanced command indicated by a random access response. The wireless device may send (e.g., transmit) one or more transport blocks, for example, based on an uplink grant indicated by a random access response. Subcarrier spacing for PUSCH transmission for Msg3 1240 may be provided by at least one higher layer (e.g., RRC) parameter. The wireless device may send (e.g., transmit) a random access preamble via a PRACH, and Msg3 1240 via PUSCH, on the same cell. A base station may indicate an UL BWP for a PUSCH transmission of Msg3 1240 via system information block. The wireless device may use HARQ for a retransmission of Msg 3 1240.

[162] Multiple wireless devices may perform Msg 1 1220, for example, by sending (e.g., transmitting) the same preamble to a base station. The multiple wireless devices may

receive, from the base station, the same random access response comprising an identity (e.g., TC-RNTI). Contention resolution (e.g., comprising the wireless device 110 receiving contention resolution 1250) may be used to increase the likelihood that a wireless device does not incorrectly use an identity of another wireless device. The contention resolution 1250 may be based on, for example, a C-RNTI on a PDCCH, and/or a wireless device contention resolution identity on a DL-SCH. If a base station assigns a C-RNTI to a wireless device, the wireless device may perform contention resolution (e.g., comprising receiving contention resolution 1250), for example, based on a reception of a PDCCH transmission that is addressed to the C-RNTI. The wireless device may determine that contention resolution is successful, and/or that a random access procedure is successfully completed, for example, after or in response to detecting a C-RNTI on a PDCCH. If a wireless device has no valid C-RNTI, a contention resolution may be addressed by using a TC-RNTI. If a MAC PDU is successfully decoded and a MAC PDU comprises a wireless device contention resolution identity MAC CE that matches or otherwise corresponds with the CCCH SDU sent (e.g., transmitted) in Msg3 1250, the wireless device may determine that the contention resolution (e.g., comprising contention resolution 1250) is successful and/or the wireless device may determine that the random access procedure is successfully completed.

[163] FIG. 13 shows an example structure for MAC entities. A wireless device may be configured to operate in a multi-connectivity mode. A wireless device in RRC_CONNECTED with multiple Rx/Tx may be configured to utilize radio resources provided by multiple schedulers that may be located in a plurality of base stations. The plurality of base stations may be connected via a non-ideal or ideal backhaul over the Xn interface. A base station in a plurality of base stations may act as a master base station or as a secondary base station. A wireless device may be connected to and/or in communication with, for example, one master base station and one or more secondary base stations. A wireless device may be configured with multiple MAC entities, for example, one MAC entity for a master base station, and one or more other MAC entities for secondary base station(s). A configured set of serving cells for a wireless device may comprise two subsets: an MCG comprising serving cells of a master base station, and one

or more SCGs comprising serving cells of a secondary base station(s). FIG. 13 shows an example structure for MAC entities in which a MCG and a SCG are configured for a wireless device.

[164] At least one cell in a SCG may have a configured UL CC. A cell of the at least one cell may comprise a PSCell or a PCell of a SCG, or a PCell. A PSCell may be configured with PUCCH resources. There may be at least one SCG bearer, or one split bearer, for a SCG that is configured. After or upon detection of a physical layer problem or a random access problem on a PSCell, after or upon reaching a number of RLC retransmissions associated with the SCG, and/or after or upon detection of an access problem on a PSCell associated with (e.g., during) a SCG addition or a SCG change: an RRC connection re-establishment procedure may not be triggered, UL transmissions towards cells of a SCG may be stopped, and/or a master base station may be informed by a wireless device of a SCG failure type and DL data transfer over a master base station may be maintained.

[165] A MAC sublayer may provide services such as data transfer and radio resource allocation to upper layers (e.g., 1310 or 1320). A MAC sublayer may comprise a plurality of MAC entities (e.g., 1350 and 1360). A MAC sublayer may provide data transfer services on logical channels. To accommodate different kinds of data transfer services, multiple types of logical channels may be defined. A logical channel may support transfer of a particular type of information. A logical channel type may be defined by what type of information (e.g., control or data) is transferred. BCCH, PCCH, CCCH and/or DCCH may be control channels, and DTCH may be a traffic channel. A first MAC entity (e.g., 1310) may provide services on PCCH, BCCH, CCCH, DCCH, DTCH, and/or MAC control elements. A second MAC entity (e.g., 1320) may provide services on BCCH, DCCH, DTCH, and/or MAC control elements.

[166] A MAC sublayer may expect from a physical layer (e.g., 1330 or 1340) services such as data transfer services, signaling of HARQ feedback, and/or signaling of scheduling request or measurements (e.g., CQI). In dual connectivity, two MAC entities may be configured for a wireless device: one for a MCG and one for a SCG. A MAC entity of a wireless device may handle a plurality of transport channels. A first MAC entity may

handle first transport channels comprising a PCCH of a MCG, a first BCH of the MCG, one or more first DL-SCHs of the MCG, one or more first UL-SCHs of the MCG, and/or one or more first RACHs of the MCG. A second MAC entity may handle second transport channels comprising a second BCH of a SCG, one or more second DL-SCHs of the SCG, one or more second UL-SCHs of the SCG, and/or one or more second RACHs of the SCG.

[167] If a MAC entity is configured with one or more SCells, there may be multiple DL-SCHs, multiple UL-SCHs, and/or multiple RACHs per MAC entity. There may be one DL-SCH and/or one UL-SCH on an SpCell. There may be one DL-SCH, zero or one UL-SCH, and/or zero or one RACH for an SCell. A DL-SCH may support receptions using different numerologies and/or TTI duration within a MAC entity. A UL-SCH may support transmissions using different numerologies and/or TTI duration within the MAC entity.

[168] A MAC sublayer may support different functions. The MAC sublayer may control these functions with a control (e.g., Control 1355 and/or Control 1365) element. Functions performed by a MAC entity may comprise one or more of: mapping between logical channels and transport channels (e.g., in uplink or downlink), multiplexing (e.g., (De-) Multiplexing 1352 and/or (De-) Multiplexing 1362) of MAC SDUs from one or different logical channels onto transport blocks (TBs) to be delivered to the physical layer on transport channels (e.g., in uplink), demultiplexing (e.g., (De-) Multiplexing 1352 and/or (De-) Multiplexing 1362) of MAC SDUs to one or different logical channels from transport blocks (TBs) delivered from the physical layer on transport channels (e.g., in downlink), scheduling information reporting (e.g., in uplink), error correction through HARQ in uplink and/or downlink (e.g., 1363), and logical channel prioritization in uplink (e.g., Logical Channel Prioritization 1351 and/or Logical Channel Prioritization 1361). A MAC entity may handle a random access process (e.g., Random Access Control 1354 and/or Random Access Control 1364).

[169] FIG. 14 shows an example of a RAN architecture comprising one or more base stations. A protocol stack (e.g., RRC, SDAP, PDCP, RLC, MAC, and/or PHY) may be supported

at a node. A base station (e.g., gNB 120A and/or 120B) may comprise a base station central unit (CU) (e.g., gNB-CU 1420A or 1420B) and at least one base station distributed unit (DU) (e.g., gNB-DU 1430A, 1430B, 1430C, and/or 1430D), for example, if a functional split is configured. Upper protocol layers of a base station may be located in a base station CU, and lower layers of the base station may be located in the base station DUs. An F1 interface (e.g., CU-DU interface) connecting a base station CU and base station DUs may be an ideal or non-ideal backhaul. F1-C may provide a control plane connection over an F1 interface, and F1-U may provide a user plane connection over the F1 interface. An Xn interface may be configured between base station CUs.

[170] A base station CU may comprise an RRC function, an SDAP layer, and/or a PDCP layer. Base station DUs may comprise an RLC layer, a MAC layer, and/or a PHY layer. Various functional split options between a base station CU and base station DUs may be possible, for example, by locating different combinations of upper protocol layers (e.g., RAN functions) in a base station CU and different combinations of lower protocol layers (e.g., RAN functions) in base station DUs. A functional split may support flexibility to move protocol layers between a base station CU and base station DUs, for example, depending on service requirements and/or network environments.

[171] Functional split options may be configured per base station, per base station CU, per base station DU, per wireless device, per bearer, per slice, and/or with other granularities. In a per base station CU split, a base station CU may have a fixed split option, and base station DUs may be configured to match a split option of a base station CU. In a per base station DU split, a base station DU may be configured with a different split option, and a base station CU may provide different split options for different base station DUs. In a per wireless device split, a base station (e.g., a base station CU and at least one base station DUs) may provide different split options for different wireless devices. In a per bearer split, different split options may be utilized for different bearers. In a per slice splice, different split options may be used for different slices.

[172] FIG. 15 shows example RRC state transitions of a wireless device. A wireless device may be in at least one RRC state among an RRC connected state (e.g., RRC Connected 1530,

RRC_Connected, etc.), an RRC idle state (e.g., RRC Idle 1510, RRC_Idle, etc.), and/or an RRC inactive state (e.g., RRC Inactive 1520, RRC_Inactive, etc.). In an RRC connected state, a wireless device may have at least one RRC connection with at least one base station (e.g., gNB and/or eNB), which may have a context of the wireless device (e.g., UE context). A wireless device context (e.g., UE context) may comprise at least one of an access stratum context, one or more radio link configuration parameters, bearer (e.g., data radio bearer (DRB), signaling radio bearer (SRB), logical channel, QoS flow, PDU session, and/or the like) configuration information, security information, PHY/MAC/RLC/PDCP/SDAP layer configuration information, and/or the like configuration information for a wireless device. In an RRC idle state, a wireless device may not have an RRC connection with a base station, and a context of the wireless device may not be stored in a base station. In an RRC inactive state, a wireless device may not have an RRC connection with a base station. A context of a wireless device may be stored in a base station, which may comprise an anchor base station (e.g., a last serving base station).

[173] A wireless device may transition an RRC state (e.g., UE RRC state) between an RRC idle state and an RRC connected state in both ways (e.g., connection release 1540 or connection establishment 1550; and/or connection reestablishment) and/or between an RRC inactive state and an RRC connected state in both ways (e.g., connection inactivation 1570 or connection resume 1580). A wireless device may transition its RRC state from an RRC inactive state to an RRC idle state (e.g., connection release 1560).

[174] An anchor base station may be a base station that may keep a context of a wireless device (e.g., UE context) at least at (e.g., during) a time period that the wireless device stays in a RAN notification area (RNA) of an anchor base station, and/or at (e.g., during) a time period that the wireless device stays in an RRC inactive state. An anchor base station may comprise a base station that a wireless device in an RRC inactive state was most recently connected to in a latest RRC connected state, and/or a base station in which a wireless device most recently performed an RNA update procedure. An RNA may comprise one or more cells operated by one or more base stations. A base station may belong to one or more RNAs. A cell may belong to one or more RNAs.

[175] A wireless device may transition, in a base station, an RRC state (e.g., UE RRC state) from an RRC connected state to an RRC inactive state. The wireless device may receive RNA information from the base station. RNA information may comprise at least one of an RNA identifier, one or more cell identifiers of one or more cells of an RNA, a base station identifier, an IP address of the base station, an AS context identifier of the wireless device, a resume identifier, and/or the like.

[176] An anchor base station may broadcast a message (e.g., RAN paging message) to base stations of an RNA to reach to a wireless device in an RRC inactive state. The base stations receiving the message from the anchor base station may broadcast and/or multicast another message (e.g., paging message) to wireless devices in their coverage area, cell coverage area, and/or beam coverage area associated with the RNA via an air interface.

[177] A wireless device may perform an RNA update (RNAU) procedure, for example, if the wireless device is in an RRC inactive state and moves into a new RNA. The RNAU procedure may comprise a random access procedure by the wireless device and/or a context retrieve procedure (e.g., UE context retrieve). A context retrieve procedure may comprise: receiving, by a base station from a wireless device, a random access preamble; and requesting and/or receiving (e.g., fetching), by a base station, a context of the wireless device (e.g., UE context) from an old anchor base station. The requesting and/or receiving (e.g., fetching) may comprise: sending a retrieve context request message (e.g., UE context request message) comprising a resume identifier to the old anchor base station and receiving a retrieve context response message comprising the context of the wireless device from the old anchor base station.

[178] A wireless device in an RRC inactive state may select a cell to camp on based on at least a measurement result for one or more cells, a cell in which a wireless device may monitor an RNA paging message, and/or a core network paging message from a base station. A wireless device in an RRC inactive state may select a cell to perform a random access procedure to resume an RRC connection and/or to send (e.g., transmit) one or more packets to a base station (e.g., to a network). The wireless device may initiate a random

access procedure to perform an RNA update procedure, for example, if a cell selected belongs to a different RNA from an RNA for the wireless device in an RRC inactive state. The wireless device may initiate a random access procedure to send (e.g., transmit) one or more packets to a base station of a cell that the wireless device selects, for example, if the wireless device is in an RRC inactive state and has one or more packets (e.g., in a buffer) to send (e.g., transmit) to a network. A random access procedure may be performed with two messages (e.g., 2-stage or 2-step random access) and/or four messages (e.g., 4-stage or 4-step random access) between the wireless device and the base station.

[179] A base station receiving one or more uplink packets from a wireless device in an RRC inactive state may request and/or receive (e.g., fetch) a context of a wireless device (e.g., UE context), for example, by sending (e.g., transmitting) a retrieve context request message for the wireless device to an anchor base station of the wireless device based on at least one of an AS context identifier, an RNA identifier, a base station identifier, a resume identifier, and/or a cell identifier received from the wireless device. A base station may send (e.g., transmit) a path switch request for a wireless device to a core network entity (e.g., AMF, MME, and/or the like), for example, after or in response to requesting and/or receiving (e.g., fetching) a context. A core network entity may update a downlink tunnel endpoint identifier for one or more bearers established for the wireless device between a user plane core network entity (e.g., UPF, S-GW, and/or the like) and a RAN node (e.g., the base station), such as by changing a downlink tunnel endpoint identifier from an address of the anchor base station to an address of the base station).

[180] A base station may communicate with a wireless device via a wireless network using one or more technologies, such as new radio technologies (e.g., NR, 5G, etc.). The one or more radio technologies may comprise at least one of: multiple technologies related to physical layer; multiple technologies related to medium access control layer; and/or multiple technologies related to radio resource control layer. Enhancing the one or more radio technologies may improve performance of a wireless network. System throughput, and/or data rate of transmission, may be increased. Battery consumption of a wireless device may be reduced. Latency of data transmission between a base station and a

wireless device may be improved. Network coverage of a wireless network may be improved. Transmission efficiency of a wireless network may be improved.

[181] A base station may send (e.g., transmit) DCI via a PDCCH for at least one of: a scheduling assignment and/or grant; a slot format notification; a preemption indication; and/or a power-control command. The DCI may comprise at least one of: an identifier of a DCI format; a downlink scheduling assignment(s); an uplink scheduling grant(s); a slot format indicator; a preemption indication; a power-control for PUCCH/PUSCH; and/or a power-control for SRS.

[182] A downlink scheduling assignment DCI may comprise parameters indicating at least one of: an identifier of a DCI format; a PDSCH resource indication; a transport format; HARQ information; control information related to multiple antenna schemes; and/or a command for power control of the PUCCH. An uplink scheduling grant DCI may comprise parameters indicating at least one of: an identifier of a DCI format; a PUSCH resource indication; a transport format; HARQ related information; and/or a power control command of the PUSCH.

[183] Different types of control information may correspond to different DCI message sizes. Supporting multiple beams, spatial multiplexing in the spatial domain, and/or noncontiguous allocation of RBs in the frequency domain, may require a larger scheduling message, in comparison with an uplink grant allowing for frequency-contiguous allocation. DCI may be categorized into different DCI formats. A DCI format may correspond to a certain message size and/or usage.

[184] A wireless device may monitor (e.g., in common search space or wireless device-specific search space) one or more PDCCH for detecting one or more DCI with one or more DCI format. A wireless device may monitor a PDCCH with a limited set of DCI formats, for example, which may reduce power consumption. The more DCI formats that are to be detected, the more power may be consumed by the wireless device.

[185] The information in the DCI formats for downlink scheduling may comprise at least one of: an identifier of a DCI format; a carrier indicator; an RB allocation; a time resource

allocation; a bandwidth part indicator; a HARQ process number; one or more MCS; one or more NDI; one or more RV; MIMO related information; a downlink assignment index (DAI); a TPC for PUCCH; an SRS request; and/or padding (e.g., if necessary). The MIMO related information may comprise at least one of: a PMI; precoding information; a transport block swap flag; a power offset between PDSCH and a reference signal; a reference-signal scrambling sequence; a number of layers; antenna ports for the transmission; and/or a transmission configuration indication (TCI).

[186] The information in the DCI formats used for uplink scheduling may comprise at least one of: an identifier of a DCI format; a carrier indicator; a bandwidth part indication; a resource allocation type; an RB allocation; a time resource allocation; an MCS; an NDI; a phase rotation of the uplink DMRS; precoding information; a CSI request; an SRS request; an uplink index/DAI; a TPC for PUSCH; and/or padding (e.g., if necessary).

[187] A base station may perform CRC scrambling for DCI, for example, before transmitting the DCI via a PDCCH. The base station may perform CRC scrambling by binarily adding multiple bits of at least one wireless device identifier (e.g., C-RNTI, CS-RNTI, TPC-CS-RNTI, TPC-PUCCH-RNTI, TPC-PUSCH-RNTI, SP CSI C-RNTI, and/or TPC-SRS-RNTI) on the CRC bits of the DCI. The wireless device may check the CRC bits of the DCI, for example, if detecting the DCI. The wireless device may receive the DCI, for example, if the CRC is scrambled by a sequence of bits that is the same as the at least one wireless device identifier.

[188] A base station may send (e.g., transmit) one or more PDCCH in different CORESETs, for example, to support a wide bandwidth operation. A base station may transmit one or more RRC messages comprising configuration parameters of one or more CORESETs. A CORESET may comprise at least one of: a first OFDM symbol; a number of consecutive OFDM symbols; a set of resource blocks; and/or a CCE-to-REG mapping. A base station may send (e.g., transmit) a PDCCH in a dedicated CORESET for particular purpose, for example, for beam failure recovery confirmation. A wireless device may monitor a PDCCH for detecting DCI in one or more configured CORESETs, for example, to reduce the power consumption.

[189] A base station may send (e.g., transmit) one or more MAC PDUs to a wireless device. A MAC PDU may comprise a bit string that may be byte aligned (e.g., multiple of eight bits) in length. Bit strings may be represented by tables in which the most significant bit is the leftmost bit of the first line of the table, and the least significant bit is the rightmost bit on the last line of the table. The bit string may be read from the left to right, and then, in the reading order of the lines. The bit order of a parameter field within a MAC PDU may be represented with the first and most significant bit in the leftmost bit, and with the last and least significant bit in the rightmost bit.

[190] A MAC SDU may comprise a bit string that is byte aligned (e.g., multiple of eight bits) in length. A MAC SDU may be included in a MAC PDU, for example, from the first bit onward. In an example, a MAC CE may be a bit string that is byte aligned (e.g., multiple of eight bits) in length. A MAC subheader may be a bit string that is byte aligned (e.g., multiple of eight bits) in length. A MAC subheader may be placed immediately in front of the corresponding MAC SDU, MAC CE, and/or padding. A MAC entity may ignore a value of reserved bits in a DL MAC PDU.

[191] A MAC PDU may comprise one or more MAC subPDUs. A MAC subPDU of the one or more MAC subPDUs may comprise at least one of: a MAC subheader only (e.g., including padding); a MAC subheader and a MAC SDU; a MAC subheader and a MAC CE; and/or a MAC subheader and padding. The MAC SDU may be of variable size. A MAC subheader may correspond to a MAC SDU, a MAC CE, and/or padding.

[192] A MAC subheader may comprise: an R field comprising one bit; an F field with one bit in length; an LCID field with multiple bits in length; an L field with multiple bits in length, for example, if the MAC subheader corresponds to a MAC SDU, a variable-sized MAC CE, and/or padding.

[193] FIG. 16A shows an example of a MAC subheader comprising an eight-bit L field. The LCID field may have six bits in length. The L field may have eight bits in length.

[194] FIG. 16B shows an example of a MAC subheader with a sixteen-bit L field. The LCID field may have six bits in length. The L field may have sixteen bits in length. A MAC

subheader may comprise: a R field comprising two bits in length; and an LCID field comprising multiple bits in length (e.g., if the MAC subheader corresponds to a fixed sized MAC CE), and/or padding.

[195] FIG. 16C shows an example of the MAC subheader. The LCID field may comprise six bits in length, and the R field may comprise two bits in length.

[196] FIG. 17A shows an example of a DL MAC PDU. Multiple MAC CEs may be placed together. A MAC subPDU comprising MAC CE may be placed before any MAC subPDU comprising a MAC SDU, and/or before a MAC subPDU comprising padding.

[197] FIG. 17B shows an example of a UL MAC PDU. Multiple MAC CEs may be placed together. A MAC subPDU comprising a MAC CE may be placed after all MAC subPDU comprising a MAC SDU. The MAC subPDU may be placed before a MAC subPDU comprising padding.

[198] FIG. 18 shows first examples of LCIDs. FIG. 19 shows second examples of LCIDs. In each of FIG. 18 and FIG. 19, the left columns comprise indices, and the right columns comprises corresponding LCID values for each index.

[199] FIG. 18 shows an example of an LCID that may be associated with the one or more MAC CEs. A MAC entity of a base station may send (e.g., transmit) to a MAC entity of a wireless device one or more MAC CEs. The one or more MAC CEs may comprise at least one of: an SP ZP CSI-RS Resource Set Activation/Deactivation MAC CE; a PUCCH spatial relation Activation/Deactivation MAC CE; a SP SRS Activation/Deactivation MAC CE; a SP CSI reporting on PUCCH Activation/Deactivation MAC CE; a TCI State Indication for UE-specific PDCCH MAC CE; a TCI State Indication for UE-specific PDSCH MAC CE; an Aperiodic CSI Trigger State Subselection MAC CE; a SP CSI-RS/CSI-IM Resource Set Activation/Deactivation MAC CE; a wireless device (e.g., UE) contention resolution identity MAC CE; a timing advance command MAC CE; a DRX command MAC CE; a long DRX command MAC CE; an SCell activation and/or deactivation MAC CE (e.g., 1 Octet); an SCell activation and/or deactivation MAC CE (e.g., 4 Octet); and/or a duplication activation and/or

deactivation MAC CE. A MAC CE may comprise an LCID in the corresponding MAC subheader. Different MAC CEs may have different LCID in the corresponding MAC subheader. An LCID with 111011 in a MAC subheader may indicate a MAC CE associated with the MAC subheader is a long DRX command MAC CE.

[200] FIG. 19 shows further examples of LCIDs associated with one or more MAC CEs. The MAC entity of the wireless device may send (e.g., transmit), to the MAC entity of the base station, one or more MAC CEs. The one or more MAC CEs may comprise at least one of: a short buffer status report (BSR) MAC CE; a long BSR MAC CE; a C-RNTI MAC CE; a configured grant confirmation MAC CE; a single entry power headroom report (PHR) MAC CE; a multiple entry PHR MAC CE; a short truncated BSR; and/or a long truncated BSR. A MAC CE may comprise an LCID in the corresponding MAC subheader. Different MAC CEs may have different LCIDs in the corresponding MAC subheader. The LCID with 111011 in a MAC subheader may indicate a MAC CE associated with the MAC subheader is a short-truncated command MAC CE.

[201] Two or more component carriers (CCs) may be aggregated, for example, in a carrier aggregation (CA). A wireless device may simultaneously receive and/or transmit on one or more CCs, for example, depending on capabilities of the wireless device. The CA may be supported for contiguous CCs. The CA may be supported for non-contiguous CCs.

[202] A wireless device may have one RRC connection with a network, for example, if configured with CA. At (e.g., during) an RRC connection establishment, re-establishment and/or handover, a cell providing a NAS mobility information may be a serving cell. At (e.g., during) an RRC connection re-establishment and/or handover procedure, a cell providing a security input may be a serving cell. The serving cell may be referred to as a primary cell (PCell). A base station may send (e.g., transmit), to a wireless device, one or more messages comprising configuration parameters of a plurality of one or more secondary cells (SCells), for example, depending on capabilities of the wireless device.

[203] A base station and/or a wireless device may use an activation and/or deactivation mechanism of an SCell for an efficient battery consumption, for example, if the base

station and/or the wireless device is configured with CA. A base station may activate or deactivate at least one of the one or more SCells, for example, if the wireless device is configured with one or more SCells. The SCell may be deactivated, for example, after or upon configuration of an SCell.

[204] A wireless device may activate and/or deactivate an SCell, for example, after or in response to receiving an SCell activation and/or deactivation MAC CE. A base station may send (e.g., transmit), to a wireless device, one or more messages comprising an sCellDeactivationTimer timer. The wireless device may deactivate an SCell, for example, after or in response to an expiry of the sCellDeactivationTimer timer.

[205] A wireless device may activate an SCell, for example, if the wireless device receives an SCell activation/deactivation MAC CE activating an SCell. The wireless device may perform operations (e.g., after or in response to the activating the SCell) that may comprise: SRS transmissions on the SCell; CQI, PMI, RI, and/or CRI reporting for the SCell on a PCell; PDCCH monitoring on the SCell; PDCCH monitoring for the SCell on the PCell; and/or PUCCH transmissions on the SCell.

[206] The wireless device may start and/or restart a timer (e.g., an sCellDeactivationTimer timer) associated with the SCell, for example, after or in response to activating the SCell. The wireless device may start the timer (e.g., sCellDeactivationTimer timer) in the slot, for example, if the SCell activation/deactivation MAC CE has been received. The wireless device may initialize and/or re-initialize one or more suspended configured uplink grants of a configured grant Type 1 associated with the SCell according to a stored configuration, for example, after or in response to activating the SCell. The wireless device may trigger a PHR, for example, after or in response to activating the SCell.

[207] The wireless device may deactivate the activated SCell, for example, if the wireless device receives an SCell activation/deactivation MAC CE deactivating an activated SCell. The wireless device may deactivate the activated SCell, for example, if a timer (e.g., an sCellDeactivationTimer timer) associated with an activated SCell expires. The wireless device may stop the timer (e.g., sCellDeactivationTimer timer) associated with

the activated SCell, for example, after or in response to deactivating the activated SCell. The wireless device may clear one or more configured downlink assignments and/or one or more configured uplink grant Type 2 associated with the activated SCell, for example, after or in response to the deactivating the activated SCell. The wireless device may suspend one or more configured uplink grant Type 1 associated with the activated SCell, for example, after or in response to deactivating the activated SCell. The wireless device may flush HARQ buffers associated with the activated SCell.

[208] A wireless device may not perform certain operations, for example, if an SCell is deactivated. The wireless device may not perform one or more of the following operations if an SCell is deactivated: transmitting SRS on the SCell; reporting CQI, PMI, RI, and/or CRI for the SCell on a PCell; transmitting on UL-SCH on the SCell; transmitting on a RACH on the SCell; monitoring at least one first PDCCH on the SCell; monitoring at least one second PDCCH for the SCell on the PCell; and/or transmitting a PUCCH on the SCell.

[209] A wireless device may restart a timer (e.g., an sCellDeactivationTimer timer) associated with the activated SCell, for example, if at least one first PDCCH on an activated SCell indicates an uplink grant or a downlink assignment. A wireless device may restart a timer (e.g., an sCellDeactivationTimer timer) associated with the activated SCell, for example, if at least one second PDCCH on a serving cell (e.g. a PCell or an SCell configured with PUCCH, such as a PUCCH SCell) scheduling the activated SCell indicates an uplink grant and/or a downlink assignment for the activated SCell. A wireless device may abort the ongoing random access procedure on the SCell, for example, if an SCell is deactivated and/or if there is an ongoing random access procedure on the SCell.

[210] FIG. 20A shows an example of an SCell activation/deactivation MAC CE that may comprise one octet. A first MAC PDU subheader comprising a first LCID may identify the SCell activation/deactivation MAC CE of one octet. An SCell activation/deactivation MAC CE of one octet may have a fixed size. The SCell activation/deactivation MAC CE of one octet may comprise a single octet. The single octet may comprise a first number of C-fields (e.g., seven) and a second number of R-fields (e.g., one).

[211] FIG. 20B shows an example of an SCell Activation/Deactivation MAC CE of four octets. A second MAC PDU subheader with a second LCID may identify the SCell Activation/Deactivation MAC CE of four octets. An SCell activation/deactivation MAC CE of four octets may have a fixed size. The SCell activation/deactivation MAC CE of four octets may comprise four octets. The four octets may comprise a third number of C-fields (e.g., 31) and a fourth number of R-fields (e.g., 1). A $C_i$ field may indicate an activation/deactivation status of an SCell with an SCell index i, for example, if an SCell with SCell index i is configured. An SCell with an SCell index i may be activated, for example, if the $C_i$ field is set to one. An SCell with an SCell index i may be deactivated, for example, if the $C_i$ field is set to zero. The wireless device may ignore the $C_i$ field, for example, if there is no SCell configured with SCell index i. An R field may indicate a reserved bit. The R field may be set to zero.

[212] A base station may configure a wireless device with uplink (UL) bandwidth parts (BWPs) and downlink (DL) BWPs, for example, to enable bandwidth adaptation (BA) for a PCell. The base station may configure the wireless device with at least DL BWP(s) (e.g., an SCell may not have UL BWPS) to enable BA for an SCell, for example, if CA is configured. For the PCell, an initial BWP may be a first BWP used for initial access. For the SCell, a first active BWP may be a second BWP configured for the wireless device to first operate on the SCell if the SCell is activated.

[213] A base station and/or a wireless device may switch a DL BWP and an UL BWP independently, for example, in paired spectrum (e.g., FDD). A base station and/or a wireless device may switch a DL BWP and an UL BWP simultaneously, for example, in unpaired spectrum (e.g., TDD). Switching between configured BWPs may be based on DCI and/or an inactivity timer. The base station and/or the wireless device may switch an active BWP to a default BWP, for example, based on or in response to an expiry of the inactivity timer associated with a cell (e.g., if the inactivity timer is configured for a serving cell). The default BWP may be configured by the network.

[214] One UL BWP for each uplink carrier and one DL BWP may be active at a time in an active serving cell, for example, in FDD systems configured with BA. One DL/UL BWP

pair may be active at a time in an active serving cell, for example, in TDD systems. Operating on the one UL BWP and the one DL BWP (and/or the one DL/UL pair) may enable a wireless device to use a reasonable amount of power (e.g., reasonable battery consumption). BWPs other than the one UL BWP and the one DL BWP that the wireless device may be configured with may be deactivated. The wireless device may refrain from monitoring a PDCCH, and/or may refrain from transmitting via a PUCCH, PRACH and/or UL-SCH, for example, on deactivated BWPs.

[215] A serving cell may be configured with a first number (e.g., four) of BWPs. A wireless device and/or a base station may have one active BWP at any point in time, for example, for an activated serving cell. A BWP switching for a serving cell may be used to activate an inactive BWP and/or deactivate an active BWP. The BWP switching may be controlled by a PDCCH indicating a downlink assignment or an uplink grant. The BWP switching may be controlled by an inactivity timer (e.g., bandwidthpartInactivityTimer). The BWP switching may be controlled by a MAC entity, for example, based on initiating a random access procedure. A BWP may be initially active without receiving a PDCCH indicating a downlink assignment or an uplink grant, for example, based on an addition of an SpCell or an activation of an SCell. The active BWP for a serving cell may be indicated by an RRC message and/or a PDCCH message (e.g., PDCCH order). A DL BWP may be paired with an UL BWP, and/or BWP switching may be common for both UL and DL, for example, for unpaired spectrum.

[216] FIG. 21 shows an example of BWP switching. The BWP switching may be on a PCell. A base station 2102 may send (e.g., transmit) one or more messages (e.g., one or more RRC messages) 2112 for configuring multiple BWPs (e.g., multiple BWPs comprising a DL BWP 0, a DL BWP 1, a DL BWP 2, a DL BWP 3, a UL BWP 0, a UL BWP 1, a UL BWP 2, and a UL BWP 3 shown in a table 2108). The DL (and/or UL) BWP 0 may be a default BWP. The DL (and/or UL) BWP 1 may be an initial active BWP (e.g., an initial DL BWP or an initial UL BWP). A wireless device 2104 may determine the multiple BWPs configured for the wireless device 2104, for example, based on the one or more messages 2112. The base station 2102 may send DCI 2114 for a DL assignment (e.g., at a time n). The DCI 2114 may be sent via the DL BWP 1 (e.g., an initial DL BWP). The

wireless device 2104 may receive a packet via the DL BWP 1 or via another active DL BWP (e.g., at a time n+k), for example, based on the DL assignment. The wireless device 2104 may start a BWP inactivity timer (e.g., at the time n+k). The wireless device 2104 may start the BWP inactivity timer, for example, after receiving scheduled downlink packets. The base station 2102 may send DCI 2114 for a UL grant (e.g., at the time n). The DCI 2114 may be sent via the DL BWP 1 (e.g., a first DL BWP or an initial DL BWP). The wireless device 2104 may send a packet via a UL BWP 1 (e.g., via a first UL BWP or an initial UL BWP at a time n+k), for example, based on the UL grant. The wireless device 2104 may start a BWP inactivity timer (e.g., at the time n+k). The wireless device 2104 may start the BWP inactivity timer, for example, after sending scheduled uplink packets.

[217] The base station 2102 may send DCI 2116 for BWP switching (e.g., a BWP switching from the DL BWP 1 to the DL BWP 2). The DCI 2116 may be sent via the active DL BWP 1 (e.g., at a time m). The wireless device 2104 may receive the DCI 2116, for example, by monitoring a PDCCH on the active DL BWP 1. The wireless device 2104 may switch the DL BWP 1 to the DL BWP 2 (e.g., at a time m+l), for example, based on the DCI 2116. There may be a delay (e.g., a gap) between the wireless device 2104 receiving the DCI 2116 and the wireless device 2104 switching to the DL BWP 2. The wireless device 2104 may start and/or re-start the BWP inactivity timer (e.g., at the time m+l), for example, after the BWP switching. The BWP inactivity timer may expire (e.g., at a time o), for example, if the wireless device 2104 does not perform reception or transmission for a period of time (e.g., a period from the time m+l to the time o). The wireless device 2104 may switch the DL BWP 2 to the DL BWP 0 (e.g., a default BWP). The fallback to the DL BWP 0 may occur (e.g., at a time o+q), for example, after the BWP inactivity timer expires. There may be a delay (e.g., a gap) between the BWP timer expiration (e.g., at a time o) and the wireless device 2104 switching to the DL BWP 0 (e.g., at a time o+q). BWPs are described as example resources, and any wireless resource may be applicable to one or more procedures described herein.

[218] FIG. 22 shows an example of BWP switching. The BWP switching may be performed on an SCell. A base station 2202 may send (e.g., transmit) one or more messages (e.g., one

or more RRC messages) 2212 for configuring multiple BWPs (e.g., multiple BWPs comprising a DL BWP 0, a DL BWP 1, a DL BWP 2, a DL BWP 3, a UL BWP 0, a UL BWP 1, a UL BWP 2, and a UL BWP 3 shown in tables 2206 and 2208, respectively). The multiple BWPs may be BWPs of an SCell. The DL (and/or UL) BWP 0 may be a default BWP. The DL (and/or UL) BWP 1 may be a first (or initial) active BWP (e.g., a first DL BWP or a first UL BWP). A wireless device 2204 may determine the multiple BWPs configured for the wireless device 2204, for example, based on the one or more messages 2212. The base station 2202 may send, to the wireless device 2204, a MAC CE 2214 for activating the SCell (e.g., at a time n). The wireless device 2204 may activate the SCell (e.g., at a time n+k). The wireless device 2204 may start to monitor a PDCCH on (e.g., sent via) the DL BWP 1. The base station 2202 may send DCI 2216 for a DL assignment (e.g., at a time m). The DCI 2216 may be sent via the DL BWP 1 (e.g., a first DL BWP). The wireless device 2204 may receive a packet via the DL BWP 1 or via another active DL BWP (e.g., at a time m+l), for example, based on the DL assignment. The wireless device 2204 may start a BWP inactivity timer (e.g., at the time m+l). The wireless device 2204 may start the BWP inactivity timer, for example, after receiving scheduled downlink packets. The base station 2202 may send DCI 2216 for a UL grant (e.g., at the time m). The DCI 2216 may be sent via the DL BWP 1 (e.g., a first DL BWP or an initial DL BWP). The wireless device 2204 may send a packet via a UL BWP 1 (e.g., via a first UL BWP or an initial UL BWP at a time m+l), for example, based on the UL grant. The wireless device 2204 may start a BWP inactivity timer (e.g., at the time m+l). The wireless device 2204 may start the BWP inactivity timer, for example, after sending scheduled uplink packets.

[219] The BWP inactivity timer may expire (e.g., at a time s). The BWP inactivity may expire, for example, if the wireless device 2204 does not perform reception or transmission for a period of time (e.g., a period from the time m+l to the time s). The wireless device 2204 may switch the DL BWP 1 to the DL BWP 0 (e.g., a default BWP). The fallback to the DL BWP 0 may occur (e.g., at a time s+t), for example, after the BWP inactivity timer expires. The base station 2202 may send, to the wireless device 2204, a MAC CE 2218 for deactivating the SCell (e.g., at a time o). The wireless device 2204 may deactivate the

SCell and/or stop the BWP inactivity timer (e.g., at a time o+p). The wireless device 2204 may deactivate the SCell and/or stop the BWP inactivity timer, for example, after receiving and/or checking an indication of the MAC CE 2218.

[220] A MAC entity may use operations on an active BWP for an activated serving cell configured with a BWP, such as one or more of: transmitting via an UL-SCH; transmitting via a RACH; monitoring a PDCCH; transmitting via a PUCCH; receiving via a DL-SCH; initializing and/or reinitializing suspended configured uplink grants of configured grant Type 1 according to a stored configuration, if any and/or to start in a symbol based on a procedure. On an inactive BWP for each activated serving cell configured with a BWP, a MAC entity: may refrain from transmitting via an UL-SCH, may refrain from transmitting via a RACH, may refrain from monitoring a PDCCH, may refrain from transmitting via a PUCCH, may refrain from transmitting an SRS, may refrain from receiving via a DL-SCH, may clear any configured downlink assignment and configured uplink grant of configured grant Type 2, and/or may suspend any configured uplink grant of configured Type 1.

[221] A random access procedure (e.g., based on an initiation of the random access procedure) on an active DL BWP and the active UL BWP may be performed, for example, if PRACH resources are configured for the active UL BWP. The random access procedure may be performed, for example, by a MAC entity. A MAC entity may switch to an initial DL BWP and an initial UL BWP, for example, if PRACH resources are not configured for an active UL BWP (e.g., based on initiation of a random access procedure). The MAC entity may perform the random access procedure on the initial DL BWP and the initial UL BWP, for example, based on the BWP switching.

[222] A wireless device may perform BWP switching to a BWP indicated by a PDCCH, for example, if a MAC entity receives a PDCCH (e.g., a PDCCH order) for a BWP switching of a serving cell, for example, if a random access procedure associated with this serving cell is not ongoing.

[223] A wireless device may determine whether to switch a BWP or ignore the PDCCH for the BWP switching, for example, if a MAC entity received a PDCCH for a BWP switching while a random access procedure is ongoing in the MAC entity. The MAC entity may stop the ongoing Random Access procedure and initiate a second Random Access procedure on a new activated BWP, for example, if the MAC entity decides to perform the BWP switching. The MAC entity may continue with the ongoing Random Access procedure on the active BWP, for example if the MAC decides to ignore the PDCCH for the BWP switching. A wireless device may perform the BWP switching to a BWP indicated by the PDCCH, for example, if a MAC entity receives a PDCCH for a BWP switching addressed to a C-RNTI for a successful completion of a Random Access procedure.

[224] The MAC entity may start or restart the BWP-InactivityTimer associated with the active DL BWP for a variety of reasons. The MAC entity may start or restart the BWP-InactivityTimer associated with the active DL BWP, for example, if one or more of the following occur: a BWP-InactivityTimer is configured for an activated serving sell, if a Default-DL-BWP is configured and an active DL BWP is not a BWP indicated by the Default-DL-BWP, if the Default-DL-BWP is not configured and the active DL BWP is not the initial BWP; and/or if one or more of the following occur: if a PDCCH addressed to C-RNTI or CS-RNTI indicating downlink assignment or uplink grant is received on the active BWP, and/or if there is not an ongoing random access procedure associated with the activated serving cell.

[225] The MAC entity may start or restart the BWP-InactivityTimer associated with the active DL BWP, for example, if one or more of the following occur: if a BWP-InactivityTimer is configured for an activated serving cell, if a Default-DL-BWP is configured and an active DL BWP is not a BWP indicated by the Default-DL-BWP, and/or if the Default-DL-BWP is not configured and the active DL BWP is not the initial BWP; and/or if one or more of the following occur: if a MAC-PDU is transmitted in a configured uplink grant or received in a configured downlink assignment, and/or if there is not an ongoing random access procedure associated with the activated serving cell.

[226] The MAC entity may start or restart the BWP-InactivityTimer associated with the active DL BWP, for example, if one or more of the following occur: if a BWP-InactivityTimer is configured for an activated serving cell, if a Default-DL-BWP is configured and an active DL BWP is not a BWP indicated by the Default-DL-BWP, and/or if the Default-DL-BWP is not configured and the active DL BWP is not the initial BWP; and/or if one or more of the following occur: if a PDCCH addressed to C-RNTI or CS-RNTI indicating downlink assignment or uplink grant is received on the active BWP, if a MAC-PDU is transmitted in a configured uplink grant or received in a configured downlink assignment, and/or if an ongoing random access procedure associated with the activated Serving Cell is successfully completed in response to receiving the PDCCH addressed to a C-RNTI.

[227] The MAC entity may start or restart the BWP-InactivityTimer associated with the active DL BWP based on switching the active BWP. For example, the MAC entity may start or restart the BWP-InactivityTimer associated with the active DL BWP if a PDCCH for BWP switching is received and the wireless device switches an active DL BWP to the DL BWP, and/or if one or more of the following occur: if a default downlink BWP is configured and the DL BWP is not the default downlink BWP, and/or if a default downlink BWP is not configured and the DL BWP is not the initial downlink BWP.

[228] The MAC entity may stop the BWP-InactivityTimer associated with an active DL BWP of the activated serving cell, for example, if one or more of the following occur: if BWP-InactivityTimer is configured for an activated serving cell, if the Default-DL-BWP is configured and the active DL BWP is not the BWP indicated by the Default-DL-BWP, and/or if the Default-DL-BWP is not configured and the active DL BWP is not the initial BWP; and/or if a random access procedure is initiated. The MAC entity may stop a second BWP-InactivityTimer associated with a second active DL BWP of an SpCell, for example, if the activated Serving Cell is an SCell (other than a PSCell).

[229] The MAC entity may perform BWP switching to a BWP indicated by the Default-DL-BWP, for example, if one or more of the following occur: if a BWP-InactivityTimer is configured for an activated serving cell, if the Default-DL-BWP is configured and the active DL BWP is not the BWP indicated by the Default-DL-BWP, if the Default-DL-

BWP is not configured and the active DL BWP is not the initial BWP, if BWP-InactivityTimer associated with the active DL BWP expires, and/or if the Default-DL-BWP is configured.. The MAC entity may perform BWP switching to the initial DL BWP, for example, if the MAC entity may refrain from performing BWP switching to a BWP indicated by the Default-DL-BWP.

[230] A wireless device may be configured for operation in BWPs of a serving cell. The wireless device may be configured by higher layers for the serving cell for a set of (e.g., four) bandwidth parts (BWPs) for receptions by the wireless device (e.g., DL BWP set) in a DL bandwidth by a parameter (e.g., DL-BWP). The wireless device may be configured with a set of (e.g., four) BWPs for transmissions by the wireless device (e.g., UL BWP set) in an UL bandwidth by a parameter (e.g., UL-BWP) for the serving cell. An initial active DL BWP may be determined, for example, by: a location and number of contiguous PRBs; a subcarrier spacing; and/or a cyclic prefix (e.g., for the control resource set for a Type0-PDCCH common search space). A wireless device may be provided (e.g., by a higher layer) a parameter (e.g., initial-UL-BWP) for an initial active UL BWP for a random access procedure, for example, for operation on a primary cell. The wireless device may be provided (e.g., by a higher layer) a parameter (e.g., Active-BWP-DL-Pcell) for first active DL BWP for receptions, for example, if a wireless device has a dedicated BWP configuration. The wireless device may be provided (e.g., by a higher layer) a parameter (e.g., Active-BWP-UL-Pcell) for a first active UL BWP for transmissions on a primary cell, for example, if a wireless device has a dedicated BWP configuration.

[231] The wireless device may be configured with a variety of parameters for a DL BWP and/or for an UL BWP in a set of DL BWPs and/or UL BWPs, respectively, for a serving cell. The wireless device may be configured with one or more of: a subcarrier spacing (e.g., provided by higher layer parameter DL-BWP-mu or UL-BWP-mu), a cyclic prefix (e.g., provided by higher layer parameter DL-BWP-CP or UL-BWP-CP), a PRB offset with respect to the PRB (e.g., determined by higher layer parameters offset-pointA-low-scs and ref-scs) and a number of contiguous PRBs (e.g., provided by higher layer parameter DL-BWP-BW or UL-BWP-BW), an index in the set of DL BWPs or UL

BWPs (e.g., by respective higher layer parameters DL-BWP-index or UL-BWP-index), a DCI format 1_0 or DCI format 1_1 detection to a PDSCH reception timing values (e.g., provided by higher layer parameter DL-data-time-domain), a PDSCH reception to a HARQ-ACK transmission timing values (e.g., provided by higher layer parameter DL-data-DL-acknowledgement), and/or a DCI 0_0 or DCI 0_1 detection to a PUSCH transmission timing values (e.g., provided by higher layer parameter UL-data-time-domain).

[232] A DL BWP from a set of configured DL BWPs (e.g., with an index provided by higher layer parameter DL-BWP-index) may be paired with an UL BWP from a set of configured UL BWPs (e.g., with an index provided by higher layer parameter UL-BWP-index). A DL BWP from a set of configured DL BWPs may be paired with an UL BWP from a set of configured UL BWPs, for example, if the DL BWP index and the UL BWP index are equal (e.g., for unpaired spectrum operation). A wireless device may not be expected to receive a configuration where the center frequency for a DL BWP is different from the center frequency for an UL BWP, for example, if the DL-BWP-index of the DL BWP is equal to the UL-BWP-index of the UL BWP (e.g., for unpaired spectrum operation).

[233] A wireless device may be configured with control resource sets (e.g., coresets) for every type of common search space and/or for wireless device-specific search space, for example, for a DL BWP in a set of DL BWPs on a primary cell. The wireless device may not be expected to be configured without a common search space on the PCell, or on the PSCell, in the active DL BWP. The wireless device may be configured with control resource sets for PUCCH transmissions, for example, for an UL BWP in a set of UL BWPs. A wireless device may receive a PDCCH message and/or a PDSCH message in a DL BWP, for example, according to a configured subcarrier spacing and/or a CP length for the DL BWP. A wireless device may transmit via a PUCCH and/or via a PUSCH in an UL BWP, for example, according to a configured subcarrier spacing and CP length for the UL BWP.

[234] The BWP indicator field value may indicate an active DL BWP, from the configured DL BWP set, for DL receptions, for example, if a BWP indicator field is configured in DCI format 1_1. The BWP indicator field value may indicate the active UL BWP, from the configured UL BWP set, for UL transmissions. A wireless device may be provided (e.g., for the primary cell) with a higher layer parameter (e.g., Default-DL-BWP, or any other a default DL BWP among the configured DL BWPs), for example, if a BWP indicator field is configured in DCI format 0_1. The default BWP may be the initial active DL BWP, for example, if a wireless device is not provided a default DL BWP by higher layer parameter Default-DL-BWP. A wireless device may be expected to detect a DCI format 0_1 indicating active UL BWP change, or a DCI format 1_1 indicating active DL BWP change, for example, if a corresponding PDCCH is received within first 3 symbols of a slot.

[235] A wireless device may be provided (e.g., for a primary cell) with a higher layer parameter (e.g., Default-DL-BWP, or any other a default DL BWP among the configured DL BWPs). The default DL BWP may be the initial active DL BWP, for example, if a wireless device is not provided a default DL BWP by the higher layer parameter Default-DL-BWP. A wireless device may be provided with a higher layer parameter (e.g., BWP-InactivityTimer) for a timer value for the primary cell. The wireless device may increment the timer, if running, every interval of 1 millisecond for frequency range 1, every 0.5 milliseconds for frequency range 2, or any other interval, for example, if the wireless device may not detect a DCI format 1_1 for paired spectrum operation or, for example, if the wireless device may not detect a DCI format 1_1 or DCI format 0_1 for unpaired spectrum operation during the interval.

[236] Wireless device procedures on the secondary cell may be same as on the primary cell. Wireless device procedures may use the timer value for the secondary cell and the default DL BWP for the secondary cell, for example, if a wireless device is configured for a secondary cell with a higher layer parameter (e.g., Default-DL-BWP) indicating a default DL BWP among the configured DL BWPs and the wireless device is configured with a higher layer parameter (e.g., BWP-InactivityTimer) indicating a timer value. The wireless device may use the indicated DL BWP and the indicated UL BWP on the secondary cell

as the respective first active DL BWP and first active UL BWP on the secondary cell or carrier, for example, if a wireless device is configured by a higher layer parameter (e.g., Active-BWP-DL-SCell) for a first active DL BWP and by a higher layer parameter (e.g., Active-BWP-UL-SCell) for a first active UL BWP on a secondary cell or carrier.

[237] A wireless device may have difficulty in determining whether DCI is indicating a BWP switching, a BWP activation, or a BWP deactivation, for example, if multiple active BWPs in a cell (e.g., PCell or SCell) are supported. A DCI format may be used (e.g., any legacy DCI format, a DCI format of NR Release 15, or any other DCI format). The DCI format may comprise a BWP index indicating a new BWP. Misalignment between a base station and the wireless device may occur regarding a state of a BWP. A base station may send (e.g., transmit) DCI comprising: a first field indicating a BWP, and/or a second field indicating a BWP action. The BWP action may comprise one or more of: switching to the BWP, activating the BWP, and/or deactivating the BWP. A base station may send (e.g., transmit) a MAC CE comprising an n-bit bitmap (e.g., an 8-bit bitmap associated with 4 bits for DL BWPs and/or 4 bits for UL BWPs, or any other quantity of bits) indicating that one or more BWPs may be activated/deactivated (e.g., activated or deactivated). A base station may designate a first BWP of a cell as a primary active BWP. The base station may send (e.g., transmit), via the primary active BWP, DCI activating/deactivating (e.g., activating or deactivating) a secondary BWP of the cell.

[238] Multiple active BWPs may increase spectral efficiency, communication speed, interference mitigation, provide service-friendly BWP management, and/or other performance measures, for example, relative to a configuration supporting a single active BWP at a time (e.g., a single DL BWP and a single UL BWP at a time). Multiple active BWPs may support a plurality of active DL BWPs and/or a plurality of active UL BWPs. Configuring multiple active BWPS may require more complex BWP control protocols and technical designs, for example, relative to a single active BWP configuration. Some RRC signaling and/or DCI formats (e.g., legacy signaling and/or format, and/or other signaling and/or formats) may cause one or more problems, such as the misalignment between a base station and a wireless device regarding states of multiple BWPs.

[239] One or more RRC signaling messages and/or one or more DCI formats may be enhanced. An RRC message may configure multiple active BWPs. An RRC message may configure one or more primary BWPs and one or more secondary BWPs. An RRC message may configure whether the one or more primary BWPs are switchable by DCI and/or a MAC CE. An RRC message may configure different BWPs for sending DCI for indicating a BWP change, for example, based on whether the one or more primary BWPs are switchable by DCI and/or a MAC CE. DCI may have a plurality of fields associated with a BWP control. A first field of DCI may indicate a BWP ID. A second field of the DCI may indicate an action associated with a BWP indicated by the BWP ID. The second field may have different sizes, for example, depending on different configurations and/or requirements. The size of the second field may be (e.g., semi-statically) changed (e.g., based on one or more RRC messages). The size of the second field may be determined, for example, based on whether a designated BWP is indicated as a primary active BWP and/or whether the designated BWP is allowed to be switched dynamically.

[240] One or more MAC CEs may be configured for a plurality of BWP control, for example, if multiple active BWPs are supported. A MAC CE may comprise a bitmap associated with a plurality of DL BWPs and/or a plurality of UL BWPs. The MAC CE may indicate activation/deactivation of each of multiple BWPs.

[241] Some communications (e.g., communications based on one or more DCIs) may enable dynamic BWP state changes without (or with reduced) processing delays and may avoid or reduce misalignments between a base station and a wireless device. These communications may be applicable, for example, if services, channel quality, and/or traffic loading on BWPs change frequently. Some other communications (e.g., communications based on one or more MAC CEs) may provide more robust BWP state controls and/or may reduce blind decoding complexity and/or power consumption of wireless devices. The latter communications may change states of a plurality of BWPs at the same time and may reduce signaling overhead. The latter communications may be applicable, for example, if services, channel quality, and/or traffic loading on BWPs change infrequently. Different communications may be used together or may be

separately configured between a base station and a wireless device, for example, depending on varying requirements and signaling environments.

[242] A base station may send (e.g., transmit) to, or receive from, a wireless device one or more data packets. The one or more data packets may be sent, or received, via one or more radio resources. The one or more date packets may be one or more URLLC (Ultra-Reliable Low Latency Communication) data packets with a small packet size (e.g., <100 bytes), which may require ultra-reliable (e.g., BLER less than $10^{\wedge(-5)}$) and low latency delivery (e.g., less than 1 millisecond) between the base station and the wireless device. The one or more data packets may be one or more eMBB (enhanced Mobile Broadband) data packets with a large packet size (e.g., >1000 bytes), which may require a large bandwidth (e.g., 400MHz~1GHz) and/or a large amount of radio resources for transmission. The one or more date packets may be one or more machine-type communication (e.g., MTC) data packets with a small packet size, which require a wide communication coverage (e.g., 10KM ~100KM) or a transmission to a wireless device located in a basement. Other types of the one or more data packets may comprise vehicle to everything (V2X) packet(s) which may be transmitted between vehicles, or between vehicle and pedestrian, or between vehicle and roadside node, packet of industrial internet of things (IIOT), and the like. It may be beneficial to transmit a first type of service (eMBB, URLLC, MTC, V2X and/or IIOT) on a first active BWP of a cell and transmit a second type of service (eMBB, URLLC, V2X and/or IIOT) on a second active BWP of the cell, for example, if multiple services are launched in a cell. BWP and/or CA operation configurations may support at most one active BWP in a cell. The BWP and/or CA operation configurations may be less efficient and/or result in significant transmission latency, for example, if a base station attempts to send (e.g., transmit), to a wireless device, data packets for multiple services on multiple active BWPs. Activation/deactivation of an SCell based on a MAC CE (e.g., for adding an additional active BWP) may take a long time (e.g., several tens of milliseconds) and a significant delay may occur, for example, if the base station attempts to send the data packets by frequently activating and/or deactivating the multiple BWPs. Data transmission associated with some types of service on an additional active BWP of the SCell may not

be tolerant of a delay caused by the activation/deactivation. The transmission latency may be improved, for example, by supporting multiple active BWPs in a cell.

[243] A base station and/or a wireless device may be configured with multiple BWPs for a cell. A base station and a wireless device may communicate with each other via multiple active BWPs of the multiple BWPs in parallel (e.g., simultaneously or overlapped in time) to accommodate multiple services (e.g., eMBB, URLLC, VTX, IIOT, and/or MTC). A base station may send (e.g., transmit), via a first active BWP, an eMBB data packet to a wireless device. The base station may send (e.g., transmit), via a second active BWP, a URLLC data packet to the wireless device. The base station may send (e.g., transmit), via a third active BWP, an MTC data packet to the wireless device. Transmitting multiple data packets for different services via different active BWPs in parallel (e.g., simultaneously or overlapped in time) may reduce latency. Transmitting first data (e.g., eMBB data) and second data (e.g., URLLC data) via a single active BWP may cause interruption of one transmission (e.g., the eMBB data transmission) by another transmission (e.g., the URLLC data transmission). Transmitting multiple data packets for different services via different active BWPs in parallel (e.g., simultaneously or overlapped in time) may avoid the interruption. Physical and MAC layer procedures configured for the BWP operation configuration that does not support multiple active BWPs in a cell may not be suitable for the BWP operation configuration that supports multiple active BWPs in a cell (e.g., such an implementation may result in an inefficient BWP management process). Multiple active BWPs may not be efficiently supported in some systems (e.g., legacy systems and/or NR physical layer and MAC layer operation procedures). Physical layer and MAC layer procedures may be enhanced, and evolved signaling for an efficient BWP operation procedure may be configured to support multiple active BWPs operation in a cell.

[244] A base station may send (e.g., transmit), to a wireless device, one or more messages comprising configuration parameters of a cell. The one or more messages may comprise one or more RRC messages (e.g., an RRC connection reconfiguration message, an RRC connection reestablishment message, and/or an RRC connection setup message). The cell may be a PCell (or a PSCell) or an SCell, for example, if a carrier aggregation or dual

connectivity is configured. The cell may comprise a plurality of downlink BWPs. Each of the plurality of downlink BWPs may be associated with a BWP ID (e.g., a BWP specific ID) and/or one or more parameters. The cell may comprise a plurality of uplink BWPs. Each of the plurality of uplink BWPs may be associated with a BWP ID (e.g., a BWP specific ID) and/or one or more second parameters.

[245] Each of the plurality of the downlink BWPs may be in one of an active state and an inactive state. A wireless device may perform operations via an active BWP (e.g., a DL BWP or a UL BWP). The operations may comprise transmitting a UL-SCH, transmitting a RACH, monitoring a PDCCH, transmitting a PUCCH, receiving a DL-SCH, and/or initializing (or reinitializing) any suspended configured uplink grants of configured grant Type 1 according to a stored configuration. For an inactive BWP (e.g., a DL BWP or a UL BWP), the wireless device may not transmit a UL-SCH, may not transmit a RACH, may not monitor a PDCCH, may not transmit a PUCCH, may not transmit an SRS, may not receive a DL-SCH, may clear any configured downlink assignment and configured uplink grant of configured grant Type 2, and/or may suspend any configured uplink grant of configured Type 1.

[246] The one or more parameters (and/or the one or more second parameters) may comprise at least one of: a control resource set identified by a control resource set index; a subcarrier spacing; a cyclic prefix; a DM-RS scrambling sequence initialization value; a number of consecutive symbols; a set of resource blocks in frequency domain; a CCE-to-REG mapping; an REG bundle size; a cyclic shift for the REG bundle; an antenna port quasi-co-location; and/or an indication for a presence or absence of a TCI field for DCI format 1_0 or 1_1 transmitted on the control resource set. The one or more parameters may comprise cell-specific parameters. The one or more second parameters may comprise BWP-specific parameters. The configuration parameters may further indicate at least one of: an initial active DL BWP, of the plurality of DL BWPs, identified by a first BWP ID and/or a default DL BWP, of the plurality of DL BWPs, identified by a second BWP ID. The second BWP ID may be same as, or different from, the first BWP ID. The default DL BWP may be in inactive state, for example, if the second BWP ID is different from the first BWP ID of the initial active DL BWP.

[247] The initial active DL BWP may be associated with one or more control resource set for one or more common search space (e.g., type0-PDCCH common search space). A wireless device may monitor a first PDCCH sent via the initial active DL BWP of a PCell (or a PSCell) to detect DCI in the first PDCCH, for example, if the wireless device switches from RRC idle state to RRC connected state.

[248] A base station may activate an additional BWP dynamically (e.g., via DCI, a MAC CE, etc.), for example, if at least one of multiple types of services are triggered for transmission via the additional BWP. The base station may send (e.g., transmit) a first command to the wireless device to activate a second DL BWP, of the plurality of DL BWPs, indicated (e.g., identified) by a third BWP ID. The first command may be a MAC CE or DCI. The third BWP ID may be different from the first BWP ID and/or different from the second BWP ID. The wireless device may transition (e.g., switch) the second DL BWP from inactive state to active state and/or may maintain the initial active BWP in active state, for example, after or in response to the activating. The wireless device may monitor a first PDCCH sent via the initial active DL BWP. The wireless device may monitor a second PDCCH sent via the second DL BWP in parallel (e.g., simultaneously or overlapped in time), for example, after or in response to the activating. Activating the second DL BWP may not change the state of the initial active DL BWP.

[249] FIG. 23A shows an example of configuring multiple active BWPs. The base station may send (e.g., transmit) the first command (e.g., at a time T1) to the wireless device to activate another BWP (e.g., an A-BWP2), for example, if there is at least one active DL BWP (e.g., an A-BWP1) of a plurality of active BWPs in a cell. The A-BWP2 may be different from the A-BWP1. The wireless device may transition (e.g., switch) the A-BWP2 from inactive state to active state and/or maintain the A-BWP1 in active state (e.g., at a time T2 after the time T1). Activating the A-BWP2 may not change the state of the A-BWP1.

[250] A base station may send (e.g., transmit), to a wireless device, one or more RRC messages comprising configuration parameters indicating a first active DL BWP and at least one second active DL BWP of a PCell (or a PSCell), for example, if multiple active BWPs

are supported by the wireless device. The wireless device may monitor a first PDCCH sent via the first active DL BWP of a PCell (or a PSCell) and monitor at least one second PDCCH sent via the at least one second active DL BWP of the PCell (or the PSCell). The wireless device may monitor the first PDCCH and the at least one second PDCCH to detect one or more DCIs (e.g., when the wireless device is in RRC connected mode or the wireless devices switches from RRC idle state to RRC connected state). Configuring multiple active BWPs by the one or more RRC messages may reduce signaling overhead for BWP activation.

[251] A base station may send (e.g., transmit), to a wireless device, one or more RRC messages comprising configuration parameters indicating a first active DL BWP of an SCell and at least one second active DL BWP of the SCell, for example, if multiple active BWPs are supported by the wireless device. The wireless device may monitor a first PDCCH sent via the first active DL BWP and at least one second PDCCH sent via the at least one second active DL BWP of the SCell. The wireless device may monitor the first PDCCH and the at least one second PDCCH to detect one or more DCIs (e.g., after or in response to the SCell being activated by a MAC CE or DCI). Configuring multiple active BWPs by the one or more RRC messages may reduce signaling overhead for BWP activation.

[252] FIG. 23B shows an example of a BWP switching if multiple active BWPs are supported. A base station may send (e.g., transmit) a second command to a wireless device to switch from an A-BWP1 to an A-BWP3 (at a time T2), for example, if there are at least two active DL BWPs (e.g., the A-BWP1 and an A-BWP2) of a plurality of active BWPs in a cell (at a time T1 before the time T2). The A-BWP1 may be the initial active DL BWP configured by the one or more messages. The A-BWP2 may be a DL BWP activated by the first command. The second command may be a MAC CE or DCI. The A-BWP3 may be different from the A-BWP1 and from the A-BWP2. The wireless device may transition (e.g., switch) the A-BWP1 from active state to inactive state, transition (e.g., switch) the A-BWP3 from inactive state to active state, and/or maintain the A-BWP2 in active state, for example, after or in response to the switching. The wireless device may monitor a first PDCCH sent via the A-BWP3 and/or monitor a second PDCCH sent via the A-BWP2 in parallel (e.g., simultaneously or overlapped in time), for example, after or

in response to the switching. Switching to the A-BWP3 from A-BWP1 may comprise deactivating the A-BWP1 and activating the A-BWP3.

[253] FIG. 23C shows an example of BWP deactivation if multiple active BWPs are supported. A base station may send (e.g., transmit) a third command to a wireless device to deactivate an A-BWP2, for example, if there are at least two active DL BWPs (e.g., an A-BWP1 and the A-BWP2) of a plurality of active BWPs in a cell. The third command may be a MAC CE or DCI. The base station and/or the wireless device may deactivate the A-BWP2, for example, after or in response to an expiration of a BWP inactivity timer (e.g., associated with the A-BWP2 or associated with the cell). The deactivating may comprise transiting (e.g., switching) the A-BWP2 from active state to inactive state and/or maintaining the A-BWP1 in active state (e.g., at a time T2). The wireless device may monitor a first PDCCH sent via the A-BWP1 and/or stop monitoring a second PDCCH associated with the A-BWP2, for example, after or in response to the deactivating. The deactivating the A-BWP2 may not change the state of the A-BWP1 (e.g., the active state of the A-BWP1).

[254] A base station and/or a wireless device may communicate via more than two active DL BWPs in a cell. The base station and/or the wireless device may perform BWP activation, BWP deactivation, and BWP switching, for example, to flexibly provide different services. A base station and/or a wireless device may maintain a first active DL BWP for a first transmission of a first service. The base station may activate a second DL BWP to be a second active DL BWP, for example, if a second service is triggered. The wireless device may monitor one or more PDCCHs and/or receive data packets on both the first active DL BWP and the second active DL BWP, for example, after or in response to the activating. The base station and/or the wireless device may activate a third DL BWP to be a third active DL BWP, for example, if a third service is triggered. The wireless device may monitor one or more PDCCHs and/or receive data packets on the first active DL BWP, the second active DL BWP, and the third active DL BWP, for example, after or in response to the activating.

[255] A base station may cross-BWP schedule a second active DL BWP based on a first active DL BWP, for example, which may reduce blind decoding complexity. Cross-BWP scheduling may comprise scheduling, by a base station, a transmission (e.g., downlink or uplink transmissions) on a shared channel (e.g., downlink or uplink shared channels) of a second BWP via control channels of a first BWP. The first active DL BWP may be configured with a first number of control resource sets and/or a second number of search spaces. The second active DL BWP may be configured with a third number of control resource sets, and/or a fourth number of search spaces. The first number may be greater than the third number. The second number may be greater than the fourth number. The second active DL BWP may be configured with no PDCCH resource.

[256] FIG. 24A shows an example of a cross-BWP scheduling. A base station may send (e.g., transmit), to a wireless device, a first PDCCH 2401A via a first active DL BWP (e.g., a BWP 1) to schedule a first PDSCH 2411A of the BWP 1. The base station may send (e.g., transmit) a second PDCCH 2402A via the BWP 1 to schedule a second PDSCH 2412A of a second active BWP (e.g., a BWP 2), for example, if the BWP 2 is configured to be cross-BWP scheduled by the BWP 1. The base station may send (e.g., transmit) a third PDCCH 2403A via the BWP 1 to schedule a third PDSCH 2413A of a third active BWP (e.g., a BWP 3), for example, if the BWP 3 is configured to be cross-BWP scheduled by the BWP 1. The base station may send (e.g., transmit) a fourth PDCCH 2404A via the BWP 3 to schedule a fourth PDSCH 2414A of the BWP 3, for example, if BWP 3 is configured to be self-scheduled. A wireless device may monitor one or more PDCCHs sent via the BWP 1 for at least one second BWP, for example, if the cross-BWP scheduling is supported and the at least one second BWP is configured to be cross-BWP scheduled by the BWP 1. The first PDCCH 2401A, the second PDCCH 2402A, and the third PDCCH 2403A may be three distinct PDCCHs on a same search space. Each of the three distinct PDCCHs may be sent via different locations in the same search space.

[257] FIG. 24B shows an example of a self-BWP scheduling. A PDSCH of an active BWP may be self-scheduled by a PDCCH of the active BWP. A base station may schedule a first PDSCH resource 2411B on a first active BWP (e.g., a BWP 1) by a first PDCCH 2401B on the first active BWP. The base station may schedule a second PDSCH resource 2412B

on a second active BWP (e.g., a BWP 2) by a second PDCCH 2402B on the second active BWP. The base station may schedule a third PDSCH resource 2413B on a third active BWP (e.g., a BWP 3) by a third PDCCH 2403B on the third active BWP.

[258] A wireless device may monitor one or more PDCCHs in one or more common search spaces on the multiple active DL BWPs, for example, with multiple active DL BWPs in a cell (e.g., as shown in FIG. 23A, FIG. 23B and FIG. 23C). Each of the multiple active DL BWPs may be associated with one of the one or more common search spaces. Configuring a common search space for each of multiple active DL BWPs may not be efficient for a PDCCH resource utilization in the cell. Configuring a common search space for each of the multiple active DL BWPs may require a wireless device to monitor multiple common search spaces for the multiple active DL BWPs, which may consume battery power in an inefficient manner. PDCCH resource utilization efficiency and battery power efficiency may be improved by one or more configurations described herein. The one or more configurations may comprise designating a first active DL BWP, of multiple active DL BWPs, as a primary active DL BWP (PBWP). The primary active DL BWP may be the initial active DL BWP configured in the one or more messages. The primary active DL BWP may be associated with one or more common search spaces, and/or one or more wireless device-specific search spaces (e.g., UE-specific search spaces). The primary active BWP may be a BWP via which the wireless device may perform an initial connection establishment procedure or may initiate a connection re-establishment procedure. The primary active DL BWP may be associated with one or more common search spaces for one or more DCI formats with CRC scrambled by one of SI-RNTI, RA-RNTI, TC-RNTI, P-RNTI, INT-RNTI, SFI-RNTI, TPC-PUSCH-RNTI, TPC-PUCCH-RNTI, TPC-SRS-RNTI, CS-RNTI, SP-CSI-RNTI, and/or C-RNTI. The one or more common search spaces may comprise at least one of: a type0-PDCCH common search space; a type0A-PDCCH common search space; a type1-PDCCH common search space; a type2-PDCCH common search space; and/or a type3-PDCCH common search space. The one or more DCI formats may comprise at least one of: a DCI format 0_0; a DCI format 0_1; a DCI format 1_0; a DCI format 1_1; a DCI format 2_0; a DCI format 2_1; a DCI format 2_2; and/or a DCI format 2_3.

[259] The determination of the PBWP may be indicated by an RRC message, a first MAC CE, and/or first DCI. At least one second active DL BWP of the multiple active DL BWPs may be designated as at least one secondary active DL BWP (SBWP). The determination of the at least one SBWP may be indicated by a second MAC CE and/or second DCI. A secondary active DL BWP may be associated with one or more wireless device-specific search spaces. A wireless device may monitor one or more common search spaces and one or more first wireless device-specific search spaces on a PBWP of the cell and/or one or more second wireless device-specific search spaces on an SBWP of the cell, for example, if the PBWP and the SBWP are designated in the cell.

[260] FIG. 25A shows an example of a PBWP switching. A base station may designate, from the multiple active DL BWPs, a first active DL BWP as a PBWP (e.g., a PBWP1), and a second active DL BWP as an SBWP (e.g., an SBWP1), for example, if multiple DL BWPs are in active states in a cell. A wireless device may monitor a first PDCCH on the PBWP1 and a second PDCCH on the SBWP1 (e.g., at a time T1). A base station may send (e.g., transmit), to a wireless device, a first command to instruct a switch from the PBWP1 to a third BWP as a new primary BWP (e.g., a PBWP2). The wireless device may transition (e.g., switch) the PBWP1 from active state to inactive state and transition (e.g., switch) the third BWP (e.g., the PBWP2) from inactive state to active state, for example, after or in response to switching from the PBWP1 to the PBWP2. The activated third BWP may be a primary active BWP, for example, after or in response to the switching. The wireless device may monitor a first PDCCH on common search spaces and first wireless device-specific search spaces on the PBWP2 and/or may monitor a second PDCCH on second wireless device-specific search spaces on the SBWP1, for example, after or in response to the switching from the PBWP1 to the PBWP2.

[261] FIG. 25B shows an example of SBWP activation. A base station may send (e.g., transmit) a second command to a wireless device to activate a second DL BWP (e.g., an SBWP1) as a secondary BWP, for example, if a primary active BWP (e.g., a PBWP1) of a plurality of active BWPs are designated in a cell. The second DL BWP may be different from the PBWP1 and/or the plurality of active BWPs. The wireless device may transition (e.g., switch) the second DL BWP from inactive state to active state and maintain the

PBWP1 in active state, for example, after or in response to the activating. The second DL BWP may be designated as an SBWP (e.g., an SBWP1), for example, after or in response to the activation. The wireless device may monitor a first PDCCH on common search spaces and first wireless device-specific search spaces on the PBWP1 and may monitor a second PDCCH on second wireless device-specific search spaces on the SBWP1, for example, after or in response to the activation.

[262] FIG. 25C shows an example of SBWP switching. A base station may assign, to a wireless device and/or from the multiple active DL BWPs, a first active DL BWP as a PBWP (e.g., a PBWP1) and a second active DL BWP as an SBWP (e.g., an SBWP1), for example, if a primary active BWP (e.g., the PBWP1) of a plurality of active BWPs is designated in a cell. The wireless device may monitor a first PDCCH on a PBWP1 and/or a second PDCCH on an SBWP1. The base station may send (e.g., transmit), to the wireless device, a third command to switch from the SBWP1 to a third BWP (e.g., an SBWP2) as a new secondary BWP. The wireless device may transition (e.g., switch) the SBWP1 from active state to inactive state and/or transition (e.g., switch) the third BWP from inactive state to active state, for example, after or in response to switching from the SBWP1 to the SBWP2. The activated third BWP may be a secondary active BWP, for example, after or in response to the switching. The wireless device may monitor the first PDCCH on common search spaces and/or first wireless device-specific search spaces on the PBWP1 and/or a third PDCCH on second wireless device-specific search spaces on the SBWP2, for example, after or in response to the switching from the SBWP1 to the SBWP2.

[263] FIG. 25D shows an example of SBWP deactivation from a configuration in which multiple active DL BWPs are supported. A base station may send (e.g., transmit) a fourth command to a wireless device to deactivate an SBWP1, for example, if a primary active BWP (e.g., a PBWP1) and a secondary active BWP (e.g., the SBWP1) of a plurality of active DL BWPs are designated in a cell. The fourth command may be a MAC CE or DCI. The base station and/or the wireless device may deactivate the SBWP1, for example, after or in response to an expiration of a BWP inactivity timer. The BWP inactivity timer may be associated with the SBWP1. The wireless device may transition

(e.g., switch) the SBWP1 from active state to inactive state and/or maintain the PBWP1 in active state, for example, after or in response to the deactivating. The wireless device may monitor a first PDCCH on (e.g., sent via) the PBWP1 and/or stop monitoring a second PDCCH on (e.g., associated with) the SBWP1, for example, after or in response to the deactivating. Deactivating the SBWP1 may not change the state of the PBWP1.

[264] A base station and/or a wireless device may not allow a PBWP switching to a second active BWP by a MAC CE or by DCI, for example, in a configuration in which multiple active DL BWPs comprise a PBWP and at least one SBWP in a cell. The base station and/or the wireless device may trigger an SBWP deactivation, an SBWP activation, and/or an SBWP switching. Configuring the PBWP to be unswitchable may simplify signaling designs and/or reduce implementation complexity of the wireless device. The PBWP may be switched to the second PBWP, for example, only by an RRC message but not by a MAC CE or DCI. The RRC message triggering a PBWP switching may enable a base station to statically (or semi-statically) switch the PBWP. FIG. 26A, FIG. 26B and FIG. 26C show examples of configurations in which a PBWP is configured to be unswitchable (e.g., always active), such as by DCI. Configuring a PBWP to be unswitchable (e.g., at least by DCI) may simplify implementation of procedures for a base station and a wireless device, reduce signaling overhead, and/or reduce battery consumption of the wireless device. A wireless device may switch the PBWP to a new PBWP, for example, after or in response to receiving an RRC message indicating PBWP switching.

[265] FIG. 26A shows an example of SBWP activation. A base station may send (e.g., transmit) a first command to a wireless device to activate a second DL BWP as a secondary BWP (e.g., an SBWP1), for example, if a primary active BWP (e.g., a PBWP1) of a plurality of active DL BWPs is designated in a cell. The second DL BWP may be different from the PBWP1 and/or the plurality of active BWPs. The wireless device may transition (e.g., switch) the second DL BWP from inactive state to active state and may maintain the PBWP1 in active state, for example, after or in response to the activating. The second DL BWP may be designated as an SBWP (e.g., an SBWP1), for example, after or in response to the activation. The wireless device may monitor a first

PDCCH on common search spaces and/or first wireless device-specific search spaces on PBWP1 and/or a second PDCCH on second wireless device-specific search spaces on the SBWP1, for example, after or in response to the activation.

[266] FIG. 26B shows an example of SBWP deactivation. A base station may send (e.g., transmit) a second command to a wireless device to deactivate the SBWP1, for example, if a primary active BWP (e.g., a PBWP1) and a secondary active BWP (e.g., the SBWP1) of a plurality of active DL BWPs are designated in a cell. The second command may be a MAC CE or DCI. The base station and/or the wireless device may deactivate the SBWP1, for example, after or in response to an expiration of a BWP inactivity timer. The BWP inactivity timer may be associated with the SBWP1. The wireless device may transition (e.g., switch) the SBWP1 from active state to inactive state and/or may maintain the PBWP1 in active state, for example, after or in response to the deactivating. The wireless device may monitor a first PDCCH on (e.g., sent via) the PBWP1 and/or may stop monitoring a second PDCCH on (e.g., associated with) the SBWP1, for example, after or in response to the deactivating.

[267] FIG. 26C shows an example of SBWP switching. A base station may assign, to a wireless device and/or from multiple DL active BWPs, a first active DL BWP as a PBWP (e.g., a PBWP1) and a second active DL BWP as an SBWP (e.g., an SBWP1), for example, if the multiple DL active BWPs are configured in a cell. The wireless device may monitor a first PDCCH on (e.g., sent via) the PBWP1 and a second PDCCH on (e.g., sent via) the SBWP1. A base station may send (e.g., transmit), to the wireless device, a third command to switch from the SBWP1 to a third BWP as a secondary BWP (e.g., the SBWP2). The wireless device may transition (e.g., switch) the SBWP1 from active state to inactive state and/or transition (e.g., switch) the third BWP from inactive state to active state, for example, after or in response to switching from the SBWP1 to the SBWP2. The activated third BWP may be the secondary active BWP (e.g., the SBWP2). The wireless device may monitor the first PDCCH on common search spaces and/or first wireless device-specific search spaces on the PBWP1 and/or a third PDCCH on second wireless device-specific search spaces on the SBWP2, for example, after or in response to the switching from the SBWP1 to the SBWP2.

[268] Some wireless devices (e.g., a first wireless device) may support at most one active BWP in a cell. Other wireless devices (e.g., a second wireless device) may support more than one active BWP in a cell. A base station and/or the first wireless device may trigger a BWP switching to a second BWP as an active BWP.

[269] Some wireless device (e.g., a second wireless device) may support a plurality of active BWPs in a cell. For at least some of these wireless devices (e.g., a second wireless device), no specific designation of a PBWP or an SBWP of the plurality of active BWPs may be performed (e.g., as shown in FIGS. 23A, 23B, and 23C). Each of the plurality of active BWPs may be associated with one or more common search spaces. The second wireless device may communicate with the base station via the plurality of active BWPs in the cell. The base station and/or the second wireless device may trigger activating/deactivating a BWP and/or switching from a first BWP to a second BWP as a second active BWP.

[270] Some wireless devices (e.g., a third wireless device) may support a plurality of active BWPs in a cell. For some wireless devices (e.g., the third wireless device), a PBWP and at least one SBWP of the plurality of active BWPs may be designated, and/or the PBWP may be maintained in active state, for example, at least until the third wireless device receives an indication of (e.g., an RRC message indicating) a PBWP switching. The PBWP may not be switched to a new active BWP dynamically (e.g., by DCI transmitted on a PDCCH). The third wireless device may communicate with the base station via the plurality of active BWPs in the cell. The base station and/or the third wireless device may trigger activating/deactivating an SBWP and/or switching from a first SBWP to a second BWP as a second SBWP.

[271] Some wireless devices (e.g., a fourth wireless device) may support a plurality of active BWPs in a cell. For the some wireless devices (e.g., the fourth wireless device), a PBWP and at least one SBWP of the plurality of active BWPs may be designated, and/or the PBWP may be switched to a new BWP as a new PBWP dynamically (e.g., by DCI transmitted on a PDCCH). The fourth wireless device may communicate with the base station via the plurality of active BWPs in the cell. The base station and/or the wireless

device may trigger activating/deactivating an SBWP, switching from a first PBWP to a second BWP as a second PBWP, and/or switching from a first SBWP to a third BWP as a second SBWP.

[272] Different wireless devices may support different BWP operation modes. A wireless device may send (e.g., transmit) various information to a base station indicating the wireless device's capability of one or more of multiple BWP operation modes in a cell. The multiple BWP operation modes in a cell may comprise at least one of: a first mode in which the wireless may support a single active BWP in the cell; a second mode in which the wireless device may support multiple active BWPs, without a PBWP designation, in the cell; a third mode in which the wireless device may support multiple active BWPs with a PBWP and at least one SBWP designated and the PBWP switchable by an RRC message; a fourth mode in which the wireless device may support multiple active BWPs with a PBWP and at least one SBWP designated and the PBWP switchable by DCI; a fifth mode in which the wireless device may support multiple active BWPs with multiple PBWPs and multiple SBWPs designated and the PBWP switchable by an RRC or DCI; and/or any other modes. A base station may send (e.g., transmit), to a wireless device, one or more messages indicating one or more of the multiple BWP operation modes.

[273] A base station and/or a wireless device may communicate via the multiple active BWPs with a default BWP operation mode, for example, if multiple active BWPs are supported. The default BWP operation mode may be one of the multiple BWP operation modes. A wireless device capable of supporting a first specification (e.g., a legacy device, a device configured to 3GPP Release 15, or a device configured for any other specification) may perform a BWP operation with the first mode (e.g., supporting a single active BWP in a cell) of the multiple BWP operation modes. A wireless device capable of supporting a second specification (e.g., a legacy device, a device configured to 3GPP Release 16, or a device configured for any other specification) may perform a BWP operation with the default BWP mode of the multiple BWP operation modes. To support multiple active BWPs in a cell, a default BWP mode may be preconfigured (e.g., predefined) as one of the second mode, the third mode, the fourth mode, the fifth mode, and/or any other mode, of multiple BWP operation modes.

[274] A base station may send (e.g., transmit), to a wireless device, one or more messages comprising configuration parameters of a plurality of DL BWPs in a cell. Multiple DL BWPs of a plurality of DL BWPs may be activated as active DL BWPs. A wireless device and/or a base station may communicate via the active DL BWPs comprising a PBWP and an SBWP. The PBWP may switch to a first DL BWP as a new PBWP. The SBWP may switch to a second DL BWP as a new SBWP. The SBWP may be deactivated. A third BWP may be activated as a second SBWP. A base station may send (e.g., transmit) one or more DCIs indicating a PBWP switching, an SBWP activation, an SBWP deactivation, an SBWP switching, and/or a PDSCH scheduling on a PBWP or on an SBWP. The indication by the one or more DCIs may be, for example, based on at least one of: one or more values of one or more fields of the one or more DCI; and/or whether the one or more DCI is transmitted via a PBWP or an SBWP. The one or more DCIs may be sent (e.g., transmitted) with DCI format 1_0 or 1_1 indicating a PDSCH scheduling. The one or more fields may comprise at least one of: a carrier indicator; an identifier for a DCI format; a BWP indicator; a first field indicating a frequency domain resource assignment; a second field indicating a time domain resource assignment; a PUCCH resource indicator; a TPC command for a scheduled PUCCH; and/or a PDSCH-to-HARQ_feedback timing indicator. Reusing an existing DCI format (e.g., DCI format 1_0 or 1_1) for a BWP operation supporting multiple active BWPs may reduce blind decoding complexity at a wireless device.

[275] A wireless device may switch the PBWP to a first BWP as a new PBWP indicated (e.g., identified) by the BWP indicator, for example, based on at least one of: the one or more DCI being transmitted via the PBWP; the BWP indicator indicating the first BWP different from the PBWP and the SBWP (e.g., if configured); and/or a value of the first field and/or the second field being different from a first value (e.g., all zeros) and/or a second value (e.g., all ones). The first value and/or the second value may be predefined (e.g., fixed). The wireless device may switch the SBWP to a second BWP as a new SBWP indicated (e.g., identified) by the BWP indicator, for example, based on at least one of: the one or more DCIs being transmitted via the SBWP; the BWP indicator indicating the second BWP different from the PBWP and from the SBWP; and/or a value

of the first field and/or the second field being different from the first value (e.g., all zeros) and/or the second value (e.g., all ones).

[276] The wireless device may activate a third BWP as a new SBWP indicated (e.g., identified) by the BWP indicator, for example, based on at least one of: the BWP indicator indicating the third BWP different from the PBWP and from the SBWP; and/or the value of the first field and/or the second field being the first value (e.g., all zeros). The wireless device may deactivate the SBWP, for example, based on at least one of: the one or more DCIs being transmitted via the PBWP; the BWP indicator indicating the SBWP; and/or the value of the first field or the second field being the second value (e.g., all ones).

[277] The wireless device may receive a DL assignment via a PBWP (e.g., without a PBWP switching), for example, based on at least one of: the BWP indicator indicating the PBWP; and/or the value of the first field or the second field being different from the first value (e.g., all zeros) and/or the second value (e.g., all ones). The wireless device may receive a DL assignment via an SBWP (e.g., without an SBWP switching/activation/deactivation), for example, based on at least one of: the BWP indicator indicating the SBWP; and/or the value of the first field or the second field being different from the first value (e.g., all zeros) and/or the second value (e.g., all ones). The wireless device may receive one or more DL data packets from a first PDSCH on (e.g., sent via) the PBWP, for example, after or in response to receiving the DL assignment on the PBWP. The wireless device may receive one or more DL data packets from a second PDSCH on (e.g., sent via) the SBWP, for example, after or in response to receiving the DL assignment via the SBWP.

[278] The base station and the wireless device may dynamically switch a PBWP to a new PBWP, activate an SBWP, deactivate an SBWP, or switch an SBWP to a new SBWP, for example, based on one or more fields of one or more DCIs. Blind decoding complexity and implementation cost of the wireless device may be reduced, and multiple active BWPs may be flexibly supported. A base station and/or a wireless device may support, for example, a PBWP and at most one SBWP of a plurality of BWPs. Supporting the PBWP and the at most one SBWP, compared with one single active BWP in a cell, may

improve spectrum efficiency and maintain an acceptable level of implementation complexity of the base station and/or the wireless device.

[279] A base station may send (e.g., transmit) one or more DCIs indicating a PBWP switching, an SBWP activation, and/or a PDSCH scheduling on a PBWP or on an SBWP, for example, based on at least one of: one or more values of one or more fields of the one or more DCIs; and/or whether the one or more DCIs are transmitted via a PBWP or an SBWP. The one or more DCIs may be sent, for example, if a PBWP and at most one SBWP of a plurality of DL BWPs are supported. Activation of an SBWP may comprise deactivating a first SBWP and activating a first inactive BWP as an SBWP (e.g., at a time). Activation of an SBWP may comprise activating a first inactive BWP as an SBWP (e.g., if there is no SBWP before the activating).

[280] A base station may send (e.g., transmit) one or more DCIs indicating a PBWP switching, for example, if a PBWP and at most one SBWP of a plurality of BWPs are supported. The base station may send the one or more DCIs indicating the PBWP switching based on at least one of: the BWP indicator indicating a first BWP different from the PBWP and from the SBWP; the one or more DCIs being transmitted via the PBWP; and/or one or more value of the first field and/or the second field being different from a first value (e.g., all zeros) and/or a second value (e.g., all ones). The first value and/or the second value may be predefined (e.g., fixed).

[281] A base station may send (e.g., transmit) one or more DCIs indicating an SBWP activation, for example, if a PBWP and at most one SBWP of a plurality of BWPs are supported. The base station may send the one or more DCIs indicating the SBWP activation based on at least one of: the BWP indicator indicating a BWP different from the PBWP (e.g., if there is no SBWP in the cell); the BWP indicator indicating the BWP different from the SBWP; the one or more DCIs being transmitted via the PBWP; the one or more DCIs being transmitted via the SBWP; one or more value of the first field and/or the second field being the first value (e.g., all zeros); and/or the value of the first field or the second field being the second value (e.g., all ones).

[282] The wireless device may receive a DL assignment on (e.g., sent via) a PBWP (e.g., without PBWP switching), for example, based on the BWP indicator indicating the PBWP. The wireless device may receive a DL assignment on (e.g., sent via) an SBWP (e.g., without SBWP switching/activation), for example, based on the BWP indicator indicating the SBWP. The wireless device may receive one or more DL data packets from a first PDSCH on the PBWP, for example, after or in response to receiving the DL assignment on the PBWP. The wireless device may receive one or more DL data packets from a second PDSCH on the SBWP, for example, after or in response to receiving the DL assignment on the SBWP. Blind decoding complexity and implementation cost of the wireless device may be reduced, and a PBWP and at most one SBWP may be flexibly supported, for example, based on the one or more configurations.

[283] A base station may send (e.g., transmit), to a wireless device, a MAC CE to activate or deactivate an SBWP, for example, if an SBWP activation or deactivation is not urgent (e.g., not time sensitive). The base station may send (e.g., transmit) DCI to switch from a first PBWP to a second BWP as a second PBWP and/or to switch from a first SBWP to a third BWP as a second SBWP. The base station may send the DCI to switch a BWP, for example, if BWP switching is urgent (e.g., time sensitive, such as for URLLC).

[284] FIG. 27A, FIG. 27B, FIG. 27C, and FIG. 27D show examples of a MAC CE and a corresponding MAC subheader for one or more SBWPs (or one or more PBWPs) activation/deactivation. FIG. 27A shows an example of the MAC CE comprising at least one of: one or more first fields indicating activation or deactivation of one or more DL BWPs; and/or one or more second fields indicating activation or deactivation of one or more UL BWPs. The one or more first fields may comprise a quantity of bits (e.g., D4, D3, D2, and D1 for four bits associated with four DL BWPs, respectively). Di may indicate activation/deactivation (e.g., activation or deactivation) of the DL BWP associated with DL BWP ID=i (e.g., i = 1, 2, 3, and 4). As shown in FIG. 27A, Di (i = 1, 2, 3, and 4) may correspond to four most significant bits of an octet 2 (Oct 2). The Oct 2 may comprise 8 bits and each of the 8 bits may be associated with an index (e.g., index k = 0, 1, 2, 3, 4, 5, 6, and 7). k may be i+3, for example, if Di (i=1, 2, 3, and 4) corresponds to four most significant bits of the Oct 2 identified by the indexes (k=4, 5, 6, and 7). Each

of the number of bits may indicate activation of a corresponding DL BWP, for example, based on the bit being set to a first value (e.g., 1). Each of the number of bits may indicate deactivation of a corresponding DL BWP, for example, based on the bit being set to a second value (e.g., 0). D4 being set to the first value may indicate a DL BWP associated with a BWP ID 4 is activated if the DL BWP is configured. D4 being set to the second value may indicate the DL BWP associated with the BWP ID 4 is deactivated if the DL BWP is configured. The wireless device may ignore the value of D4, for example, if the DL BWP associated with the BWP ID 4 is not configured. The wireless device may activate/deactivate a DL BWP associated with a BWP ID 3 based on a value of D3, for example, if the DL BWP associated with the BWP ID 3 is configured. The wireless device may activate/deactivate a DL BWP associated with a BWP ID 2 based on a value of D2, for example, if the DL BWP associated with the BWP ID 2 is configured. The wireless device may activate/deactivate a DL BWP associated with a BWP ID 1 based on a value of D1, for example, if the DL BWP associated with the BWP ID 1 is configured. An RRC message may indicate an association between a DL BWP and a BWP ID (e.g., the mapping relationships between the BWP ID 1 and a first DL BWP, between the BWP ID 2 and a second DL BWP, between the BWP ID 3 and a third DL BWP, and/or between the BWP ID 4 and a fourth DL BWP). An RRC message may not use the indexes i, j and/or k. The RRC message may indicate that the four DL BWPs and/or the four UL BWPs are associated with one of the eight indexes (e.g., the index k).

[285] The one or more second fields may comprise a quantity of bits (e.g., U4, U3, U2, and U1 for 4 bits associated with four UL BWPs, respectively). Uj may indicate activation/deactivation (e.g., activation or deactivation) of the UL BWP associated with UL BWP ID=j (e.g., j = 1, 2, 3, and 4). As shown in FIG. 27A, Uj (j = 1, 2, 3, and 4) may correspond to four least significant bits of the Oct 2. k may be j-1, for example, if Uj (j = 1, 2, 3, and 4) corresponds to four least significant bits of the Oct 2 identified by the indexes (k = 0, 1, 2, and 3). Each of the number of bits may indicate activation of a corresponding UL BWP, for example, based on the bit being set to a first value (e.g., 1), if the UL BWP is configured. Each of the number of bits may indicate deactivation of a corresponding UL BWP, for example, based on the bit being set to a second value (e.g.,

0), if the UL BWP is configured. The wireless device may ignore the value of Uj, for example, if the UL BWP associated with the UL BWP ID j is not configured.

[286] FIG. 27B shows an example of the MAC CE comprising at least one of: one or more first fields indicating activation or deactivation of one or more DL BWPs; and/or one or more second fields indicating activation or deactivation of one or more UL BWPs. The configuration shown in FIG. 27B is similar to the configuration shown in FIG. 27A, for example, except that Uj (j = 1, 2, 3, and 4) corresponds to four most significant bits of the Oct 2 identified by the indexes (k = 4, 5, 6, and 7) and that Di (i = 1, 2, 3, and 4) corresponds to four least significant bits of the Oct 2 identified by the indexes (k = 0, 1, 2, and 3). k may be j+3, and k may be i-1.

[287] FIG. 27C shows an example of the MAC CE comprising at least one of: one or more first fields indicating activation or deactivation of one or more DL BWPs; and/or one or more second fields indicating activation or deactivation of one or more UL BWPs. The configuration shown in FIG. 27C is similar to the configuration shown in FIG. 27A, for example, except that Uj (j = 1, 2, 3, and 4) corresponds to four odd-numbered bits of the Oct 2 identified by the indexes (k = 1, 3, 5, and 7) and that Di (i = 1, 2, 3, and 4) corresponds to four even-numbered bits of the Oct 2 identified by the indexes (k = 0, 2, 4, and 6). k may be 2j-1, and/or k may be 2i-2. Also or alternatively, Uj (j = 1, 2, 3, and 4) may correspond to four even-numbered bits of the Oct 2 identified by the indexes (k = 0, 2, 4, and 6) and Di (i = 1, 2, 3, and 4) may correspond to four odd-numbered bits of the Oct 2 identified by the indexes (k = 1, 3, 5, and 7). k may be 2j-2, and/or k may be 2i-1. A base station and/or a wireless device may dynamically use the eight bits of the Oct 2. The four most significant bits may be used for other purposes or may be reserved, for example, if the wireless device is configured with two DL BWPs (e.g., DL BWPs associated with D1 and D2) and with two UL BWPs (e.g., UL BWPs associated with U1 and U2). Two least significant bits (e.g., associated with D1 and U1) may always have the first value (e.g., 1), for example, a primary DL BWP and a primary UL BWP are designated (e.g., semi-statically). The two least significant bits may always have the first value (e.g., 1), for example, for the configurations of FIGS. 26A, 26B, and 26C (e.g., the primary DL BWP and the primary UL BWP are unswitchable).

[288] FIG. 27D shows an example of the MAC subheader for BWP activation/deactivation. The MAC subheader may comprise at least one of: a reserved field; a flag field; an LCID field with a first value indicating the MAC CE for BWP activation/deactivation; and/or a length field. The LCID field may indicate the first value different from other LCID values (e.g., other LCID values as shown in FIG. 18 and/or FIG. 19). The MAC subheader may not comprise the length field, for example, based on the MAC CE for SBWP activation/deactivation having a fixed bit length.

[289] The base station may send (e.g., transmit) one or more DCIs to switch from a first PBWP to a second BWP as a second PBWP or switch from a first SBWP to a third BWP as a second SBWP, for example, if one or more MAC CEs are used for activating/deactivating one or more SBWPs. The base station may send the one or more DCIs to switch from the first PBWP to the second BWP or switch from the first SBWP to the third BWP, for example, based on at least one of: one or more values of one or more fields of the one or more DCIs; and/or whether the one or more DCIs are transmitted on a PBWP or an SBWP.

[290] The wireless device may switch the PBWP to a first BWP as a new PBWP indicated (e.g., identified) by the BWP indicator, for example, based on at least one of: the one or more DCIs being transmitted on the PBWP; and/or the BWP indicator indicating the first BWP different from the PBWP and from the SBWP (e.g., if configured). The wireless device may switch the SBWP to a second BWP as a new SBWP indicated (e.g., identified) by the BWP indicator, for example, based on at least one of: the one or more DCIs being transmitted on the SBWP; and/or the BWP indicator indicating the second BWP different from the PBWP and from the SBWP.

[291] The wireless device may receive a DL assignment on (e.g., sent via) a PBWP (e.g., without PBWP switching), for example, after or in response to the BWP indicator indicating the PBWP. The wireless device may receive a DL assignment on (e.g., sent via) an SBWP (e.g., without SBWP switching/activation), for example, after or in response to the BWP indicator indicating the SBWP. The wireless device may receive one or more DL data packets from a first PDSCH mapped on the PBWP, for example,

after or in response to receiving the DL assignment via the PBWP. The wireless device may receive one or more DL data packets from a second PDSCH mapped on the SBWP, for example, after or in response to receiving the DL assignment via the SBWP.

[292] A base station may send (e.g., transmit) one or more DCIs indicating a PBWP switching or a PDSCH scheduling on a PBWP or on an SBWP, for example, if the PBWP and at most one SBWP of a plurality of BWPs are supported and/or one or more MAC CEs are used for activating/deactivating an SBWP. The base station may send the one or more DCIs indicating the PBWP switching or the PDSCH scheduling on the PBWP or on the SBWP, for example, based on a BWP indicator. The wireless device may switch the PBWP to a first BWP as a new PBWP indicated (e.g., identified) by the BWP indicator, for example, based on the BWP indicator indicating the first BWP different from the PBWP and from the SBWP (e.g., if configured). The wireless device may receive a DL assignment on (e.g., sent via) a PBWP (e.g., without PBWP switching), for example, after or in response to the BWP indicator indicating the PBWP. The wireless device may receive a DL assignment on (e.g., sent via) an SBWP (e.g., without SBWP switching/activation), for example, after or in response to the BWP indicator indicating the SBWP. The wireless device may receive one or more DL data packets from a first PDSCH mapped on the PBWP, after or in response to receiving the DL assignment via the PBWP. The wireless device may receive one or more DL data packets from a second PDSCH mapped on the SBWP, for example, after or in response to receiving the DL assignment via the SBWP. Combining MAC CE for SBWP activation/deactivation and DCI for PBWP/SBWP switching may reduce blind decoding complexity and dynamical signaling overhead (e.g., DCI for SBWP activation/deactivation) to support multiple active BWPs in a cell.

[293] One or more MAC CEs for SBWP activation/deactivation may introduce intolerant transition latency (e.g., scheduling the MAC CE in PDSCH resources and sending one or more HARQ feedback for the MAC CE in PUCCH/PUSCH resources) for some services (e.g., URLLC services). A wireless device may receive multiple types of services, at least some of which may require a quick SBWP activation/deactivation. The transition latency may be reduced and/or avoided by introducing a first DCI format, different from one or

more other (e.g., existing) DCI formats (e.g., DCI format 1_0/1_1). The first DCI format may comprise one or more fields indicating a PBWP switching, an SBWP activation, an SBWP deactivation, and/or an SBWP switching based on one or more values of the one or more fields of the first DCI format. The first DCI format may comprise at least one of: a BWP indicator; and/or a second field (e.g., BWP action/mode indication) indicating one of a PBWP switching, an SBWP activation, an SBWP deactivation, and/or an SBWP switching.

[294] FIG. 28A shows an example of a first DCI format comprising a BWP ID field and a second field. The second field may be an action indication field (e.g., a field indicating an action associated with a BWP indicated by the BWP ID field). A wireless device may switch a PBWP to a first BWP as a new PBWP, for example, if the wireless device receives one or more DCIs based on the first DCI format. The wireless device may switch the PBWP to the first BWP, for example, based on at least one of: the BWP indicator (e.g., a BWP ID in the BWP ID field) indicating the first BWP; the first BWP being different from the PBWP; and/or the second field being set to a first value (e.g., "00" if a size of the second field corresponds to two bits). The wireless device may receive a DL assignment on (e.g., sent via) a PBWP (e.g., without PBWP switching), for example, based on the BWP indicator indicating the PBWP and/or the second field being set to the first value (e.g., "00").

[295] The wireless device may activate a second BWP as an SBWP, for example, if the wireless device receives the one or more DCIs based on the first DCI format. The wireless device may activate the second BWP, for example, based on at least one of: the BWP indicator indicating the second BWP; and/or the second field being set to a second value (e.g., "01" if the size of the second field corresponds to two bits).

[296] The wireless device may deactivate an SBWP, for example, if the wireless device receives the one or more DCIs based on the first DCI format. The wireless device may deactivate the SBWP, for example, based on at least one of: the BWP indicator indicating the SBWP; and the second field being set to a third value (e.g., "10").

[297] The wireless device may switch an SBWP to a third BWP, for example, if the wireless device receives the one or more DCIs based on the first DCI format. The wireless device may switch the SBWP to the third BWP, for example, based on at least one of: the BWP indicator indicating the third BWP; the third BWP being different from the PBWP and from the SBWP; and/or the second field being set to a fourth value (e.g., "11" if the size of the second field corresponds to two bits). The wireless device may receive a DL assignment on (e.g., sent via) an SBWP (e.g., without SBWP switching), for example, after or in response to the BWP indicator indicating the SBWP and/or the second field being set to the fourth value (e.g., "11").

[298] A base station may send (e.g., transmit) first DCI based on an existing DCI format (e.g., DCI format 1_0/1_1) indicating PBWP/SBWP switching and/or indicating a DL scheduling on the PBWP/SBWP. A base station may send (e.g., transmit) second DCI based on second DCI format (e.g., different from the existing DCI format) indicating SBWP activation/deactivation. The second DCI format may comprise at least one of: a BWP indicator; and/or a second field indicating activation or deactivation of an SBWP.

[299] FIG. 28B shows an example DCI format comprising a BWP ID field and a second field. A wireless device may switch from the PBWP to a first BWP as a new PBWP, for example, if the wireless device receives the first DCI based on a particular DCI format (e.g., an existing DCI format, such as DCI format 1_0/1_1, or any other DCI format). The wireless device may receive first DCI, for example, based on the BWP indicator indicating the first BWP different from the PBWP and/or first DCI being transmitted via the PBWP. The wireless device may receive a DL assignment on (e.g., sent via) the PBWP, for example, after or in response to the BWP indicator indicating the PBWP.

[300] A wireless device may switch from the SBWP to a second BWP as a new SBWP, for example, if the wireless device receives first DCI based on a particular DCI format (e.g., an existing DCI format such as DCI format 1_0/1_1, or any other DCI format). The wireless device may receive the first DCI, for example, based on the BWP indicator indicating the second BWP different from the SBWP and/or the first DCI being transmitted via the SBWP. The wireless device may receive a DL assignment on (e.g.,

sent via) the SBWP, for example, after or in response to the BWP indicator indicate the SBWP.

[301] A wireless device may activate a third BWP indicated by the BWP indicator as a second SBWP, for example, if the wireless device receives the second DCI based on the second DCI format (e.g., different from DCI format 1_0/1_1). The wireless device may activate the third BWP, for example, based on the second field of the second DCI being a first value (e.g., "1" if a size of the second fields corresponds to one bit).

[302] A wireless device may deactivate the SBWP indicated by the BWP indicator, for example, if the wireless device receives the second DCI based on the second DCI format (e.g., different from DCI format 1_0/1_1). The wireless device may deactivate the SBWP, for example, based on the second field of the second DCI being a second value (e.g., "0").

[303] A base station may send (e.g., transmit) DCI based on a third DCI format (e.g., different from an existing format such as DCI format 1_0/1_1, or any other DCI format) indicating a PBWP switching or an SBWP activation, for example, if at most one SBWP is supported. The third DCI format may comprise at least one of: a BWP indicator; and/or a second field indicating a PBWP switching or an SBWP activation. The PBWP switching or the SBWP activation may be indicated based on a value of the second field. Activation of a BWP as a new SBWP may deactivate an active SBWP and activate the BWP as the new SBWP (e.g., at a time), for example, if at most one SBWP is supported.

[304] A base station may send (e.g., transmit) the DCI based on the third DCI format to a wireless device. The wireless device may switch from the PBWP to a first BWP indicated by the BWP indicator, as a new PBWP, for example, if the wireless device receives the DCI and at most one SBWP is supported. The wireless device may switch from the PBWP to the first BWP, for example, based on the second field being a first value (e.g., "1" if a size of the second field corresponds to one bit). The wireless device may receive a DL assignment on (e.g., sent via) the PBWP, for example, if the BWP indicator indicates the PBWP.

[305] The wireless device may activate a second BWP indicated by the BWP indicator, as a new SBWP, for example, if the wireless device receives the DCI based on the third DCI format and at most one SBWP is supported. The wireless device may activate the second BWP, for example, based on the second field being a second value (e.g., "0" if a size of the second field corresponds to one bit). The wireless device may deactivate a first SBWP (e.g., if the first SBWP is configured and in active state), for example, after or in response to activating the second BWP. The wireless device may receive a DL assignment on (e.g., sent via) the SBWP, for example, if the BWP indicator indicates the SBWP.

[306] A base station may send (e.g., transmit) one or more DCIs (e.g., DCI format 1_0/1_1), to a wireless device, indicating an SBWP activation, an SBWP deactivation, or an SBWP switching, for example, based on at least one of: one or more values of one or more fields of the one or more DCIs; and/or whether the one or more DCIs are transmitted via a PBWP or via an SBWP. The one or more DCIs may be transmitted based on DCI format 1_0 or 1_1 indicating a PDSCH scheduling. The one or more fields may comprise at least one of: a carrier indicator; an identifier for a DCI format; a BWP indicator; a first field indicating a frequency domain resource assignment; a second field indicating a time domain resource assignment; a PUCCH resource indicator; a TPC command for a scheduled PUCCH; and/or a PDSCH-to-HARQ_feedback timing indicator. Reusing an existing DCI format (e.g., DCI format 1_0 or 1_1) for a BWP operation supporting multiple active BWPs may reduce blind decoding complexity at a wireless device. A PBWP may be in active state, for example, at least until receiving an RRC message.

[307] The wireless device may switch the SBWP to a first BWP as a new SBWP indicated (e.g., identified) by the BWP indicator, for example, based on at least one of: the one or more DCIs being transmitted via the SBWP; the BWP indicator indicating the first BWP different from the PBWP and from the SBWP; a value of the first field or the second field being different from a first value (e.g., all zeros); and/or the value of the first field or the second field being different from a second value (e.g., all ones). The first value and/or the second value may be predefined (e.g., fixed).

[308] The wireless device may activate a second BWP as a new SBWP indicated (e.g., identified) by the BWP indicator, for example, based on at least one of: the BWP indicator indicating the second BWP different from the PBWP and from the SBWP; and/or the value of the first field or the second field being the first value (e.g., all zeros). The wireless device may deactivate the SBWP, for example, based on at least one of: the one or more DCIs being transmitted via the PBWP; the BWP indicator indicating the SBWP different from the PBWP; and/or the value of the first field or the second field being the second value (e.g., all ones).

[309] The wireless device may receive a DL assignment on (e.g., sent via) a PBWP, for example, based on the BWP indicator indicating the PBWP. The wireless device may receive a DL assignment on (e.g., sent via) an SBWP (e.g., without SBWP switching/activation/ deactivation), for example, based on the BWP indicator indicating the SBWP. The wireless device may receive one or more DL data packets from a first PDSCH mapped on the PBWP, for example, after or in response to receiving the DL assignment via the PBWP. The wireless device may receive one or more DL data packets from a second PDSCH mapped on the SBWP, for example, after or in response to receiving the DL assignment via the SBWP.

[310] The base station and the wireless device may dynamically activate an SBWP, deactivate an SBWP, and/or switch an SBWP to a new SBWP, for example, based on one or more fields of one or more DCIs. Transition latency and/or implementation cost of the wireless device may be reduced, and/or multiple active BWPs may be flexibly supported.

[311] A base station may send (e.g., transmit) one or more DCIs indicating an SBWP activation, for example, if a PBWP and at most one SBWP are supported. The base station may send the one or more DCIS indicating the SBWP activation, for example, based on at least one of: the BWP indicator indicating a BWP different from the PBWP (e.g., if there is no SBWP in the cell); the BWP indicator indicating the BWP different from the SBWP; the one or more DCIs being transmitted via the PBWP; and/or the one or more DCIs being transmitted via the SBWP.

[312] Activation of an SBWP may comprise deactivating a first SBWP and activating a first inactive BWP as the SBWP (e.g., at a time). Activation of an SBWP may comprise activating a first inactive BWP as the SBWP, for example, if there is no active SBWP before the activating.

[313] The wireless device may receive a DL assignment via a PBWP (e.g., without PBWP switching), for example, based on the BWP indicator indicating the PBWP. The wireless device may receive a DL assignment via an SBWP (e.g., without SBWP switching/activation), for example, based on the BWP indicator indicating the SBWP. The wireless device may receive one or more DL data packets from a first PDSCH via the PBWP, for example, after or in response to receiving the DL assignment via the PBWP. The wireless device may receive one or more DL data packets from a second PDSCH via the SBWP, for example, after or in response to receiving the DL assignment via the SBWP. Blind decoding complexity and/or implementation cost of the wireless device may be reduced, and/or a PBWP and an SBWP (e.g., at most one SBWP) may be flexibly supported.

[314] A base station may send (e.g., transmit), to a wireless device, a MAC CE to activate or deactivate an SBWP, for example, if an SBWP activation or deactivation is not urgent (or time sensitive). The base station may send (e.g., transmit) DCI to switch from a first SBWP to a second BWP as a second SBWP, for example, if a PBWP is in an active state until switched by an RRC message. FIG. 27A, FIG. 27B, FIG. 27C, and FIG. 27D show examples of a MAC CE and a corresponding MAC subheader for one or more SBWP activation/deactivation.

[315] The base station may send (e.g., transmit) one or more DCIs (e.g., DCI format 1_0/1_1) to switch from a first SBWP to a second BWP as a second SBWP, for example, if one or more MAC CEs are used for activating/deactivating an SBWP and the PBWP is always in active state until switched by an RRC message. The base station may send the one or more DCIs to switch from the first SBWP to the second BWP, for example, based on at least one of: one or more values of one or more fields of the one or more DCIs; and/or whether the one or more DCIs are transmitted via a PBWP or via an SBWP. The wireless

device may switch a first SBWP to a second BWP as a second SBWP indicated (e.g., identified) by the BWP indicator, for example, based on at least one of: the one or more DCIs being transmitted via the first SBWP; and/or the BWP indicator indicating the second BWP different from the PBWP and from the first SBWP.

[316] The wireless device may receive a DL assignment via a PBWP, for example, based on the BWP indicator indicating the PBWP. The wireless device may receive a DL assignment via an SBWP (e.g., without SBWP switching), for example, based on the BWP indicator indicating the SBWP. The wireless device may receive one or more DL data packets from a first PDSCH via the PBWP, for example, after or in response to receiving the DL assignment via the PBWP. The wireless device may receive one or more DL data packets from a second PDSCH via the SBWP, for example, after or in response to receiving the DL assignment via the SBWP.

[317] A base station may send (e.g., transmit) one or more DCIs indicating a PDSCH scheduling on a PBWP or an SBWP, for example, if a PBWP and at most one SBWP of a plurality of BWPs are supported and one or more MAC CEs are used for activating/deactivating an SBWP. The base station may send the one or more DCIs indicating the PDSCH scheduling, for example, based on a BWP indicator of the one or more DCIs. The wireless device may receive a DL assignment via a PBWP, for example, based on the BWP indicator indicating the PBWP. The wireless device may receive a DL assignment via an SBWP (e.g., without SBWP switching/activation), for example, based on the BWP indicator indicating the SBWP. The wireless device may receive one or more DL data packets from a first PDSCH via the PBWP, for example, after or in response to receiving the DL assignment via the PBWP. The wireless device may receive one or more DL data packets from a second PDSCH via the SBWP, for example, after or in response to receiving the DL assignment via the SBWP.

[318] A wireless device may perform SBWP switching based on the one or more MAC CEs. A base station may send (e.g., transmit) the one or more MAC CEs indicating an activation of a second SBWP and/or a deactivation of a first SBWP, for example, by setting a second field of the one or more first fields corresponding the second SBWP to a first

value (e.g., "1") and/or setting a first field of the one or more first fields corresponding to the first SBWP to a second value (e.g., "0"). The wireless device may switch from the first SBWP to the second SBWP, for example, after or in response to receiving the one or more MAC CEs. Combining MAC CE for SBWP activation/deactivation and DCI for SBWP switching may reduce blind decoding complexity and/or dynamic signaling overhead (e.g., DCI for SBWP activation/deactivation) to support multiple active BWPs in a cell.

[319] One or more MAC CEs for SBWP activation/deactivation may introduce intolerant transition latency (e.g., which may be caused by scheduling the MAC CE in PDSCH resources at a base station and sending one or more HARQ feedbacks for the MAC CE in PUCCH/PUSCH resources at a wireless device) for some services (e.g., URLLC). A wireless device may receive multiple types of services, which may require a quick SBWP activation/deactivation. The transition latency may be reduced, for example, by introducing a first DCI format, which may be different from one or more other DCI formats (e.g., an existing DCI format such as DCI format 1_0/1_1, or any other DCI format). The first DCI format may comprise one or more fields indicating SBWP activation/deactivation/switching based on one or more values of the one or more fields of the first DCI format. The first DCI format may comprise at least one of: a BWP indicator; a second field (e.g., BWP action/mode indication) indicating one of SBWP activation, SBWP deactivation, and/or SBWP switching, for example, if a PBWP is in active state until switched/deactivated by an RRC message.

[320] FIG. 29A shows an example of a first DCI format comprising a BWP ID field and an action indication field (e.g., a second field for indicating a change of a BWP). A wireless device may receive a DL assignment via a PBWP, for example, if the wireless device receives one or more DCIs based on the first DCI format. The wireless device may receive the DL assignment via the PBWP, for example, based on a BWP indicator indicating the PBWP and/or the second field being set to a first value (e.g., "00" if a size of the second field corresponds to two bits). A wireless device may receive a DL assignment via an SBWP, for example, if the wireless device receives one or more DCIs based on the first DCI format. The wireless device may receive the DL assignment via

the SBWP, for example, based on the BWP indicator indicating the SBWP and/or the second field being set to a first value (e.g., "00").

[321] The wireless device may activate a first BWP as an SBWP, for example, if the wireless device receives the one or more DCIs based on the first DCI format. The wireless device may activate the first BWP as an SBWP, for example, based on at least one of: the BWP indicator indicating the first BWP; and/or the second field being set to a second value (e.g., "01" if a size of the second field corresponds to two bits).

[322] The wireless device may deactivate an SBWP, for example, if the wireless device receives the one or more DCIs based on the first DCI format. The wireless device may deactivate the SBWP, for example, based on at least one of: the BWP indicator indicating the SBWP; and the second field being set to a third value (e.g., "10").

[323] The wireless device may switch an SBWP to a second BWP, for example, if the wireless device receives the one or more DCIs based on the first DCI format. The wireless device may switch the SBWP to the second BWP, for example, based on at least one of: the BWP indicator indicating the second BWP; the second BWP being different from the PBWP and from the SBWP; and/or the second field being set to a fourth value (e.g., "11").

[324] FIG. 29B shows an example of second DCI format comprising a BWP ID field and an action indication field (e.g., a second field for indicating a change of a BWP). A base station may send (e.g., transmit) first DCI based on a DCI format (e.g., an existing DCI format such as DCI format 1_0/1_1, or any other DCI format) indicating SBWP switching, or DL scheduling on the PBWP/SBWP. A base station may send (e.g., transmit) second DCI based on the second DCI format (e.g., different from the existing DCI format, such as DCI format 1_0/1_1, or any other DCI format) indicating SBWP activation/deactivation. The second DCI format may comprise at least one of: a BWP indicator; and/or a second field indicating activation or deactivation of an SBWP.

[325] A wireless device may switch from the SBWP to a first BWP as a new SBWP, for example, if the wireless device receives the first DCI based on the DCI format (e.g., an

existing such as DCI format 1_0/1_1, or any other DCI format). The wireless device may switch from the SBWP to the first BWP, for example, based on the BWP indicator indicating the first BWP different from the SBWP and/or the first DCI being transmitted via the SBWP.

[326] A wireless device may activate a second BWP indicated by the BWP indicator as a second SBWP, for example, if the wireless device receives the second DCI based on the second DCI format (e.g., different from DCI format 1_0/1_1 or another DCI format). The wireless device may activate the second BWP as the second SBWP, for example, based on the second field of the second DCI being a first value (e.g., "1" if a size of the second field corresponds to one bit). A wireless device may deactivate the SBWP indicated by the BWP indicator, for example, if the wireless device receives the second DCI based on the second DCI format (e.g., different from DCI format 1_0/1_1 or another DCI format). The wireless device may deactivate the SBWP indicated by the BWP indicator, for example, based on the second field of the second DCI being a second value (e.g., "0").

[327] A base station may send (e.g., transmit) DCI based on a DCI format (e.g., an existing DCI format such as DCI format 1_0/1_1, or any other DCI format) indicating an SBWP activation, for example, if at most one SBWP is supported. A wireless device may activate a first BWP as a second SBWP, for example, based on the BWP indicator indicating the first BWP is different from a first SBWP and from the PBWP. The activating the first BWP as the second SBWP may comprise deactivating the first SBWP and activating the first BWP as the second SBWP (e.g., at a time), for example, if at most one SBWP is supported and the PBWP is in active state at least until switched/deactivated by an RRC message. The activating the first BWP as the second SBWP may comprise activating the first BWP as the second SBWP, for example, if there is no SBWP before the activating and/or if at most one SBWP is supported and the PBWP is in an active state at least until switched/deactivated by an RRC message.

[328] A wireless device may support a plurality of active BWPs in a cell, for example, if a determination of a PBWP or an SBWP of the plurality of active BWPs is not performed. A base station may send (e.g., transmit) one or more DCIs indicating an active BWP

switching, a BWP activation, a BWP deactivation, or a PDSCH scheduling on the active BWP, for example, based on at least one of: one or more values of one or more fields of the one or more DCIs. The one or more DCIs may be sent (e.g., transmitted) based on a DCI format (e.g., DCI format 1_0 or 1_1, or any other DCI format) indicating a PDSCH scheduling. The one or more fields may comprise at least one of: a carrier indicator; an identifier for a DCI format; a BWP indicator; a first field indicating a frequency domain resource assignment; a second field indicating a time domain resource assignment; a PUCCH resource indicator; a TPC command for scheduled PUCCH; and/or a PDSCH-to-HARQ_feedback timing indicator. Reusing a DCI format (e.g., an existing DCI format such as DCI format 1_0 or 1_1, or any other DCI format) for a BWP operation supporting multiple active BWPs may reduce blind decoding complexity at a wireless device.

[329] A wireless device (e.g., with active BWPs in active state) may switch from a first active BWP to a second BWP indicated (e.g., identified) by the BWP indicator, for example, based on at least one of: the one or more DCIs being transmitted via the first active BWP; the BWP indicator indicating the second BWP different from the active BWPs; one or more values of the first field and/or the second field being different from a first value (e.g., all zeros); and/or the value of the first field or the second field being different from a second value (e.g., all ones).

[330] A wireless device (e.g., tith active BWPs in active state) may activate a third BWP indicated (e.g., identified) by the BWP indicator, for example, based on at least one of: the BWP indicator indicating the third BWP different from the active BWPs; and/or the value of the first field or the second field being the first value (e.g., all zeros). A wireless device (e.g., with active BWPs in active state) may deactivate an active BWP, for example, based on at least one of: the BWP indicator indicating the active BWP; and/or the value of the first field or the second field being the second value (e.g., all ones).

[331] A wireless device may receive a DL assignment via an active BWP (e.g., without active BWP switching), for example, based on at least one of: the BWP indicator indicating the active BWP; the value of the first field or the second field not being the first value (e.g.,

all zeros); and/or the value of the first field or the second field not being the second value (e.g., all ones). The wireless device may receive one or more DL data packets from a PDSCH via the active BWP, for example, after or in response to receiving the DL assignment via the active BWP.

[332] A base station and/or a wireless device may dynamically switch/activate/deactivate a BWP based on one or more fields of one or more DCIs. Blind decoding complexity and implementation cost of the wireless device may be reduced and/or multiple active BWPs may be flexibly supported.

[333] A wireless device may support a plurality of active BWPs in a cell, for example, if a determination of a PBWP or an SBWP of the plurality of active BWPs is not performed. A base station may send (e.g., transmit), to a wireless device, a MAC CE to activate or deactivate a BWP, for example, if BWP activation or deactivation is not urgent (e.g., not time sensitive). The base station may send (e.g., transmit) DCI to switch from a first active BWP to a second BWP as a second active BWP. FIG. 27A, FIG. 27B, FIG. 27C, and FIG. 27D show examples of a MAC CE and a corresponding MAC subheader for one or more BWP activation/deactivation.

[334] A wireless device (e.g., with active BWPs in active state) may switch from a first active BWP to a second BWP indicated (e.g., identified) by the BWP indicator, for example, based on at least one of: the BWP indicator indicating the second BWP different from the active BWPs; and/or the DCI being transmitted via the first active BWP. A wireless device may receive a DL assignment via an active BWP (e.g., without active BWP switching), for example, based on the BWP indicator indicating the active BWP. A wireless device may receive one or more DL data packets from a PDSCH via the active BWP, for example, after or in response to receiving the DL assignment via the active BWP.

[335] A wireless device may support a plurality of active BWPs in a cell, for example, if a determination of a PBWP or an SBWP of the plurality of active BWPs is not performed. One or more MAC CEs for SBWP activation/deactivation may introduce intolerant

transition latency (e.g., caused by scheduling the MAC CE in PDSCH resources and sending one or more HARQ feedbacks for the MAC CE in PUCCH/PUSCH resources) for some services (e.g., URLLC). A wireless device may receive one or more of multiple types of services, at least some of which may require quick SBWP activation/deactivation. The transition latency by introducing a first DCI format, different from one or more other DCI formats (e.g., an existing DCI format such as DCI format 1_0/1_1, or any other DCI format), may be improved. The first DCI format may comprise one or more fields indicating one of BWP switching, BWP activation, and/or BWP deactivation, for example, based on one or more values of the one or more fields of the first DCI format. The first DCI format may comprise at least one of: a BWP indicator; and/or a second field (e.g., BWP action/mode indication) indicating one of BWP switching, BWP activation, and/or BWP deactivation.

[336] FIG. 30A shows an example of a first DCI format comprising a BWP ID field and an action indication field (e.g., a second field for indicating a change of a BWP). A wireless device may switch a first active BWP to a first BWP as a second active BWP, for example, if the wireless device receives one or more DCIs based on the first DCI format and multiple BWPs are in active state. The wireless device may switch the first active BWP to the first BWP, for example, based on at least one of: the BWP indicator indicating the first BWP; the first BWP being different from the multiple BWPs; and/or the second field being set to a first value (e.g., "00" if a size of the second field corresponds to two bits). The wireless device may receive a DL assignment via an active BWP (e.g., without BWP switching), for example, based on the BWP indicator indicating the active BWP and/or the second field being set to a first value (e.g., "00" if a size of the second field corresponds to two bits).

[337] The wireless device may activate a second BWP as an active BWP, for example, if the wireless device receives the one or more DCIs based on the first DCI format and multiple BWPs are in active state. The wireless device may activate the second BWP as an active BWP, for example, based on at least one of: the BWP indicator indicating the second BWP; and/or the second field being set to a second value (e.g., "01" if the size of the second field corresponds to two bits).

[338] The wireless device may deactivate an active BWP, for example, if the wireless device receives the one or more DCIs based on the first DCI format and multiple BWPs are in active state. The wireless device may deactivate the active BWP, for example, based on at least one of: the BWP indicator indicating the active BWP; and the second field being set to a third value (e.g., "10" if the size of the second field corresponds to two bits).

[339] The wireless device may switch a first active BWP to a third BWP, for example, if the wireless device receives the one or more DCIs based on the first DCI format and multiple BWPs are in active state. The wireless device may switch the first active BWP to the third BWP, for example, based on at least one of: the BWP indicator indicating the third BWP; the third BWP being different from the multiple BWPs; and/or the second field being set to a fourth value (e.g., "11" if the size of the second field corresponds to two bits).

[340] FIG. 30B shows an example of a second DCI format comprising a BWP ID field and an action indication field (e.g., a second field for indicating a change of a BWP). A base station may send (e.g., transmit) first DCI based on a DCI format (e.g., an existing DCI format such as DCI format 1_0/1_1, or any other DCI format) indicating BWP switching, and/or DL scheduling on an active BWP.

[341] A base station may send (e.g., transmit) second DCI based on the second DCI format (e.g., different from the first DCI format and/or different from an existing DCI format) indicating BWP activation/deactivation. The second DCI format may comprise at least one of: a BWP indicator; and/or a second field indicating activation or deactivation of a BWP.

[342] A wireless device may switch from a first active BWP to a first BWP as a second active BWP, for example, if the wireless device receives the first DCI based on a DCI format (e.g., an existing DCI format such as DCI format 1_0/1_1, or any other DCI format) and multiple BWPs are in active states. The wireless device may switch from the first active BWP to the first BWP, for example, based on the BWP indicator indicating the first BWP different from the multiple active BWPs and/or the first DCI being transmitted via the

first active BWP. The wireless device may receive a DL assignment via the first active BWP, for example, if the BWP indicator indicates the first active BWP.

[343] A wireless device may activate a third BWP indicated by the BWP indicator as a second active BWP, for example, if the wireless device receives the second DCI based on the second DCI format (e.g., different from DCI format 1_0/1_1 or another DCI format). The wireless device may activate the third BWP as the second active BWP, for example, based on the second field of the second DCI being a first value (e.g., "1" if a size of the second field corresponds to one bit).

[344] A wireless device may deactivate an active BWP indicated by the BWP indicator, for example, if the wireless device receives the second DCI based on the second DCI format (e.g., different from DCI format 1_0/1_1). The wireless device may deactivate the active BWP, for example, based on the second field of the second DCI being a second value (e.g., "0" if the size of the second field corresponds to one bit).

[345] FIG. 31 shows an example of a flowchart of changing one or more BWP states for a configuration of multiple active BWPs. At step 3101, a wireless device may receive, from a base station, one or more messages comprising configuration parameters of BWPs of a cell. The BWPs may comprise a first active BWP and a second BWP. At step 3102, the wireless device may monitor a PDCCH on (e.g., sent via) the first active BWP. At step 3103, the wireless device may detect a DCI. The DCI may comprise a first field and a second field. The first field may indicate a second BWP index of the second BWP. The wireless device may perform one of multiple BWP operations based on a first value of the first field and/or a second value of the second field. The multiple BWP operations may comprise at least one of: switching from the first active BWP to a second BWP; activating the second BWP and maintaining an activation state of the first active BWP; deactivating the second BWP; switching from the second BWP to a third BWP; and/or receiving DL/UL scheduling assignment via the first active BWP.

[346] Switching to the second BWP may comprise switching an active BWP from the primary active BWP to the second BWP and monitoring a PDCCH on (e.g., sent via) the second

BWP. The activating the second BWP may comprise monitoring a PDCCH on the second BWP. The activating the second BWP may comprise monitoring a PDCCH on (e.g., sent via) the PBWP for the second BWP, for example, if the second BWP is configured to be cross-BWP scheduled by the PBWP.

[347] At step 3104, the wireless device may determine whether a first command (e.g., in the DCI) indicates a PBWP switching to a first BWP. At step 3105, the wireless device may switch to the first BWP as a new PBWP, for example, based on the first command indicating a PBWP switching to the first BWP. At step 3106, the wireless device may determine whether the first command indicates activating a second BWP. At step 3107, the wireless device may switch to the second BWP as a SBWP, for example, based on the first command indicating activating a second BWP. At step 3108, the wireless device may determine whether the first command indicates deactivating a first SBWP. At step 3109, the wireless device may deactivate the first SBWP, for example, based on the first command indicating deactivating the first SBWP. At step 3110, the wireless device may determine whether the first command indicates a SBWP switching to a third BWP. At step 3111, the wireless device may switch the SBWP to the third BWP as a new SBWP, for example, based on the first command indicating a SBWP switching to the third BWP. The wireless device may perform any one or more of steps 3104, 3106, 3108, and/or 3110, for example, in any order. The wireless device may perform any one or more of steps 3105, 3107, 3109, and/or 3111, for example, in any order.

[348] FIG. 32 shows an example of a procedure at a cell that may be configured with a plurality of BWPs. A base station 3202 may transmit one or more messages, comprising configuration parameters 3212 of a cell, to a wireless device 3204. The configuration parameters may correspond to one or more RRC messages (e.g., one or more of an RRC connection configured message, an RRC connection reestablishment messages, and an RRC connection setup message, etc.). The configuration parameters 3212 may comprise a configuration of a plurality of BWPs 3206 of the cell. The plurality of BWPs may comprise N+1 BWPs: BWP 0, BWP 1, BWP 2 … BWP N. The wireless device 3204 may receive the one or more messages at time $t_1$.

[349] The wireless device 3204 may activate, for example, a first BWP at $t_2$. The wireless device 3204 may activate, for example, in addition to the first BWP, a second BWP at $t_2$. The first BWP and the second BWP may be, for example, the BWP 1 and the BWP 2, respectively, of the plurality of BWPs 3206. The wireless device 3204 may activate, for example, more than two BWPs of the plurality of BWPs 3206. The wireless device 3204 may activate, for example, one or more other BWPs among the plurality of BWPs 3206 in addition to or instead of the BWP 1 and/or the BWP 2. The wireless device may activate one or more BWPs of the plurality of BWPs 3206, for example, based on the configuration parameters received at $t_1$.

[350] The base station 3202 may transmit DCI 3214 via a downlink channel, such as a PDCCH on the first BWP. The DCI 3214 may comprise, for example, a BWP ID field and an action indication field. The action indication field may indicate, based on its contents, one of: a switching of a BWP as indicated in the BWP ID field, an activation of a BWP as indicated in the BWP ID field, or a deactivation of a BWP as indicated in the BWP ID field. The action indication field may be, for example, two bits in length (or any other quantity of bits). The wireless device 3204 may receive the DCI at time $t_3$. The wireless device 3204 may interpret the contents of the action indication field in the DCI based on a predefined rule, such as the table 3208. The wireless device 3204 may interpret the contents of the action indication field via the predefined rule (e.g., as per the table 3208), for example, if the BWP ID field indicates a BWP different from the first BWP.

[351] The BWP ID field may indicate, for example, a BWP ID corresponding to the second BWP. The wireless device 3204 may determine, for example, one of: an activation of the second BWP, a deactivation of the second BWP, and a switch to the second BWP, based on the contents of the action indication field, at time $t_4$. The wireless device 3204 may switch operation to the second BWP, for example, by deactivating the first BWP and activating the second BWP, for example, if contents of the action indication field indicate a first value (e.g., “00”). The wireless device 3204 may activate the second BWP, for example, if contents of the action indication field indicate a second value (e.g., “01”). The wireless device 3204 may deactivate the second BWP, for example, if contents of the action indication field indicate a third value (e.g., “10”). A fourth value (e.g., “11”) may

be reserved, for example, for future use. The wireless device 3204 may perform UL/DL operations on active BWPs 3210 as determined at time $t_4$.

[352] The BWP ID field of DCI may indicate, for example, a BWP ID corresponding to the BWP 2. Initial active BWPs at $t_2$ may correspond to, for example, (i) the BWP 1, or (ii) both the BWP 1 and the BWP 2. The active BWPs 3210 as determined at time $t_4$ may depend on the initial active BWPs at time $t_2$ and contents of an action indication field of the DCI 3214. The active BWPs 3210 as determined at time $t_4$ may correspond to one of: (i) both the BWP 1 and the BWP 2, (ii) the BWP 1, or (iii) the BWP 2. The active BWPs 3210 may correspond to, for example, both the BWP 1 and the BWP 2 if (i) the BWP 1 was activated at time $t_2$, and (ii) contents of the action indication field indicate activation of the BWP 2 (e.g., "01"). The active BWPs 3210 may correspond to, for example, the BWP 1 if (i) both the BWP 1 and the BWP 2 were activated at time $t_2$, and (ii) contents of the action indication field indicate deactivation of the BWP 2 (e.g., "10"). The active BWPs 3210 may correspond to, for example, the BWP 2 if (i) the BWP 1 was activated at time $t_2$, and (ii) contents of the action indication field indicates switching of the BWP 1 to the BWP 2 (e.g., "00").

[353] FIG. 33 shows an example method that may be performed by a wireless device to configure a plurality of BWPs. The procedure of FIG. 33 may correspond to operations of a wireless device associated with the cell. At step 3302, the wireless device may receive one or more messages comprising configuration parameters corresponding to the cell. The one or more messages may comprise one or more RRC messages. The configuration parameters may comprise parameters for one or more configurations of the plurality of BWPs of the cell.

[354] At step 3303, the wireless device may determine whether all active BWPs of the cell are allowed to be switched by DCI. At step 3304, the wireless device may determine that an action indication field of DCI is configured with two bits, for example, if the wireless device determines that all active BWPs of the cell are allowed to be switched by DCI. At step 3306, the wireless device may perform actions based on a two-bit action indication field of DCI (e.g., actions as described above with reference to FIG. 28A, FIG. 29A, or

FIG. 30A), for example, based on the determination that the action indication field is configured with two bits. The wireless device may interpret an action indication field of DCI as described above, for example, with reference to FIG. 28A, FIG. 29A, or FIG. 30A.

[355] At step 3307, the wireless device may determine whether at least one active BWP of the cell is not allowed to be switched by DCI. At step 3308, the wireless device may determine that an action indication field of DCI is configured with one bit, for example, if the wireless device determines that at least one active BWP of the cell is not allowed to be switched by the DCI. At step 3310, the wireless device may perform actions based on a one-bit action indication field of DCI (e.g., actions as described above with reference to FIG. 28B, FIG. 29B, or FIG. 30B), for example, based on the determination that the action indication field is configured with one bit. The wireless device may interpret an action indication field of DCI as described above, for example, with reference to FIG. 28B, FIG. 29B, or FIG. 30B.

[356] FIG. 34 shows an example method that may be performed by a base station to configure a plurality of BWPs. The procedure of FIG. 34 may correspond to operations of a base station associated with the cell. At step 3402, the base station may transmit, to a wireless device, one or more messages, comprising configuration parameters corresponding to the cell. The one or more messages may comprise one or more RRC messages. The configuration parameters may comprise parameters for one or more configurations of the plurality of BWPs of the cell.

[357] At step 3403, the base station may determine, for a wireless device, whether all active BWPs of the cell are allowed to be switched by DCI. At step 3404, the base station may determine an action indication field of DCI to be configured with two bits, for example, if the base station determines that all active BWPs of the cell are allowed to be switched by the DCI. At step 3406, the base station may transmit, for example, DCI with an action indication field configured with two bits that indicates actions to be performed by the wireless device (e.g., as described above with reference to FIG. 28A, FIG. 29A, or FIG. 30A).

[358] At step 3407, the base station may determine, for a wireless device, whether at least one active BWP of the cell is not allowed to be switched by DCI. At step 3408, the base station may determine an action indication field of DCI to be configured with one bit, for example, if the base station determines that at least one active BWP of the cell is not allowed to be switched by the DCI. At step 3410, the base station may transmit, for example, DCI with an action indication field configured with one bit that indicates actions to be performed by the wireless device (e.g., as described above with reference to FIG. 28B, FIG. 29B, or FIG. 30B).

[359] FIG. 35 shows an example of configuring a plurality of BWPs. A base station 3502 may transmit one or more messages, comprising configuration parameters 3512 of a cell, to a wireless device 3504. The configuration parameters may correspond to one or more RRC messages (e.g., one or more of an RRC connection configured message, an RRC connection reestablishment messages, and an RRC connection setup message, etc.). The configuration parameters 3512 may comprise a configuration of a plurality of BWPs 3506 of the cell. The plurality of BWPs may comprise N+1 BWPs: BWP 0, BWP 1, BWP 2 … BWP N. The wireless device 3504 may receive the one or more messages at time $t_0$.

[360] The wireless device 3504 may activate, for example, a first BWP (e.g., an initial BWP, a default BWP, etc.) at $t_1$. The wireless device 3504 may activate additional BWP(s) of the plurality of BWPs 3506 at $t_1$. The wireless device 3504 may receive a MAC CE 3513 indicating activation/deactivation (e.g., activation or deactivation) of a plurality of BWPs at $t_2$. The BWP 2, the BWP 4, and the BWP 5 may be activated, for example, based on the MAC CE 3513. The MAC CE 3513 may also indicate deactivation of one or more BWPs activated at or before $t_2$. A single MAC CE may indicate activation/deactivation (e.g., activation or deactivation) state changes of a plurality of BWPs at the same time.

[361] The base station 3502 may transmit DCI 3514 via a downlink channel, such as a PDCCH, to indicate activation/deactivation (e.g., for reducing latency that may be caused by the MAC CE signaling). The DCI 3514 may be transmitted via the first BWP (e.g., a primary BWP). The first BWP may be unswitchable by DCI (e.g., but may be switchable by an

RRC message). The DCI 3514 may comprise, for example, a BWP ID field. The BWP ID field may indicate a BWP state (activation/deactivation) toggling of a BWP as indicated in the BWP ID field. The DCI 3514 may not comprise an action indication field (or an action indication field may be used for another purpose). The wireless device 3504 may receive the DCI 3514 at time $t_3$. The wireless device 3504 may determine that the DCI 3514 indicates deactivating the active BWP 2 to an inactive state (e.g., toggling from active to inactive), for example, if the BWP ID field indicates the active BWP 2. The wireless device 3504 may determine that the DCI 3514 indicates deactivating the active BWP 2 to an inactive state (e.g., toggling from active to inactive), for example, if the BWP ID field indicates the active BWP 2 and one or more DCI fields of the DCI are set to predefined values. The wireless device 3504 may determine that the DCI 3514 indicates activating an inactive BWP 3 to an active state (e.g., toggling from inactive to active), for example, if the BWP ID field indicates the active BWP 3.

[362] The base station 3502 may transmit DCI 3514 via a downlink channel, such as a PDCCH, to indicate switching (e.g., for reducing latency that may be caused by the MAC CE signaling). The DCI 3514 may be transmitted via an active BWP (e.g., the BWP 2 other than the unswitchable primary BWP). The DCI 3514 may comprise, for example, a BWP ID field. The BWP ID field may indicate a switching of the active BWP (e.g., the BWP 2) to a different BWP (e.g., an inactive BWP 3) as indicated in the BWP ID field. The DCI 3514 may not comprise an action indication field (or an action indication field may be used for another purpose). The wireless device 3504 may receive the DCI 3514 at time $t_3$.

[363] The wireless device 3204 may determine, for example, one of: an activation, a deactivation, or a switch to a BWP, indicated by the BWP ID field, at time $t_4$. The activation and the deactivation may be based on the primary BWP. The switching may be based on the active BWP via which the DCI is transmitted 3514. One or more DCIs and/or one or more MAC CEs may be transmitted between $t_1$ and $t_2$ and/or between $t_2$ and $t_3$, etc.

[364] FIG. 36 shows an example of a procedure at a cell that may be configured with a plurality of BWPs. A base station 3602 may transmit one or more messages, comprising configuration parameters 3612 of a cell, to a wireless device 3604. The configuration parameters may correspond to one or more RRC messages (e.g., one or more of an RRC connection configured message, an RRC connection reestablishment messages, and an RRC connection setup message, etc.). The configuration parameters 3612 may comprise a configuration of a plurality of BWPs 3606 of the cell. The plurality of BWPs may comprise N+1 BWPs: BWP 0, BWP 1, BWP 2 ... BWP N. The wireless device 3604 may receive the one or more messages at time $t_0$.

[365] The wireless device 3604 may activate, for example, a first BWP (e.g., an initial BWP, a default BWP, etc.) at $t_1$. The wireless device 3604 may activate additional BWP(s) of the plurality of BWPs 3606 at $t_1$. The wireless device 3604 may receive a MAC CE 3613 indicating activation/deactivation (e.g., activation or deactivation) of a plurality of BWPs at $t_2$. The BWP 2, the BWP 4, and the BWP 5 may be activated, for example, based on the MAC CE 3613. The MAC CE 3613 may indicate deactivation of one or more BWPs activated at or before $t_2$. A single MAC CE may indicate activation/deactivation (e.g., activation or deactivation) state changes of a plurality of BWPs at the same time.

[366] The base station 3602 may transmit DCI 3614 via a downlink channel, such as a PDCCH. The DCI 3614 may be transmitted via the first BWP (e.g., a primary BWP). The DCI 3614 may comprise, for example, a BWP ID field and an action indication field. The action indication field may indicate, based on its contents, one of: a switching of a BWP as indicated in the BWP ID field or an activation/deactivation toggling of a BWP as indicated in the BWP ID field. The action indication field may be, for example, one bit in length (or any quantity of bits in length). The wireless device 3604 may receive the DCI at time $t_3$. The wireless device 3604 may interpret the contents of the action indication field in the DCI based on a predefined rule, for example, such as per the table 3608. The wireless device 3204 may interpret the contents of the action indication field based on the predefined rule, such as per the table 3608, for example, if the BWP ID field indicates a BWP different from the first BWP.

[367] The BWP ID field may indicate, for example, a BWP ID corresponding to the second BWP. The wireless device 3604 may determine, for example, one of: an activation of the second BWP, a deactivation of the second BWP, and a switch to the second BWP, based on the contents of the action indication field, at time $t_4$. The wireless device 3604 may switch operation to the second BWP, for example, by deactivating the first BWP and activating the second BWP, for example, if contents of the action indication field indicate a first value (e.g., "1"). The wireless device 3604 may activate the second BWP, for example, if contents of the action indication field indicate a second value (e.g., "0") and the second BWP is in inactive state. The wireless device 3604 may deactivate the second BWP, for example, if contents of the action indication field indicate the second value (e.g., "0") and the second BWP is in active state. The wireless device 3604 may perform UL/DL operations on active BWPs s determined at time $t_4$.

[368] FIG. 37 shows an example method of configuring a plurality of BWPs. The procedure of FIG. 37 may correspond to operations of a base station associated with the cell. At step 3702, the base station may determine one or more BWP changes associated with a wireless device. At step 3704, the base station may determine urgency (e.g., based on a type of service, such as eMBB, URLLC, etc.) and/or amount of BWP changes (e.g., a quantity of BWP changes such as activation, deactivation, switching, etc.). At step 3705, the base station may determine one or more BWP changes are urgent and/or the amounts of BWP changes satisfy a threshold (e.g., the amounts are less than the threshold). The base station may determine, for example, that a BWP switching from a BWP 1 to a BWP 2 is urgent and that BWP activation/deactivation (e.g., activation or deactivation) of BWPs 3, 4, 5, 6, and 7 are not urgent. At step 3706, the base station may determine one or more DCIs for a first BWP change, for example, if the first BWP change is urgent and/or its amounts are satisfying a threshold (e.g., the number of BWPs to be changed is less than the threshold). The base station may determine DCI for the switching of BWP 1 to the BWP 2.

[369] At step 3707, the base station may determine one or more BWP changes are not urgent and/or the amounts of BWP changes do not satisfy a threshold (e.g., the quantity of BWP changes is greater than the threshold). The base station may determine, for example, that

a BWP switching from a BWP 1 to a BWP 2 is urgent and that BWP activation/deactivation (e.g., activation or deactivation) of BWPs 3, 4, 5, 6, and 7 are not urgent. At step 3708, the base station may determine a MAC CE for a second BWP change, for example, if the second BWP change is not urgent and/or its amounts are not satisfying a threshold (e.g., the number of BWPs to be changed is greater than the threshold). The base station may determine a MAC CE for the activation/deactivation of the BWPs 3, 4, 5, 6, and 7.

[370] A problem may arise, for example, if multiple active BWPs are supported, for managing a BWP actions (e.g., activation, deactivation, switching, etc.), such as by using an inactivity timer. A BWP switching and/or deactivation operation may be performed, for example, based on one or more BWP inactivity timers expiring. A first active BWP may schedule a second BWP and, based on a time period of inactivity, a wireless device may switch to a default BWP. The wireless device may have difficulty in determining from which BWP the wireless device shall switch to the default BWP. The wireless device may have difficulty in determining a state of the second BWP scheduled by the first BWP, based on the first BWP switching. Misalignment between a base station and a wireless device may occur based on a state of one or more active BWPs. The wireless device may deactivate a second active BWP of the cell, for example, based on switching a first active BWP of a cell to a default BWP. The wireless device may restart a BWP inactivity timer for a first active BWP of the cell, for example, based on DCI being sent via the first active BWP and/or based on receiving DCI activating, deactivating, and/or switching a second BWP of a cell.

[371] A wireless device may have difficulty determining a state of a second BWP based on switching of a first BWP to a default BWP, for example, if multiple active BWPs are supported. The wireless device may have difficulty determining from which BWP the wireless device shall switch to the default BWP, and/or determining a state of the second BWP, for example, based on the second BWP being scheduled by the first BWP and/or the first BWP switching to another BWP. Misalignment between a base station and the wireless device may occur regarding a state of one or more active BWPs. The first BWP and second BWP may have a similar or same numerology. The default BWP numerology

may be different from the first BWP and/or second BWP. The difference in numerology between BWPs may cause difficulty for the wireless device (e.g., misalignment, link interruption, power drain, synchronization, etc.). The wireless device may miss detecting a further instruction from the base station via the first BWP, based on the first BWP having switched to a default BWP.

[372] A wireless device may deactivate a second BWP based on a first BWP switching to a default BWP. The wireless device may activate a first BWP based on first DCI received from a base station (e.g., from any of one or more base stations). The wireless device may activate a second BWP based on second DCI, for example, after activating the first BWP. The first BWP may be switched to a default BWP, for example, based on an expiration of a time period of inactivity and/or third DCI. The second BWP may be deactivated, for example, based on the first BWP switching to the default BWP. This deactivating of the second BWP, based on the first BWP switching, may reduce device power demand, reduce power consumption, simplify a wireless device's implementation, and/or reduce wireless device cost. The solution may also improve system throughput, for example, by allowing the base station to use resources of the second active BWP for data transmission for other wireless devices.

[373] A wireless device may receive, via a first active BWP of a cell, DCI activating/deactivating (e.g., activating or deactivating) a second BWP of the cell, for example, if multiple active BWPs are supported. A wireless device may miss detecting further instruction (e.g., associated with the second BWP) from the base station on the first active BWP, for example, based on the first active BWP switching if a BWP timer expires. Misalignment may occur, for example, as a result of the wireless device missing a detection of an instruction from the base station.

[374] A wireless device may restart a BWP inactivity timer for a first BWP based on receiving DCI activating, deactivating, and/or switching a second BWP. The wireless device may activate a first BWP based on first DCI received from a base station. The wireless device may activate and/or deactivate a second BWP based on second DCI, for example, after activating the first BWP. The BWP inactivity timer for the first BWP may be reset, for

example, based on the second DCI. This reset of the BWP inactivity timer may reduce unexpected BWP switching to a default BWP. For example, if a wireless device is configured to switch to a default BWP based on a period of inactivity (e.g., an expiration of an inactivity timer), the wireless device may prevent such BWP switching by resetting the BWP inactivity timer prior to reaching the end of a threshold period of inactivity (e.g., an expiration of an inactivity timer). This reset of the BWP inactivity timer may improve system throughput and/or reduce signaling overhead which otherwise may be used to maintain the active state of the first active BWP. The wireless device may reduce the frequency of missing an instruction from the base station via the first BWP, based on the first BWP having switched to a default BWP.

[375] Deactivating a second BWP (e.g., based on a first BWP switching to a default BWP), and/or restarting a BWP inactivity timer for a first BWP (e.g., based on receiving DCI activating and/or deactivating a second BWP) may provide an efficient BWP operation mechanism for supporting multiple active BWPs operation in a cell. Deactivating a second BWP, and/or restarting a BWP inactivity timer, may provide increased efficiency of BWP management for supporting multiple active BWPs operations in a cell.

[376] A base station may send one or more messages comprising configuration parameters of a plurality of cells. At least one cell of the plurality of cells may comprise a plurality of BWPs comprising a default BWP. The configuration parameters may indicate that the at least one cell may be associated with a BWP timer and a timer value. A first timer value associated with a first cell of the at least one cell may be the same as or different from a second timer value associated with a second cell of the at least one cell.

[377] A base station may send, to a wireless device, a PDCCH of a first active BWP. The wireless device may start a BWP timer (e.g., a BWP inactivity timer) using a timer value based on receiving the PDCCH via the first active BWP.

[378] A base station may send first DCI via a PDCCH on or using a first active BWP of a first cell, of the at least one cell, for scheduling a second BWP of a second active cell of the at least one cell, for example, if cross-carrier scheduling is supported. The wireless device

may transition the second BWP of the second cell from an inactive state to an active state, for example, if the second BWP is in an inactive state before receiving the first DCI. The wireless device may start and/or restart a first BWP timer with a timer value associated with the first cell (or the first active BWP), for example, based on receiving the first DCI. The wireless device may start and/or restart a second BWP timer with the timer value associated with the second cell (or the second BWP), for example, based on receiving the first DCI via the first active BWP. The base station and/or the wireless device may switch to the default BWP as an active BWP, based on an expiry of the BWP timer associated with the at least one cell.

[379] Some BWP and/or CA operations (e.g., by legacy devices and/or other by other devices) may allow at most one active BWP in a cell. The cell may be associated with a BWP timer and/or a timer value. A wireless device may start the BWP timer using the timer value, for example, based on or in response to receiving first DCI via a first BWP (e.g., an active BWP). The wireless device may switch to a second BWP, for example, based on or in response to receiving the first DCI for BWP switching from the first BWP to the second BWP. The wireless device may start and/or restart the BWP timer with the timer value, for example, based on or in response to the BWP switching. Some BWP operations (e.g., by legacy devices and/or by other devices) may not support multiple active BWPs in a cell. Some BWP and/or CA operations (e.g., by legacy devices and/or by other devices) may not efficiently manage a state (e.g., active state and/or inactive state) of multiple active BWPs, for example, if multiple active BWPs are supported. Some BWP and/or CA operations (e.g., by legacy devices and/or other devices) may not efficiently manage a state (e.g., active state or inactive state) of multiple active BWPs, for example, if multiple active BWPs are supported, and/or if multiple BWP timers are associated with the multiple active BWPs.

[380] A base station and/or a wireless device may communicate via multiple active BWPs of a plurality of BWPs for sending and/or receiving multiple types of services in a cell. Each of the plurality of BWPs may be in an active state or an inactive state. The plurality of BWPs may comprise a default BWP. The default BWP may be in an inactive state, for example, if the default BWP is different from one or more of the multiple active BWPs.

A wireless device may switch a first active BWP of the multiple active BWPs to the default BWP, for example, based on or in response to at least one of: receiving DCI indicating BWP switching to the default BWP, and/or a first BWP timer associated with the first active BWP expiring. A wireless device may switch a second active BWP of the multiple active BWPs to the default BWP, for example, based on or in response to at least one of: receiving DCI indicating BWP switching to the default BWP, and/or a second BWP timer associated with the second active BWP expiring. The first inactivity timer may be associated with a first timer value. The second inactivity timer may be associated with a second timer value.

[381] A base station may send one or more messages comprising configuration parameters indicating a default BWP and/or a plurality of BWPs in a cell. The configuration parameters may indicate each of the plurality of BWPs may be associated with a BWP specific timer that may differ from other BWPs, and/or a BWP timer value that may differ from other BWPs. A first BWP timer value of a first BWP of the plurality of BWPs may be different from a second BWP timer value of a second BWP of the plurality of BWPs. The configuration parameters may indicate each of the plurality of BWPs may be associated with a particular BWP timer and/or a cell timer value. The BWP timers of the plurality of BWPs may be associated with the same cell timer value.

[382] A base station may send one or more messages comprising configuration parameters indicating a cell comprising a default BWP and/or a plurality of BWP groups. The configuration parameters may indicate each BWP group of the plurality of BWP groups are associated with a BWP group specific timer and/or a BWP group timer value.

[383] FIG. 38 shows an example of BWP management comprising BWP deactivation of a secondary BWP in a cell. A wireless device 3802 may be configured for at least two active BWPs, such as a primary BWP 3804 (e.g., BWP 0) and a secondary BWP 3808 (e.g., BWP 1). The wireless device 3802 may receive one or more messages to activate one or more BWPs, for example at an initial time 3810 (e.g., T0). The wireless device 3802 may receive one or more transport blocks (TBs) via the active BWPs (e.g., BWP 0 and/or BWP 1), for example, after the initial time 3810 (e.g., T0). The wireless device

3802 may be configured with at least one inactive BWP, such as a default BWP 3806 (e.g., BWP 2). At a first time period 3812 (e.g., T1), the wireless device 3802 may switch from the primary BWP 3804 to the default BWP 3806, for example, based on or in response to a period of inactivity (e.g., a timer expiration) and/or receiving DCI (e.g., indicating switching). After the first time period 3812, the primary BWP 3802 may be inactive and the default BWP 3806 may be active. The wireless device 3802 may switch from a primary BWP to a secondary BWP, for example, based on a timer and/or DCI. The wireless device 3802 may activate the default BWP (e.g., BWP 2) and/or deactivate BWP 1, for example, based on BWP switching. At or after the first time period 3812 (e.g., T1), the wireless device 3802 may deactivate the secondary BWP 3808 (e.g., BWP 1) of the cell, for example, based on switching the primary BWP 3804 to the default BWP 3806. The switching may be based on a timer (e.g., expiration of a BWP inactivity timer) and/or based on receiving DCI (e.g., indicating BWP 2). The secondary BWP 3808 (e.g., BWP 1) may be scheduled by the primary BWP 3804, for example, by configuring PDCCH for the secondary BWP 3808 on the primary BWP 3804. The secondary BWP 3808 may be configured with a wireless device specific search space. The primary BWP 3804 may be configured with a common search space. The secondary BWP 3808 may be configured to have a same numerology as the primary BWP 3804, which may reduce signal receiving implementation complexity. Reducing signal receiving complexity may be advantageous for various applications, such as vehicle-to-anything (V2X), URLLC, and/or any other application (e.g., service type). The primary BWP 3804 (e.g., BWP 0, a Uu BWP, etc.) may have a same numerology as a secondary BWP (e.g., BWP 1, a sidelink BWP, etc.).

[384] FIG. 39 shows an example of BWP management using multiple active BWPs in a cell. A wireless device 3902 may start a first BWP timer (e.g., a BWP inactivity timer) at an initial time 3910 (e.g., T0). The wireless device 3902 may restart the first BWP timer (e.g., a BWP inactivity timer) for a primary BWP 3904 (e.g., BWP1) of a cell, for example, based on receiving DCI at a first time 3912 (e.g., T1) activating, deactivating, and/or switching a second BWP 3906 (e.g., BWP2) of the cell. By restarting the first BWP timer at the first time 3912, the wireless device may prevent from switching to a

default BWP (not shown) that may otherwise result if the timer expires (e.g., if the timer is a BWP inactivity timer). The second BWP 3906 (e.g., BWP2) may not be accessible to the wireless device 3902, for example, based on switching to the default BWP. A base station may send the DCI on or using the primary BWP 3904 (e.g., BWP1). The default BWP (not shown) may be configured with a narrow bandwidth, for example, which may not accommodate cross-BWP scheduling of the second BWP 3906. The wireless device 3902 may activate or deactivate the second BWP 3906 (e.g., BWP2), based on receiving DCI on or using the primary BWP 3904 (e.g., BWP1) to activate or deactivate, respectively, the second BWP (e.g., BWP2). For example, the wireless device 3902 may receive, on or using the primary BWP 3904, DCI at a first time period 3912 (e.g., T1). The DCI may indicate activation or deactivation of the secondary BWP 3906. The wireless device 3902 may activate or deactivate the second BWP 3906, for example, based on the DCI (e.g., at or after the first time period 3912). Cross-BWP activation/deactivation (e.g., activation or deactivation) may improve communications between a base station and the wireless device 3902, such as by reducing misalignment, reducing power consumption, and/or reducing signaling overhead.

[385] FIG. 40 shows an example of BWP management with multiple BWPs in a cell. A wireless device 4002 may start and/or restart BWP timers based on BWP activation and/or receipt of DCI. The wireless device 4002 may start and/or restart a first BWP timer at an initial time 4010 (e.g., T0), for example, based on or in response to activating a first BWP 4004 (e.g., BWP 0). The wireless device 4002 may start and/or restart a second BWP timer at a first time 4012 (e.g., T1), for example, based on activating a second BWP 4006 (e.g., BWP 1). The wireless device 4002 may receive first DCI via a first PDCCH at a second time 4014 (e.g., T2) via the first BWP 4004 of the multiple BWPs. The wireless device 4002 may start and/or restart a first BWP specific timer associated with a first BWP 4004 (or a cell) using a first timer value, for example, based on receiving the first DCI via the first BWP 4004. The wireless device 4002 may receive second DCI at a third time 4016 (e.g., T3) via a second PDCCH on or using the second BWP 4006 of the multiple BWPs. The wireless device 4002 may start and/or restart a second BWP timer associated with a second BWP (or the cell) using a second timer

value, for example, based on receiving the second DCI via the second BWP 4006. The wireless device 4002 may independently manage the first BWP timer associated with the first BWP 4004 and/or the second BWP timer associated with the second BWP 4006.

[386] The wireless device 4002 may start and/or restart a first BWP group specific timer using a first BWP group (or a cell) timer value, for example, based on receiving DCI on or using a first BWP of a first BWP group of a plurality of BWP groups. The wireless device may start and/or restart a second BWP group specific timer using a second BWP group (or the cell) timer value, for example, based on receiving DCI on or using a second BWP of a second BWP group of the plurality of BWP groups. The wireless device may independently manage the first BWP group specific timer of the first BWP group and the second BWP group specific timer of the second BWP group.

[387] FIG. 41 shows an example of BWP management with a primary BWP and multiple secondary BWPs in a cell. A wireless device 4102 may start and/or restart one or more BWP timers, for example, based on receiving one or more DCIs, and/or based on switching between a first secondary BWP 4106 and a second secondary BWP 4108. A wireless device 4102 may configure a primary BWP 4104 (e.g., BWP 0) for use, for example, at or before an initial time 4110 (e.g., T0). The wireless device 4102 may start and/or restart a first BWP timer at a first time 4112 (e.g., T1), for example, based on or in response to activating a first secondary BWP 4106 (e.g., BWP1). The wireless device 4102 may start and/or restart a second BWP timer at a second time 4114 (e.g., T2), for example, based on or in response to activating and/or switching to a second secondary BWP 4108 (e.g., BWP2). The wireless device 4102 may restart and/or start a first BWP timer at third time 4116 (e.g., T3), for example, based on or in response to receiving DCI on or using the first secondary BWP 4106. The wireless device 4102 may restart and/or start a second BWP timer at time T4 4118, for example, based on receiving DCI via the second secondary BWP 4108. By starting/restarting a timer (e.g., the first BWP timer, the second BWP timer, etc.), the wireless device 4102 may prevent from switching to a default BWP (not shown) that may otherwise result if the timer expires (e.g., if the timer is a BWP inactivity timer).

[388] A base station may send, to the wireless device 4102, one or more messages comprising configuration parameters indicating a cell comprising a primary active BWP and multiple secondary BWPs in a cell. The configuration parameters may indicate each of the plurality of BWPs be associated with a BWP specific timer, a BWP timer value, and/or a cell specific timer value. A primary active BWP (e.g., primary BWP 4104) may remain in an active state until receiving a second command indicating a primary active BWP switching. The second command may comprise an RRC message, a MAC CE, and/or DCI (e.g., DCI indicating a primary active BWP switching). The primary active BWP may not be associated with a BWP specific timer. The wireless device 4102 may manage a first BWP specific timer of a first BWP of multiple BWPs, and a second BWP specific timer of a second BWP of the multiple BWPs independently. The wireless device 4102 may keep the primary active BWP active until receiving the second command.

[389] FIG. 42 shows an example of BWP management using cross-BWP scheduling for multiple active BWPs in a cell. A wireless device 4202 may start and/or restart one or more BWP timers based on BWP activation and/or receiving DCI. The wireless device 4202 may start and/or restart a first BWP timer at an initial time 4210 (e.g., T0), for example, based on or in response to activation of a first BWP 4202 (e.g., BWP0). The wireless device 4202 may start and/or restart a second BWP timer at first time 4212 (e.g., T1), for example, based on or in response to activation of a second BWP 4206. The wireless device 4202 may receive first DCI via the first BWP 4204 indicating cross-scheduling (e.g., cross-BWP scheduling) on the second BWP 4206. The wireless device 4202 may restart and/or start the first BWP timer and/or the second BWP timer at a second time 4214 (e.g., T2), for example, based on receiving the first DCI. For example, the wireless device 4202 may start and/or restart the second BWP timer associated with the second BWP 4206 based on or in response to receiving an indication of activation of the first BWP 4204 and/or DCI on or using the first BWP 4204. By activating the second BWP 4206, starting the second BWP timer, and/or restarting the second BWP timer in the above manner, the wireless device 4202 may improve communications with a base station, such as by reducing misalignment, reducing power consumption, and/or reducing signaling overhead.

[390] A base station may send first DCI via a first BWP (e.g., a first DL BWP) of a plurality of BWPs. The first DCI may indicate a DL assignment or an UL grant for a second BWP of the plurality of BWPs. The first BWP may be associated with a first BWP specific timer and/or a first BWP timer value (or a cell timer value). The first BWP may be a primary active BWP. The second BWP may be associated with a second BWP specific timer and/or a second BWP timer value (or a cell timer value). The wireless device may start and/or restart the first BWP specific timer using the first BWP timer value (or the cell timer value), for example, based on or in response to receiving the first DCI. The wireless device may start and/or restart the second BWP specific timer using the second BWP timer value (or the cell timer value), for example, based on or in response to receiving the first DCI.

[391] First DCI sent via a first BWP may indicate a configured (or dynamic) downlink assignment via a second BWP (e.g., a second DL BWP). The first DCI sent via the first BWP may indicate a configured (or dynamic) uplink grant via the second BWP (e.g., an UL BWP). The first DCI sent via the first BWP may be sent via a PDCCH addressed to a first identifier via the first BWP. The first identifier may be at least one of C-RNTI and/or CS-RNTI. The first identifier may be at least one of: SI-RNTI, RA-RNTI, TC-RNTI, P-RNTI, INT-RNTI, SFI-RNTI, TPC-PUSCH-RNTI, TPC-PUCCH-RNTI, TPC-SRS-RNTI, CS-RNTI, SP-CSI-RNTI, and/or C-RNTI.

[392] FIG. 43 shows an example of BWP management using cross-BWP scheduling for multiple active BWPs in a cell. A wireless device 4302 may perform cross-BWP scheduling, for example, by activating a second BWP 4306 (and/or start and/or restart a second BWP timer) based on or in response to receiving DCI via a first BWP 4304 (e.g., BWP0) indicating activating the second BWP 4306 (e.g., BWP1). A wireless device 4302 may receive (e.g., from a base station) an indication of a BWP activation for the first BWP 4304, for example, at an initial time 4310 (e.g., T0). The wireless device 4302 may start and/or restart a first BWP timer, for example, based on or in response to the indication of the BWP activation for the first BWP 4304. The base station may send second DCI (and/or a MAC CE) on or using the first BWP 4304 indicating activating the second BWP 4306. The first BWP 4304 may be associated with a first BWP specific

timer and/or a first BWP timer value (or a cell timer value). The first BWP 4304 may be a primary active BWP. The second BWP 4306 may be associated with a second BWP specific timer and/or a second BWP timer value (or a cell timer value). The wireless device 4302 may start and/or restart the first BWP specific timer using the first BWP timer value (or the cell timer value) at a first time 4312 (e.g., T1), for example, based on or in response to receiving the second DCI. The wireless device 4302 may activate the second BWP 4306, for example, based on or in response to receiving the second DCI. The wireless device may start and/or restart the second BWP specific timer using the second BWP timer value (or the cell timer value) at a second time 4314 (e.g., T2), for example, based on the activating the second BWP 4306. A gap may be zero or a value greater than zero, between the first time 4312 (e.g., a first time after DCI for the activation is received) and the second time 4314 (e.g., a second time after the activation is complete).

[393] A base station may send third DCI (and/or a MAC CE) on or using a first BWP of a plurality of BWPs. The third DCI may indicate deactivating a second BWP of the plurality of BWPs. The first BWP may be associated with a first BWP specific timer and/or a first BWP timer value (or a cell timer value). The first BWP may be a primary active BWP. The second BWP may be associated with a second BWP specific timer and/or a second BWP timer value (or a cell timer value). The wireless device may not start and/or restart the first BWP specific timer using the first BWP timer value (or the cell timer value), for example, based on or in response to receiving the second DCI. The wireless device may deactivate the second BWP, for example, based on or in response to receiving the second DCI. The wireless device may reset the second BWP specific timer to the second BWP specific timer value (or the cell specific timer value) and/or not start the second BWP specific timer, for example, based on or in response to the deactivating the second BWP.

[394] FIG. 44 shows an example of BWP management for multiple active BWPs in a cell. A wireless device 4402 may activate a BWP, deactivate a BWP, start a BWP timer, and/or restart BWP timers based on switching BWPs. A wireless device 4402 may receive an indication for activating a first BWP 4404 (e.g., BWP0), for example, at an initial time

4410 (e.g., T0). The wireless device 4402 may start and/or restart a first BWP timer at the initial time 4410, for example, based on activation of the first BWP 4404. A base station may send fourth DCI on or using the first active BWP 4404 indicating switching from a second active BWP 4406 to a third BWP 4408 as a third (or additional) active BWP. The first BWP 4404 may be associated with a first BWP specific timer and/or a first BWP timer value (or a cell timer value). The first BWP 4404 may be a primary active BWP. The second BWP 4406 may be associated with a second BWP specific timer and/or a second BWP timer value (or a cell timer value). The third BWP 4408 may be associated with a third BWP specific timer and/or a third BWP timer value (or a cell timer value). The wireless device 4402 may start and/or restart the first BWP specific timer using the first BWP timer value (or the cell timer value) at a first time 4412 (e.g., T1), for example, based on or in response to receiving the fourth DCI. The wireless device 4402 may deactivate the second active BWP 4406 and/or activate the third BWP 4408 as the third active BWP, for example, based on or in response to receiving the fourth DCI. The wireless device 4402 may reset the second BWP specific timer using the second BWP timer value (or the cell timer value) and/or not start the second BWP specific timer at the first time 4412, for example, based on or in response to the deactivating the second active BWP. The wireless device 4402 may start and/or restart the third BWP specific timer using the third BWP timer value at a second time 4414 (e.g., T2) (or the cell timer value), for example, based on or in response to the activating the third BWP. A gap may be zero or a value greater than zero, between the first time 4412 (e.g., a first time after DCI for the switching is received) and the second time 4414 (e.g., a second time after the switching is completed). By switching from the second BWP 4406 to the third BWP 4408 based on or in response to DCI on or using the first BWP 4404, the wireless device 4402 may improve communications with a base station, such as by reducing misalignment, reducing power consumption, and/or reducing signaling overhead.

[395] A base station may send one or more messages comprising configuration parameters indicating a cell comprising a default BWP and a plurality of BWPs in a cell. The configuration parameters may indicate each of the plurality of BWPs may be associated with a BWP specific timer and/or a BWP timer value or a cell timer value. A first active

BWP of multiple active BWPs of the plurality of BWPs may be designated as a primary active BWP (PBWP). At least a second active BWP of multiple active BWPs of the plurality of BWPs may be designated as a secondary active BWP (SBWP). The default BWP may be in an inactive state if the default BWP is different from the PBWP.

[396] A wireless device may start and/or restart a first BWP specific timer, for example, based on or in response to receiving a first command indicating at least one of: the PBWP being activated, a PBWP switching, and/or DL assignment/UL grant on or using the PBWP. The wireless device may start and/or restart a second BWP specific timer, for example, based on or in response to receiving a second command indicating at least one of: the SBWP being activated, a SBWP switching, and/or DL assignment/UL grant on or using the SBWP.

[397] The wireless device may monitor a first PDCCH on or using the PBWP, for example, if the first BWP specific timer is running. The wireless device may monitor a second PDCCH on or using the SBWP, for example, if the second BWP specific timer is running.

[398] The wireless device may deactivate the SBWP, for example, based on or in response to the second BWP specific timer expiring and the first BWP specific timer running. The wireless device may keep the PBWP in an active state, for example, based on or in response to the second BWP specific timer expiring and the first BWP specific timer running. The wireless device may keep the default BWP in an inactive state, for example, based on or in response to the second BWP specific timer expiring and the first BWP specific timer running.

[399] FIG. 45 shows an example of BWP management using a primary BWP, a default BWP, and at least a secondary BWP in a cell. A wireless device 4502 may not switch to a default BWP (e.g., BWP2) until at least an expiration of multiple (or all) BWP timers associated with multiple (or all) active BWPs. By not switching to a default BWP at or after an expiration of a first BWP timer (e.g., at T2), the wireless device 4502 may improve communications with a base station, such as by reducing misalignment, reducing

power consumption, and/or reducing signaling overhead. The wireless device 4502 may activate a first BWP, such as a primary BWP 4504 (e.g., BWP0), for example, based on or in response to receiving an indication for activation of the first BWP at an initial time 4510 (e.g., T0). The wireless device 4502 may start a first BWP timer based on or in response to the primary BWP 4504 activation. The wireless device 4502 may activate a second BWP, such as a secondary BWP 4508 (e.g., BWP0), for example, based on or in response to receiving an indication for activation of the second BWP at a first time 4512 (e.g., T1). The wireless device 4502 may start a second BWP timer based on or in response to the secondary BWP 4508 activation. The wireless device 4502 may switch and/or deactivate BWPs based on a greater of multiple BWP timers expiring. For example, if the first BWP timer is still running, the wireless device 4502 may not switch from the secondary BWP 4508 to the default BWP 4506, based on or in response to the second BWP timer expiring (e.g., at a second time 4512). If the greater of the BWP timers associated with active BWPs expires (e.g., at a third time 4516), the wireless device 4502 may switch from the primary BWP 4504 to the default BWP 4506 at fourth time 4518 (e.g., T4), for example, based on the second BWP timer expiring and the first BWP timer both having expired. The wireless device 4502 may switch from the primary BWP 4504 to the default BWP 4506, for example, based on one or more BWP timers expiring (e.g., the last of a plurality of BWP timers each associated with an active BWP). The one or more BWP timers may comprise at least the second BWP timer and the first BWP timer. The wireless device 4502 may activate the default BWP 4506 and deactivate the primary BWP 4504, for example, based on the switching. A gap may be zero or a value greater than zero, between the third time 4516 (e.g., a first time after the switching is started) and the fourth time 4518 (e.g., a second time after the switching is completed). The wireless device may deactivate the secondary BWP 4508 based on or in response to the BWP switching from the primary BWP 4504 to the default BWP 4506. Deactivating the secondary active BWP 4508 in the manner described above may conserve wireless resources, for example, relative to switching the secondary BWP 4508 to the default BWP 4506. The secondary BWP 4508 and/or an additional BWP (not shown) may be activated, for example, based on the wireless device 4502 receiving an addition indication

for activation of a BWP (not shown), which may be more efficient than switching the secondary BWP 4508 to a third BWP.

[400] A base station may send one or more messages comprising configuration parameters indicating a cell comprising a default BWP and multiple other BWPs in a cell. The configuration parameters may indicate each of the BWPs may be associated with a BWP specific timer and/or a BWP timer value or a cell timer value. A first active BWP of multiple active BWPs may be designated as a primary active BWP (PBWP). At least a second active BWP of multiple active BWPs may be designated as a secondary active BWP (SBWP). The default BWP may be in an inactive state, for example, if the default BWP is different from the PBWP. The SBWP may be not configured with a PDCCH. A base station may send a downlink scheduling and/or an uplink grant for the SBWP via a PDCCH on or using the PBWP. The SBWP may be not associated with a BWP specific timer, for example, if the SBWP is not configured with a PDCCH via the SBWP.

[401] A wireless device may start and/or restart a first BWP specific timer, for example, based on or in response to receiving a first command indicating at least one of: the PBWP being activated, a PBWP switching, a DL assignment via the PBWP, and/or a UL grant on or using the PBWP. The wireless device may start and/or restart a second BWP specific timer (if configured), for example, based on or in response to receiving a second command indicating at least one of: the SBWP being activated, a SBWP switching, a DL assignment via the SBWP, and/or a UL grant via the SBWP.

[402] The wireless device may monitor a first PDCCH on or using the PBWP, for example, if the first BWP specific timer is running. The wireless device may monitor the first PDCCH or a second PDCCH on or using the PBWP for the SBWP, for example, if the second BWP specific timer is running.

[403] FIG. 46 shows an example of BWP management using a primary BWP, default BWP, and at least a secondary BWP in a cell. A wireless device 4602 may switch to a default BWP (e.g., BWP2) and/or deactivate a secondary BWP, for example, if a primary BWP timer expires. By switching to a default BWP at or after an expiration of a primary BWP

timer (e.g., at T4), the wireless device 4602 may improve communications with a base station, such as by reducing misalignment, reducing power consumption, and/or reducing signaling overhead. The wireless device 4602 may activate a first BWP, such as a primary BWP 4604 (e.g., BWP0), for example, based on or in response to receiving an indication for activation of the first BWP at an initial time 4610 (e.g., T0). The wireless device 4602 may start a first BWP timer based on or in response to the primary BWP 4604 activation. The wireless device 4602 may activate a second BWP, such as a secondary BWP 4608 (e.g., BWP0), for example, based on or in response to receiving an indication for activation of the second BWP at a first time 4612 (e.g., T1). The wireless device 4602 may start a second BWP timer based on or in response to the secondary BWP 4608 activation. The wireless device 4602 may switch and/or deactivate BWPs based on the primary BWP timer expiring. The wireless device 4602 may deactivate a secondary BWP 4608 (e.g., BWP1) based on or in response to switching from a primary BWP 4604 to a default BWP 4606. The wireless device 4602 may perform BWP switching based on an expiration of one or more BWP timers (e.g., the primary BWP timer). The wireless device may start a first BWP timer at an initial time 4610 (e.g., T0), for example, based on activation of the primary BWP 4608. The wireless device 4602 may start a second BWP timer at a first time 4612 (e.g., T1), for example, based on activation of the secondary BWP 4608. The wireless device may switch from the primary BWP 4604 to the default BWP 4606, for example, based on a first BWP timer expiring at a second time 4614 (e.g., T2) and/or a second BWP specific timer (if configured) running (e.g., the secondary BWP timer running). The wireless device 4602 may deactivate the primary BWP 4604 and activate the default BWP 4606 at a third time 4614 (e.g., T3), for example, based on the BWP switching. The wireless device 4602 may deactivate the secondary BWP 4608, for example, based on the BWP switching of the primary BWP 4604 to the default BWP 4606. A gap may be zero or a value greater than zero, between the second time 4614 (e.g., a first time after the switching is started) and the third time 4616 (e.g., a second time after the switching is completed).

[404] A base station may send one or more messages comprising configuration parameters indicating a cell comprising a default BWP and a plurality of BWPs in a cell. The

configuration parameters may indicate each of the plurality of BWPs may be associated with a BWP specific timer and a BWP timer value or a cell timer value.

[405] A wireless device may start and/or restart a first BWP specific timer, for example, based on or in response to receiving a first command indicating at least one of: a first BWP being activated, a DL assignment via the first BWP, and/or a UL grant on or using the first BWP. The wireless device may start and/or restart a second BWP specific timer (if configured), for example, based on or in response to receiving a second command indicating at least one of: a second BWP being activated, a DL assignment via the second BWP, and/or a UL grant via the second BWP.

[406] The wireless device may monitor a first PDCCH on or using the first BWP, for example, if the first BWP specific timer is running. The wireless device may monitor a second PDCCH on or using the second BWP, for example, if the second BWP specific timer is running.

[407] FIG. 47 shows an example of BWP management with multiple active BWPs in a cell. A wireless device 4702 may switch to a default BWP (e.g., BWP2) from a second BWP (e.g., BWP1), for example, if a BWP timer associated with the second BWP expires. A first BWP (e.g., BWP0) may be deactivated (e.g., and not switched to a default BWP), for example, if a first BWP timer expires and a second BWP has switched to a default BWP. The wireless device 4702 may activate a first BWP 4704 (e.g., BWP0), for example, based on or in response to receiving an indication for activation of the first BWP at an initial time 4710 (e.g., T0). The wireless device 4702 may start a first BWP timer based on or in response to the first BWP 4604 activation. The wireless device 4702 may activate a second BWP 4608 (e.g., BWP0), for example, based on or in response to receiving an indication for activation of the second BWP at a first time 4712 (e.g., T1). The wireless device 4702 may start a second BWP timer based on or in response to the second BWP 4708 activation. The wireless device 4702 may switch and/or deactivate BWPs based on a BWP timer expiring. For example, the wireless device 4702 may switch from the second BWP 4708 to the default BWP 4706 (e.g., at a third time 4716) based on the second BWP timer expiring at a second time 4714 (e.g., T2). The wireless

device 4702 may switch from the second BWP 4708 to the default BWP 4706 at the second time 4714 or between the second time 4714 and a third time 4716 (e.g., T3), for example, based on the second BWP timer expiring at the second time 4714 and/or the first BWP timer running. The wireless device 4702 may deactivate the second BWP 4708 and activate the default BWP 4706, for example, based on the BWP switching. The wireless device 4702 may keep the first BWP 4704 in an active state, for example, based on the switching. A gap may be zero or a value greater than zero, between the second time 4714 (e.g., a first time after the switching is started) and a third time (e.g., a second time after the switching is complete). The wireless device 4702 may deactivate the first BWP 4704 and keep the default BWP 4706 in active state, for example, based on or in response to one or more BWP specific timers (e.g., the first BWP timer) expiring. The one or more BWP specific timers may comprise at least: the first BWP timer and/or the second BWP timer.

[408] A base station may send one or more messages comprising configuration parameters indicating a cell comprising a default BWP and multiple other BWPs in a cell. The configuration parameters may indicate each of the BWPs being associated with a BWP specific timer and/or a BWP timer value or a cell timer value.

[409] A wireless device may start and/or restart a first BWP specific timer, for example, based on receiving a first command indicating at least one of: a first BWP being activated, a DL assignment via the first BWP, and/or a UL grant on or using the first BWP. The wireless device may start and/or restart a second BWP specific timer (if configured), for example, based on receiving a second command indicating at least one of: a second BWP being activated, a DL assignment via the second BWP, and/or a UL grant on or using the second BWP.

[410] The wireless device may monitor a first PDCCH on or using the first BWP, for example, if the first BWP specific timer is running. The wireless device may monitor a second PDCCH on or using the second BWP, for example, if the second BWP specific timer is running.

[411] FIG. 48 shows an example of BWP management with multiple active BWPs in a cell. FIG. 48 may comprise each feature described above regarding FIG. 45, except that FIG. 48 may comprise a first BWP 4804 that may (or may not) be a primary BWP and/or a second BWP 4808 that may (or may not) be a secondary BWP. A wireless device 4802 may not switch to a default BWP (e.g., BWP2) until at least an expiration of multiple (or all) BWP timers associated with multiple (or all) active BWPs. The wireless device 4802 may cause a first BWP 4804 to switch to a default BWP 4806 based on a first BWP timer expiring, for example, after a second BWP 4808 is deactivated based on a second BWP timer expiring. The wireless device 4802 may start a first BWP timer at an initial time 4810 (e.g., T0), for example, based on activation of the first BWP 4804. The wireless device 4802 may start a second BWP timer at a first time 4812 (e.g., T1), for example, based on activation of the second BWP 4808. The wireless device 4802 may deactivate the second BWP 4808, for example, based on or in response to the second BWP specific timer expiring at a second time 4814 (e.g., T2) and/or the first BWP specific timer running. The wireless device 4802 may deactivate the second BWP 4808, for example, based on the BWP switching. The wireless device 4802 may keep the first BWP 4804 in an active state, for example, based on the BWP switching. A gap may be zero or a value greater than zero, between a third time 4816 (e.g., a first time after the switching is started) and a fourth time 4818 (e.g., a second time after the switching is completed).

[412] The wireless device may switch to a default BWP, for example, based on or in response to one or more BWP specific timers expiring. The one or more BWP specific timers may comprise at least: the first BWP specific timer, and/or the second BWP specific timer. The wireless device may deactivate the first BWP or the second BWP, and activate the default BWP, for example, based on the BWP switching.

[413] A base station and/or a wireless device may align multiple BWP timers if multiple active BWPs are supported. A wireless device may reduce power consumption, for example, if multiple active BWPs are supported. A base station may reduce signaling overhead to maintain time alignments and/or synchronization on or using multiple active BWPs.

[414] FIG. 49 shows an example method for BWP management by a wireless device. A wireless device may deactivate a first BWP, and/or monitor a PDCCH on or using the second active BWP, based on a first timer expiring and a second timer running. At step 4902, a wireless device may receive, from a base station, one or more messages comprising RRC configuration(s) (e.g., for BWPs). At step 4904, the wireless device may activate multiple BWPs in a cell. The wireless device may start multiple timers associated with the multiple BWPs. At step 4906, the wireless device may monitor a PDCCH on or using the multiple active BWPs. At step 4908, a first timer associated with a first active BWP may expire and at least a second timer may be running. At step 4910, the wireless device may deactivate the first active BWP, and keep at least a second active BWP in an active state. At step 4912, the wireless device may stop monitoring a PDCCH on the first active BWP. The wireless device may monitor at least a second PDCCH on the at least second active BWP.

[415] A wireless device may receive, from a base station, one or more messages comprising configuration parameters of a cell comprising a plurality of BWPs. The plurality of BWP may comprise at least: a default BWP and a first BWP. Each of the plurality of BWPs may be in one of an active state and an inactive state. The wireless device may start a first BWP timer associated with the first BWP, for example, based on or in response to activating the first BWP. The default BWP may be in an inactive state if the default BWP is different from the first BWP. The wireless device may deactivate the first BWP, for example, based on or in response to the first BWP timer expiring. The wireless device may activate the default BWP, for example, based on each of the plurality of BWP being in an inactive state. The wireless device may keep the default BWP in an inactive state, for example, based on at least a second BWP being in active state. The wireless device may keep the first BWP in active state, for example, if the first BWP timer is running. The wireless device may monitor a first PDCCH on or using the first BWP, for example, if the first BWP is in an active state.

[416] A base station may send, to a wireless device, one or more messages comprising configuration parameters of BWPs of a cell. The cell may comprise a primary cell or a secondary cell. The BWPs may comprise a first BWP and a second BWP. The

configuration parameters may indicate at least one of: a control resource set of the first BWP; a search space set of the first BWP; a subcarrier space of the first BWP; a number of symbols of the first BWP; and/or a set of resource blocks of the first BWP. The base station and/or the wireless device may activate the first BWP as an active BWP of the cell. The base station may send, via the first BWP, DCI comprising a first field and a second field. The first field may indicate the second BWP. Based on (or in response to) a value of the second field and on the first field indicating the second BWP, the base station and/or the wireless device may perform: switching from the first BWP to the second BWP (e.g., as an active BWP); or activating the second BWP and maintaining active states of the first BWP and the second BWP. The switching from the first BWP to the second BWP may comprise deactivating the first BWP and activating the second BWP (e.g., as the active BWP). The switching from the first BWP to the second BWP may comprise deactivating the first BWP during a first time duration that is at least partially overlapped with a second time duration of activating the second BWP. The switching from the first BWP to the second BWP may comprise activating the second BWP after deactivating the first BWP. The deactivating the first BWP may comprise at least one of: stopping monitoring a downlink control channel on the first BWP; stopping receiving downlink signals on the first BWP; and/or stopping transmitting uplink signals on the first BWP. The switching from the first BWP to the second BWP (e.g., as the active BWP) may be performed based on or in response to the value of the second field being set to a first value. The activating the second BWP and maintaining the active states of the first BWP and the second BWP may be performed based on or in response to the value of the second field being set to a second value. The base station may send, to the wireless device, second DCI comprising a third field and a fourth field. The third field may indicate the second BWP. The base station and/or the wireless device may deactivate, based on a value of the fourth field and on the third field indicating the second BWP, the second BWP. The base station and/or the wireless device may maintain, based on the value of the fourth field and on the third field indicating the second BWP, an active state of the first BWP. Based on the active state of the first BWP, the wireless device may perform: monitoring a downlink control channel on a search space set (e.g., a search space set in the control resource set for receiving a downlink radio resource

assignment) associated the first BWP; determining, based on the monitoring, a downlink radio resource assignment; and/or receiving, based on the downlink radio resource assignment, a downlink transport block. The wireless device may monitor a downlink control channel on the search space set in the control resource set for receiving an uplink radio resource grant; and/or transmit, based on the uplink radio resource grant, an uplink transport block. The wireless device may monitor a downlink control channel on the first BWP, receive downlink signals on the first BWP, and/or transmit uplink signals on the first BWP. The second field may comprise a time resource allocation indicator or a frequency resource allocation indicator. The second field may comprise a BWP action indicator comprising a value that indicates at least one of: switching an active BWP from the first BWP to the second BWP; activating the second BWP and maintaining the active states of the first BWP and the second BWP; and/or deactivating the second BWP and maintaining an active state of the first BWP. The first DCI may be received based on DCI format 1_1 or DCI format 0_1. The first DCI may be based on DCI format different from DCI format 1_1 and from DCI format 0_1. The wireless device may monitor, on the first BWP, a downlink control channel for the first DCI. The wireless device may activate the first BWP based on or in response to receiving at least one of" a first command indicating activation of the cell; and/or a second command indicating switching an active BWP to the first BWP. The first command may comprise at least one of: a radio resource control message; a MAC CE; and/or second DCI. The second command may comprise at least one of: a radio resource control message; a MAC CE; and/or second DCI.

[417] A base station and/or a wireless device may activate a first BWP of a cell as a primary active BWP and a second BWP of the cell as a secondary active BWP. The base station may send, via the first BWP, DCI indicating a third BWP of the cell. Based on (or in response to) the first BWP being the primary active BWP and based on the DCI, the base station and/or the wireless device may maintain the first BWP as the primary active BWP and/or switch from the second BWP to the third BWP as the secondary active BWP. The base station may send, to the wireless device, one or more messages comprising configuration parameters of BWPs of the cell. The BWPs may comprise the first BWP and the second BWP. The switching from the second BWP to the third BWP may be

further based on a value of a field of the DCI. The base station may send, via the first BWP, second DCI comprising a first field and a second field. The first field may indicate the third BWP, and the second field may indicate a first value. Based on first field indicating the third BWP and on the second field indicating the first value, the base station and/or the wireless device may maintain the first BWP as an active BWP and deactivate the third BWP. The base station may send, to the wireless device, information indicating that the first BWP is configured as the primary active BWP of the cell. The wireless device may determine, based on a value of a field of the DCI, whether to activate the third BWP or to switch from the second BWP to the third BWP. The base station may send, to the wireless device, a MAC CE associated with a BWP activation. The base station and/or the wireless device may activate or deactivate, based on the MAC CE, each of a plurality of BWPs associated with the MAC CE.

[418] A base station and/or a wireless device may activate a first BWP of a cell (e.g., as a first active BWP) and a second BWP of the cell (e.g., as a second active BWP). The base station may send, via the first BWP, DCI comprising a first field and a second field. The first field may indicate the second BWP and the second field may indicate a first value. Based on the first field indicating the second BWP and on the second field indicating the first value, the base station and/or the wireless device may maintain the first BWP as an active BWP and deactivate the second BWP. The first BWP may be activated as a primary active BWP. The second BWP may be activated as a secondary active BWP. The base station may send, to the wireless device, information indicating that the first BWP is configured as the primary active BWP of the cell. The base station may send, via the first BWP, second DCI comprising a third field and a fourth field. The third field may indicate a third BWP and the fourth field may indicate a second value. Based on the third field indicating the third BWP and the fourth field indicating the second value, the base station and/or the wireless device may switch from the first BWP to the third BWP or activate the third BWP while maintaining an active state of the first BWP. The base station may send, to the wireless device, a MAC CE associated with a BWP activation. The wireless device may activate or deactivate, based on the MAC CE, each of a plurality of bandwidth parts (BWPs) associated with the MAC CE.

[419] A wireless device and/or a base station may activate a first BWP of a cell and a second BWP of the cell. The cell may comprise a primary cell or a secondary cell. The first BWP may be a primary BWP. The second BWP may be a secondary BWP. The activating the first BWP and/or the second BWP may comprise: activating the first BWP at a first time interval, and/or activating the second BWP at a second time interval at least partially overlapped with the first time interval. The activating the first BWP and the second BWP may comprise activating the second BWP after the wireless device activates the first BWP. The activating the first BWP and the second BWP may comprise activating the first BWP during a first time interval and activating the second BWP during a second time interval. The activating the first BWP and the second BWP further comprises maintaining and inactive state of the default BWP. The maintaining an inactive state of the default BWP comprises at least one of: not monitoring a downlink control channel on the default BWP, not receiving downlink signals on the default BWP, and/or not transmitting uplink signals on the default BWP. The activating the first BWP may comprise at least one of: monitoring, on the first BWP, a downlink control channel on a search space set in a control resource set for receiving a radio resource assignment, and/or receiving or transmitting a transport block based on the radio resource assignment. The activating the second BWP may comprise at least one of: monitoring, on the second BWP, a downlink control channel on a search space set in a control resource set for receiving a radio resource assignment, and receiving or transmitting a transport block based on the radio resource assignment. The base station may send, to the wireless device that may receive, one or more messages (e.g., a radio resource control message) comprising configuration parameters of the cell. The configuration parameters may indicate a value of a time period of inactivity. The configuration parameters may indicate: a control resource set of the first BWP, a search space set of the first BWP, a subcarrier space of the first BWP, a quantity of symbols of the first BWP, and/or a set of resource blocks of the first BWP. The base station may send, to the wireless device that may receive, a first downlink signal in a first slot. The wireless device may monitor a downlink control channel on the first BWP for downlink control information (DCI). The wireless device may switch, based on a time period of inactivity after the first slot, from the first BWP to a default BWP of the cell as an active BWP of the cell. The default BWP

may be different form the first BWP and/or the second BWP. The time period of inactivity may comprise a duration of time that a BWP inactivity timer is running. The time period of inactivity may comprise not receiving a second downlink signal on the first BWP, and/or not transmitting uplink signals on the first BWP. The first downlink signal may comprise at least one of: downlink control information, and/or a downlink transport block. The wireless device may switch from the first BWP to the default BWP as an active BWP further based on a determination that the DCI is not received during the monitoring. The wireless device may deactivate, based on the switching from the first BWP to the default BWP, the second BWP. The switching from the first BWP to the default BWP may comprise deactivating the first BWP and/or activating the default BWP as the active BWP. The deactivating the first BWP may comprise: stopping monitoring a downlink control channel on the second BWP, stopping receiving downlink signals on the second BWP, and/or stopping transmitting uplink signals on the second BWP. The wireless device may deactivate the first BWP based on or in response to receiving at least one of: a first command indicating activation of the cell, a second command indicating activation of the first BWP, and/or a third command indicating switching an active BWP to the first BWP. The command may comprise at least one of: a radio resource control message, a MAC CE, and/or DCI. The wireless device may deactivate the second BWP based on or in response to receiving at least one: a first command indicating activation of the cell, a second command indicating activation of the second BWP, and/or a third command indicating switching an active BWP to the second BWP. The wireless device may switch from the default BWP to a third BWP of the cell as an active BWP. The third BWP and the first BWP may be the same active BWP of the cell. The wireless device may have more than one active BWP. The wireless device may start, based on receiving a second downlink signal via the third BWP, a BWP inactivity timer. The wireless device may receive, via the third BWP, a third downlink signal indicating at least one of: activating a fourth BWP of the cell, deactivating the fourth BWP of the cell, switching from the fourth BWP to a fifth BWP as a second active BWP, and/or allocating radio resources for the fourth BWP. The wireless device may restart, based on the third downlink signal, the BWP inactivity timer.

[420] A wireless device and/or a base station may activate a first bandwidth part (BWP) of a cell and a second BWP of the cell. The wireless device may receive, via the first BWP, a downlink signal via the first BWP at in a first slot. The wireless device may monitor a downlink control channel on the first BWP for a downlink control information (DCI). Based on determining that DCI is not received during a time period (e.g., of inactivity) after the first slot: switching from the first BWP to a default BWP of the cell as an active BWP of the cell; and deactivating the second BWP. The time period may be associated with a duration of time that a BWP inactivity timer is running. The wireless device may switch from the default BWP to a third BWP of the cell as the active BWP. The wireless device may start, based on receiving a second downlink signal via the third BWP, a BWP inactivity timer. The wireless device may receive, via the third BWP, a third downlink signal indicating at least one of: activating a fourth BWP of the cell; deactivating the fourth BWP of the cell; switching from the fourth BWP to a fifth BWP as a second active BWP; and/or allocating radio resources for the fourth BWP. The wireless device may restart, based on the third downlink signal, the BWP inactivity timer. The third BWP and the first BWP may be a same active BWP of the cell. The default BWP may be different from the first BWP and the second BWP. The cell may comprise a primary cell or a secondary cell. The first BWP may be a primary BWP. The second BWP may be a secondary BWP. The switching from the first BWP to the default BWP may comprise: deactivating the first BWP; and activating the default BWP as the active BWP.

[421] A wireless device and/or a base station may activate a first bandwidth part (BWP) of a cell as a first active BWP. The wireless device may start, based on receiving a first downlink signal via the first BWP, a BWP inactivity timer. The wireless device may start the BWP inactivity timer with an initial timer value based on or in response to receiving a first downlink signal via the first BWP. The wireless device may receive, via the first BWP, a second downlink signal indicating at least one of: activating a second BWP of the cell/; deactivating the second BWP of the cell; switching from the second BWP to a third BWP as a second active BWP; and/or allocating radio resources allocation on for the second BWP. The wireless device may restart, based on the second downlink signal, the BWP inactivity timer. The wireless device may restart the BWP inactivity timer with

the initial timer value based on or in response to the second downlink signal. The wireless device may receive a downlink transport block via the first BWP during a time period, for example, if the BWP inactivity timer is running. The wireless device may monitor a downlink control channel on the first BWP for downlink control information (DCI). The wireless device may switch, based on a determination that the DCI is not received during the monitoring, from the first BWP to a default BWP. The wireless device may activate the second BWP of the cell. The wireless device may receive, via the first BWP, a third downlink signal in a first slot. The wireless device may switch, based on a time period of inactivity after the first slot, from the first BWP to a default BWP of the cell as an active BWP of the cell. The wireless device may deactivate, based on the switching from the first BWP to the default BWP, the second BWP. The wireless device may receive, via the first BWP during a time period that the BWP inactivity timer is running, at least one downlink transport block.

[422] Hereinafter, various characteristics will be highlighted in a set of numbered clauses or paragraphs. These characteristics are not to be interpreted as being limiting on the invention or inventive concept, but are provided merely as a highlighting of some characteristics as described herein, without suggesting a particular order of importance or relevancy of such characteristics.

[423] Clause 1. A method comprising receiving, by a wireless device, one or more messages comprising configuration parameters of bandwidth parts (BWPs) of a cell, wherein the BWPs comprise a first bandwidth part (BWP) and a second BWP.

[424] Clause 2. The method of clause 1, further comprising activating the first BWP as an active BWP of the cell.

[425] Clause 3. The method of any one of clauses 1 – 2, further comprising receiving, via the first BWP, downlink control information (DCI) comprising a first field and a second field, wherein the first field indicates the second BWP.

[426] Clause 4. The method of any one of clauses 1 – 3, further comprising based on a value of the second field and on the first field indicating the second BWP: switching from the first

BWP to the second BWP; or activating the second BWP and maintaining active states of the first BWP and the second BWP.

[427] Clause 5. The method of any one of clauses 1 – 4, wherein switching from the first BWP to the second BWP is performed based on the value of the second field being set to a first value.

[428] Clause 6. The method of any one of clauses 1 – 4, wherein activating the second BWP and maintaining the active states of the first BWP and the second BWP are performed based on the value of the second field being set to a second value.

[429] Clause 7. The method of any one of clauses 1 – 6, further comprising receiving second DCI comprising a third field and a fourth field, wherein the third field indicates the second BWP.

[430] Clause 8. The method of any one of clauses 1 – 7, further comprising deactivating, based on a value of the fourth field and on the third field indicating the second BWP, the second BWP.

[431] Clause 9. The method of any one of clauses 1 – 8, wherein the configuration parameters indicate at least one of: a control resource set of the first BWP; a search space set of the first BWP; a subcarrier space of the first BWP; a number of symbols of the first BWP; or a set of resource blocks of the first BWP.

[432] Clause 10. The method of any one of clauses 1 – 9, further comprising based on the active state of the first BWP, monitoring a downlink control channel on a search space set associated the first BWP.

[433] Clause 11. The method of any one of clauses 1 – 10, further comprising based on the active state of the first BWP, determining, based on the monitoring, a downlink radio resource assignment.

[434] Clause 12. The method of any one of clauses 1 – 11, further comprising based on the active state of the first BWP, receiving, based on the downlink radio resource assignment, a downlink transport block.

[435] Clause 13. The method of any one of clauses 1 – 12, wherein the second field comprises a time resource allocation indicator or a frequency resource allocation indicator.

[436] Clause 14. The method of any one of clauses 1 – 13, wherein the second field comprises a BWP action indicator comprising a value that indicates at least one of: switching an active BWP from the first BWP to the second BWP; or activating the second BWP and maintaining the active states of the first BWP and the second BWP.

[437] Clause 15. The method of any one of clauses 1 – 14, wherein the DCI is based on a DCI format different from DCI format 1_1 or DCI format 0_1.

[438] Clause 16. The method of any one of clauses 1 – 15, wherein switching from the first BWP to the second BWP comprises deactivating the first BWP during a first time duration that is at least partially overlapped with a second time duration of activating the second BWP.

[439] Clause 17. The method of any one of clauses 1 – 16, wherein activating the first BWP is based on receiving at least one of: a first command indicating activation of the cell; or a second command indicating switching an active BWP to the first BWP.

[440] Clause 18. The method of clause 17, wherein the first command and the second command each comprises at least one of: a radio resource control message; a medium access control control element; or second downlink control information.

[441] Clause 19. A computing device comprising: one or more processors; and memory storing instructions that, when executed, cause the computing device to perform the method of any one of clauses 1 – 18.

[442] Clause 20. A system comprising: a first computing device configured to perform the method of any one of clauses 1 – 18; and a second computing device configured to send the DCI.

[443] Clause 21. A computer-readable medium storing instructions that, when executed, cause the performance of the method of any one of clauses 1 – 18.

[444] Clause 22. A method comprising activating, by a wireless device, a first bandwidth part (BWP) of a cell as a primary active BWP and a second BWP of the cell as a secondary active BWP.

[445] Clause 23. The method of clause 22, further comprising receiving, via the first BWP, downlink control information (DCI) indicating a third BWP of the cell.

[446] Clause 24. The method of any one of clauses 22 – 23, further comprising based on the first BWP being the primary active BWP and based on the DCI: maintaining the first BWP as the primary active BWP; and switching from the second BWP to the third BWP as the secondary active BWP.

[447] Clause 25. The method of any one of clauses 22 – 24, further comprising receiving one or more messages comprising configuration parameters of bandwidth parts (BWPs) of the cell, wherein the BWPs comprise the first BWP and the second BWP.

[448] Clause 26. The method of any one of clauses 22 – 25, wherein switching from the second BWP to the third BWP is further based on a value of a field of the DCI.

[449] Clause 27. The method of any one of clauses 22 – 26, further comprising receiving, via the first BWP, second DCI comprising a first field and a second field, wherein the first field indicates the third BWP and the second field indicates a first value.

[450] Clause 28. The method of any one of clauses 22 – 27, further comprising based on the first field indicating the third BWP and on the second field indicating the first value: maintaining the first BWP as an active BWP; and deactivating the third BWP.

[451] Clause 29. The method of any one of clauses 22 – 28, further comprising receiving information indicating that the first BWP is configured as the primary active BWP of the cell.

[452] Clause 30. The method of any one of clauses 22 – 29, further comprising determining, based on a value of a field of the DCI, whether to activate the third BWP or to switch from the second BWP to the third BWP.

[453] Clause 31. The method of any one of clauses 22 – 30, further comprising receiving a media access control control element (MAC CE) associated with a BWP activation.

[454] Clause 32. The method of any one of clauses 22 – 31, further comprising activating or deactivating, based on the MAC CE, a plurality of BWPs associated with the MAC CE.

[455] Clause 33. A computing device comprising: one or more processors; and memory storing instructions that, when executed, cause the computing device to perform the method of any one of clauses 22 – 32.

[456] Clause 34. A system comprising: a first computing device configured to perform the method of any one of clauses 22 – 32; and a second computing device configured to send the DCI.

[457] Clause 35. A computer-readable medium storing instructions that, when executed, cause the performance of the method of any one of clauses 22 – 32.

[458] Clause 36. A method comprising activating, by a wireless device, a first bandwidth part (BWP) of a cell and a second BWP of the cell.

[459] Clause 37. The method of clause 36, further comprising receiving, via the first BWP, downlink control information (DCI) comprising a first field and a second field, wherein the first field indicates the second BWP and the second field indicates a first value.

[460] Clause 38. The method of any one of clauses 36 – 37, further comprising based on the first field indicating the second BWP and on the second field indicating the first value: maintaining the first BWP as an active BWP; and deactivating the second BWP.

[461] Clause 39. The method of any one of clauses 36 – 38, wherein the first BWP is activated as a primary active BWP, and wherein the second BWP is activated as a secondary active BWP.

[462] Clause 40. The method of clause 39, further comprising receiving information indicating that the first BWP is configured as the primary active BWP of the cell.

[463] Clause 41. The method of any one of clauses 36 – 40, further comprising receiving, via the first BWP, second DCI comprising a third field and a fourth field, wherein the third field indicates a third BWP and the fourth field indicates a second value.

[464] Clause 42. The method of any one of clauses 36 – 41, further comprising based on the third field indicating the third BWP and the fourth field indicating the second value: switching from the first BWP to the third BWP; or activating the third BWP while maintaining an active state of the first BWP.

[465] Clause 43. The method of any one of clauses 36 – 42, further comprising receiving a media access control control element (MAC CE) associated with a BWP activation.

[466] Clause 44. The method of any one of clauses 36 – 43, further comprising activating or deactivating, based on the MAC CE, a plurality of bandwidth parts (BWPs) associated with the MAC CE.

[467] Clause 45. A computing device comprising: one or more processors; and memory storing instructions that, when executed, cause the computing device to perform the method of any one of clauses 36 – 44.

[468] Clause 46. A system comprising: a first computing device configured to perform the method of any one of clauses 36 – 44; and a second computing device configured to send the DCI.

[469] Clause 47. A computer-readable medium storing instructions that, when executed, cause the performance of the method of any one of clauses 36 – 44.

[470] Clause 48. A method comprising activating, by a wireless device, a first bandwidth part (BWP) of a cell and a second BWP of the cell.

[471] Clause 49. The method of clause 48, further comprising receiving, via the first BWP, a first downlink signal in a first slot.

[472] Clause 50. The method of any one of clauses 48 – 49, further comprising switching, based on a time period of inactivity after the first slot, from the first BWP to a default BWP of the cell as an active BWP of the cell.

[473] Clause 51. The method of any one of clauses 48 – 50, further comprising deactivating, based on the switching from the first BWP to the default BWP, the second BWP.

[474] Clause 52. The method of any one of clauses 48 – 51, further comprising monitoring a downlink control channel on the first BWP for downlink control information (DCI).

[475] Clause 53. The method of any one of clauses 48 – 52, wherein the switching from the first BWP to the default BWP is further based on a determination that the DCI is not received during the monitoring.

[476] Clause 54. The method of any one of clauses 48 – 53, further comprising switching from the default BWP to a third BWP of the cell as the active BWP.

[477] Clause 55. The method of any one of clauses 48 – 54, further comprising starting, based on receiving a second downlink signal via the third BWP, a BWP inactivity timer.

[478] Clause 56. The method of any one of clauses 48 – 55, further comprising receiving, via the third BWP, a third downlink signal indicating at least one of: activating a fourth BWP of the cell; deactivating the fourth BWP of the cell; switching from the fourth BWP to a fifth BWP as a second active BWP; or allocating radio resources for the fourth BWP.

[479] Clause 57. The method of any one of clauses 48 – 56, further comprising restarting, based on the third downlink signal, the BWP inactivity timer.

[480] Clause 58. The method of any one of clauses 54 – 57, wherein the third BWP and the first BWP are a same active BWP of the cell.

[481] Clause 59. The method of any one of clauses 48 – 58, wherein the time period of inactivity comprises a duration of time that a BWP inactivity timer is running.

[482] Clause 60. The method of any one of clauses 48 – 59, wherein the default BWP is different from the first BWP and the second BWP.

[483] Clause 61. The method of any one of clauses 48 – 60, wherein the cell comprises a primary cell or a secondary cell.

[484] Clause 62. The method of any one of clauses 48 – 61, wherein the first BWP is a primary BWP.

[485] Clause 63. The method of any one of clauses 48 – 62, wherein the second BWP is a secondary BWP.

[486] Clause 64. The method of any one of clauses 48 – 63, wherein the switching from the first BWP to the default BWP comprises: deactivating the first BWP; and activating the default BWP as the active BWP.

[487] Clause 65. The method of any one of clauses 48 – 64, wherein the activating the first BWP and the second BWP comprises activating the first BWP during a first time interval.

[488] Clause 66. The method of any one of clauses 48 – 65, wherein the activating the first BWP and the second BWP comprises activating the second BWP during a second time interval.

[489] Clause 67. A computing device comprising: one or more processors; and memory storing instructions that, when executed, cause the computing device to perform the method of any one of clauses 48 – 66.

[490] Clause 68. A system comprising: a first computing device configured to perform the method of any one of clauses 48 – 66; and a second computing device configured to send the first downlink signal.

[491] Clause 69. A computer-readable medium storing instructions that, when executed, cause the performance of the method of any one of clauses 48 – 66.

[492] FIG. 50 shows example elements of a computing device that may be used to implement any of the various devices described herein, including, e.g., the base station 120A and/or 120B, the wireless device 110 (e.g., 110A and/or 110B), or any other base station, wireless device, or computing device described herein. The computing device 5000 may include one or more processors 5001, which may execute instructions stored in the random access memory (RAM) 5003, the removable media 5004 (such as a Universal Serial Bus (USB) drive, compact disk (CD) or digital versatile disk (DVD), or floppy disk drive), or any other desired storage medium. Instructions may also be stored in an attached (or internal) hard drive 5005. The computing device 5000 may also include a security processor (not shown), which may execute instructions of one or more computer programs to monitor the processes executing on the processor 5001 and any process that requests access to any hardware and/or software components of the computing device 5000 (e.g., ROM 5002, RAM 5003, the removable media 5004, the hard drive 5005, the device controller 5007, a network interface 5009, a GPS 5011, a Bluetooth interface 5012, a WiFi interface 5013, etc.). The computing device 5000 may include one or more output devices, such as the display 5006 (e.g., a screen, a display device, a monitor, a television, etc.), and may include one or more output device controllers 5007, such as a video processor. There may also be one or more user input devices 5008, such as a remote control, keyboard, mouse, touch screen, microphone, etc. The computing device 5000 may also include one or more network interfaces, such as a network interface 5009, which may be a wired interface, a wireless interface, or a combination of the two. The

network interface 5009 may provide an interface for the computing device 5000 to communicate with a network 5010 (e.g., a RAN, or any other network). The network interface 5009 may include a modem (e.g., a cable modem), and the external network 5010 may include communication links, an external network, an in-home network, a provider's wireless, coaxial, fiber, or hybrid fiber/coaxial distribution system (e.g., a DOCSIS network), or any other desired network. Additionally, the computing device 5000 may include a location-detecting device, such as a global positioning system (GPS) microprocessor 5011, which may be configured to receive and process global positioning signals and determine, with possible assistance from an external server and antenna, a geographic position of the computing device 5000.

[493] The example in FIG. 50 may be a hardware configuration, although the components shown may be implemented as software as well. Modifications may be made to add, remove, combine, divide, etc. components of the computing device 5000 as desired. Additionally, the components may be implemented using basic computing devices and components, and the same components (e.g., processor 5001, ROM storage 5002, display 5006, etc.) may be used to implement any of the other computing devices and components described herein. For example, the various components described herein may be implemented using computing devices having components such as a processor executing computer-executable instructions stored on a computer-readable medium, as shown in FIG. 50. Some or all of the entities described herein may be software based, and may co-exist in a common physical platform (e.g., a requesting entity may be a separate software process and program from a dependent entity, both of which may be executed as software on a common computing device).

[494] The disclosed mechanisms herein may be performed if certain criteria are met, for example, in a wireless device, a base station, a radio environment, a network, a combination of the above, and/or the like. Example criteria may be based on, for example, wireless device and/or network node configurations, traffic load, initial system set up, packet sizes, traffic characteristics, a combination of the above, and/or the like. If the one or more criteria are met, various examples may be used. It may be possible to implement examples that selectively implement disclosed protocols.

[495] A base station may communicate with a mix of wireless devices. Wireless devices and/or base stations may support multiple technologies, and/or multiple releases of the same technology. Wireless devices may have some specific capability(ies) depending on wireless device category and/or capability(ies). A base station may comprise multiple sectors. A base station communicating with a plurality of wireless devices may refer to base station communicating with a subset of the total wireless devices in a coverage area. Wireless devices referred to herein may correspond to a plurality of wireless devices of a particular LTE or 5G release with a given capability and in a given sector of a base station. A plurality of wireless devices may refer to a selected plurality of wireless devices, and/or a subset of total wireless devices in a coverage area. Such devices may operate, function, and/or perform based on or according to drawings and/or descriptions herein, and/or the like. There may be a plurality of base stations or a plurality of wireless devices in a coverage area that may not comply with the disclosed methods, for example, because those wireless devices and/or base stations perform based on older releases of LTE or 5G technology.

[496] One or more features described herein may be implemented in a computer-usable data and/or computer-executable instructions, such as in one or more program modules, executed by one or more computers or other devices. Generally, program modules include routines, programs, objects, components, data structures, etc. that perform particular tasks or implement particular abstract data types when executed by a processor in a computer or other data processing device. The computer executable instructions may be stored on one or more computer readable media such as a hard disk, optical disk, removable storage media, solid state memory, RAM, etc. The functionality of the program modules may be combined or distributed as desired. The functionality may be implemented in whole or in part in firmware or hardware equivalents such as integrated circuits, field programmable gate arrays (FPGA), and the like. Particular data structures may be used to more effectively implement one or more features described herein, and such data structures are contemplated within the scope of computer executable instructions and computer-usable data described herein.

[497] Many of the elements in examples may be implemented as modules. A module may be an isolatable element that performs a defined function and has a defined interface to other elements. The modules may be implemented in hardware, software in combination with hardware, firmware, wetware (i.e., hardware with a biological element) or a combination thereof, all of which may be behaviorally equivalent. For example, modules may be implemented as a software routine written in a computer language configured to be executed by a hardware machine (such as C, C++, Fortran, Java, Basic, Matlab or the like) or a modeling/simulation program such as Simulink, Stateflow, GNU Octave, or LabVIEWMathScript. Additionally or alternatively, it may be possible to implement modules using physical hardware that incorporates discrete or programmable analog, digital and/or quantum hardware. Examples of programmable hardware may comprise: computers, microcontrollers, microprocessors, application-specific integrated circuits (ASICs); field programmable gate arrays (FPGAs); and complex programmable logic devices (CPLDs). Computers, microcontrollers, and microprocessors may be programmed using languages such as assembly, C, C++ or the like. FPGAs, ASICs, and CPLDs may be programmed using hardware description languages (HDL), such as VHSIC hardware description language (VHDL) or Verilog, which may configure connections between internal hardware modules with lesser functionality on a programmable device. The above-mentioned technologies may be used in combination to achieve the result of a functional module.

[498] A non-transitory tangible computer readable media may comprise instructions executable by one or more processors configured to cause operations of multi-carrier communications described herein. An article of manufacture may comprise a non-transitory tangible computer readable machine-accessible medium having instructions encoded thereon for enabling programmable hardware to cause a device (e.g., a wireless device, wireless communicator, a wireless device, a base station, and the like) to allow operation of multi-carrier communications described herein. The device, or one or more devices such as in a system, may include one or more processors, memory, interfaces, and/or the like. Other examples may comprise communication networks comprising devices such as base stations, wireless devices or user equipment (wireless device),

servers, switches, antennas, and/or the like. A network may comprise any wireless technology, including but not limited to, cellular, wireless, WiFi, 4G, 5G, any generation of 3GPP or other cellular standard or recommendation, wireless local area networks, wireless personal area networks, wireless ad hoc networks, wireless metropolitan area networks, wireless wide area networks, global area networks, space networks, and any other network using wireless communications. Any device (e.g., a wireless device, a base station, or any other device) or combination of devices may be used to perform any combination of one or more of steps described herein, including, for example, any complementary step or steps of one or more of the above steps.

[499] Although examples are described above, features and/or steps of those examples may be combined, divided, omitted, rearranged, revised, and/or augmented in any desired manner. Various alterations, modifications, and improvements will readily occur to those skilled in the art. Such alterations, modifications, and improvements are intended to be part of this description, though not expressly stated herein, and are intended to be within the spirit and scope of the descriptions herein. Accordingly, the foregoing description is by way of example only, and is not limiting.

What is claimed is:

1. A method comprising:

receiving, by a wireless device, one or more messages comprising configuration parameters of bandwidth parts (BWPs) of a cell, wherein the BWPs comprise a first bandwidth part (BWP) and a second BWP;

activating the first BWP as an active BWP of the cell;

receiving, via the first BWP, downlink control information (DCI) comprising a first field and a second field, wherein the first field indicates the second BWP; and

based on a value of the second field and on the first field indicating the second BWP:

switching from the first BWP to the second BWP; or

activating the second BWP and maintaining active states of the first BWP and the second BWP.

2. The method of claim 1, wherein switching from the first BWP to the second BWP is performed based on the value of the second field being set to a first value.

3. The method of claim 1, wherein activating the second BWP and maintaining the active states of the first BWP and the second BWP are performed based on the value of the second field being set to a second value.

4. The method of any one of claims 1 – 3, further comprising:

receiving second DCI comprising a third field and a fourth field, wherein the third field indicates the second BWP; and

deactivating, based on a value of the fourth field and on the third field indicating the second BWP, the second BWP.

5. The method of any one of claims 1 – 4, wherein the configuration parameters indicate at least one of:

a control resource set of the first BWP;

a search space set of the first BWP;

a subcarrier space of the first BWP;

a quantity of symbols of the first BWP; or

a set of resource blocks of the first BWP.

6. The method of any one of claims 1 – 5, further comprising based on the active state of the first BWP:

monitoring a downlink control channel on a search space set associated the first BWP;

determining, based on the monitoring, a downlink radio resource assignment; and

receiving, based on the downlink radio resource assignment, a downlink transport block.

7. The method of any one of claims 1 – 6, wherein the second field comprises a time resource allocation indicator or a frequency resource allocation indicator.

8. The method of any one of claims 1 – 7, wherein the second field comprises a BWP action indicator comprising a value that indicates at least one of:

switching an active BWP from the first BWP to the second BWP; or

activating the second BWP and maintaining the active states of the first BWP and the second BWP.

9. The method of any one of claims 1 – 8, wherein the DCI is based on a DCI format different from DCI format 1_1 or DCI format 0_1.

10. The method of any one of claims 1 – 9, wherein switching from the first BWP to the second BWP comprises:

deactivating the first BWP during a first time duration that is at least partially overlapped with a second time duration of activating the second BWP.

11. The method of any one of claims 1 – 10, wherein activating the first BWP is based on receiving at least one of:

a first command indicating activation of the cell; or

a second command indicating switching an active BWP to the first BWP.

12. The method of claim 11, wherein the first command and the second command each comprises at least one of:

a radio resource control message;

a medium access control control element; or

second downlink control information.

13. The method of any one of claims 1 – 12, wherein the cell comprises a primary cell or a secondary cell.

14. The method of claim any one of claims 1 – 13, further comprising based on the active state of the first BWP:

monitoring a downlink control channel on a search space set associated the first BWP;

determining, based on the monitoring, an uplink radio resource grant; and

transmitting, based on the uplink radio resource grant, an uplink transport block.

15. The method of claim any one of claims 1 – 14, further comprising based on the active state of the first BWP:

monitoring a downlink control channel associated the first BWP;

receiving one or more downlink signals via the first BWP; and

transmitting one or more uplink signals via the first BWP.

16. The method of any one of claims 1 – 8, wherein the DCI is based on DCI format 1_1 or DCI format 0_1.

17. The method of any one of claims 1 – 16, further comprising monitoring, on the first BWP, a downlink control channel for the DCI.

18. The method of any one of claims 1 – 17, wherein the switching from the first BWP to the second BWP comprises:

deactivating the first BWP; and

activating the second BWP as the active BWP.

19. The method of any one of claims 1 – 9, wherein switching from the first BWP to the second BWP comprises:

activating the second BWP after deactivating the first BWP.

20. The method of any one of claims 1 – 19, further comprising:

deactivating, based on the switching, the first BWP; and

based on an inactive sate the first BWP:

stopping monitoring a downlink control channel on the first BWP;

stopping receiving one or more downlink signals via the first BWP; and

stopping transmitting one or more uplink signals via the first BWP.

21. A computing device comprising:

one or more processors; and

memory storing instructions that, when executed, cause the computing device to perform the method of any one of claims 1 – 20.

22. A system comprising:

a first computing device configured to perform the method of any one of claims 1 – 20; and

a second computing device configured to send the DCI.

23. A computer-readable medium storing instructions that, when executed, cause the performance of the method of any one of claims 1 – 20.

24. A method comprising:

activating, by a wireless device, a first bandwidth part (BWP) of a cell as a primary active BWP and a second BWP of the cell as a secondary active BWP;

receiving, via the first BWP, downlink control information (DCI) indicating a third BWP of the cell; and

based on the first BWP being the primary active BWP and based on the DCI:

maintaining the first BWP as the primary active BWP; and

switching from the second BWP to the third BWP as the secondary active BWP.

25. The method of claim 24, further comprising:

receiving one or more messages comprising configuration parameters of bandwidth parts (BWPs) of the cell, wherein the BWPs comprise the first BWP and the second BWP,

wherein switching from the second BWP to the third BWP is further based on a value of a field of the DCI.

26. The method of any one of claims 24 – 25, further comprising:

receiving, via the first BWP, second DCI comprising a first field and a second field, wherein the first field indicates the third BWP and the second field indicates a first value; and

based on the first field indicating the third BWP and on the second field indicating the first value:

maintaining the first BWP as an active BWP; and

deactivating the third BWP.

27. The method of any one of claims 24 – 26, further comprising receiving information indicating that the first BWP is configured as the primary active BWP of the cell.

28. The method of any one of claims 24 – 27, further comprising:

determining, based on a value of a field of the DCI, whether to activate the third BWP or to switch from the second BWP to the third BWP.

29. The method of any one of claims 24 – 28, further comprising:

receiving a media access control control element (MAC CE) associated with a BWP activation; and

activating or deactivating, based on the MAC CE, a plurality of BWPs associated with the MAC CE.

30. A computing device comprising:

one or more processors; and

memory storing instructions that, when executed, cause the computing device to perform the method of any one of claims 24 – 29.

31. A system comprising:

a first computing device configured to perform the method of any one of claims 24 – 29; and

a second computing device configured to send the DCI.

32. A computer-readable medium storing instructions that, when executed, cause the performance of the method of any one of claims 24 – 29.

33. A method comprising:

activating, by a wireless device, a first bandwidth part (BWP) of a cell and a second BWP of the cell;

receiving, via the first BWP, downlink control information (DCI) comprising a first field and a second field, wherein the first field indicates the second BWP and the second field indicates a first value; and

based on the first field indicating the second BWP and on the second field indicating the first value:

maintaining the first BWP as an active BWP; and

deactivating the second BWP.

34. The method of claim 33, wherein the first BWP is activated as a primary active BWP, and wherein the second BWP is activated as a secondary active BWP.

35. The method of claim 34, further comprising receiving information indicating that the first BWP is configured as the primary active BWP of the cell.

36. The method of any one of claims 33 – 35, further comprising:

receiving, via the first BWP, second DCI comprising a third field and a fourth field, wherein the third field indicates a third BWP and the fourth field indicates a second value; and

based on the third field indicating the third BWP and the fourth field indicating the second value:

switching from the first BWP to the third BWP; or

activating the third BWP while maintaining an active state of the first BWP.

37. The method of any one of claims 33 – 36, further comprising:

receiving a media access control control element (MAC CE) associated with a BWP activation; and

activating or deactivating, based on the MAC CE, a plurality of bandwidth parts (BWPs) associated with the MAC CE.

38. A computing device comprising:

one or more processors; and

memory storing instructions that, when executed, cause the computing device to perform the method of any one of claims 33 – 37.

39. A system comprising:

a first computing device configured to perform the method of any one of claims 33 – 37; and

a second computing device configured to send the DCI.

40. A computer-readable medium storing instructions that, when executed, cause the performance of the method of any one of claims 33 – 37.

41. A method comprising:

receiving, by a wireless device, one or more messages comprising configuration parameters of bandwidth parts (BWPs) of a cell, wherein the BWPs comprise a first bandwidth part (BWP) and a second BWP;

activating the first BWP as an active BWP of the cell;

receiving, via the first BWP, downlink control information (DCI) comprising a first field and a second field, wherein the first field indicates the second BWP; and

based on the first field indicating the second BWP and on a value of the second field:

activating the second BWP; and

maintaining an active state of the first BWP.

42. A computing device comprising:

one or more processors; and

memory storing instructions that, when executed, cause the computing device to perform the method of claim 41.

43. A system comprising:

a first computing device configured to perform the method of claim 41; and

a second computing device configured to send the DCI.

44. A computer-readable medium storing instructions that, when executed, cause the performance of the method of claim 41.

45. A method comprising:

activating, by a wireless device, a first bandwidth part (BWP) of a cell and a second BWP of the cell;

receiving, via the first BWP, a first downlink signal in a first slot;

switching, based on a time period of inactivity after the first slot, from the first BWP to a default BWP of the cell as an active BWP of the cell; and

deactivating, based on the switching from the first BWP to the default BWP, the second BWP.

46. The method of claim 45, further comprising:

monitoring a downlink control channel on the first BWP for downlink control information (DCI), wherein the switching from the first BWP to the default BWP is further based on a determination that the DCI is not received during the monitoring.

47. The method of claim 46, wherein the switching from the first BWP to the default BWP is further based on a determination that an uplink signal is not transmitted, during a time that a BWP inactivity timer is running, via the first BWP.

48. The method of any one of claims 45 – 47, further comprising:

switching from the default BWP to a third BWP of the cell as the active BWP;

starting, based on receiving a second downlink signal via the third BWP, a BWP inactivity timer;

receiving, via the third BWP, a third downlink signal indicating at least one of:

activating a fourth BWP of the cell;

deactivating the fourth BWP of the cell;

switching from the fourth BWP to a fifth BWP as a second active BWP; or

allocating radio resources for the fourth BWP; and

restarting, based on the third downlink signal, the BWP inactivity timer.

49. The method of claim 48, wherein the third BWP and the first BWP are a same active BWP of the cell.

50. The method of any one of claims 45 – 49, wherein the first downlink signal comprises at least one of:

downlink control information; or

a downlink transport block.

51. The method of any one of claims 45 – 50, wherein the time period of inactivity comprises a duration of time that a BWP inactivity timer is running.

52. The method of any one of claims 45 – 51, wherein the default BWP is different from the first BWP and the second BWP.

53. The method of any one of claims 45 – 52, wherein:

the cell comprises a primary cell or a secondary cell;

the first BWP is a primary BWP; and

the second BWP is a secondary BWP.

54. The method of any one of claims 45 – 53, wherein the switching from the first BWP to the default BWP comprises:

deactivating the first BWP; and

activating the default BWP as the active BWP.

55. The method of any one of claims 45 – 54, wherein the activating the first BWP and the second BWP comprises:

activating the first BWP during a first time interval; and

activating the second BWP during a second time interval.

56. The method of any one of claims 45 – 55, further comprising based on deactivating the second BWP:

stopping monitoring a downlink control channel on the second BWP;

stopping receiving one or more downlink signals via the second BWP; and

stopping transmitting one or more uplink signals via the second BWP.

57. The method of any one of claims 45 – 56, wherein the activating the first BWP and the second BWP comprises:

activating the first BWP during a first time interval; and

activating the second BWP during a second time interval at least partially overlapped with the first time interval.

58. The method of any one of claims 45 – 56, wherein the activating the first BWP and the second BWP comprises activating the second BWP after activating the first BWP.

59. The method of any one of claims 45 – 58, further comprising receiving a radio resource control message comprising configuration parameters of the cell, wherein the configuration parameters indicate a value of the time period of inactivity.

60. The method of claim 59, wherein the configuration parameters further indicate at least one of:

a control resource set of the first BWP;

a search space set of the first BWP;

a subcarrier space of the first BWP;

a quantity of symbols of the first BWP; or

a set of resource blocks of the first BWP.

61. The method of any one of claims 45 – 60, wherein the activating the first BWP is based on receiving at least one of:

a first command indicating activation of the cell;

a second command indicating activation of the first BWP; or

a third command indicating switching an active BWP to the first BWP.

62. The method of claim 61, wherein the first command comprises at least one of:

a radio resource control message;

a medium access control control element; or

downlink control information.

63. The method of any one of claims 45 – 60, wherein the activating the second BWP is based on receiving at least one of:

a first command indicating activation of the cell;

a second command indicating activation of the second BWP; or

a third command indicating switching an active BWP to the second BWP.

64. The method of any one of claims 45 – 63, wherein the activating the first BWP and the second BWP further comprises maintaining an inactive state of the default BWP.

65. The method of claim 64, further comprising based on the maintaining an inactive state of the default BWP:

stopping monitoring a downlink control channel on the default BWP;

stopping receiving one or more downlink signals via the default BWP; and

stopping transmitting one or more uplink signals via the default BWP.

66. The method of any one of claims 45 – 65, further comprising based on the activating the first BWP:

monitoring, on the first BWP, a downlink control channel on a search space set in a control resource set for receiving a radio resource assignment; and

receiving or transmitting, based on the radio resource assignment, a transport block.

67. The method of any one of claims 45 – 65, further comprising based on the activating the second BWP:

monitoring, on the second BWP, a downlink control channel on a search space set in a control resource set for receiving a radio resource assignment; and

receiving or transmitting, based on the radio resource assignment, a transport block.

68. A computing device comprising:

one or more processors; and

memory storing instructions that, when executed, cause the computing device to perform the method of any one of claims 45 – 67.

69. A system comprising:

a first computing device configured to perform the method of any one of claims 45 – 67; and

a second computing device configured to send the first downlink signal.

70. A computer-readable medium storing instructions that, when executed, cause the performance of the method of any one of claims 45 – 67.

71. A method comprising:

activating, by a wireless device, a first bandwidth part (BWP) of a cell and a second BWP of the cell;

receiving, via the first BWP, a downlink signal in a first slot;

monitoring a downlink control channel on the first BWP for downlink control information (DCI);

based on determining that the DCI is not received during a time period after the first slot:

switching from the first BWP to a default BWP of the cell as an active BWP of the cell; and

deactivating the second BWP.

72. The method of claim 71, wherein the time period is associated with a duration of time that a BWP inactivity timer is running.

73. The method of any one of claims 71 – 72, further comprising:

switching from the default BWP to a third BWP of the cell as the active BWP;

starting, based on receiving a second downlink signal via the third BWP, a BWP inactivity timer;

receiving, via the third BWP, a third downlink signal indicating at least one of:

activating a fourth BWP of the cell;

deactivating the fourth BWP of the cell;

switching from the fourth BWP to a fifth BWP as a second active BWP; or

allocating radio resources for the fourth BWP; and

restarting, based on the third downlink signal, the BWP inactivity timer.

74. The method of claim 73, wherein the third BWP and the first BWP are a same active BWP of the cell.

75. The method of any one of claims 71 – 74, wherein the default BWP is different from the first BWP and the second BWP.

76. The method of any one of claims 71 – 75, wherein:

the cell comprises a primary cell or a secondary cell;

the first BWP is a primary BWP; and

the second BWP is a secondary BWP.

77. The method of any one of claims 71 – 76, wherein the switching from the first BWP to the default BWP comprises:

deactivating the first BWP; and

activating the default BWP as the active BWP.

78. A computing device comprising:

one or more processors; and

memory storing instructions that, when executed, cause the computing device to perform the method of any one of claims 71 – 77.

79. A system comprising:

a first computing device configured to perform the method of any one of claims 71 – 77; and

a second computing device configured to send the downlink signal.

80. A computer-readable medium storing instructions that, when executed, cause the performance of the method of any one of claims 71 – 77.

81. A method comprising:

activating, by a wireless device, a first bandwidth part (BWP) of a cell as a first active BWP;

starting, based on receiving a first downlink signal via the first BWP, a BWP inactivity timer;

receiving, via the first BWP, a second downlink signal indicating at least one of:

activating a second BWP of the cell;

deactivating the second BWP of the cell;

switching from the second BWP to a third BWP as a second active BWP; or

allocating radio resources for the second BWP; and

restarting, based on the second downlink signal, the BWP inactivity timer.

82. The method of claim 81, further comprising:

monitoring a downlink control channel on the first BWP for downlink control information (DCI); and

switching, based on a determination that the DCI is not received during the monitoring, from the first BWP to a default BWP.

83. The method of any one of claims 81 – 82, further comprising:

activating the second BWP of the cell;

receiving, via the first BWP, a third downlink signal in a first slot;

switching, based on a time period of inactivity after the first slot, from the first BWP to a default BWP of the cell as an active BWP of the cell; and

deactivating, based on the switching from the first BWP to the default BWP, the second BWP.

84. The method of any one of claims 81 – 83, further comprising:

receiving, via the first BWP during a time period that the BWP inactivity timer is running, at least one downlink transport block.

85. A computing device comprising:

one or more processors; and

memory storing instructions that, when executed, cause the computing device to perform the method of any one of claims 81 – 84.

86. A system comprising:

a first computing device configured to perform the method of any one of claims 81 – 84; and

a second computing device configured to send the second downlink signal.

87. A computer-readable medium storing instructions that, when executed, cause the performance of the method of any one of claims 81 – 84.

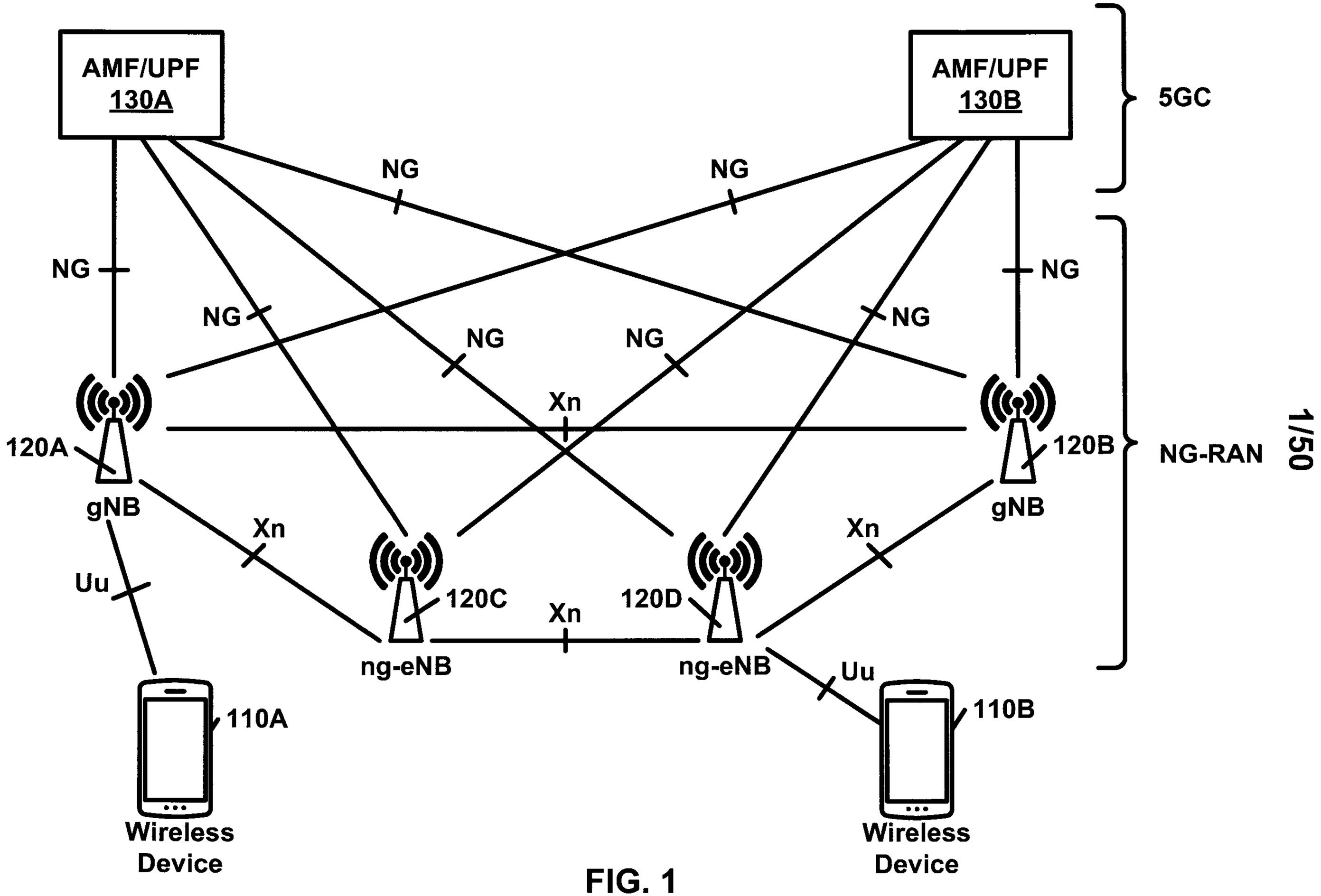
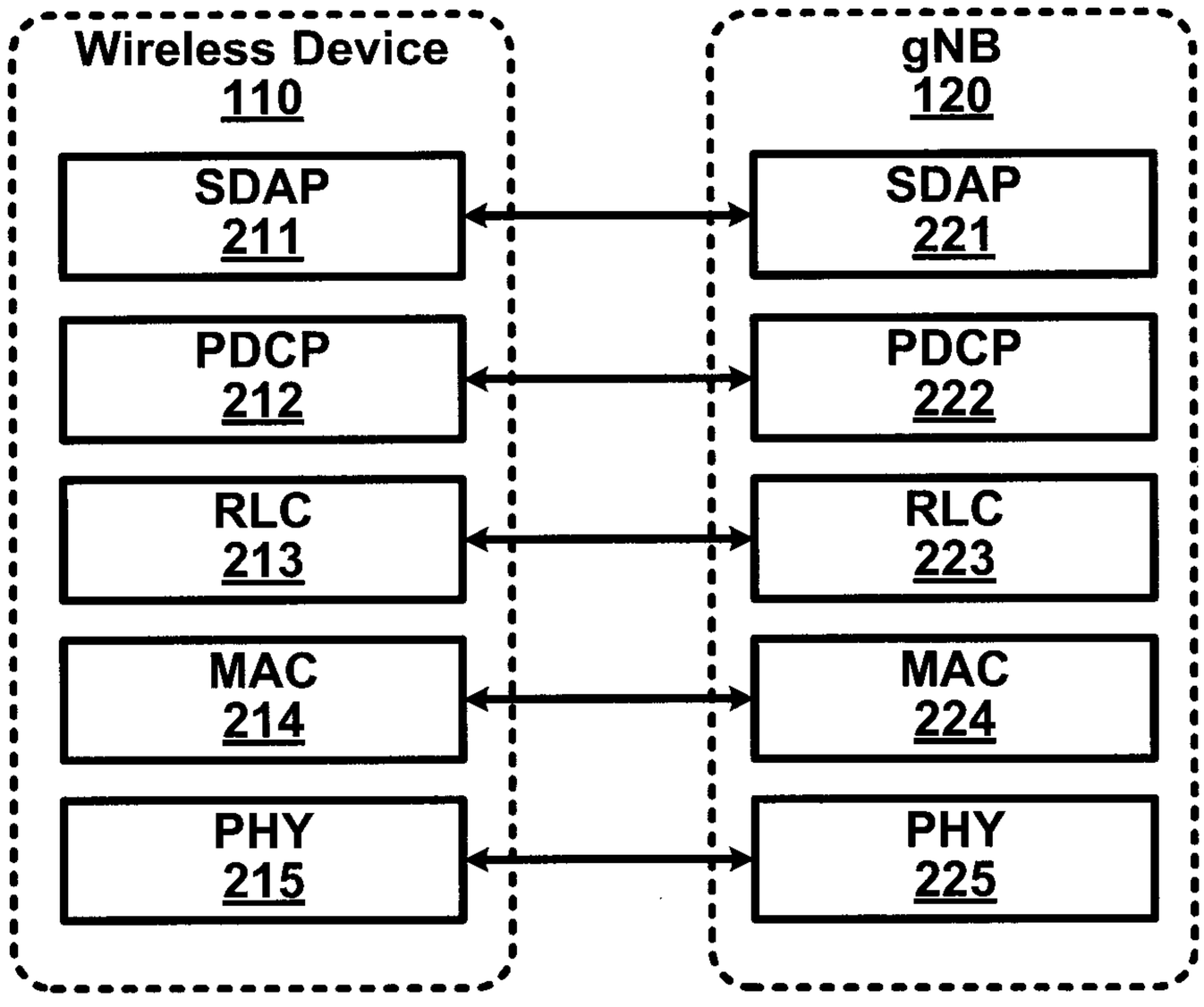
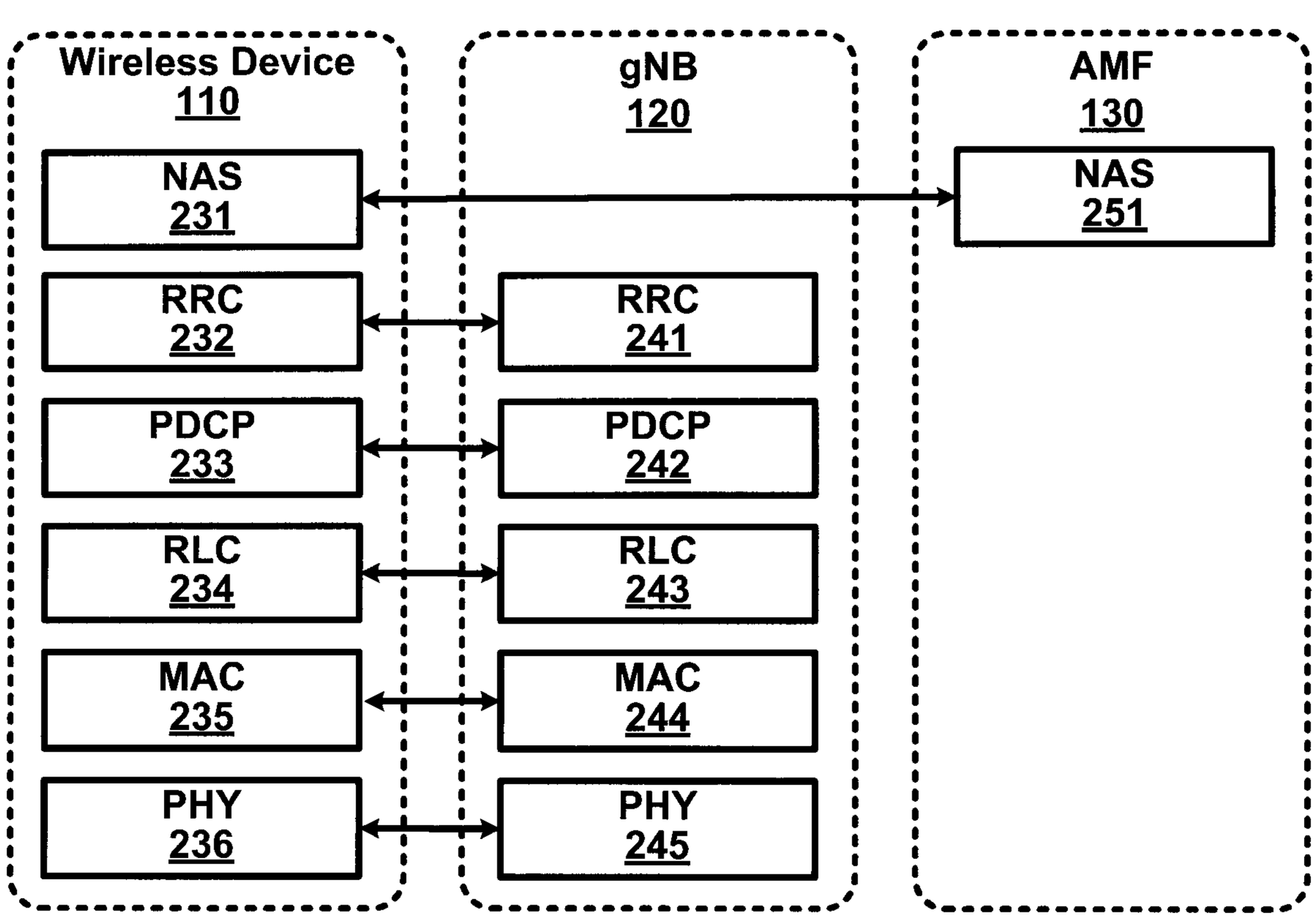

AMF/UPF
130A
AMF/UPF
130B
5GC
NG
NG
NG
NG
NG
NG
NG
NG
Xn
120A
gNB
120B
gNB
NG-RAN
Xn
Xn
Uu
120C
ng-eNB
120D
ng-eNB
Xn
Uu
110A
110B
Wireless
Device
Wireless
Device

FIG. 1




User Plane Protocol Stack

FIG. 2A




Control Plane Protocol Stack

FIG. 2B

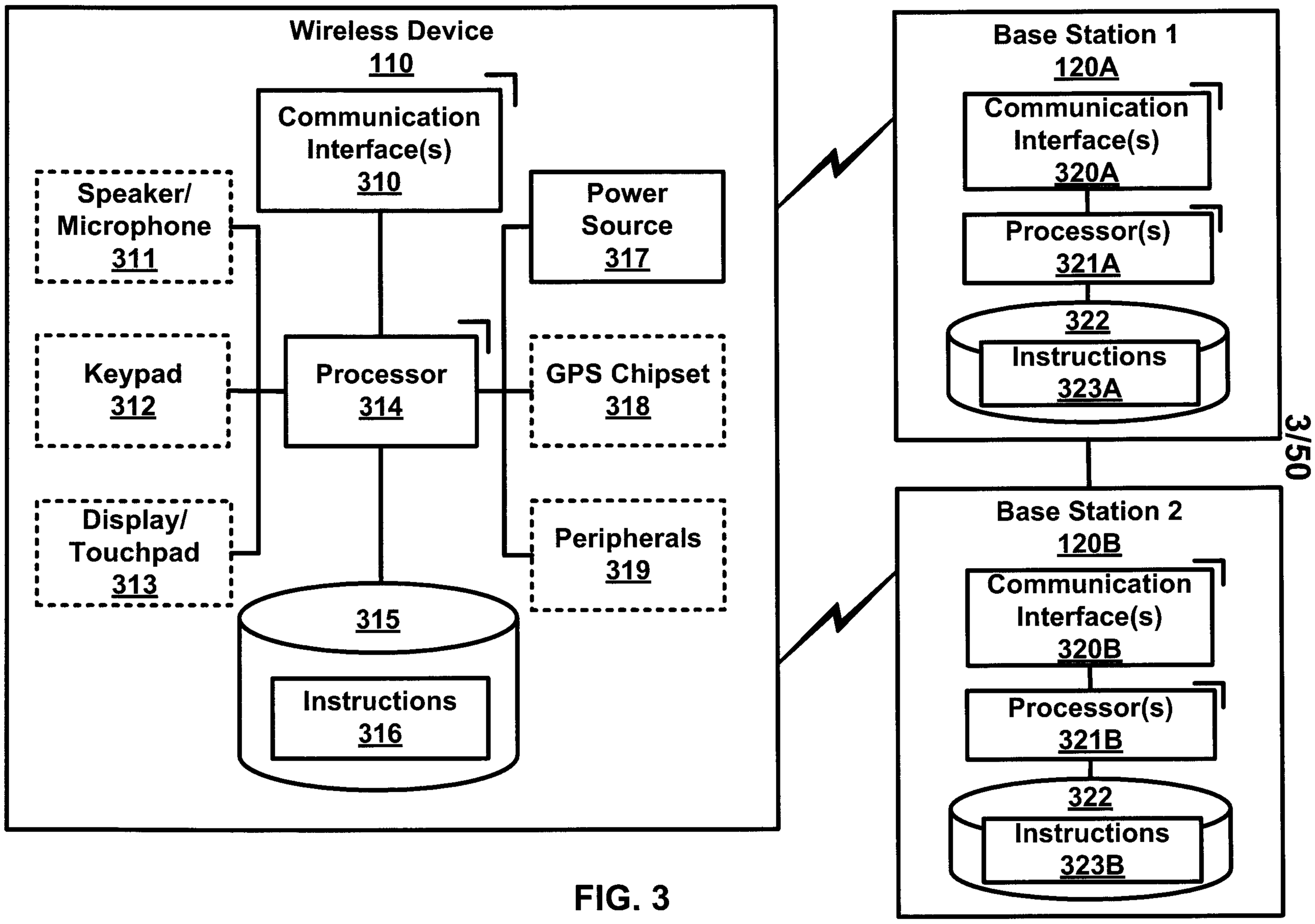

Wireless Device
110
Communication Interface(s)
310
Speaker/ Microphone
311
Power Source
317
Keypad
312
Processor
314
GPS Chipset
318
Display/ Touchpad
313
Peripherals
319
315
Instructions
316
Base Station 1
120A
Communication Interface(s)
320A
Processor(s)
321A
322
Instructions
323A
Base Station 2
120B
Communication Interface(s)
320B
Processor(s)
321B
322
Instructions
323B

FIG. 3

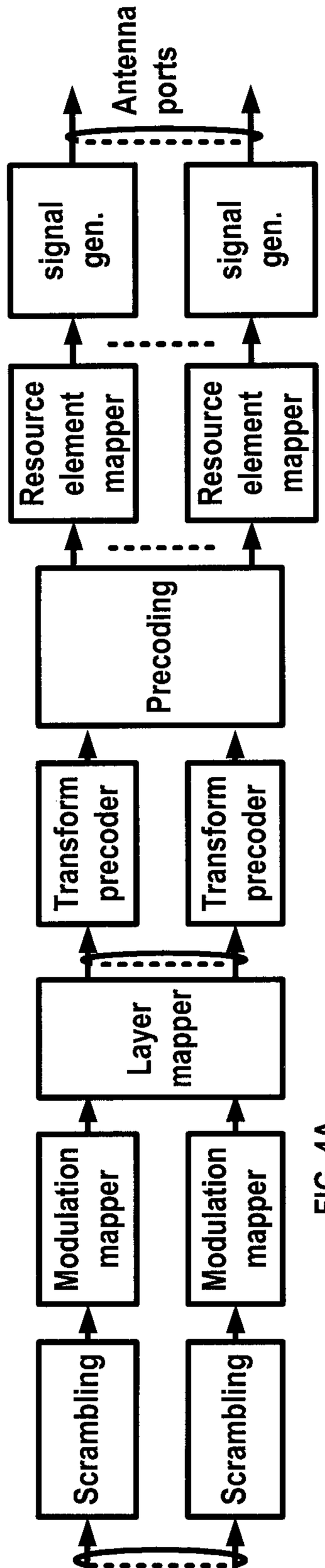



FIG. 4A

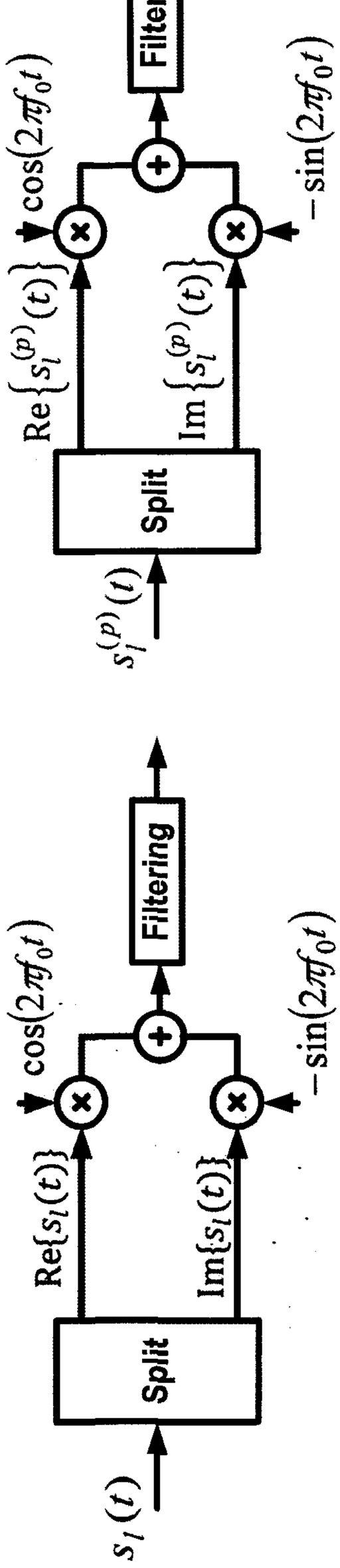



FIG. 4B

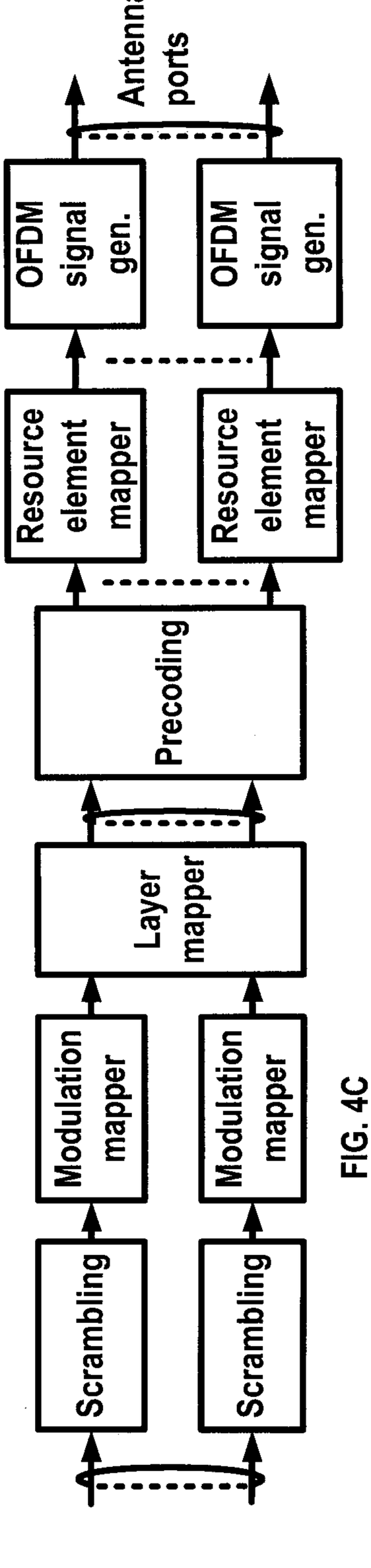



FIG. 4C




FIG. 4D

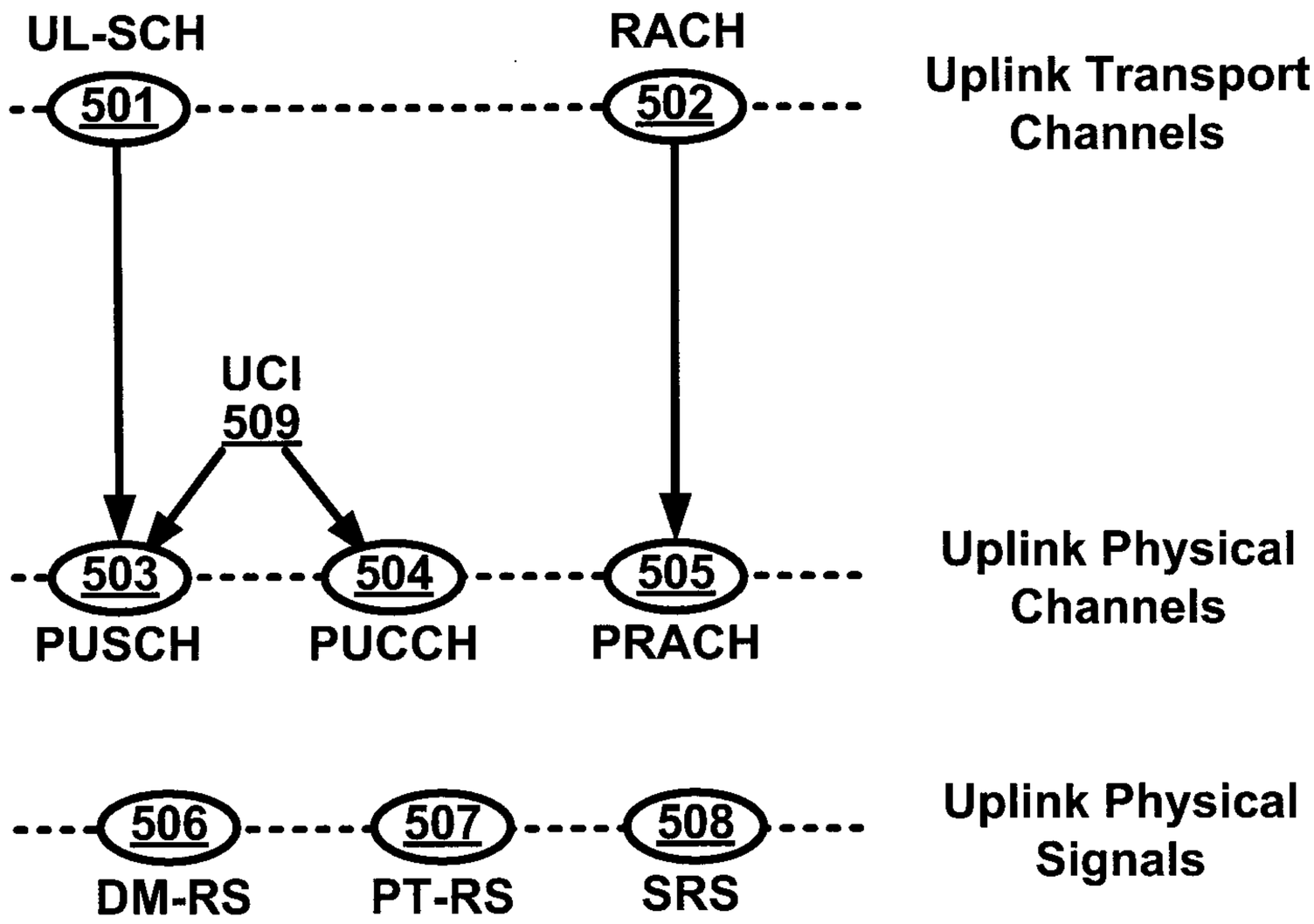

UL-SCH
RACH
Uplink Transport Channels
501
502
UCI
509
503
504
505
PUSCH
PUCCH
PRACH
Uplink Physical Channels
506
507
508
DM-RS
PT-RS
SRS
Uplink Physical Signals

FIG. 5A

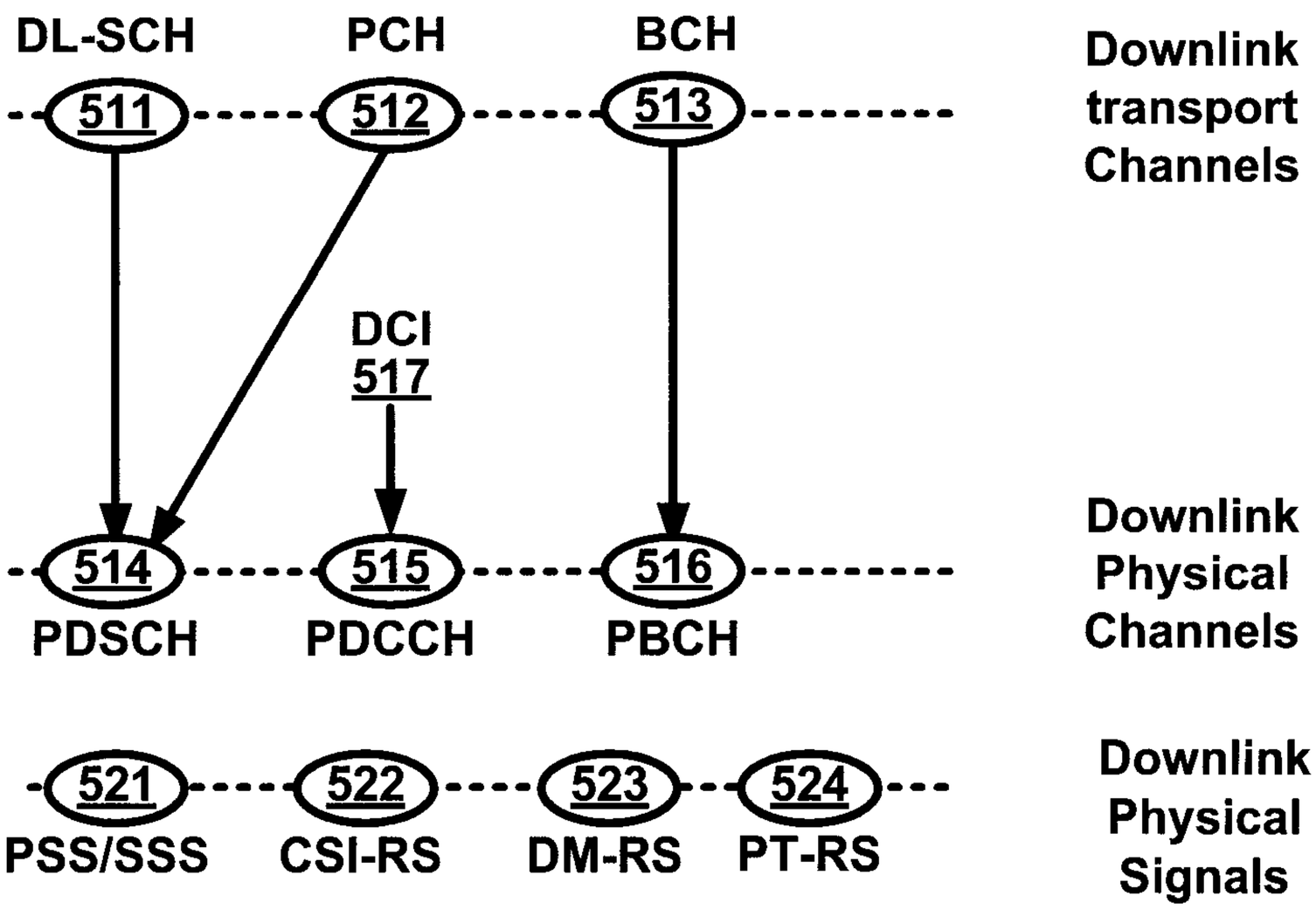

DL-SCH
PCH
BCH
Downlink transport Channels
511
512
513
DCI
517
514
515
516
PDSCH
PDCCH
PBCH
Downlink Physical Channels
521
522
523
524
PSS/SSS
CSI-RS
DM-RS
PT-RS
Downlink Physical Signals

FIG. 5B

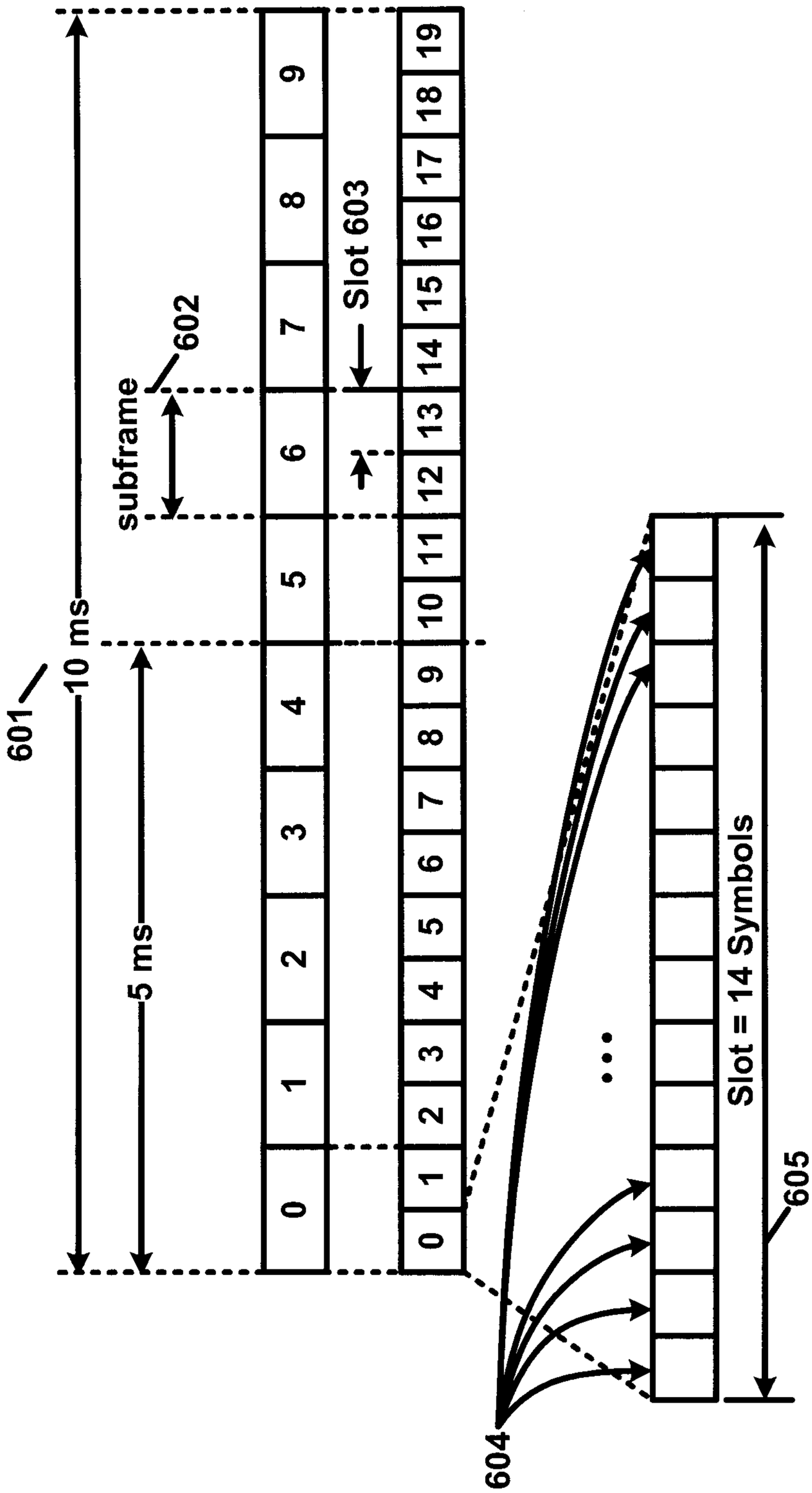

601
10 ms
5 ms
subframe
602
Slot 603
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
Slot = 14 Symbols
605
604

FIG. 6

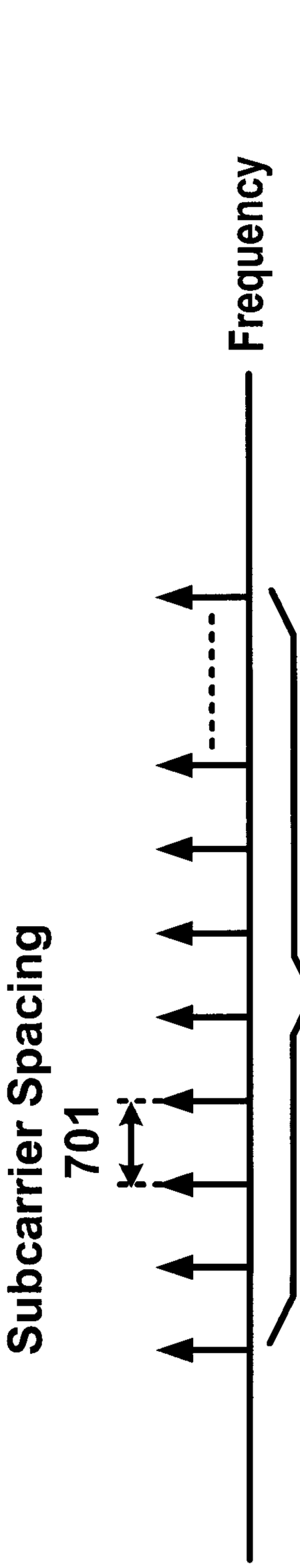

Frequency
Subcarrier Spacing
701
Subcarriers of OFDM symbol
702

FIG. 7A

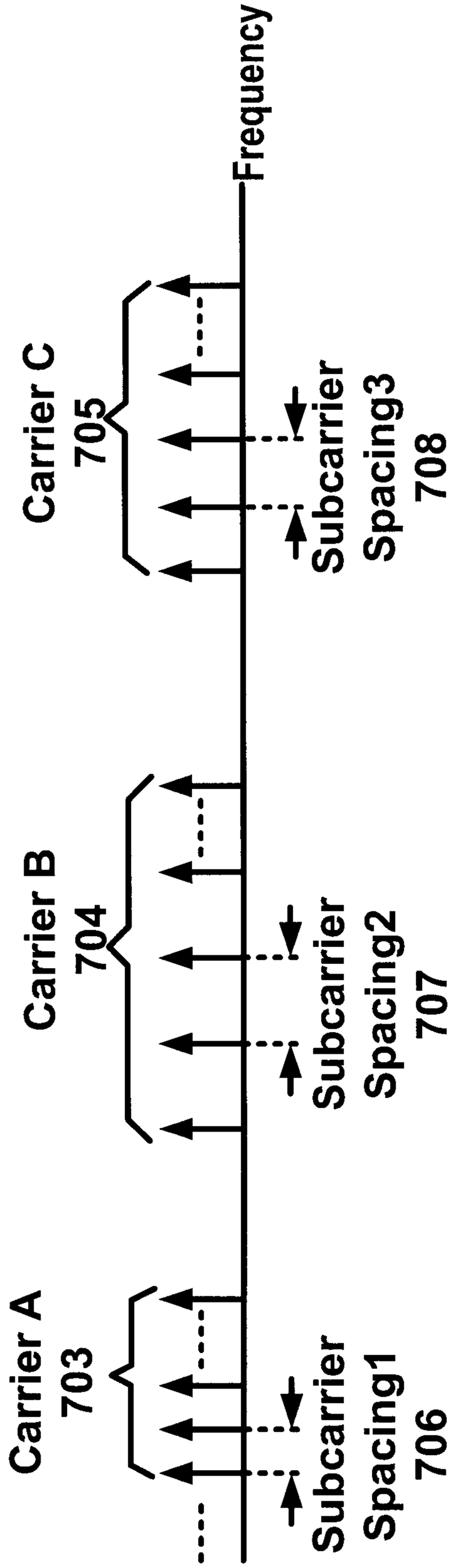

Frequency
Carrier C
705
Subcarrier
Spacing3
708
Carrier B
704
Subcarrier
Spacing2
707
Carrier A
703
Subcarrier
Spacing1
706

FIG. 7B

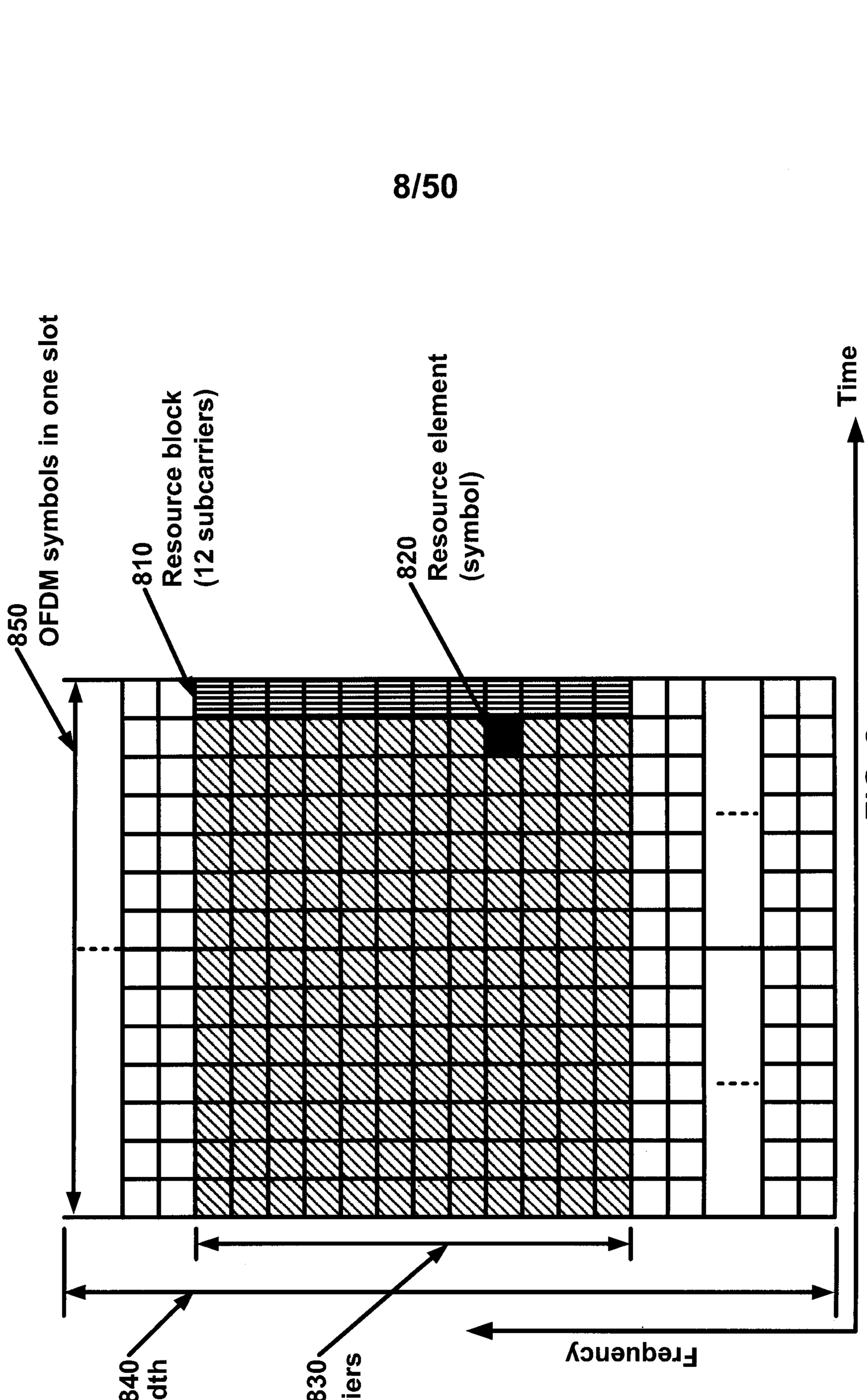

850
OFDM symbols in one slot
810
Resource block
(12 subcarriers)
820
Resource element
(symbol)
Time
840
Bandwidth
830
12 subcarriers
Frequency

FIG. 8

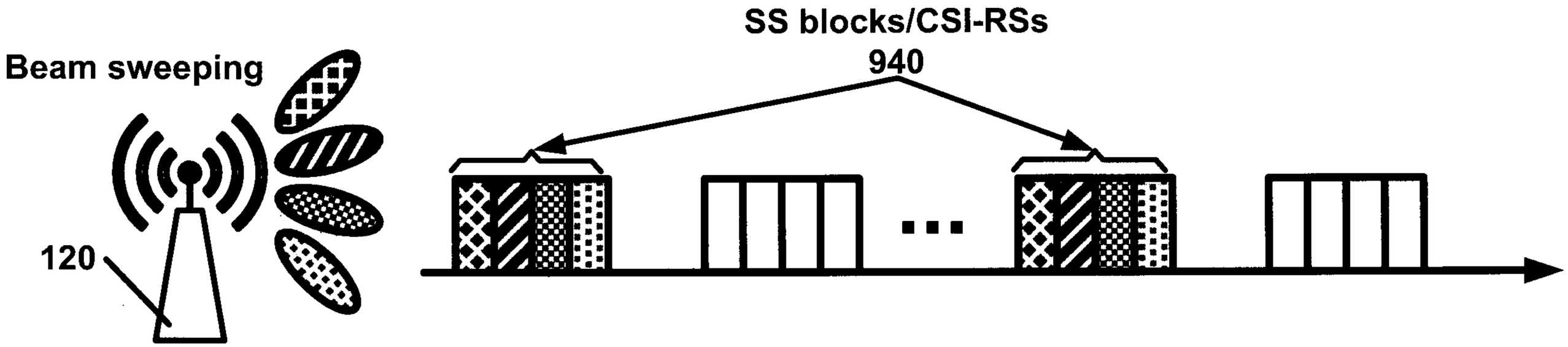

Beam sweeping
120
SS blocks/CSI-RSs
940

FIG. 9A

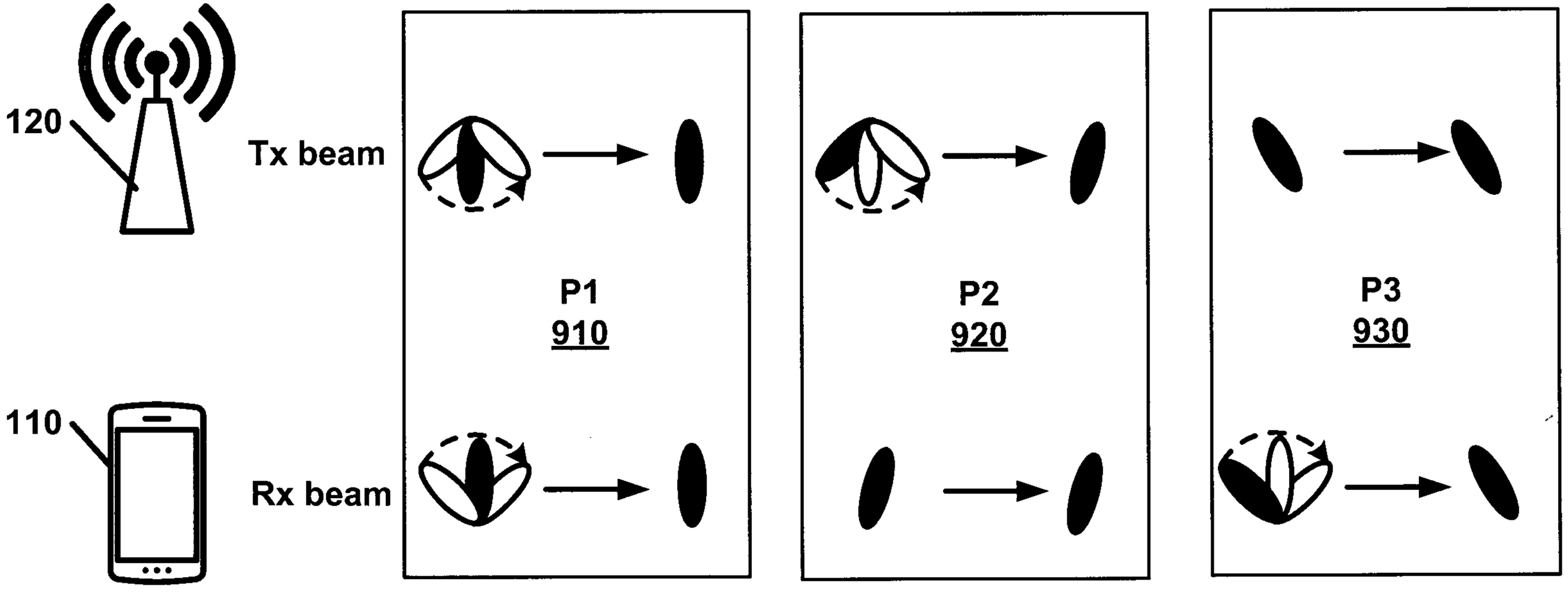

120
Tx beam
P1
910
P2
920
P3
930
110
Rx beam

FIG. 9B

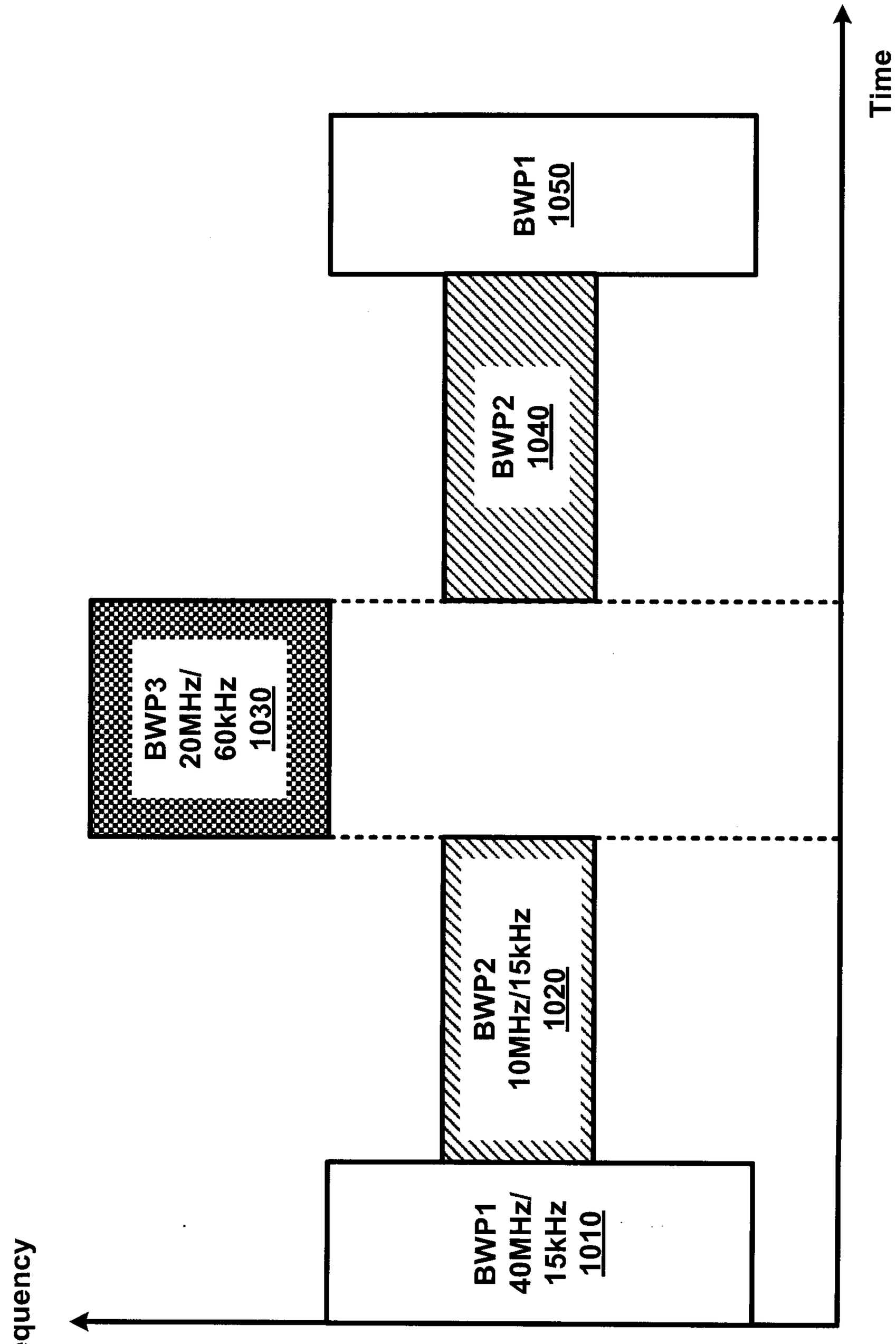

Time
BWP1
1050
BWP2
1040
BWP3
20MHz/
60kHz
1030
BWP2
10MHz/15kHz
1020
BWP1
40MHz/
15kHz
1010
Frequency

FIG. 10

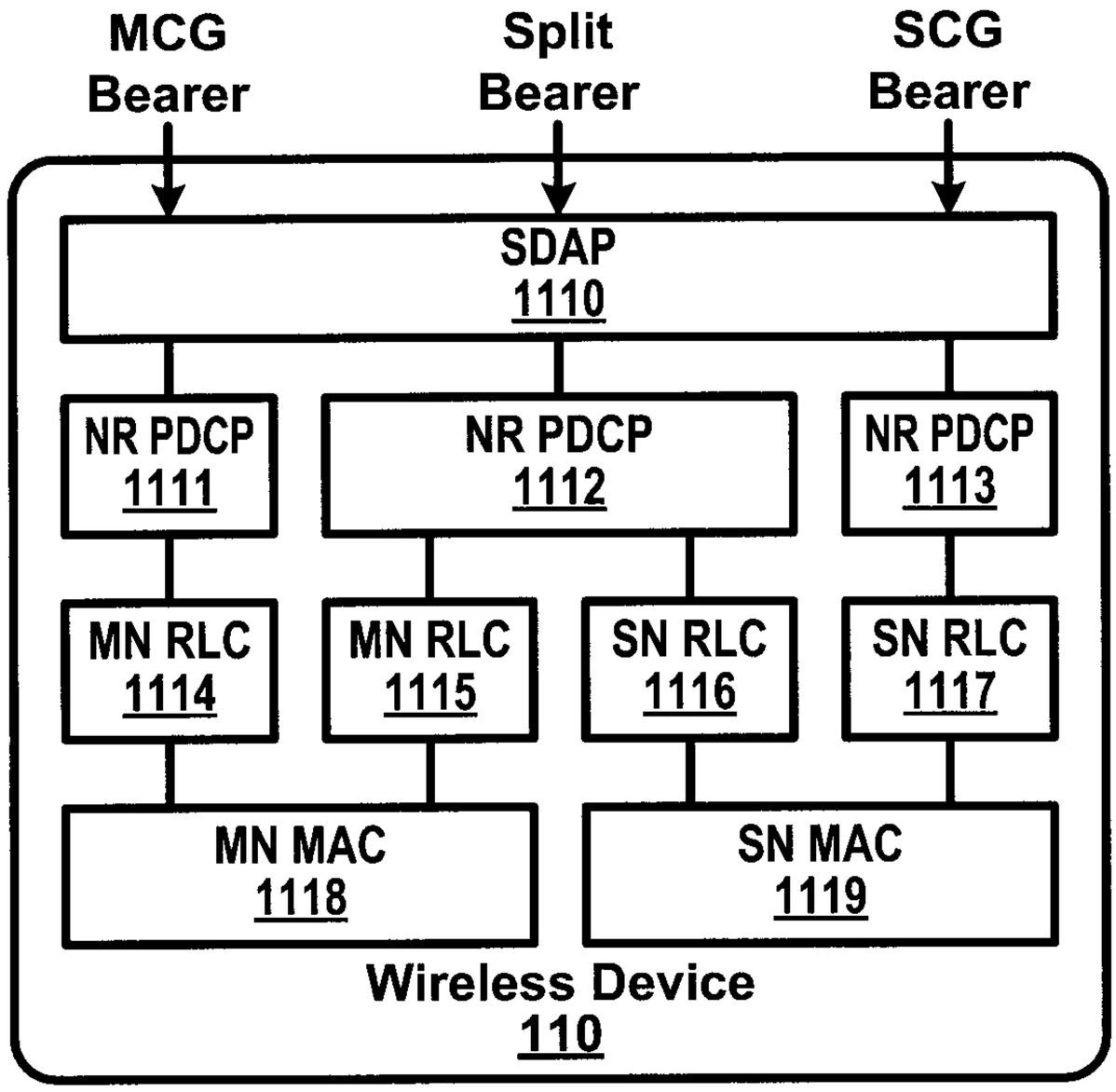



FIG. 11A

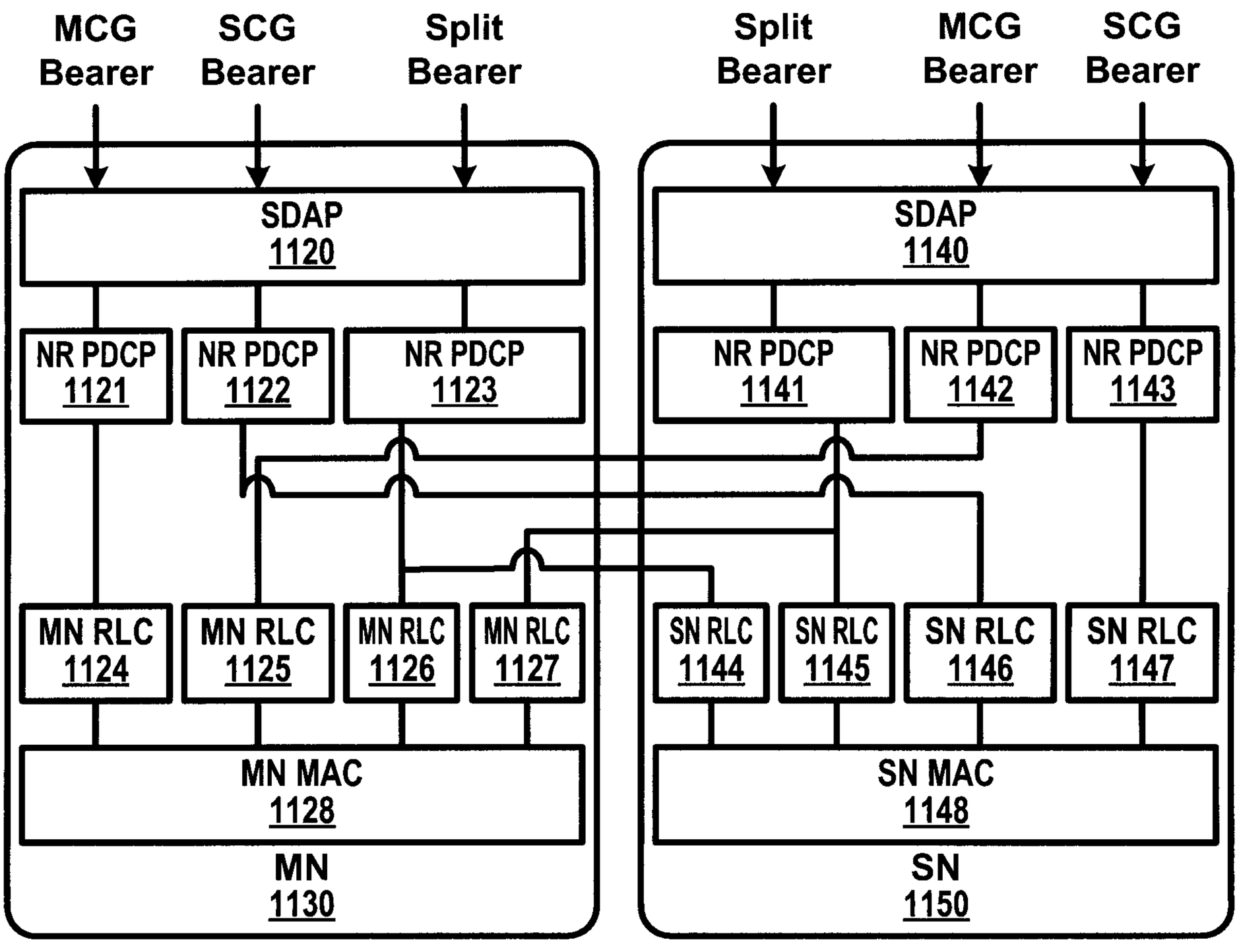



FIG. 11B

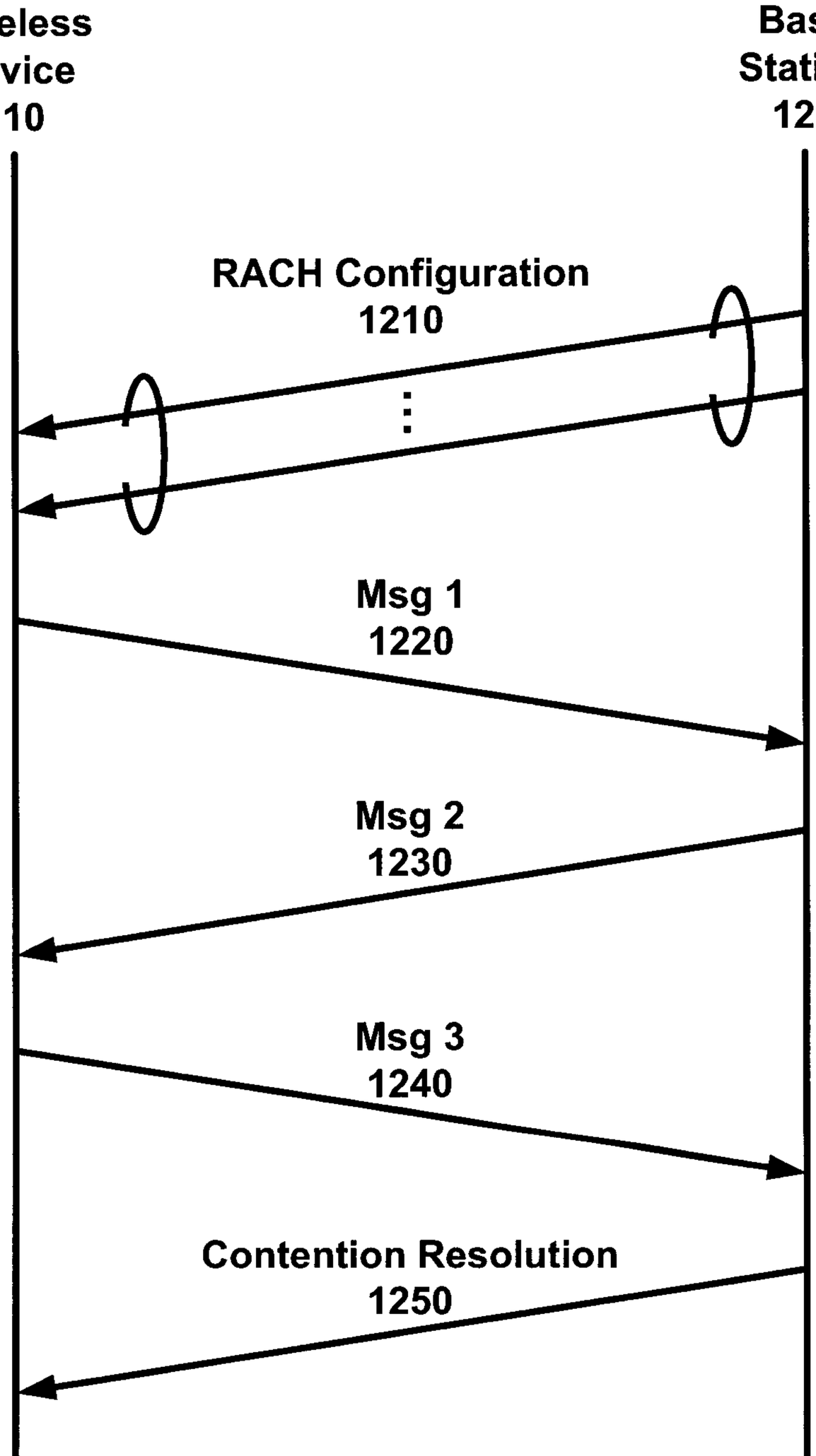

Wireless Device 110
Base Station 120
RACH Configuration 1210
Msg 1 1220
Msg 2 1230
Msg 3 1240
Contention Resolution 1250

FIG. 12

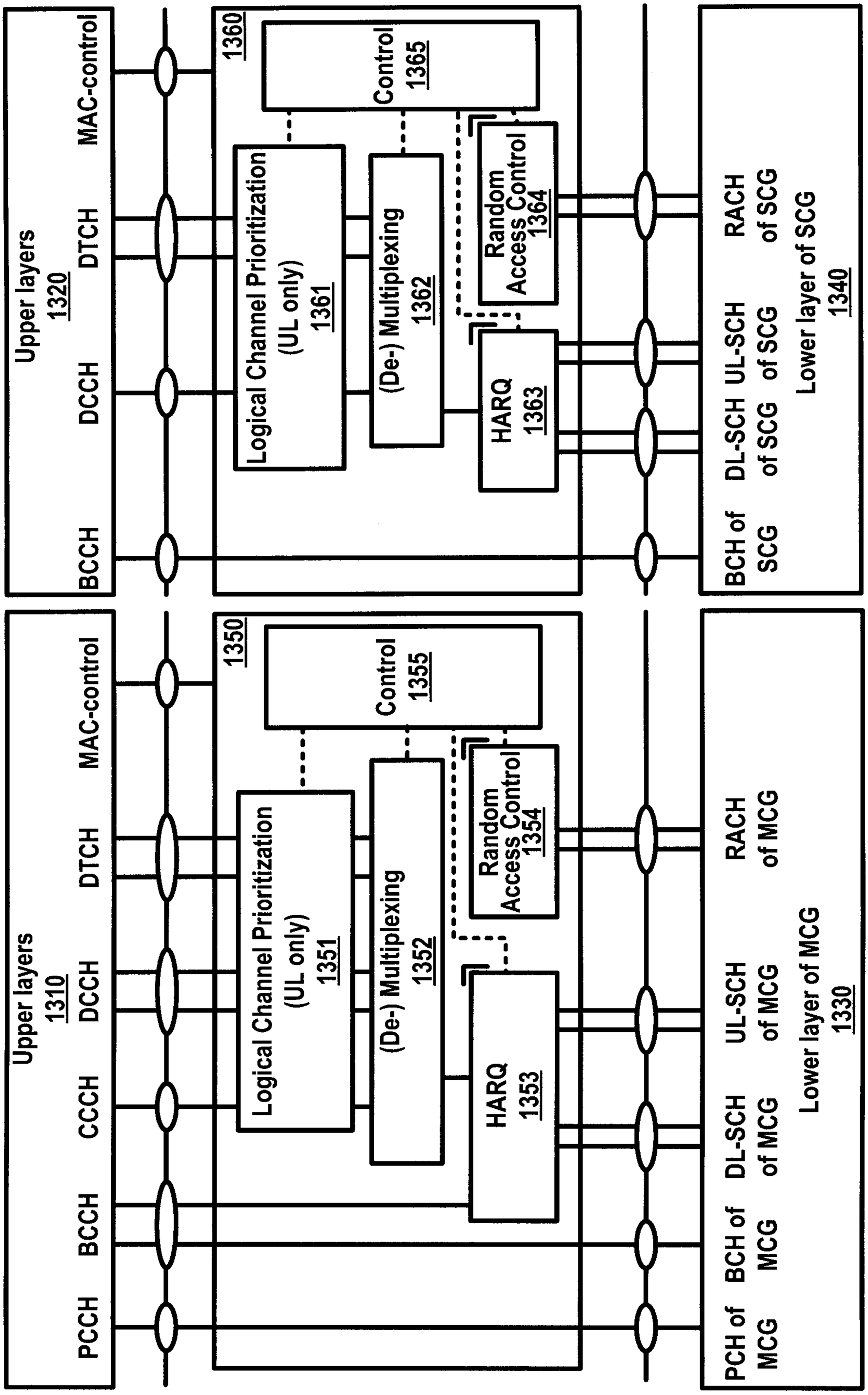

MAC-control
1360
Control
1365
Upper layers
1320
DTCH
DCCH
BCCH
Logical Channel Prioritization
(UL only)
1361
(De-) Multiplexing
1362
HARQ
1363
Random
Access Control
1364
BCH of SCG
DL-SCH of SCG
UL-SCH of SCG
RACH of SCG
Lower layer of SCG
1340
1350
Control
1355
Upper layers
1310
CCCH
DCCH
DTCH
MAC-control
BCCH
PCCH
Logical Channel Prioritization
(UL only)
1351
(De-) Multiplexing
1352
HARQ
1353
Random
Access Control
1354
PCH of MCG
BCH of MCG
DL-SCH of MCG
UL-SCH of MCG
RACH of MCG
Lower layer of MCG
1330

FIG. 13

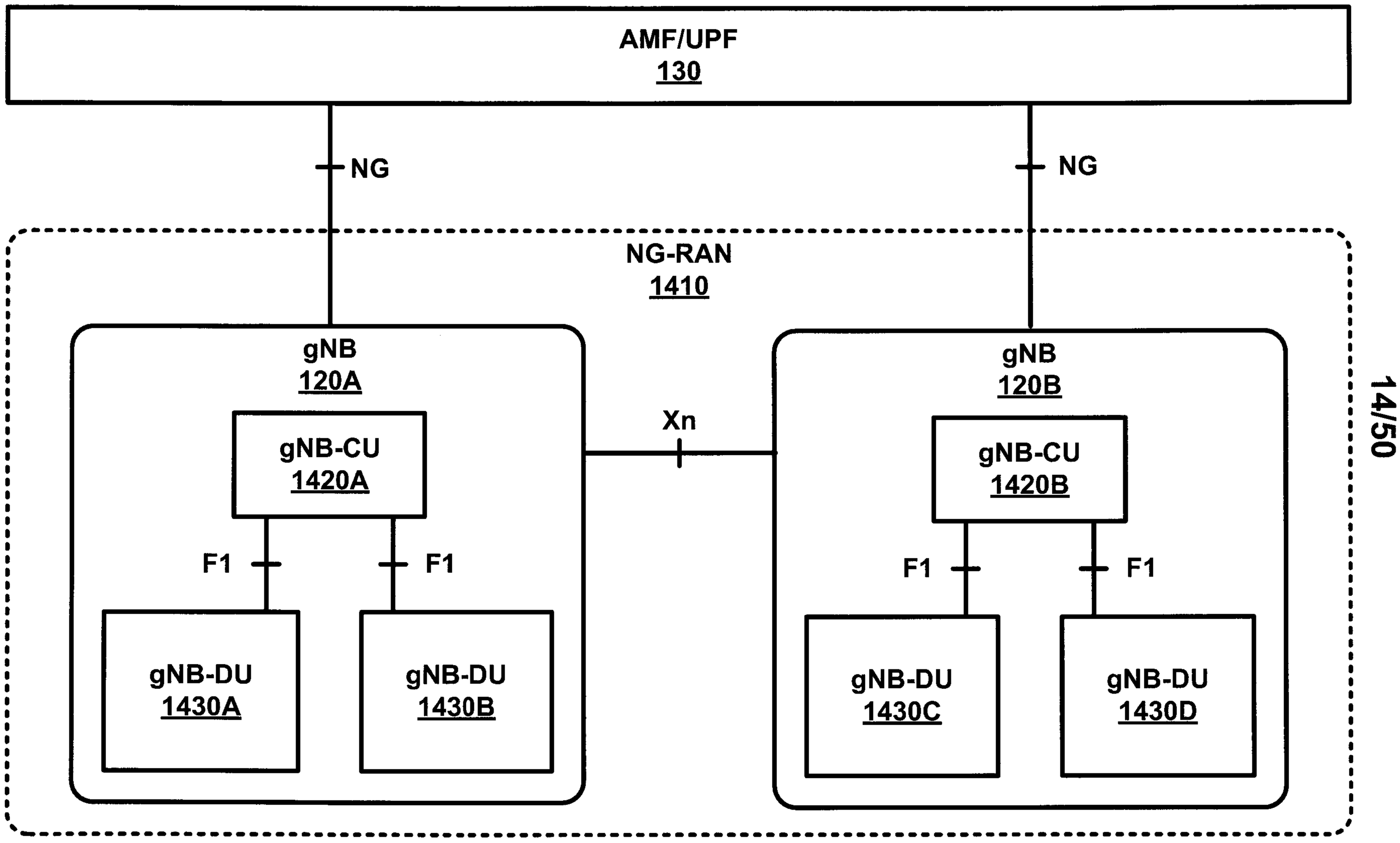

AMF/UPF
130
NG
NG
NG-RAN
1410
gNB
120A
gNB-CU
1420A
F1
F1
gNB-DU
1430A
gNB-DU
1430B
Xn
gNB
120B
gNB-CU
1420B
F1
F1
gNB-DU
1430C
gNB-DU
1430D

FIG. 14

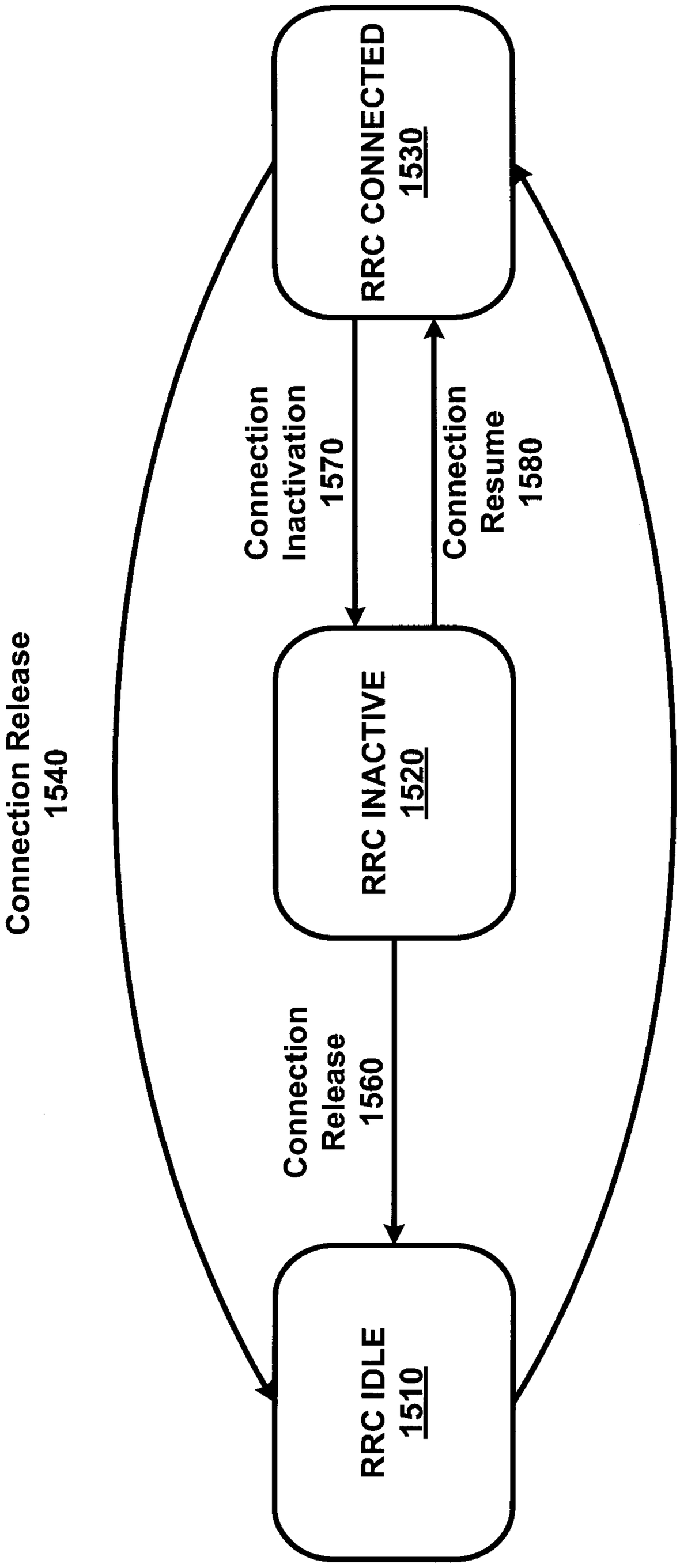

RRC CONNECTED
1530
Connection Inactivation
1570
Connection Resume
1580
RRC INACTIVE
1520
Connection Release
1560
RRC IDLE
1510
Connection Release
1540
Connection Establishment
1550

FIG. 15

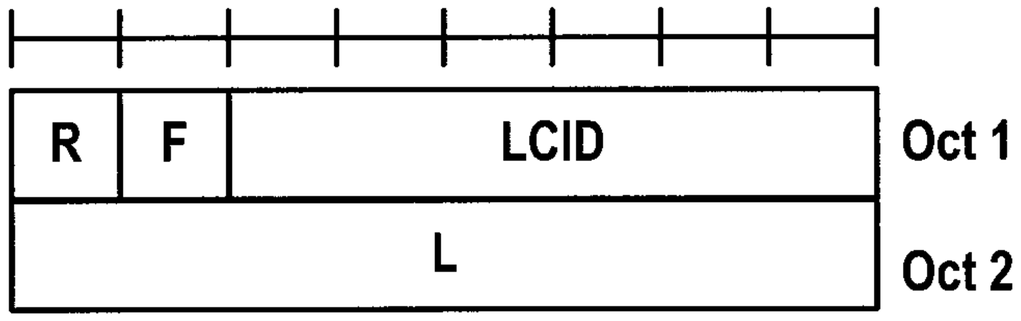



FIG. 16A

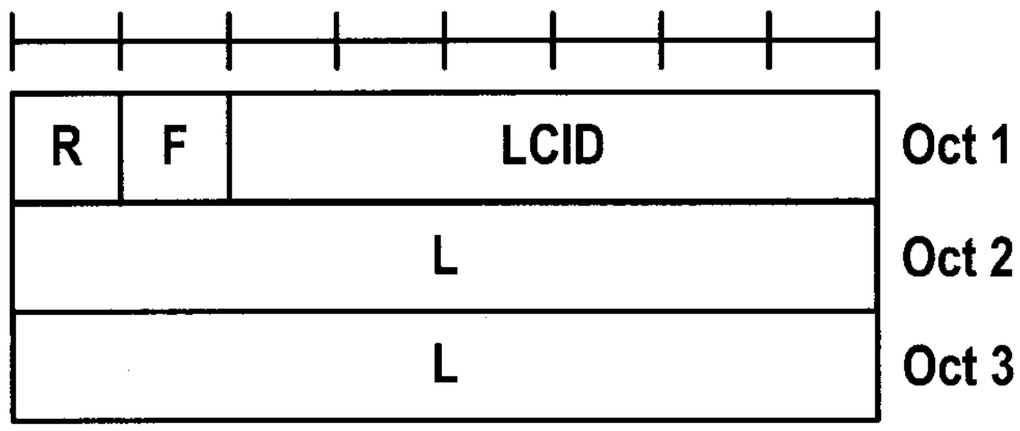



FIG. 16B

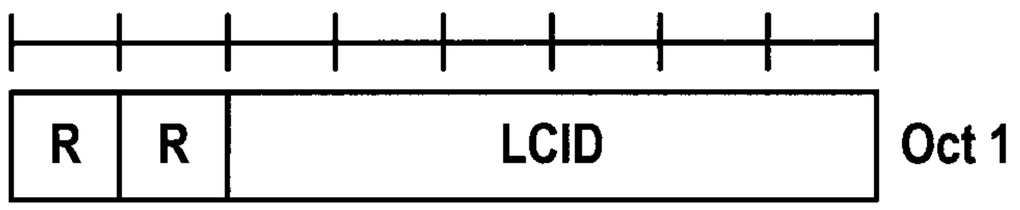



FIG. 16C

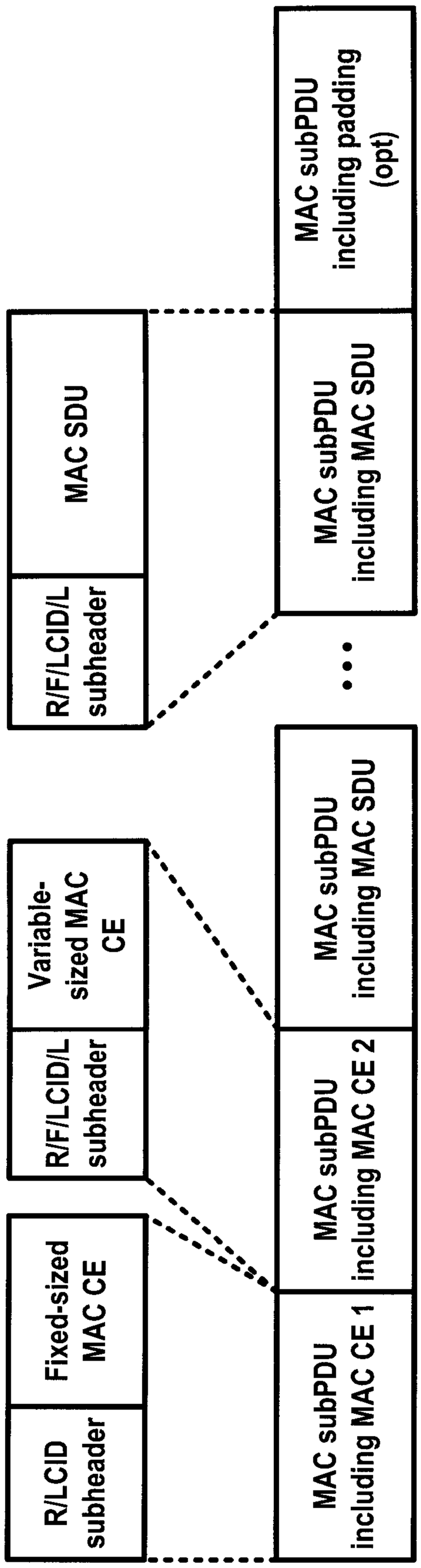



FIG. 17A

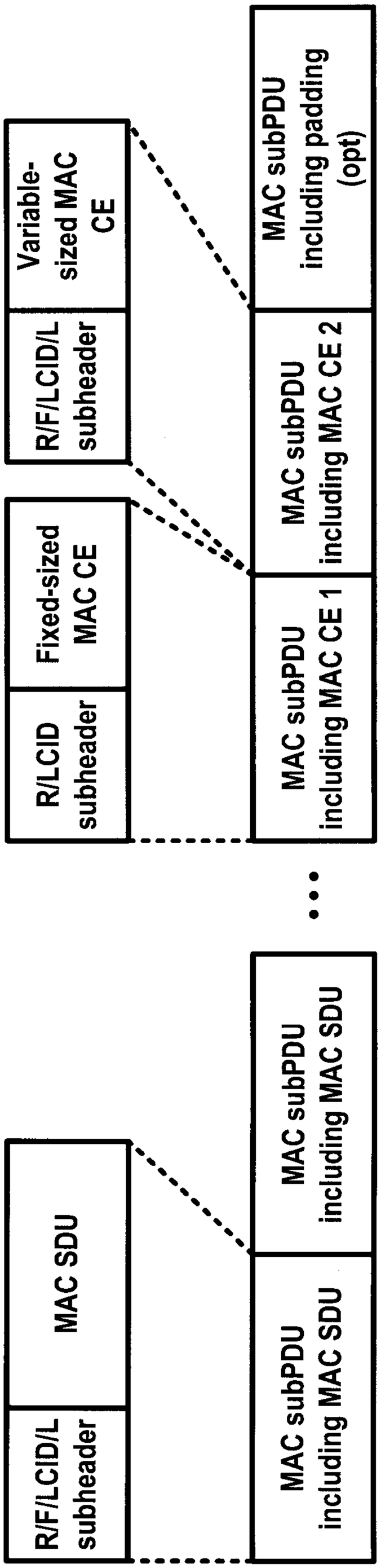



FIG. 17B

| Index | LCID values |
|---|---|
| 000000 | CCCH |
| 000001-100000 | Identity of a logical channel |
| 100001-101111 | Reserved |
| 110000 | SP ZP CSI-RS Resource Set Act./Deact. |
| 110001 | PUCCH spatial relation Act./Deact. |
| 110010 | SP SRS Act./Deact. |
| 110011 | SP CSI reporting on PUCCH Act./Deact. |
| 110100 | TCI State Indication for UE-specific PDCCH |
| 110101 | TCI State Indication for UE-specific PDSCH |
| 110110 | Aperiodic CSI Trigger State Subselection |
| 110111 | SP CSI-RS/CSI-IM Resource Set Act./Deact. |
| 111000 | Duplication Activation/deactivation |
| 111001 | SCell activation/deactivation (4 Octet) |
| 111010 | SCell activation/deactivation (1 Octet) |
| 111011 | Long DRX Command |
| 111100 | DRX Command |
| 111101 | Timing Advance Command |
| 111110 | UE Contention Resolution Identity |
| 111111 | Padding |

FIG. 18

| Index | LCID values |
|---|---|
| 000000 | CCCH |
| 000001-100000 | Identity of a logical channel |
| 100001-110110 | Reserved |
| 110111 | Configured Grant Confirmation |
| 111000 | Multiple Entry PHR |
| 111001 | Single Entry PHR |
| 111010 | C-RNTI |
| 111011 | Short Truncated BSR |
| 111100 | Long Truncated BSR |
| 111101 | Short BSR |
| 111110 | Long BSR |
| 111111 | Padding |

FIG. 19

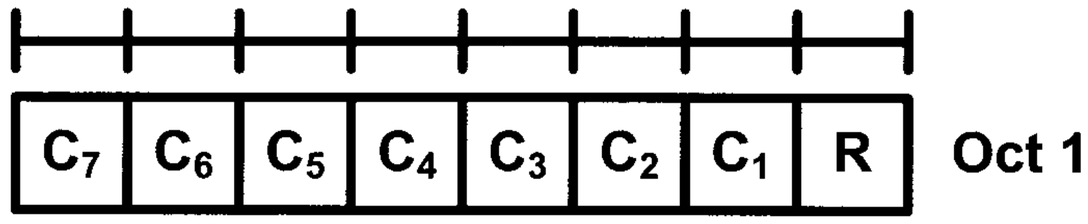



FIG. 20A

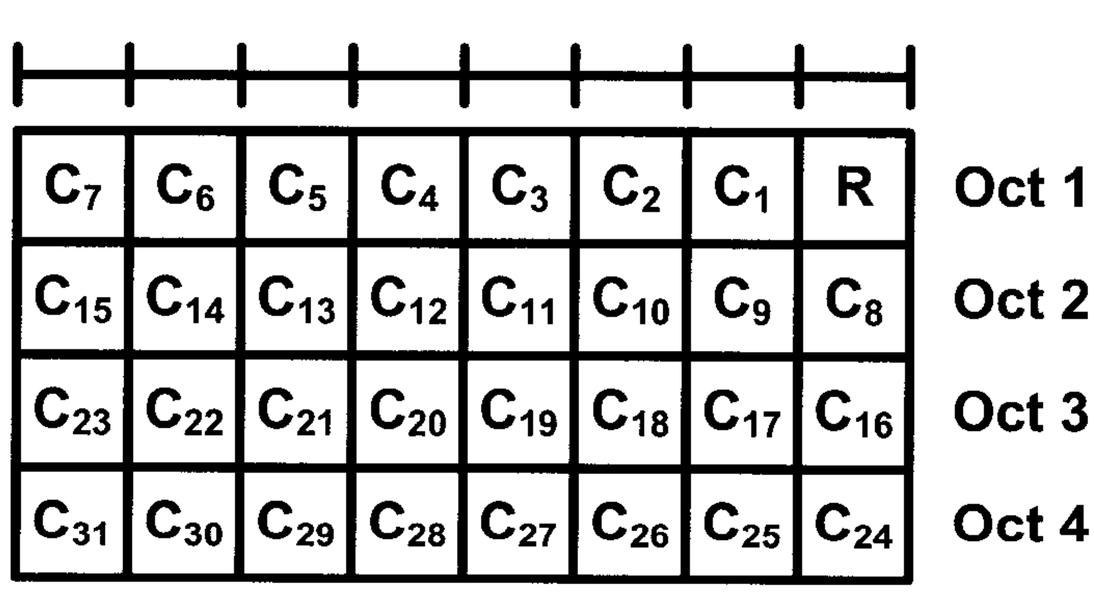



FIG. 20B

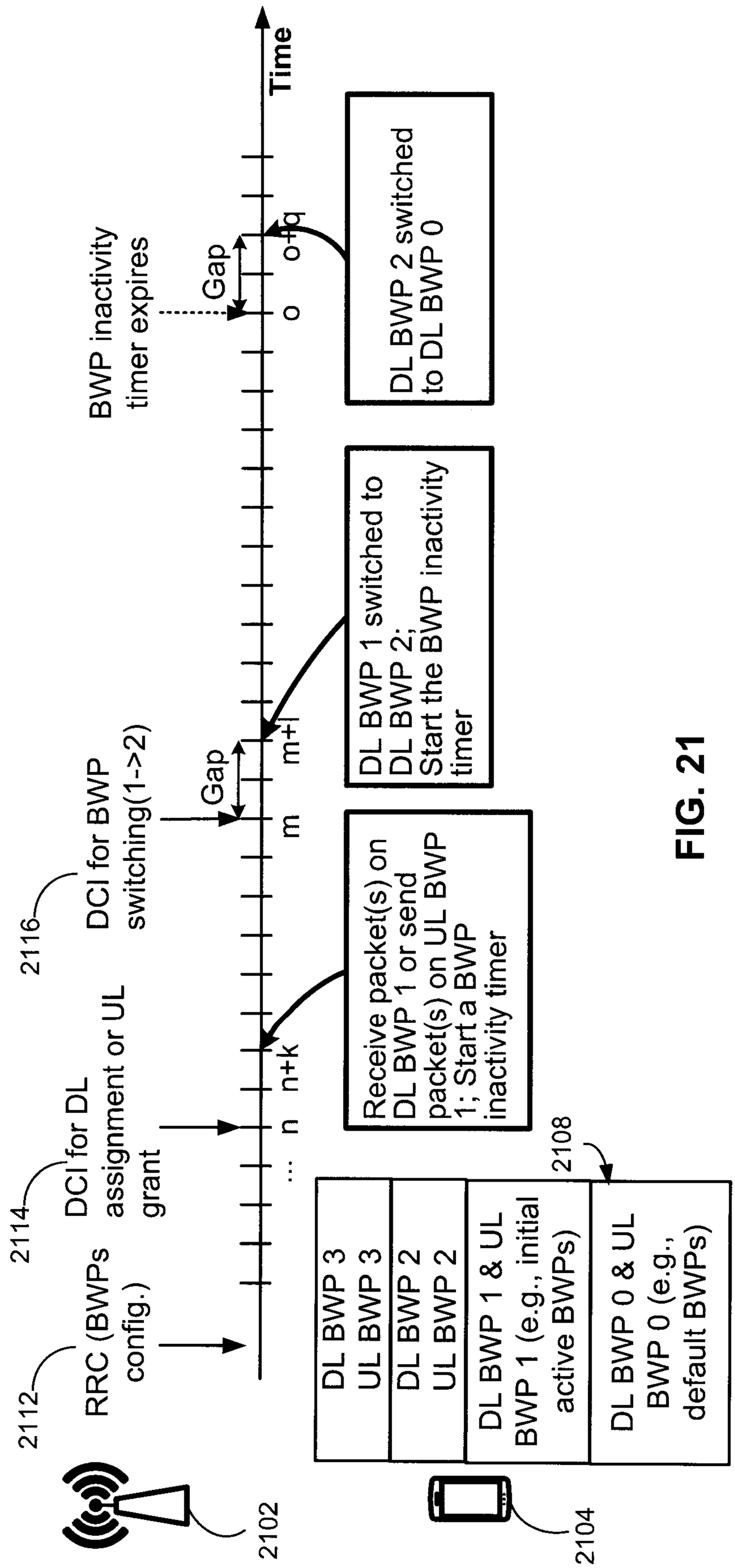

Time
BWP inactivity timer expires
Gap
o
o+q
DL BWP 2 switched to DL BWP 0
DL BWP 1 switched to DL BWP 2; Start the BWP inactivity timer
Gap
m
m+l
DCI for BWP switching(1->2)
2116
Receive packet(s) on DL BWP 1 or send packet(s) on UL BWP 1; Start a BWP inactivity timer
... n
n+k
DCI for DL assignment or UL grant
2114
2108
RRC (BWPs config.)
2112
DL BWP 3
UL BWP 3
DL BWP 2
UL BWP 2
DL BWP 1 & UL BWP 1 (e.g., initial active BWPs)
DL BWP 0 & UL BWP 0 (e.g., default BWPs)
2102
2104

FIG. 21

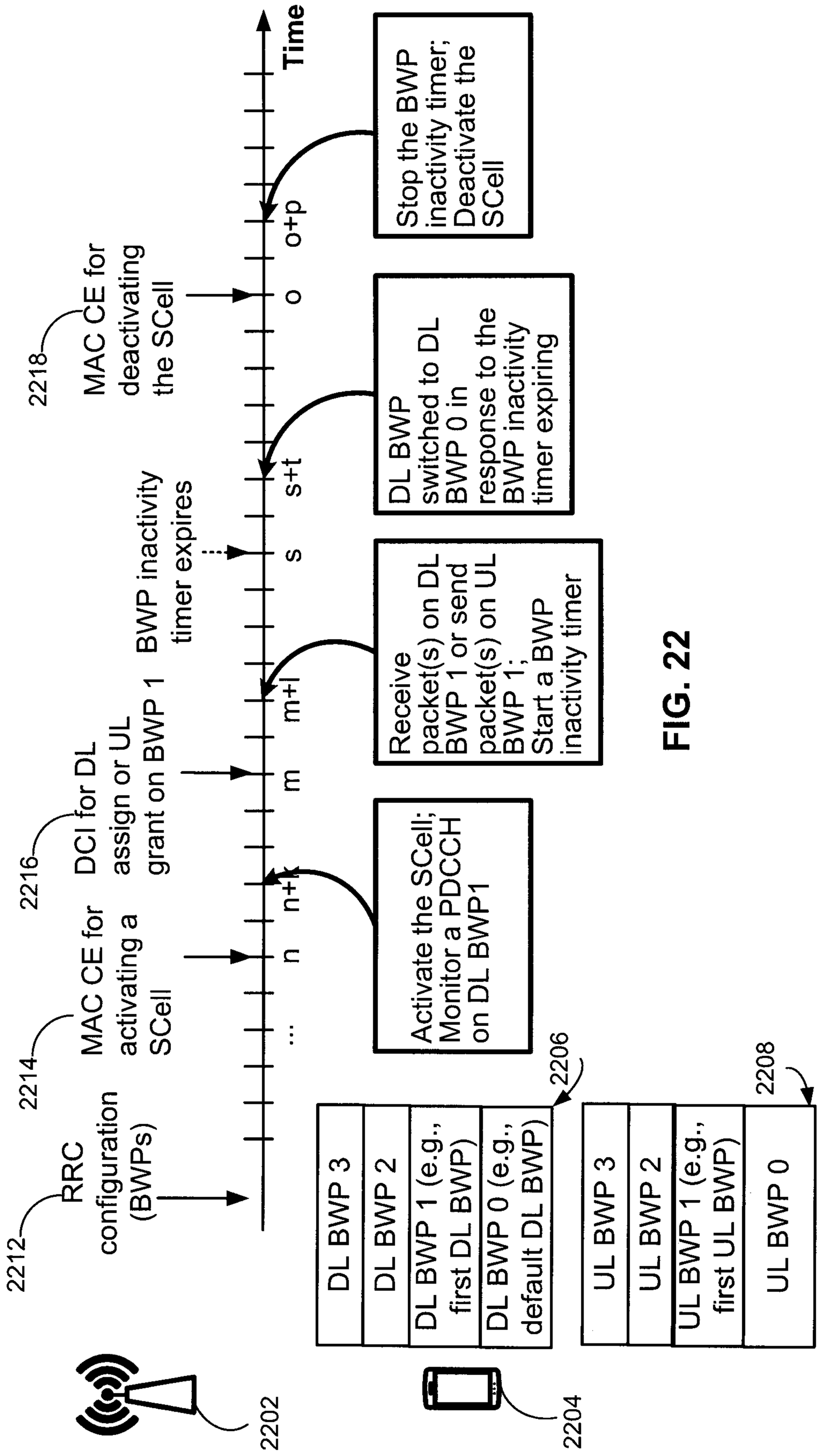

Time
2218
MAC CE for deactivating the SCell
o
o+p
Stop the BWP inactivity timer; Deactivate the SCell
2216
DCI for DL assign or UL grant on BWP 1
m
m+l
Receive packet(s) on DL BWP 1 or send packet(s) on UL BWP 1; Start a BWP inactivity timer
BWP inactivity timer expires
s
s+t
DL BWP switched to DL BWP 0 in response to the BWP inactivity timer expiring
2214
MAC CE for activating a SCell
n
n+k
Activate the SCell; Monitor a PDCCH on DL BWP1
2212
RRC configuration (BWPs)
2206
DL BWP 3
DL BWP 2
DL BWP 1 (e.g., first DL BWP)
DL BWP 0 (e.g., default DL BWP)
2208
UL BWP 3
UL BWP 2
UL BWP 1 (e.g., first UL BWP)
UL BWP 0
2202
2204

FIG. 22

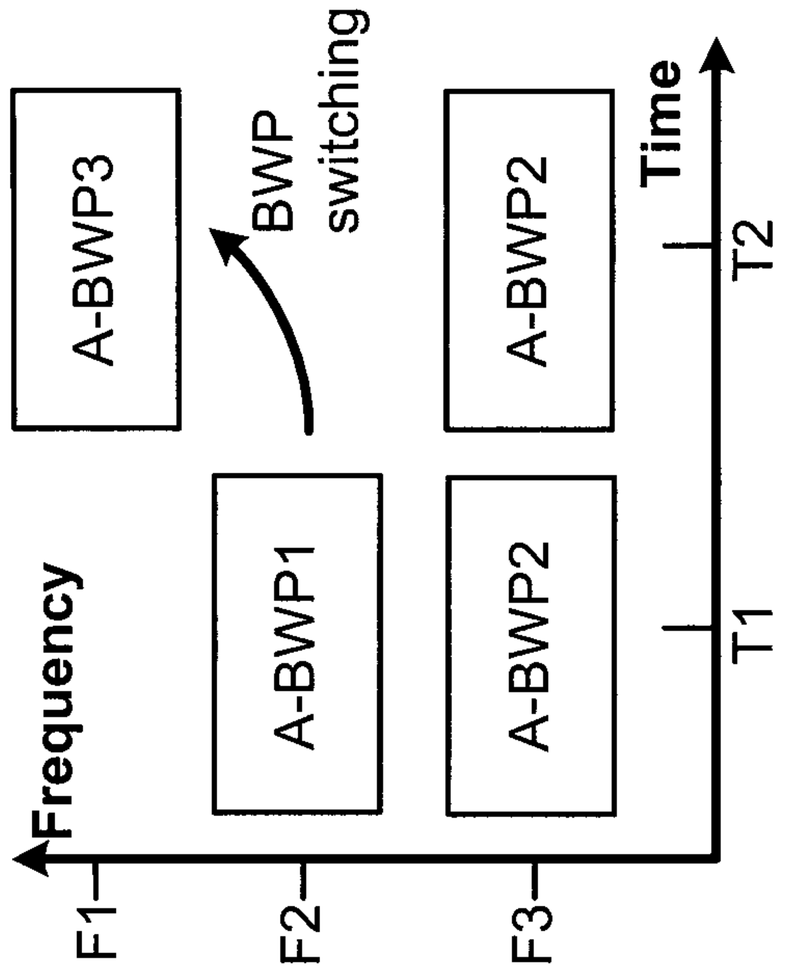



FIG. 23B

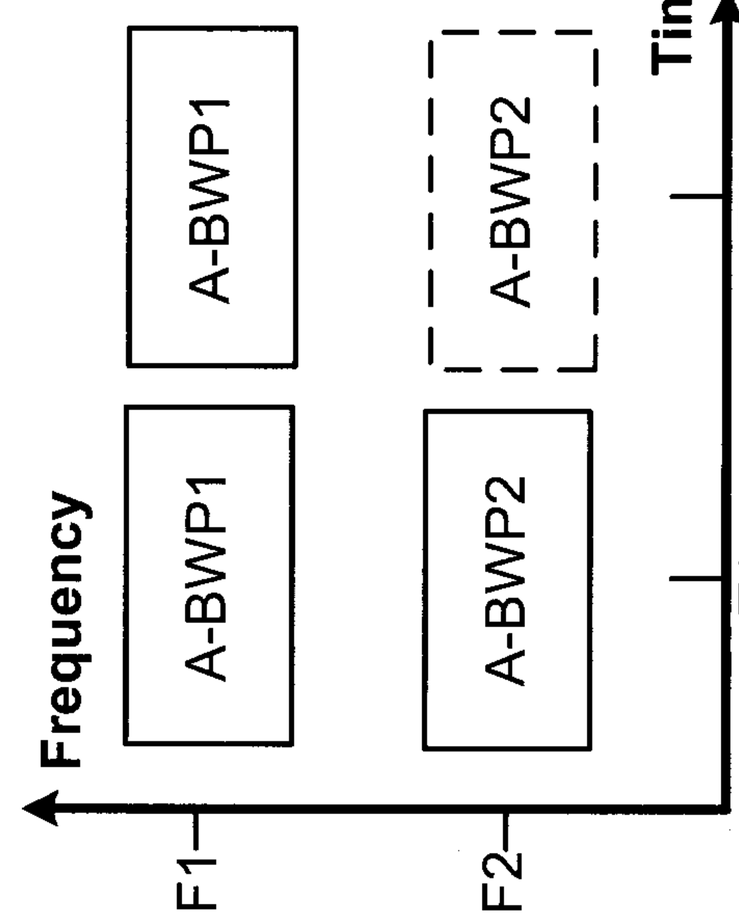



FIG. 23C

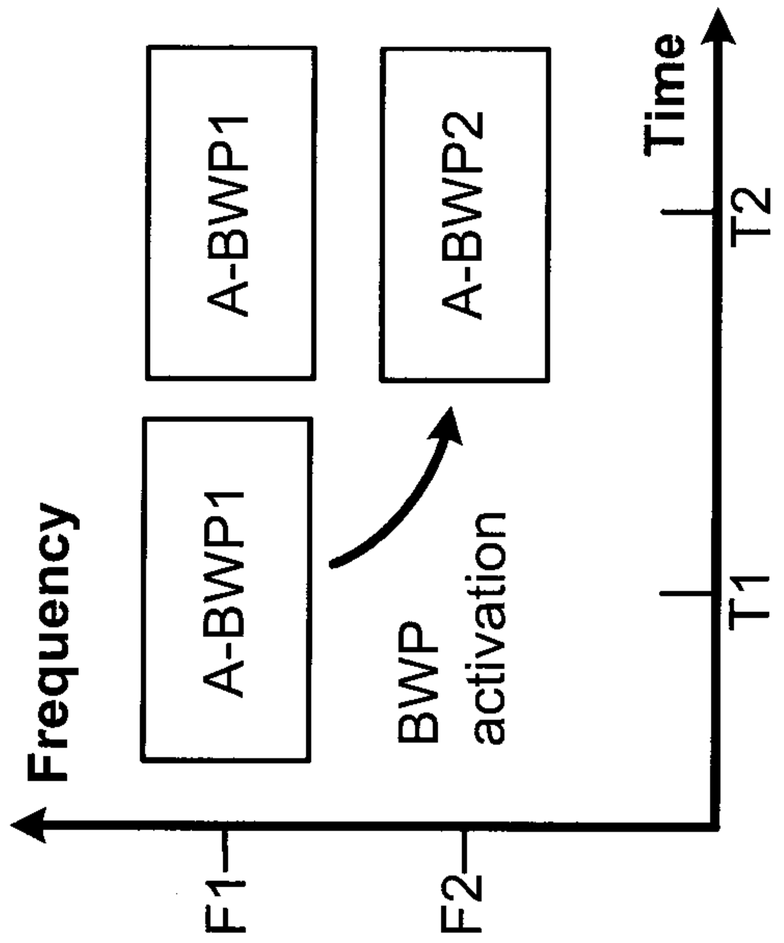



FIG. 23A

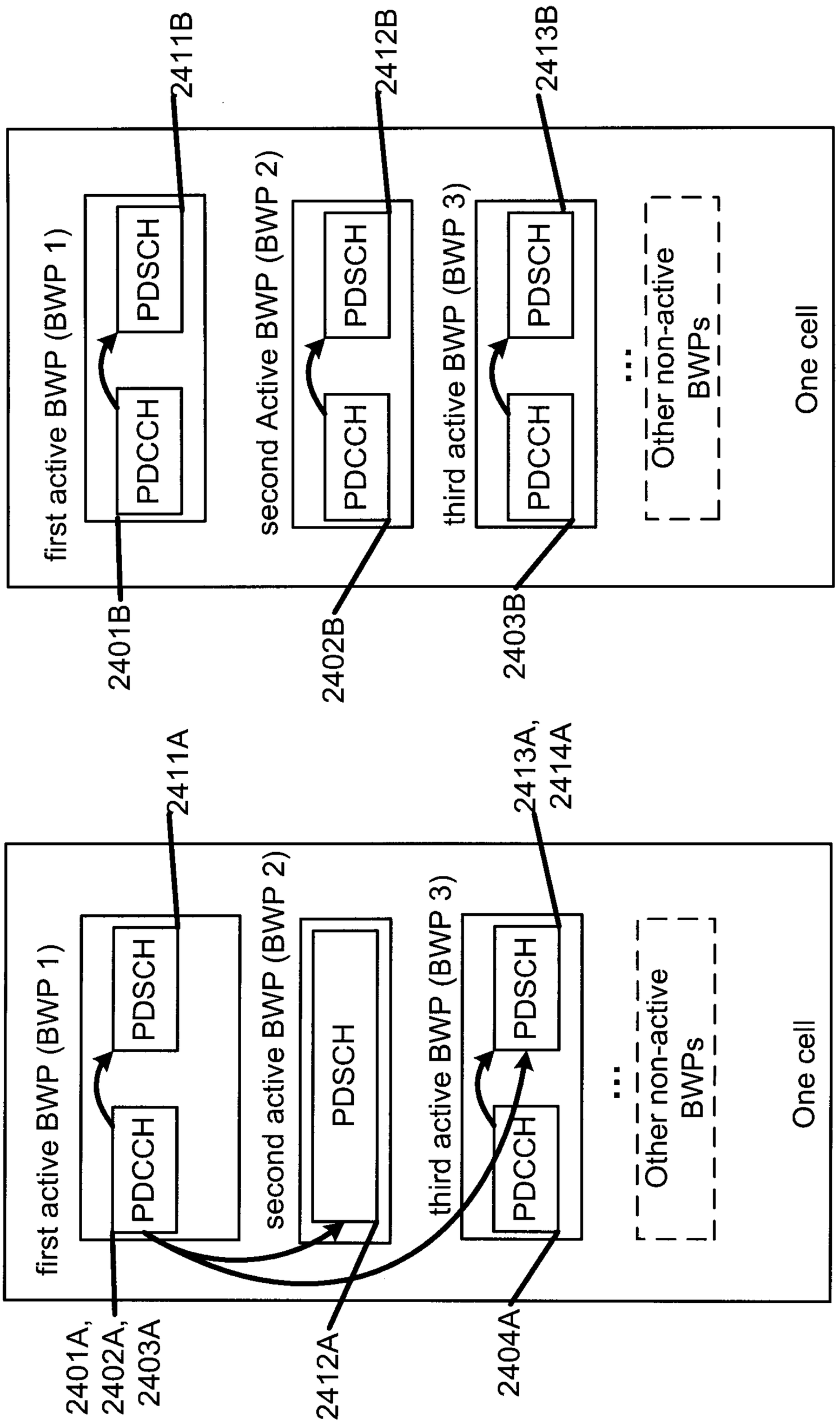



FIG. 24B




FIG. 24A

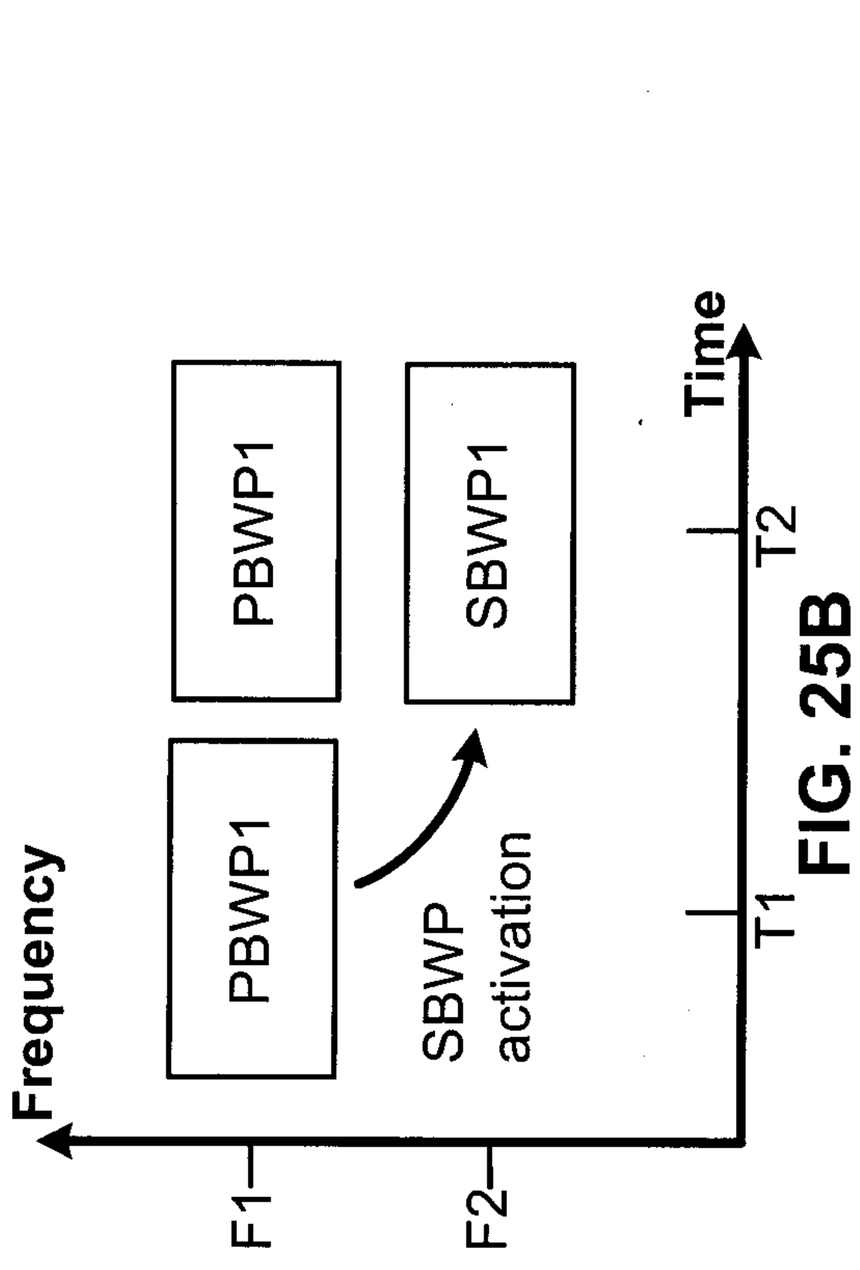



FIG. 25B

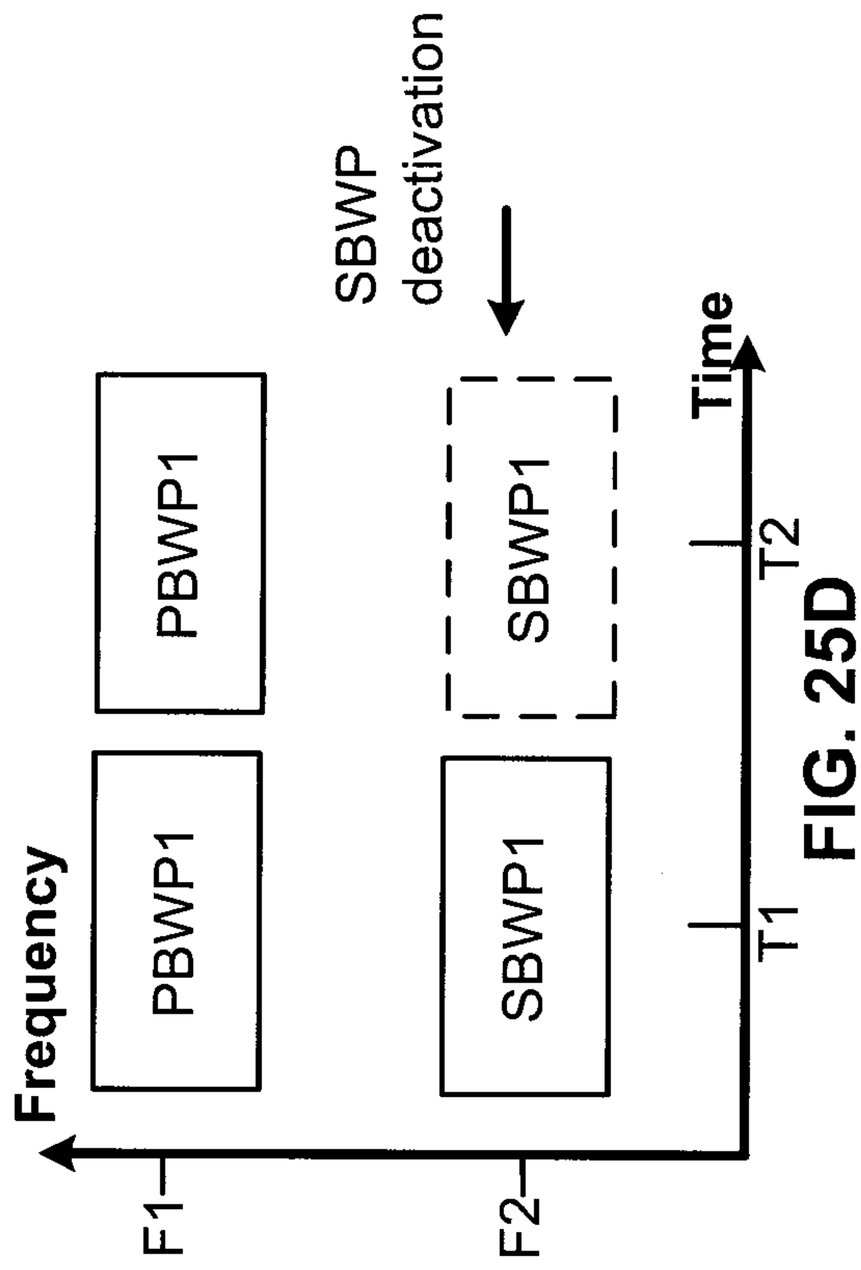



FIG. 25D




FIG. 25A

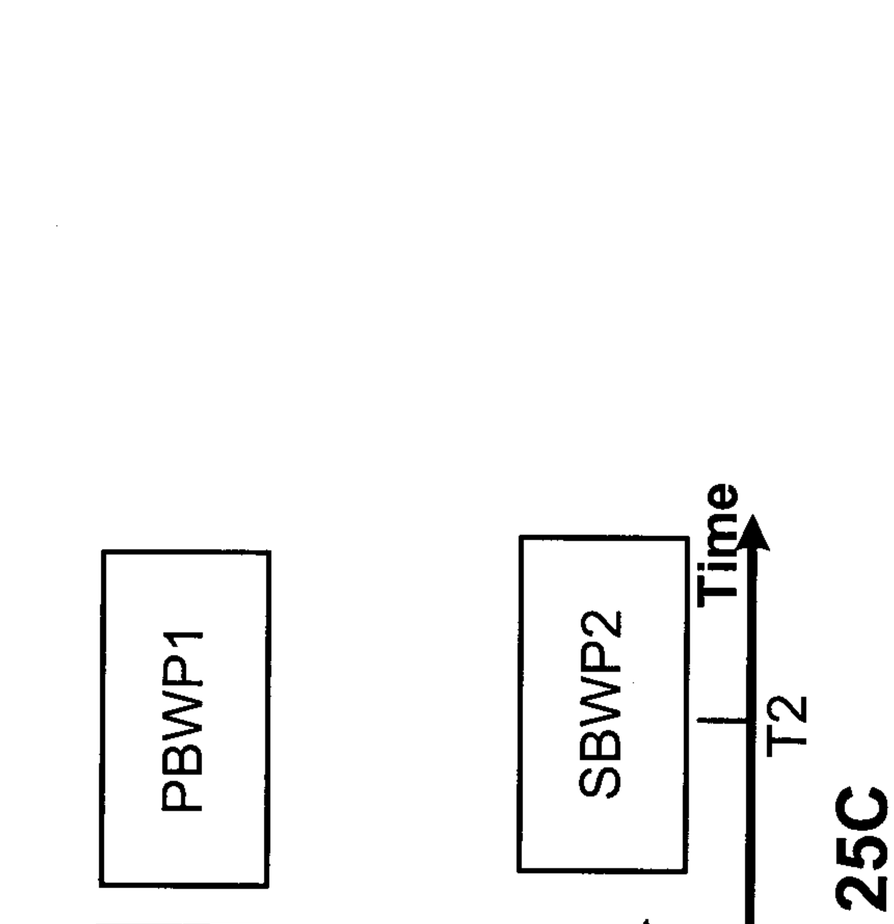



FIG. 25C

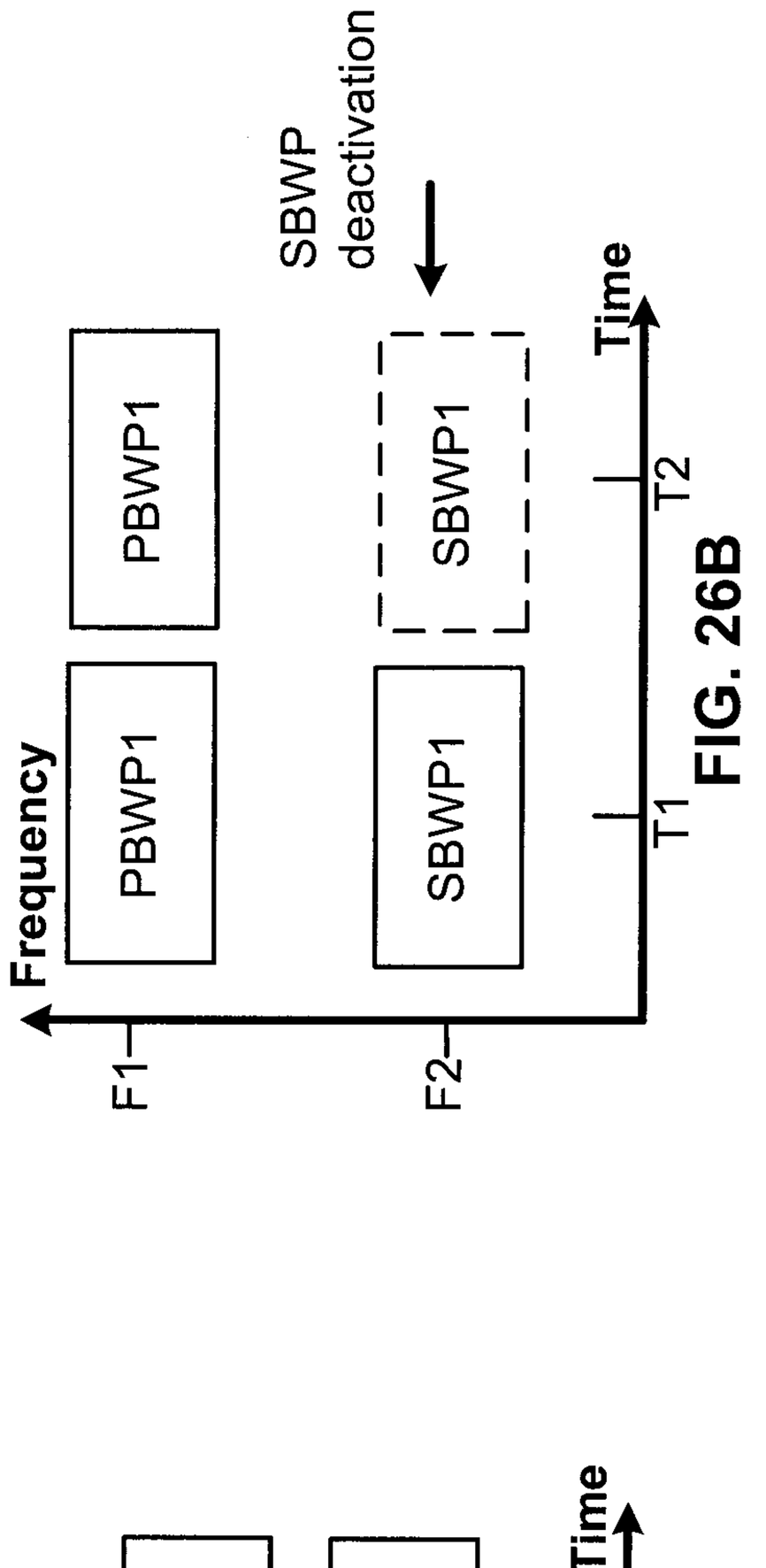



FIG. 26B

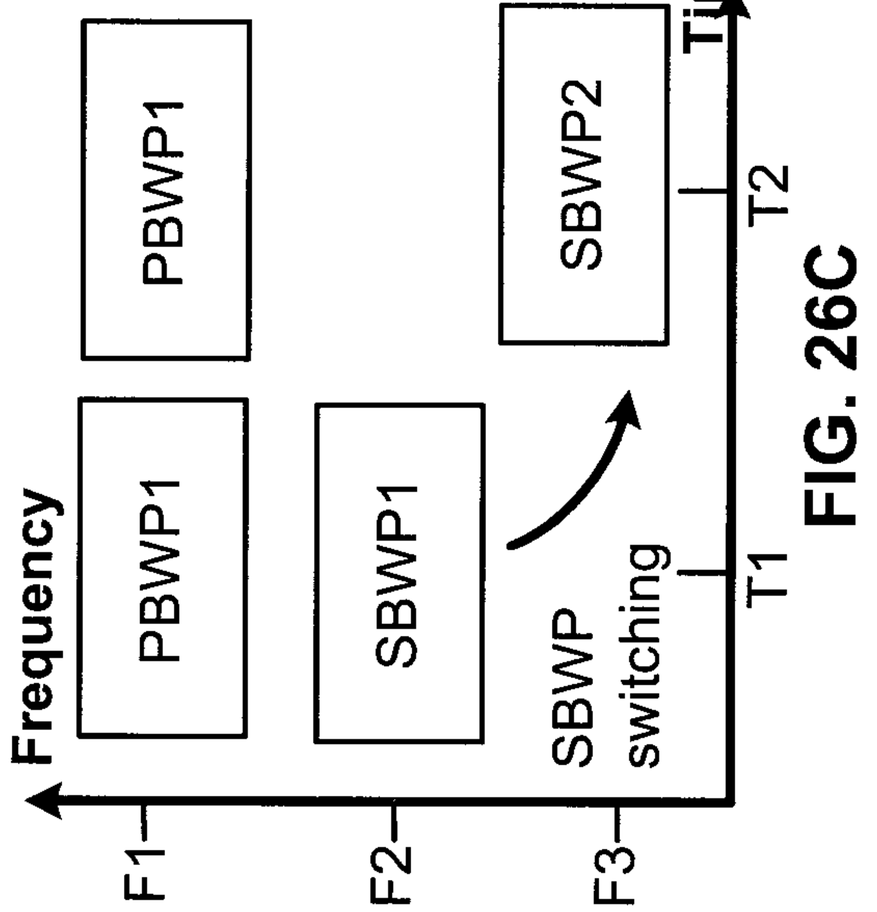



FIG. 26C

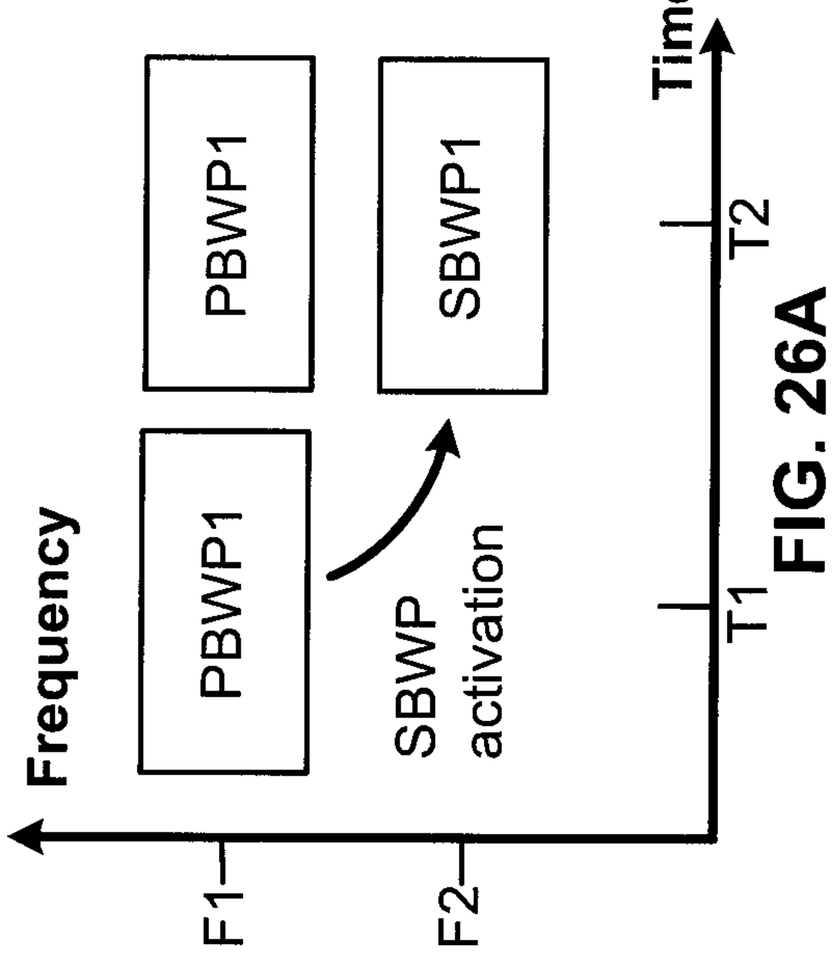



FIG. 26A

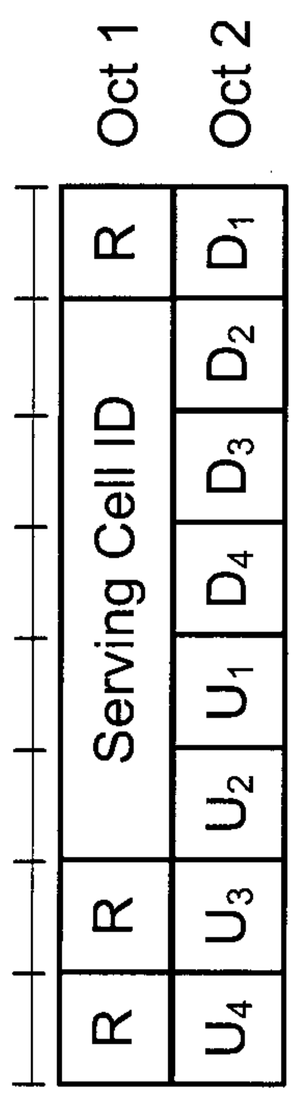



FIG. 27B

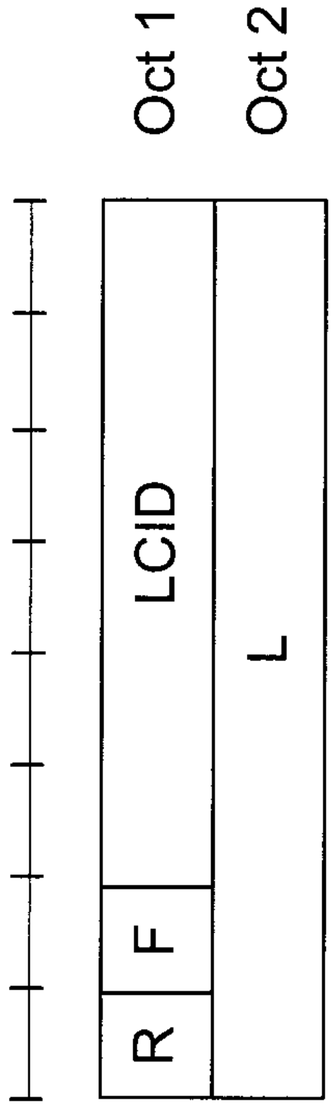



FIG. 27D




FIG. 27A




FIG. 27C

| BWP ID | a second field | Meaning for the second field |
|---|---|---|
| X | 00 | Indicating a PBWP change to BWP X if X is different from current PBWP; Indicating a DL/UL scheduling on BWP X if X is same as current PBWP; |
| Y | 01 | Indicating BWP Y activated as SBWP |
| Z | 10 | Indicating BWP Z deactivated |
| Q | 11 | Indicating a SBWP change to BWP Q if Q is different from current SBWP; Indicating a DL/UL scheduling on BWP Q if Q is same as current SBWP; |

FIG. 28A

| BWP ID field | a second field | Meaning for the second field |
|---|---|---|
| Y | 1 | Indicating BWP Y activated as SBWP |
| Z | 0 | Indicating BWP Z deactivated |

FIG. 28B

| BWP ID field | Action indication field | Meaning for action indication field |
|---|---|---|
| X | 00 | Indicating a DL/UL scheduling on BWP X if X is same as current PBWP; Indicating a DL/UL scheduling on BWP Q if Q is same as current SBWP; |
| Y | 01 | Indicating BWP Y activated as a SBWP |
| Z | 10 | Indicating BWP Z deactivated |
| Q | 11 | Indicating a SBWP change to BWP Q if Q is different from current SBWP; |

FIG. 29A

| BWP ID field | Action indication field | Meaning for action indication field |
|---|---|---|
| Y | 1 | Indicating BWP Y activated as a SBWP |
| Z | 0 | Indicating BWP Z deactivated |

FIG. 29B

| BWP ID field | Action indication field | Meaning for action indication field |
|---|---|---|
| X | 00 | Indicating a DL/UL scheduling on BWP X if X is same as an active BWP; |
| Y | 01 | Indicating BWP Y activated as an active BWP |
| Z | 10 | Indicating BWP Z deactivated |
| Q | 11 | Indicating a BWP change to BWP Q if Q is different from an active BWP on which the DCI is transmitted; |

FIG. 30A

| BWP ID field | Action indication field | Meaning for action indication field |
|---|---|---|
| Y | 1 | Indicating BWP Y activated as an active BWP |
| Z | 0 | Indicating BWP Z deactivated |

FIG. 30B

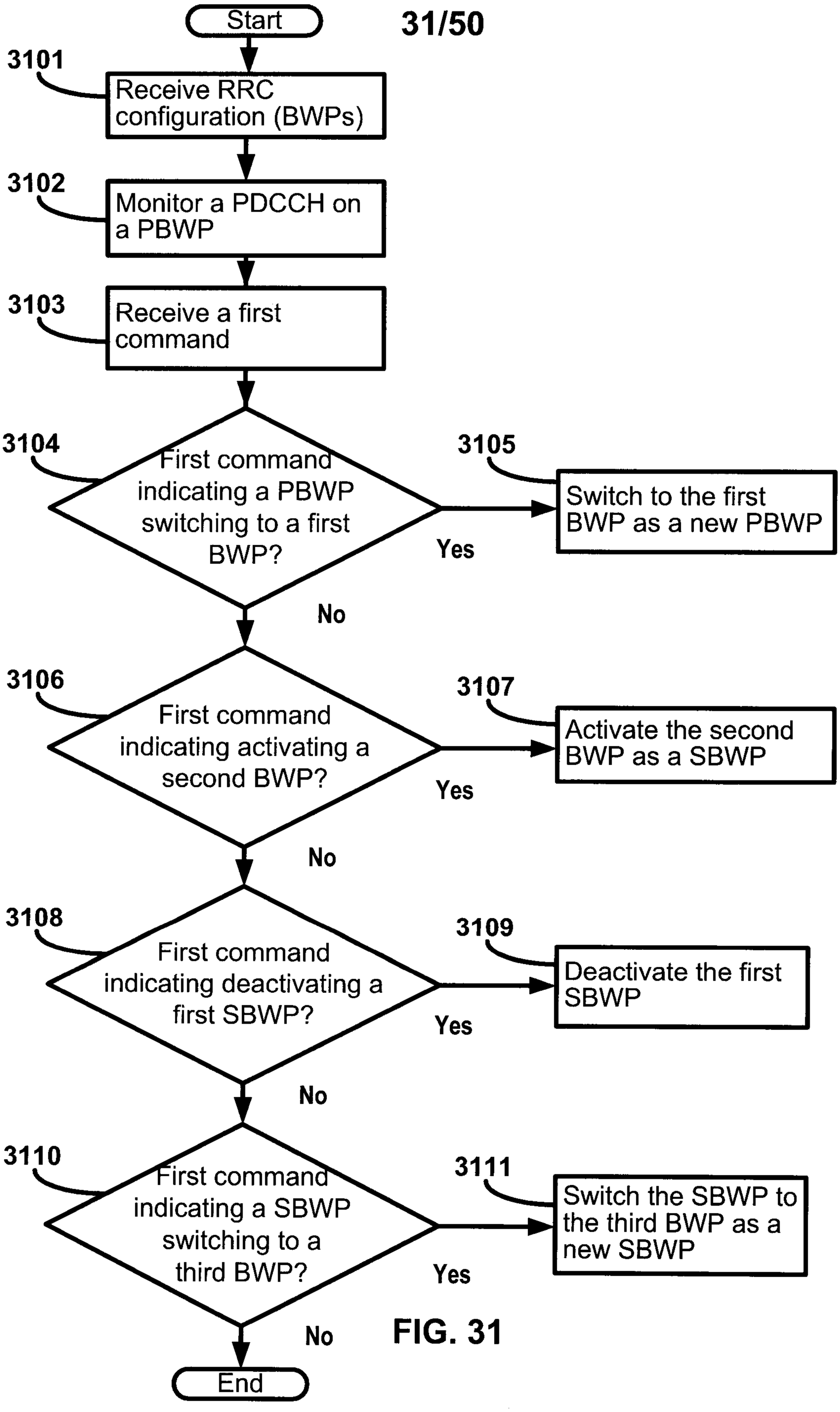

Start
3101
Receive RRC configuration (BWPs)
3102
Monitor a PDCCH on a PBWP
3103
Receive a first command
3104
First command indicating a PBWP switching to a first BWP?
Yes
3105
Switch to the first BWP as a new PBWP
No
3106
First command indicating activating a second BWP?
Yes
3107
Activate the second BWP as a SBWP
No
3108
First command indicating deactivating a first SBWP?
Yes
3109
Deactivate the first SBWP
No
3110
First command indicating a SBWP switching to a third BWP?
Yes
3111
Switch the SBWP to the third BWP as a new SBWP
No
End

FIG. 31

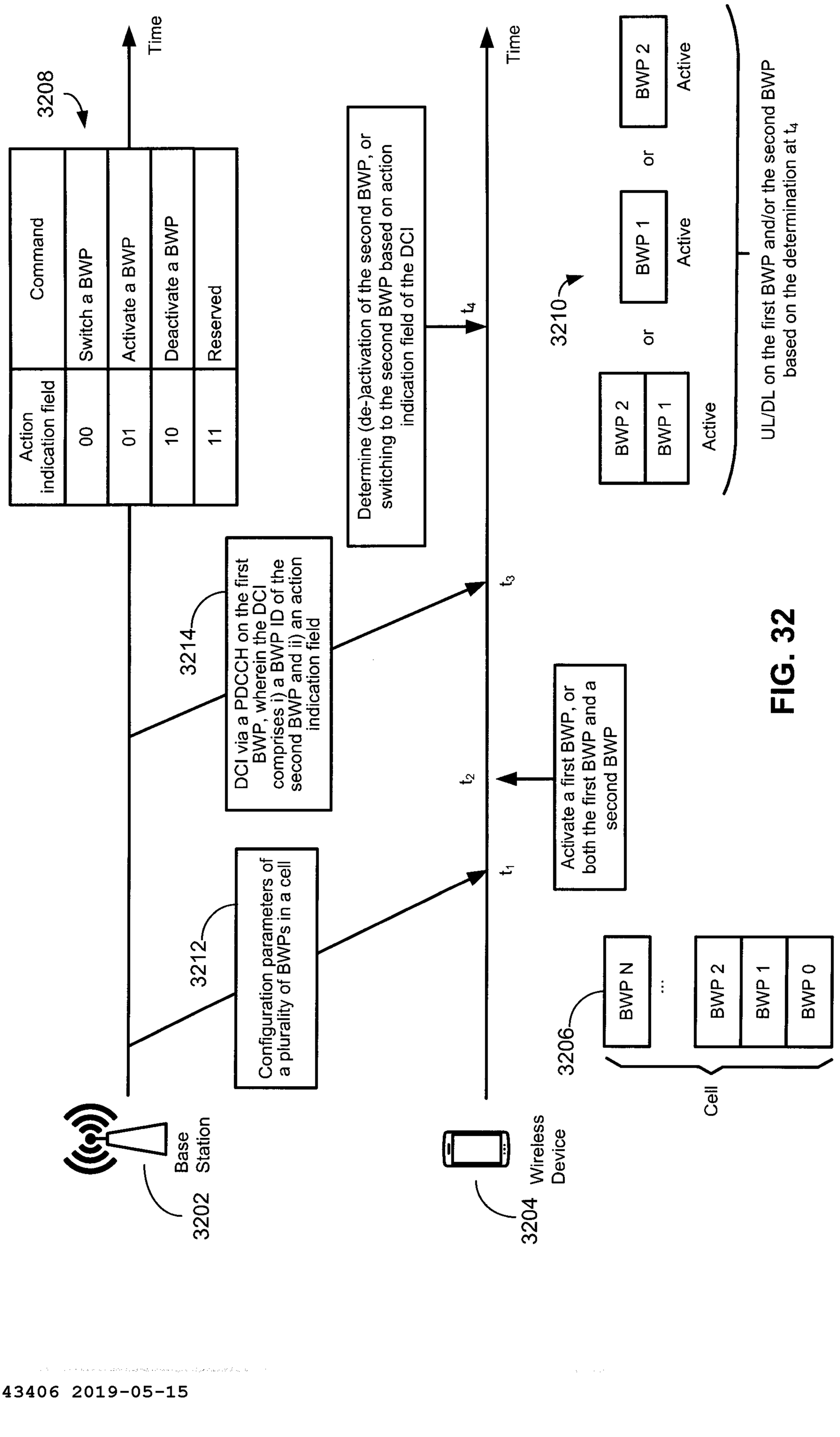

3202
Base Station
3204
Wireless Device
Cell
3206
BWP 0
BWP 1
BWP 2
...
BWP N
3208
Time
Action indication field
00
Switch a BWP
01
Activate a BWP
10
Deactivate a BWP
11
Reserved
3210
BWP 1
Active
or
BWP 2
Active
3212
Configuration parameters of a plurality of BWPs in a cell
3214
DCI via a PDCCH on the first BWP, wherein the DCI comprises i) a BWP ID of the second BWP and ii) an action indication field
Activate a first BWP, or both the first BWP and a second BWP
Determine (de-)activation of the second BWP, or switching to the second BWP based on action indication field of the DCI
UL/DL on the first BWP and/or the second BWP based on the determination at $t_4$
$t_1$
$t_2$
$t_3$
$t_4$

FIG. 32

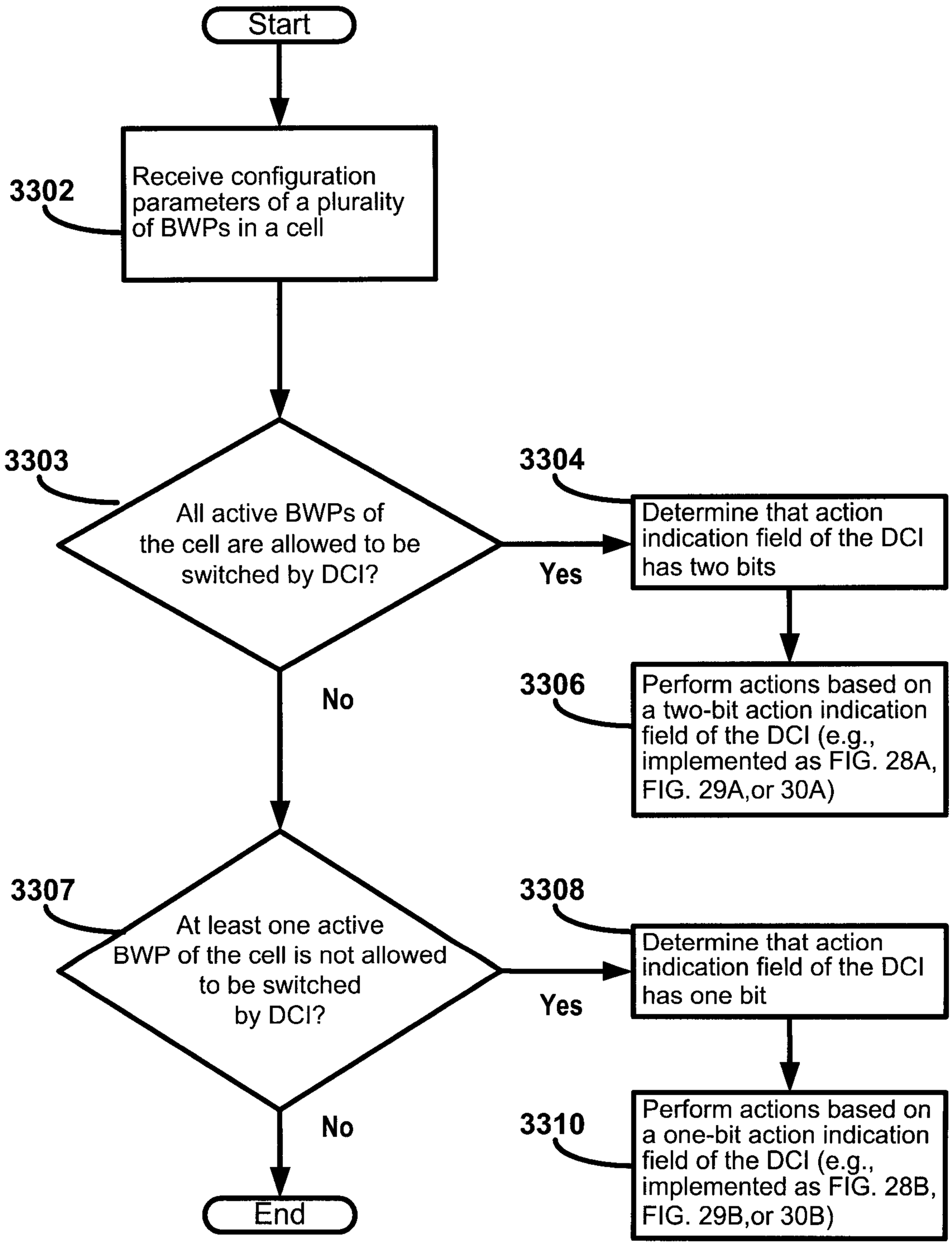

Start
3302
Receive configuration parameters of a plurality of BWPs in a cell
3303
All active BWPs of the cell are allowed to be switched by DCI?
Yes
3304
Determine that action indication field of the DCI has two bits
3306
Perform actions based on a two-bit action indication field of the DCI (e.g., implemented as FIG. 28A, FIG. 29A,or 30A)
No
3307
At least one active BWP of the cell is not allowed to be switched by DCI?
Yes
3308
Determine that action indication field of the DCI has one bit
3310
Perform actions based on a one-bit action indication field of the DCI (e.g., implemented as FIG. 28B, FIG. 29B,or 30B)
No
End

FIG. 33

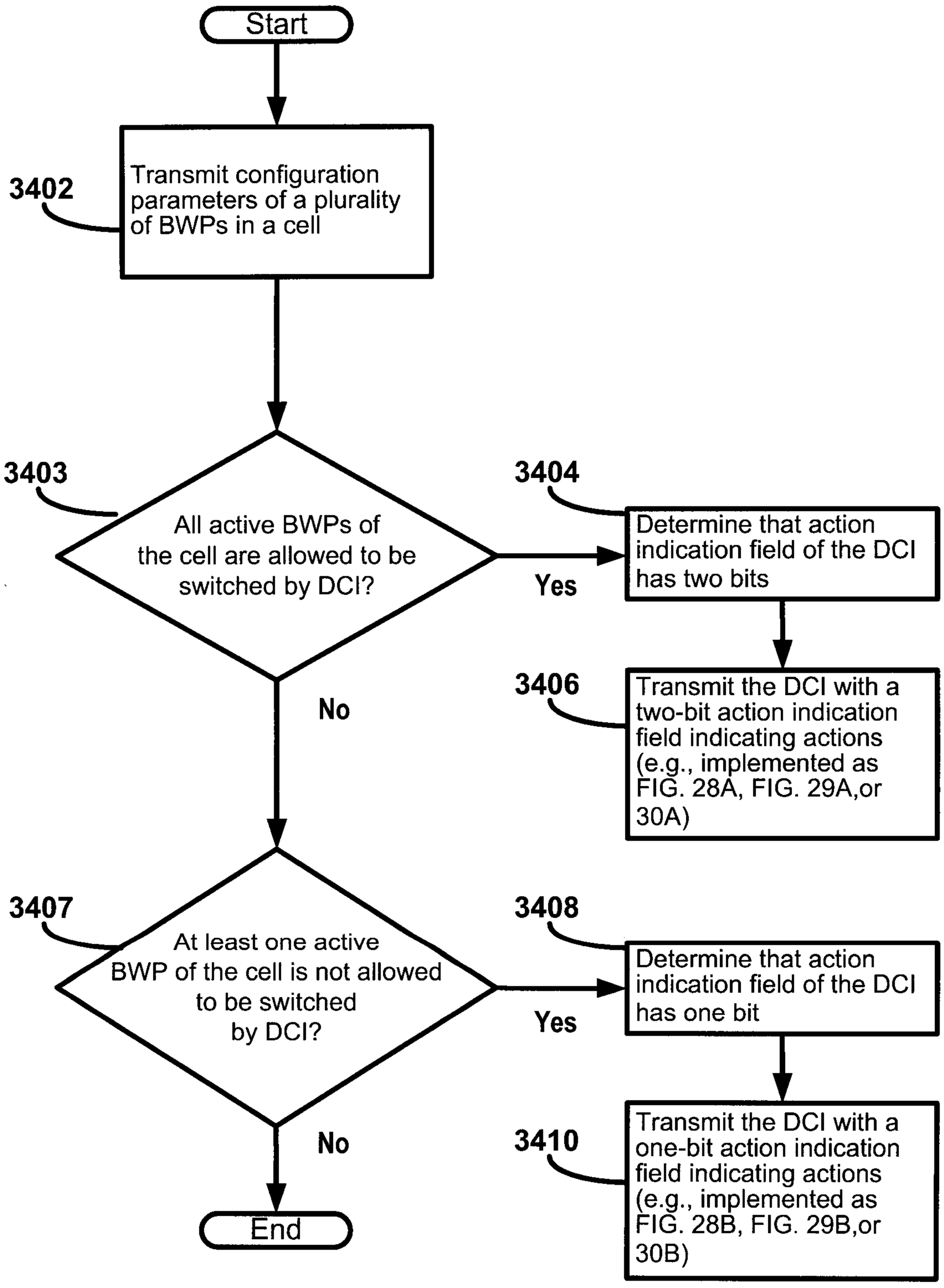

Start
3402
Transmit configuration parameters of a plurality of BWPs in a cell
3403
All active BWPs of the cell are allowed to be switched by DCI?
Yes
3404
Determine that action indication field of the DCI has two bits
3406
Transmit the DCI with a two-bit action indication field indicating actions (e.g., implemented as FIG. 28A, FIG. 29A,or 30A)
No
3407
At least one active BWP of the cell is not allowed to be switched by DCI?
Yes
3408
Determine that action indication field of the DCI has one bit
3410
Transmit the DCI with a one-bit action indication field indicating actions (e.g., implemented as FIG. 28B, FIG. 29B,or 30B)
No
End

FIG. 34

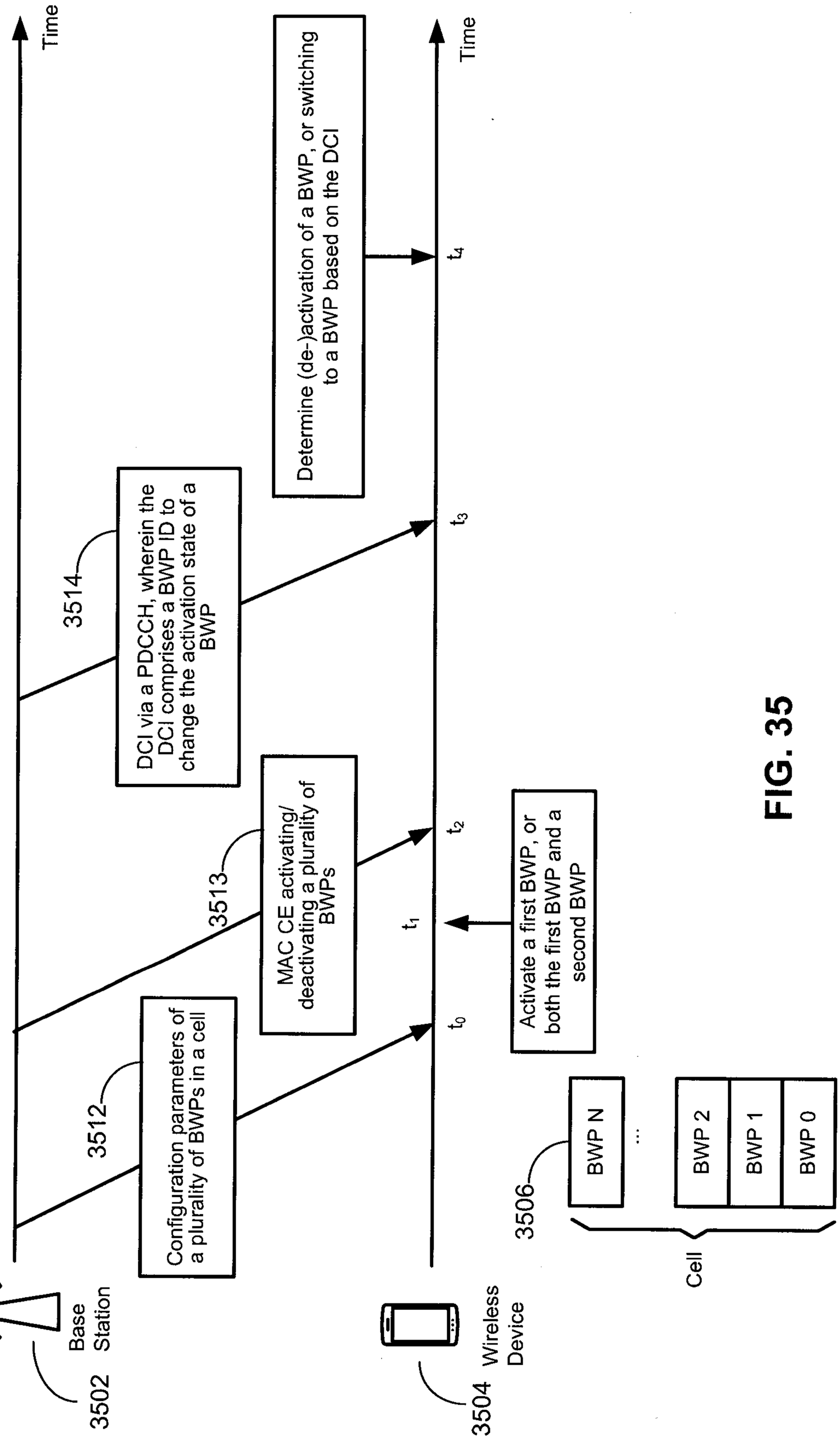

Time
Time
Base Station
3502
Wireless Device
3504
3506
BWP N
BWP 2
BWP 1
BWP 0
Cell
Configuration parameters of a plurality of BWPs in a cell
3512
MAC CE activating/ deactivating a plurality of BWPs
3513
DCI via a PDCCH, wherein the DCI comprises a BWP ID to change the activation state of a BWP
3514
Activate a first BWP, or both the first BWP and a second BWP
Determine (de-)activation of to a BWP based
$t_0$
$t_1$
$t_2$
$t_3$
$t_4$

FIG. 35

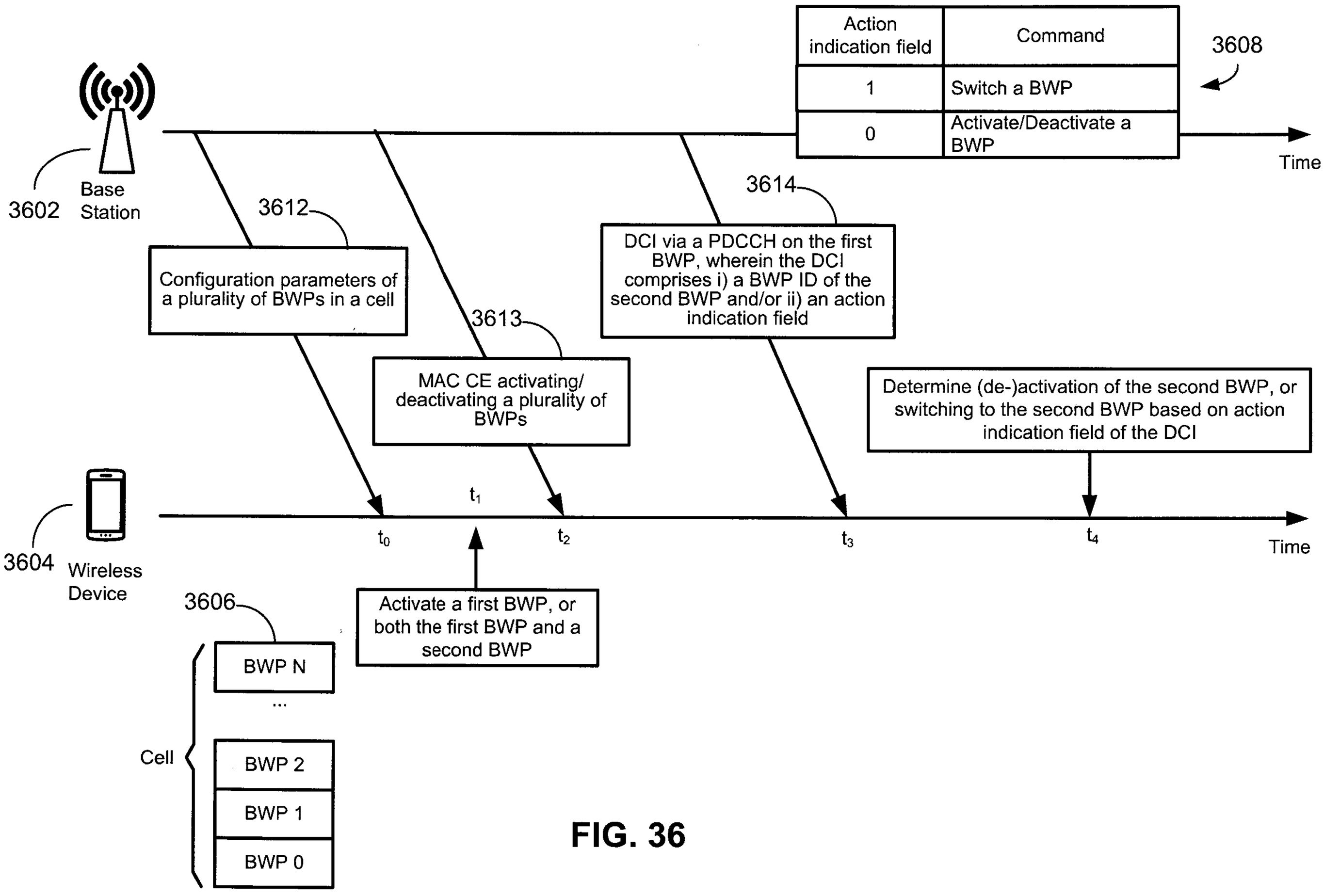

Action indication field
Command
1
Switch a BWP
0
Activate/Deactivate a BWP
3608
Time
3602
Base Station
3612
Configuration parameters of a plurality of BWPs in a cell
3613
MAC CE activating/ deactivating a plurality of BWPs
3614
DCI via a PDCCH on the first BWP, wherein the DCI comprises i) a BWP ID of the second BWP and/or ii) an action indication field
Determine (de-)activation of the second BWP, or switching to the second BWP based on action indication field of the DCI
$t_0$
$t_1$
$t_2$
$t_3$
$t_4$
Time
3604
Wireless Device
Activate a first BWP, or both the first BWP and a second BWP
3606
BWP N
...
Cell
BWP 2
BWP 1
BWP 0

FIG. 36

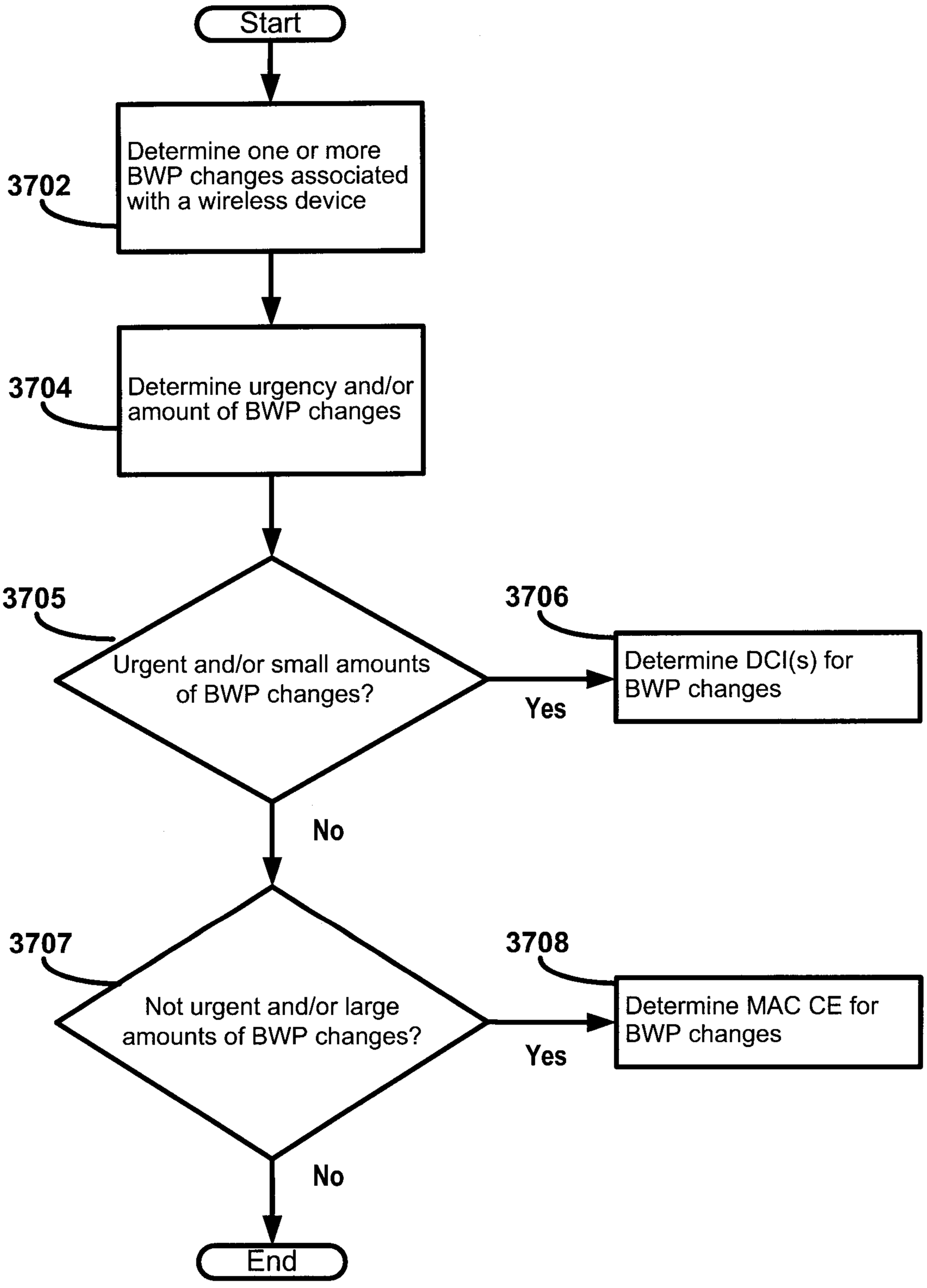

Start
Determine one or more BWP changes associated with a wireless device
3702
Determine urgency and/or amount of BWP changes
3704
3705
Urgent and/or small amounts of BWP changes?
Yes
3706
Determine DCI(s) for BWP changes
No
3707
Not urgent and/or large amounts of BWP changes?
Yes
3708
Determine MAC CE for BWP changes
No
End

FIG. 37

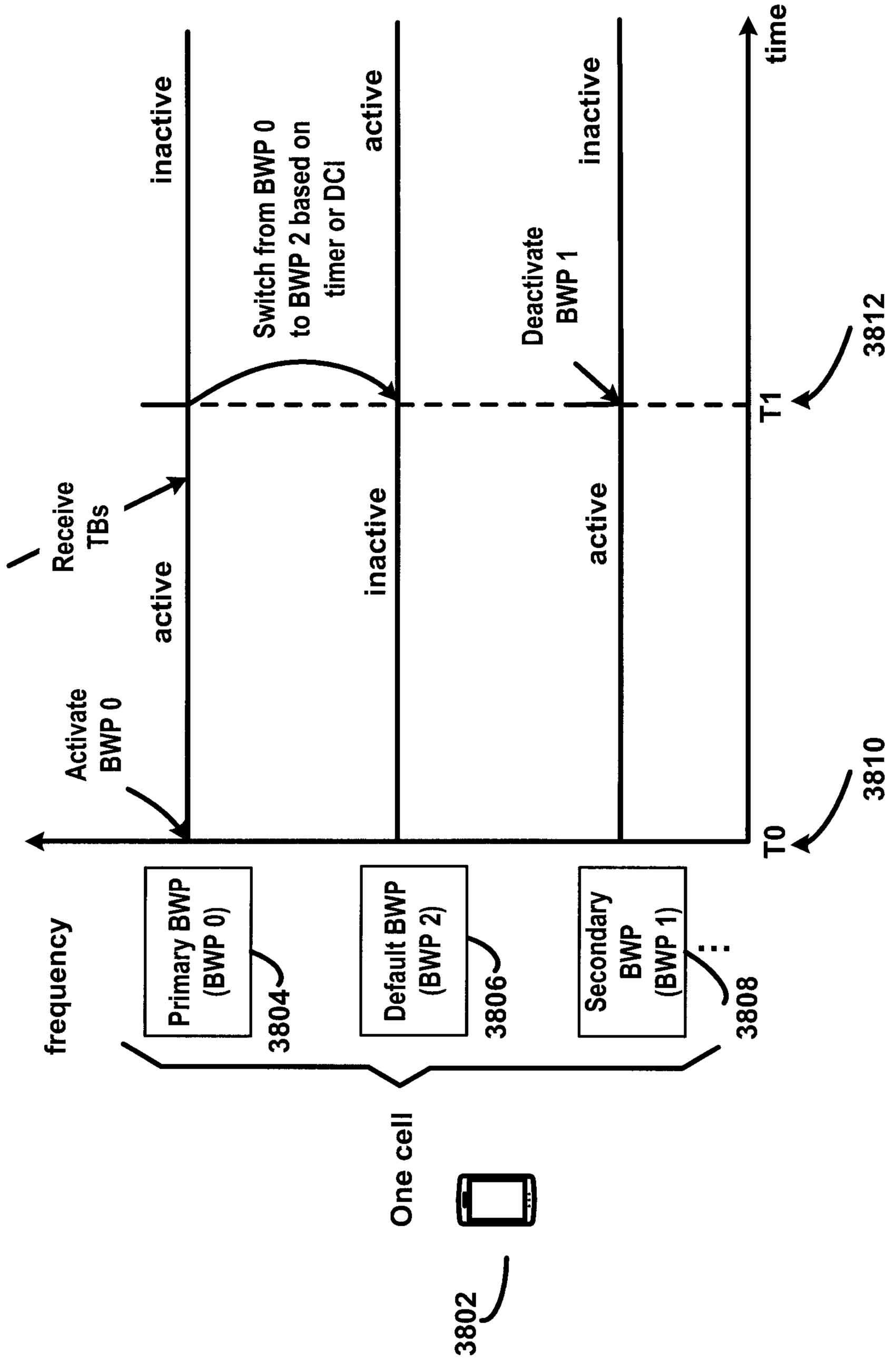

One cell
3802
frequency
Primary BWP (BWP 0)
3804
Default BWP (BWP 2)
3806
Secondary BWP (BWP 1)
3808
Activate BWP 0
T0
3810
Receive TBs
active
inactive
Switch from BWP 0 to BWP 2 based on timer or DCI
active
Deactivate BWP 1
inactive
T1
3812
time

FIG. 38

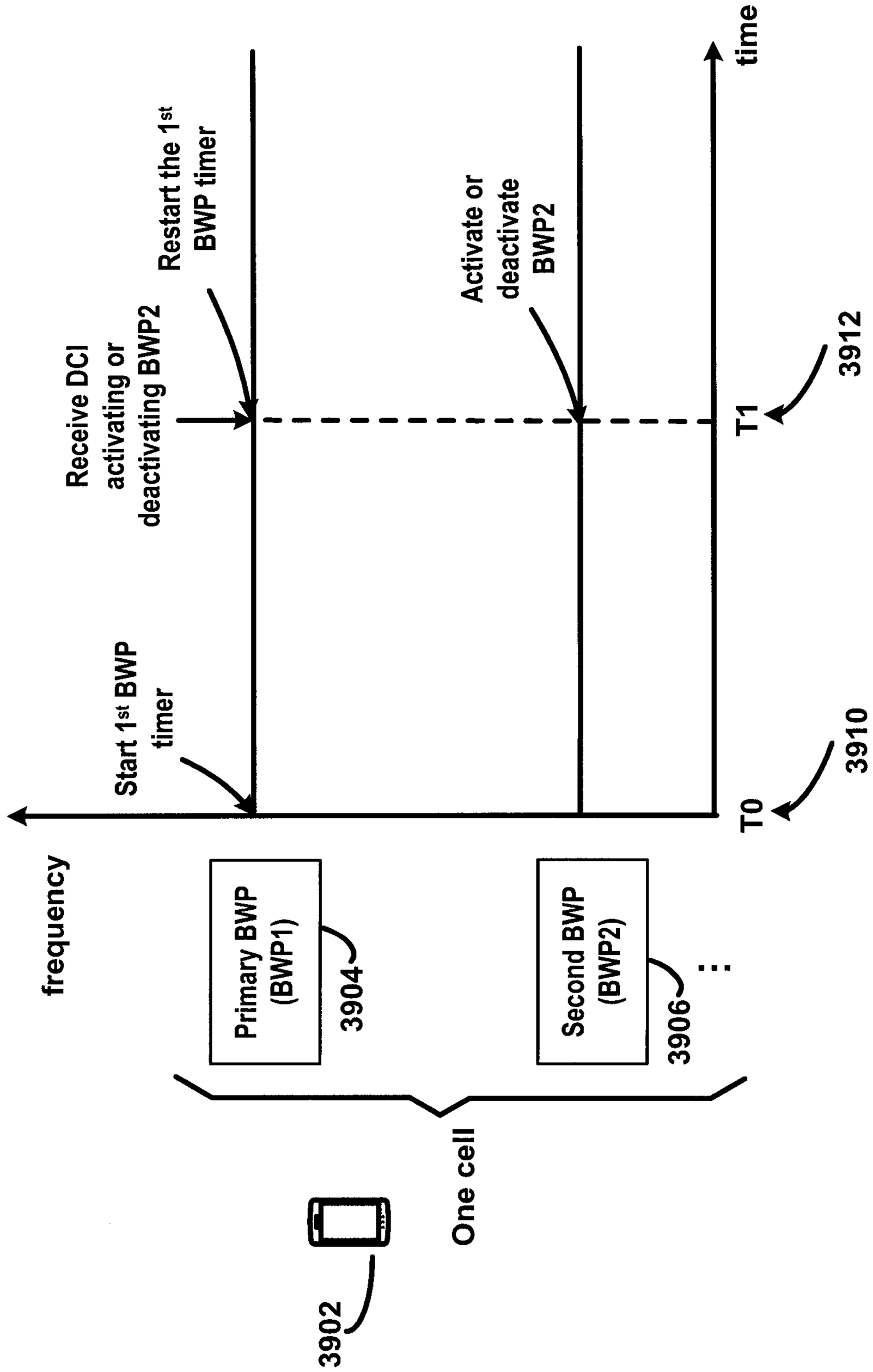

One cell
3902
frequency
Primary BWP (BWP1)
3904
Second BWP (BWP2)
3906
...
II
Start 1st BWP timer
T0
3910
Receive DCI activating or deactivating BWP2
Restart the 1st BWP timer
Activate or deactivate BWP2
T1
3912
time

FIG. 39

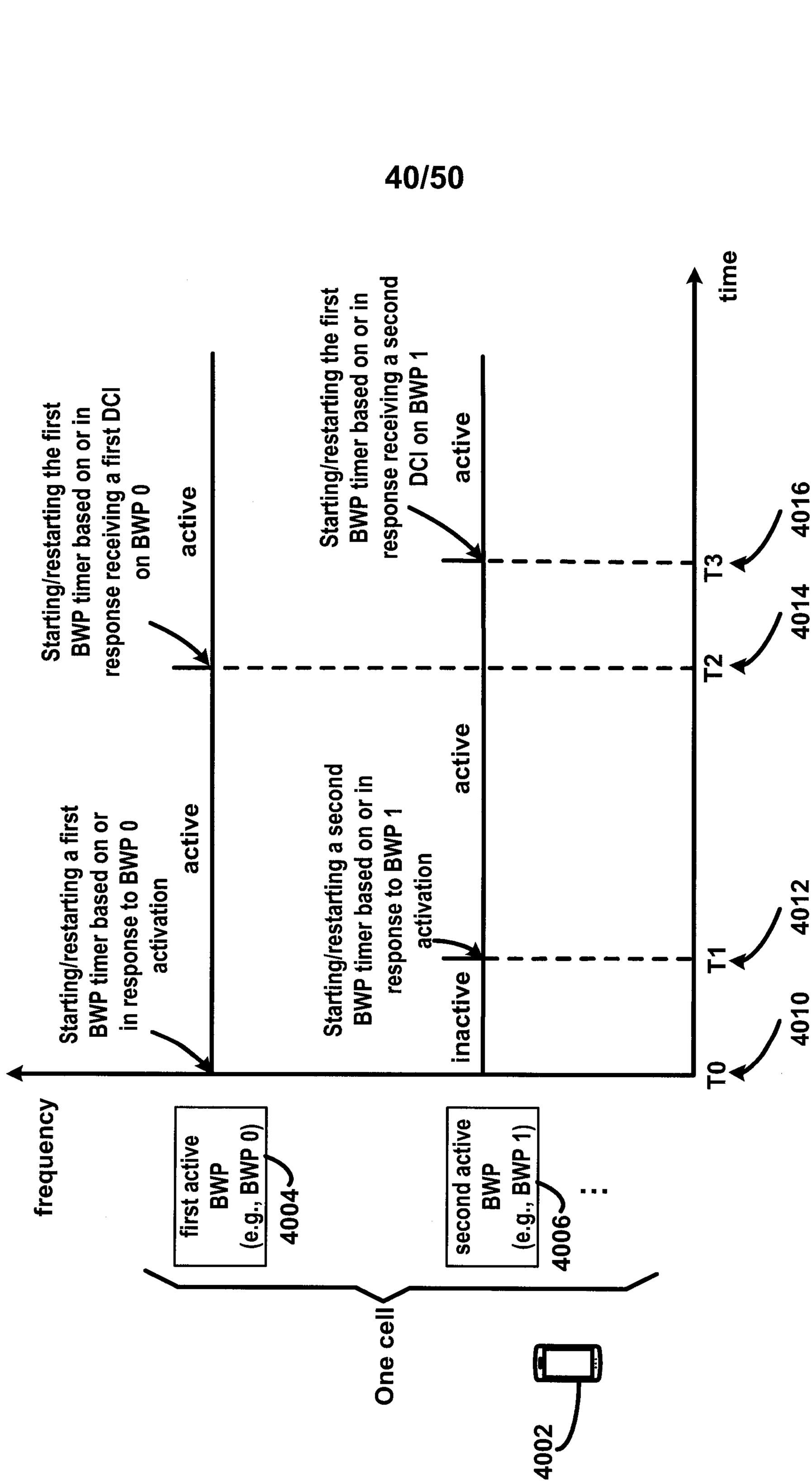

One cell
4002
frequency
first active BWP (e.g., BWP 0)
4004
second active BWP (e.g., BWP 1)
4006
...
time
T0
4010
Starting/restarting a first BWP timer based on or in response to BWP 0 activation
active
T1
4012
Starting/restarting a second BWP timer based on or in response to BWP 1 activation
inactive
T2
4014
Starting/restarting the first BWP timer based on or in response receiving a first DCI on BWP 0
active
T3
4016
Starting/restarting the second BWP timer based on or in response receiving a second DCI on BWP 1
active

FIG. 40

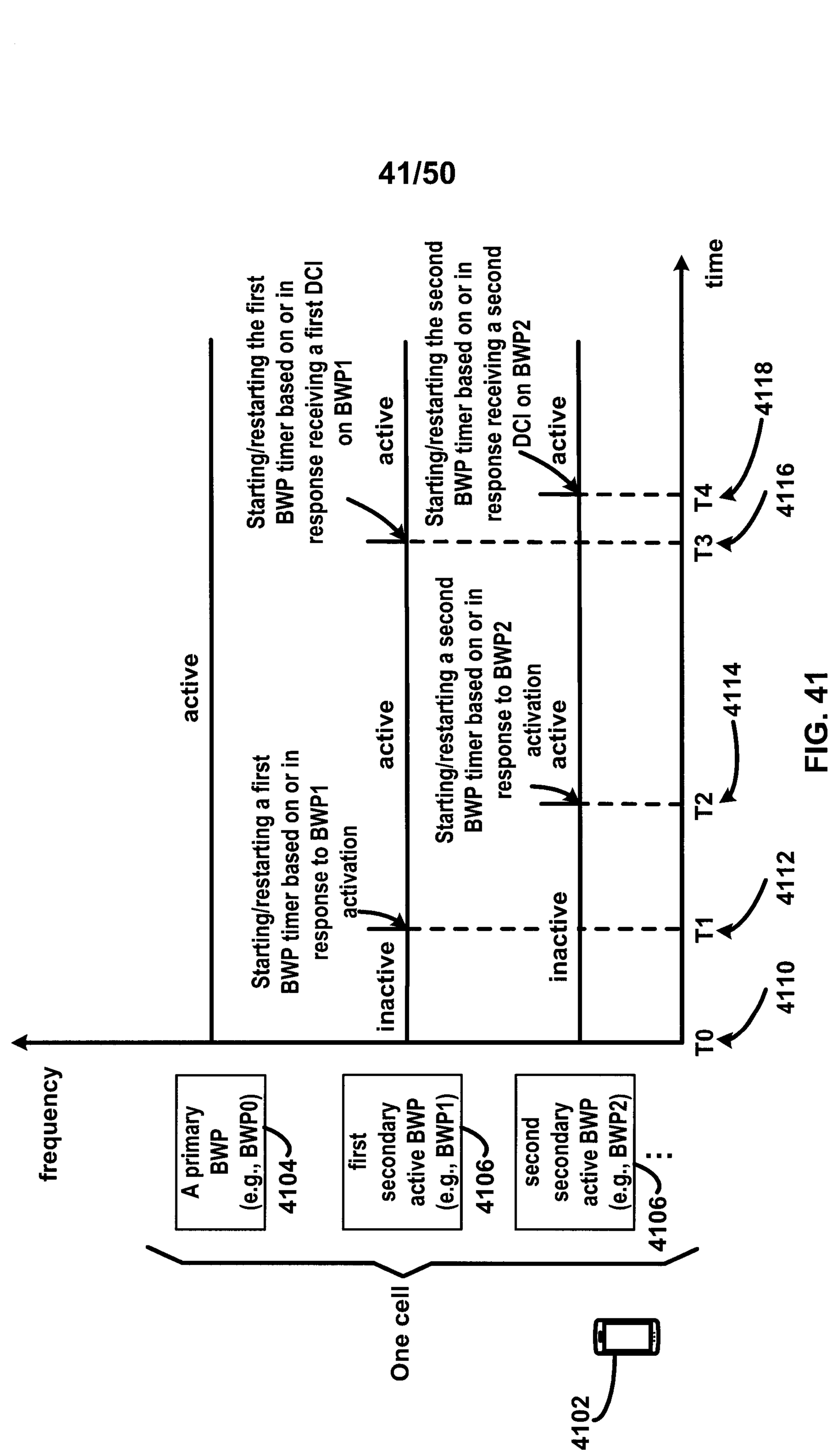

One cell
4102
frequency
time
A primary BWP (e.g., BWP0)
4104
first secondary active BWP (e.g., BWP1)
4106
second secondary active BWP (e.g., BWP2)
4106
4108
4110
4112
4114
4116
4118
T0
T1
T2
T3
T4
inactive
active
Starting/restarting a first BWP timer based on or in response to BWP1 activation
Starting/restarting the first BWP timer based on or in response receiving a first DCI on BWP1
Starting/restarting a second BWP timer based on or in response to BWP2 activation
Starting/restarting the second BWP timer based on or in response receiving a second DCI on BWP2

FIG. 41

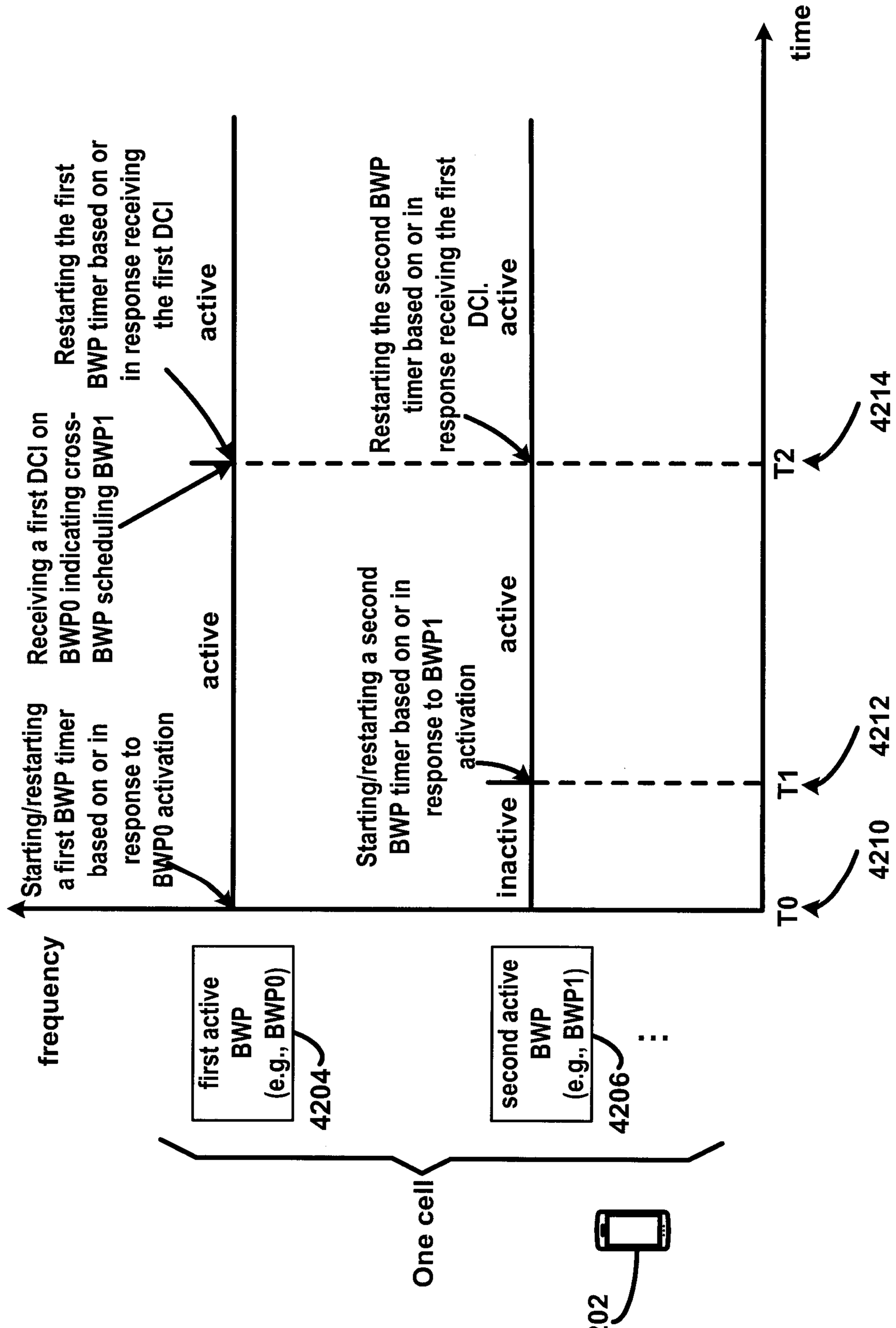

time
Receiving a first DCI on BWP0 indicating cross-BWP scheduling BWP1
Restarting the first BWP timer based on or in response receiving the first DCI
active
Restarting the second BWP timer based on or in response receiving the first DCI.
active
Starting/restarting a second BWP timer based on or in response to BWP1 activation
active
T2
4214
Starting/restarting a first BWP timer based on or in response to BWP0 activation
inactive
T1
4212
T0
4210
frequency
first active BWP (e.g., BWP0)
4204
second active BWP (e.g., BWP1)
4206
One cell
4202

FIG. 42

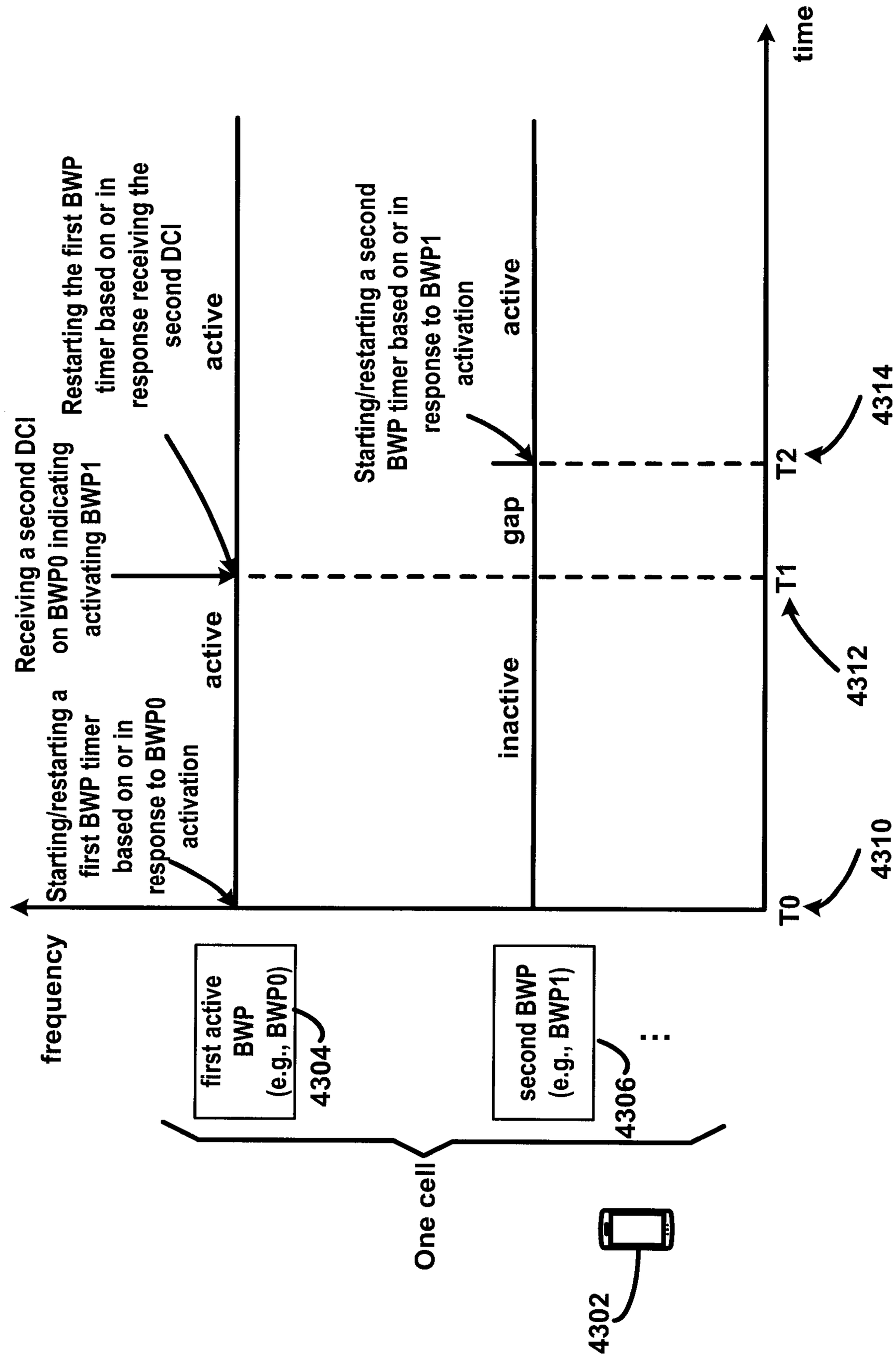

One cell
4302
frequency
first active BWP (e.g., BWP0)
4304
second BWP (e.g., BWP1)
4306
time
T0
4310
T1
4312
T2
4314
Receiving a second DCI on BWP0 indicating activating BWP1
Restarting the first BWP timer based on or in response receiving the second DCI
active
Starting/restarting a first BWP timer based on or in response to BWP0 activation
active
gap
Starting/restarting a second BWP timer based on or in response to BWP1 activation
active
inactive

FIG. 43

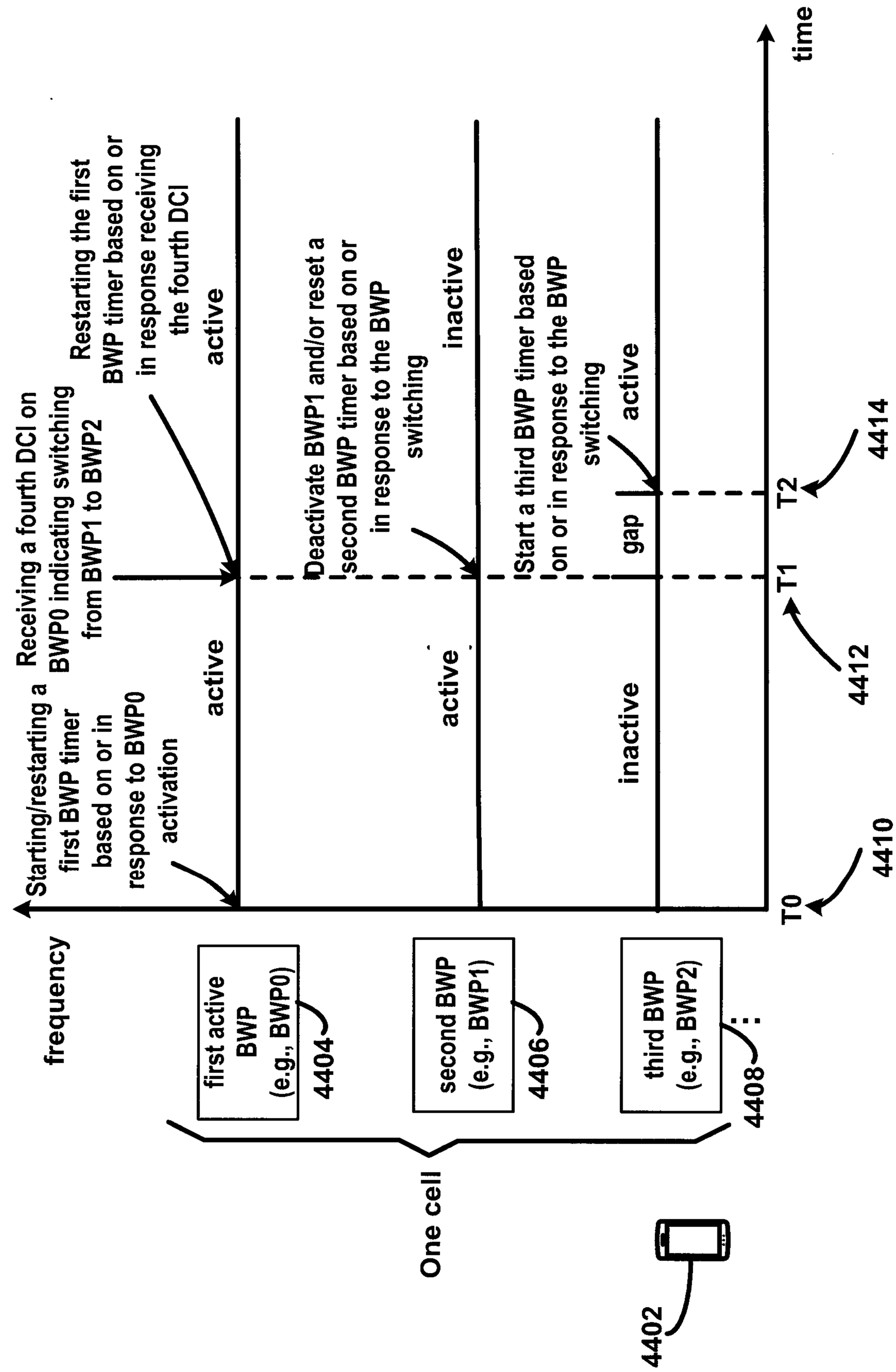

One cell
frequency
time
first active BWP (e.g., BWP0)
4404
second BWP (e.g., BWP1)
4406
third BWP (e.g., BWP2)
4408
4402
T0
T1
T2
4410
4412
4414
Starting/restarting a first BWP timer based on or in response to BWP0 activation
Receiving a fourth DCI on BWP0 indicating switching from BWP1 to BWP2
Restarting the first BWP timer based on or in response receiving the fourth DCI
Deactivate BWP1 and/or reset a second BWP timer based on or in response to the BWP switching
Start a third BWP timer based on or in response to the BWP switching
gap
active
inactive

FIG. 44

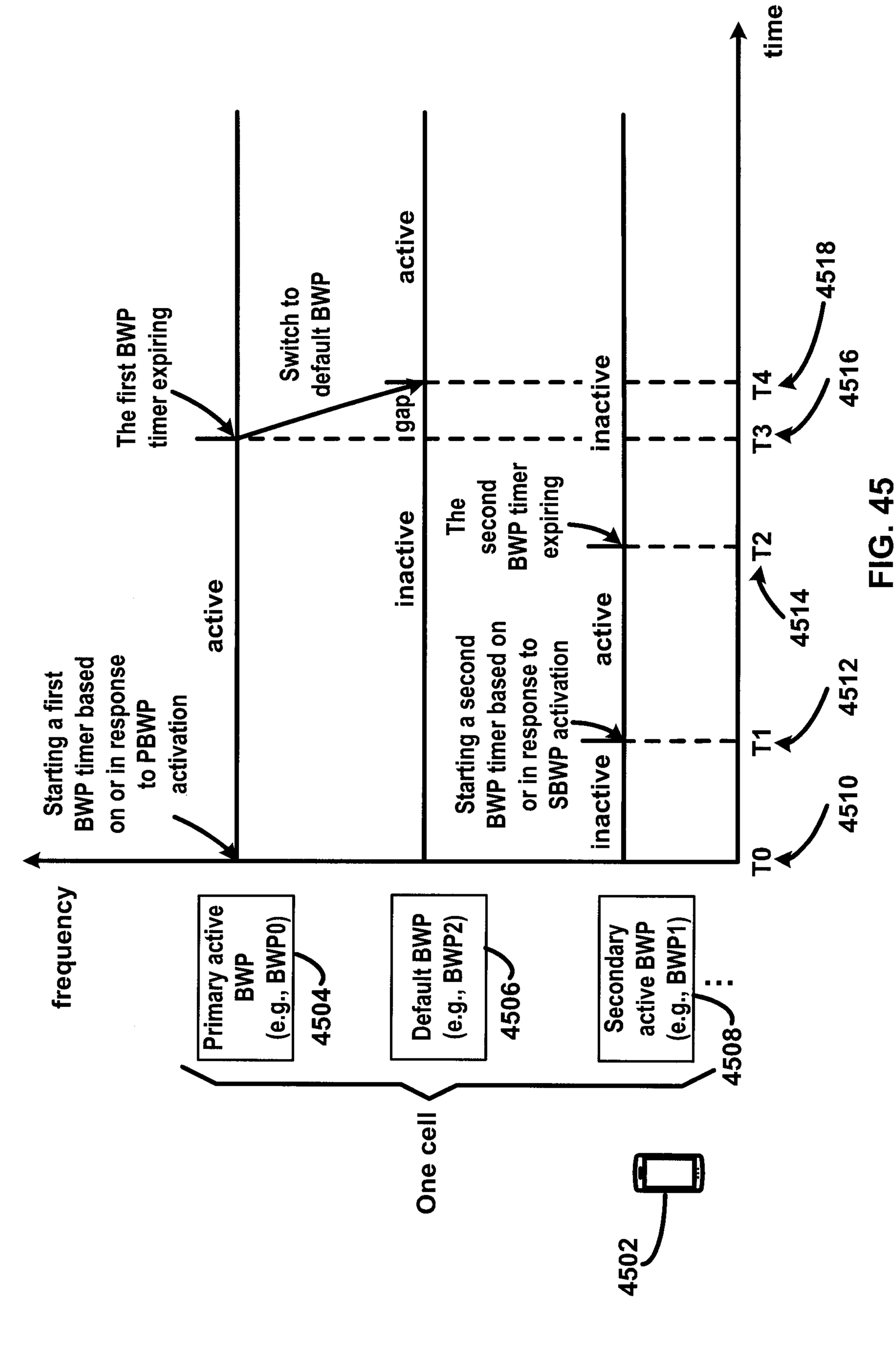

One cell
frequency
time
Primary active BWP (e.g., BWP0)
4504
Default BWP (e.g., BWP2)
4506
Secondary active BWP (e.g., BWP1)
4508
Starting a first BWP timer based on or in response to PBWP activation
Starting a second BWP timer based on or in response to SBWP activation
The first BWP timer expiring
Switch to default BWP
The second BWP timer expiring
active
inactive
gap
T0
T1
T2
T3
T4
4502
4510
4512
4514
4516
4518

FIG. 45

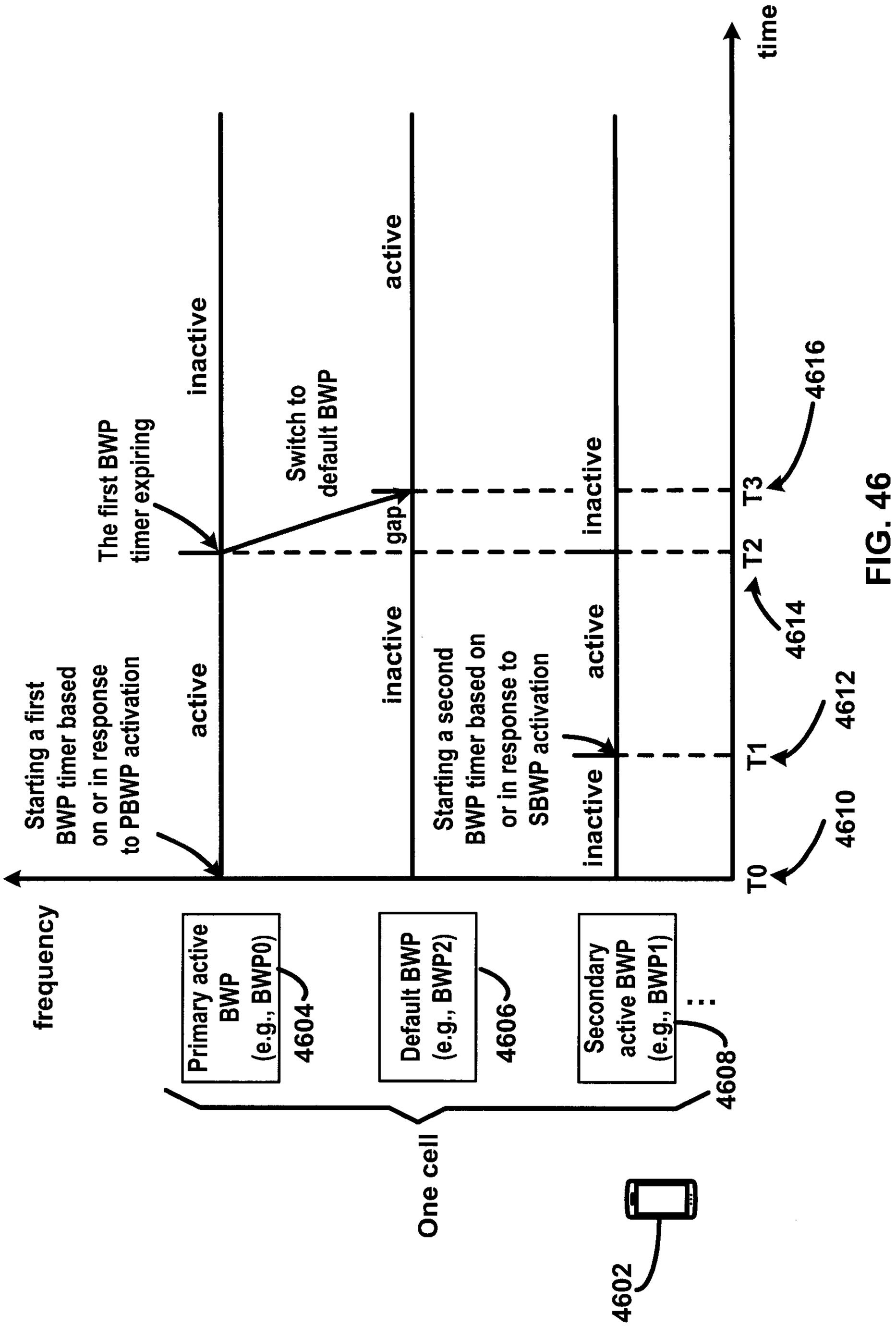

One cell
4602
frequency
Primary active BWP (e.g., BWP0)
4604
Default BWP (e.g., BWP2)
4606
Secondary active BWP (e.g., BWP1)
4608
Starting a first BWP timer based on or in response to PBWP activation
active
inactive
Starting a second BWP timer based on or in response to SBWP activation
active
inactive
T0
4610
T1
4612
T2
4614
T3
4616
time
The first BWP timer expiring
inactive
Switch to default BWP
active
gap
inactive

FIG. 46

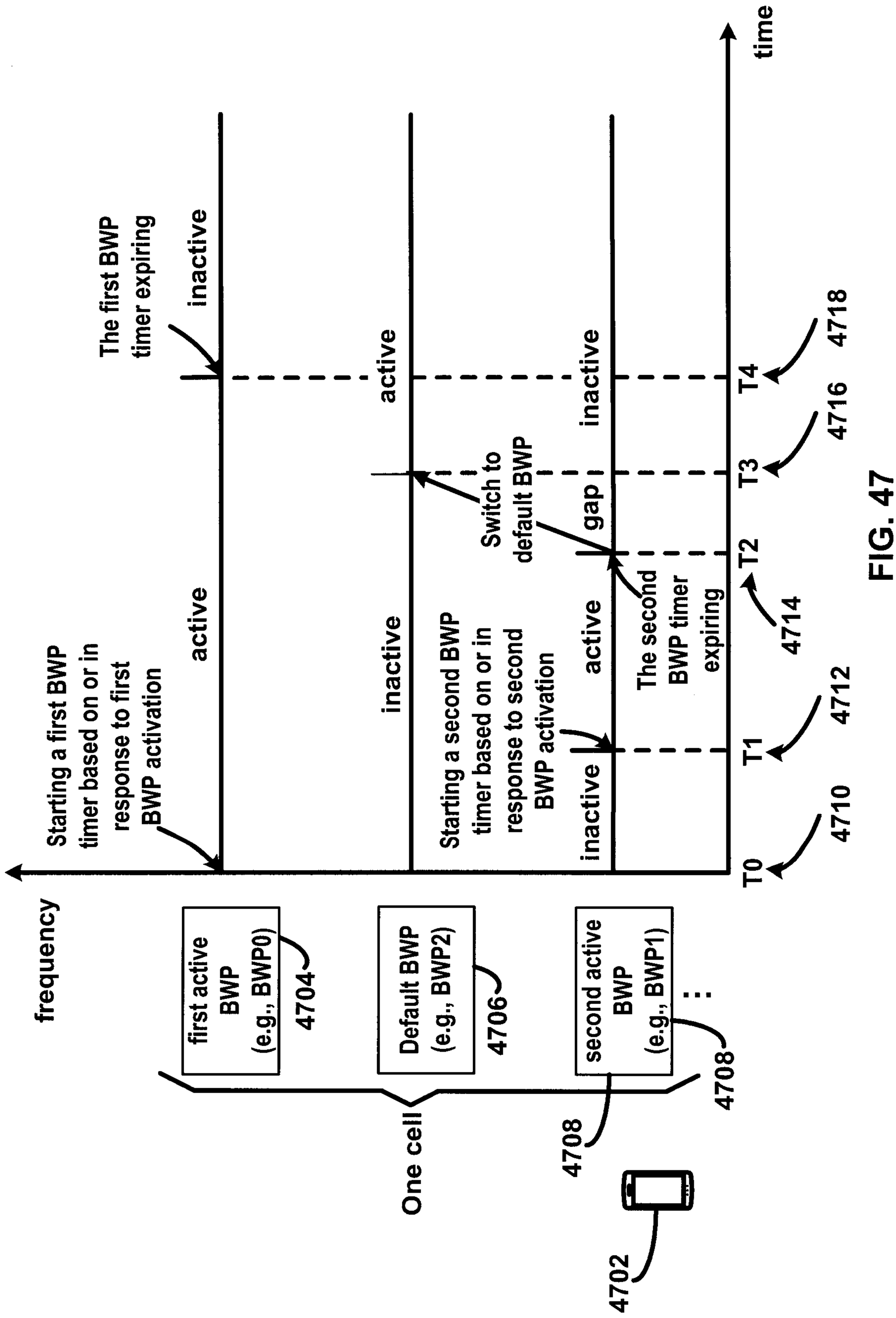

frequency
time
One cell
first active BWP (e.g., BWP0)
4704
Default BWP (e.g., BWP2)
4706
second active BWP (e.g., BWP1)
4708
4702
T0
4710
Starting a first BWP timer based on or in response to first BWP activation
active
T1
4712
The first BWP timer expiring
inactive
Switch to default BWP
T2
4714
Starting a second BWP timer based on or in response to second BWP activation
inactive
gap
active
T3
4716
The second BWP timer expiring
inactive
T4
4718

FIG. 47

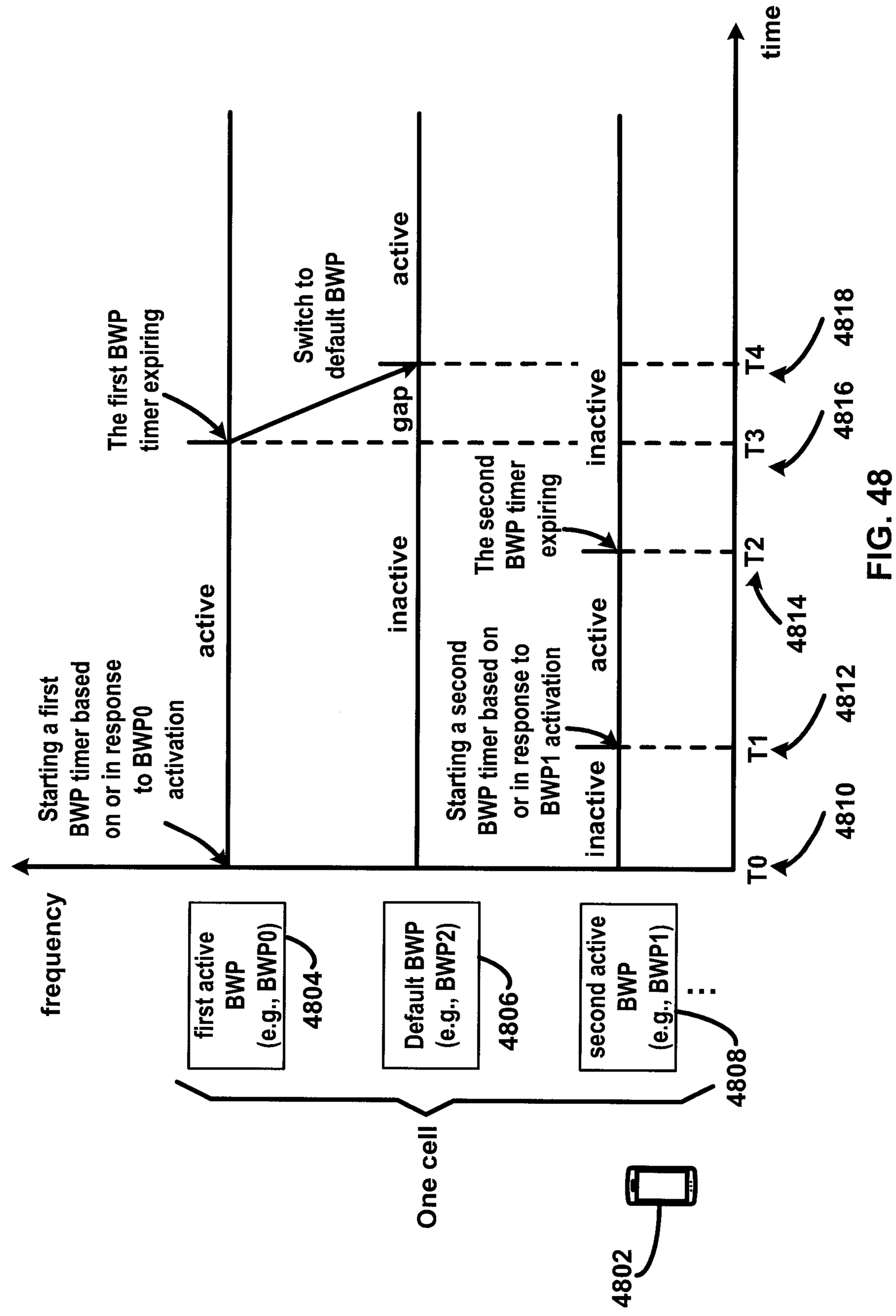

frequency
time
One cell
4802
first active BWP (e.g., BWP0)
4804
Default BWP (e.g., BWP2)
4806
second active BWP (e.g., BWP1)
4808
Starting a first BWP timer based on or in response to BWP0 activation
active
The first BWP timer expiring
Switch to default BWP
active
gap
inactive
Starting a second BWP timer based on or in response to BWP1 activation
inactive
active
The second BWP timer expiring
inactive
T0
4810
T1
4812
T2
4814
T3
4816
T4
4818

FIG. 48

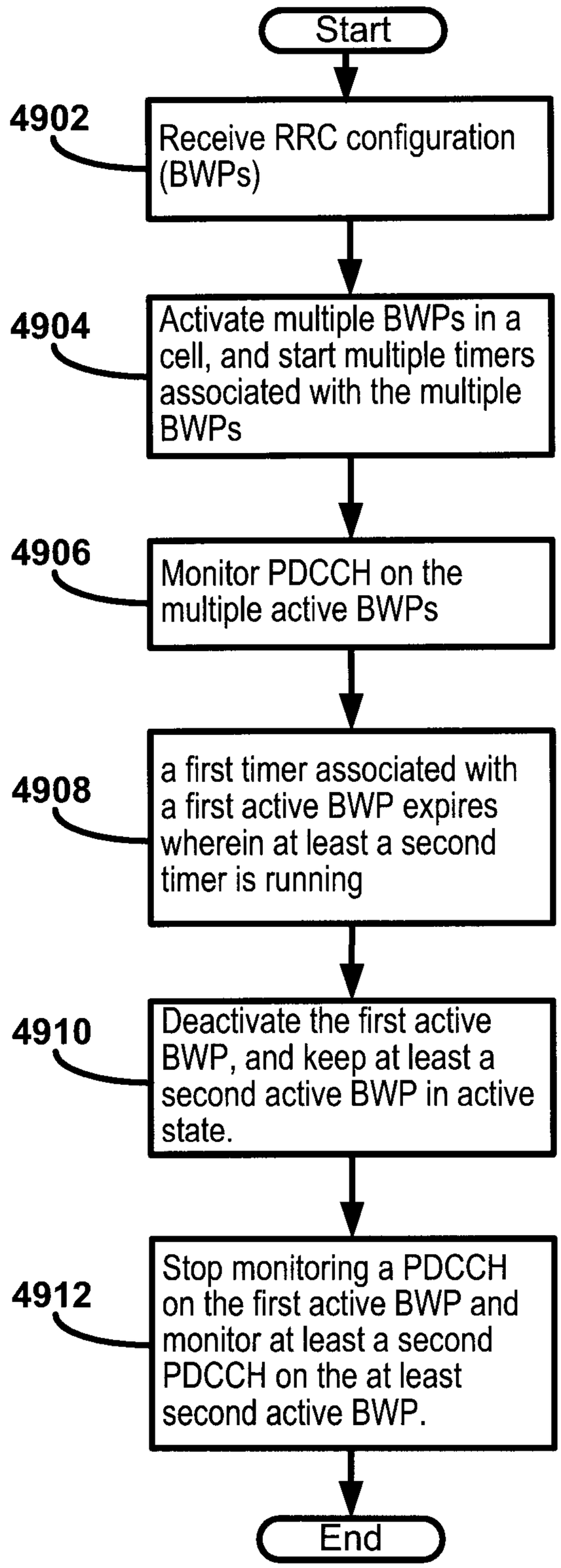

Start
4902
Receive RRC configuration (BWPs)
4904
Activate multiple BWPs in a cell, and start multiple timers associated with the multiple BWPs
4906
Monitor PDCCH on the multiple active BWPs
4908
a first timer associated with a first active BWP expires wherein at least a second timer is running
4910
Deactivate the first active BWP, and keep at least a second active BWP in active state.
4912
Stop monitoring a PDCCH on the first active BWP and monitor at least a second PDCCH on the at least second active BWP.
End

FIG. 49

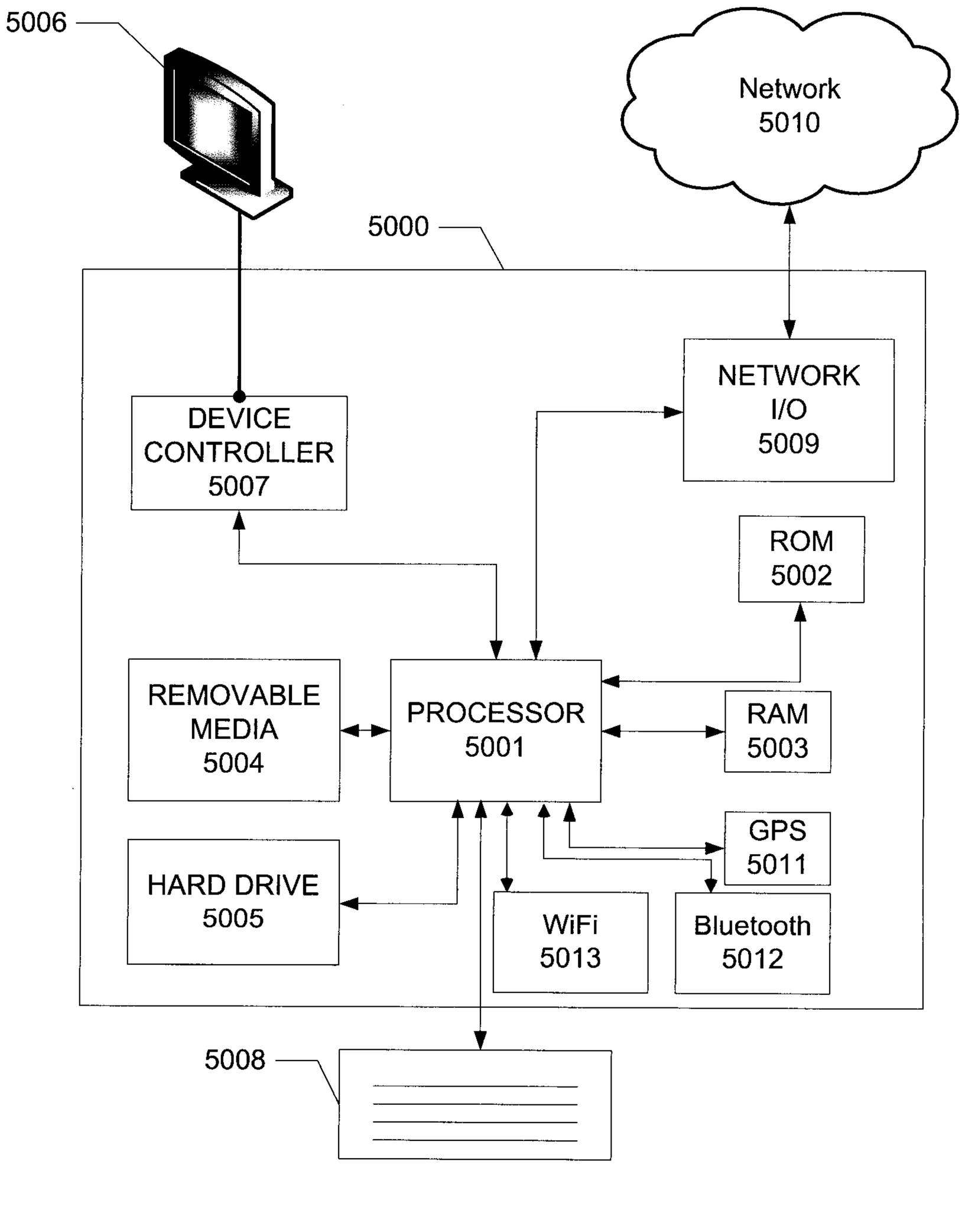
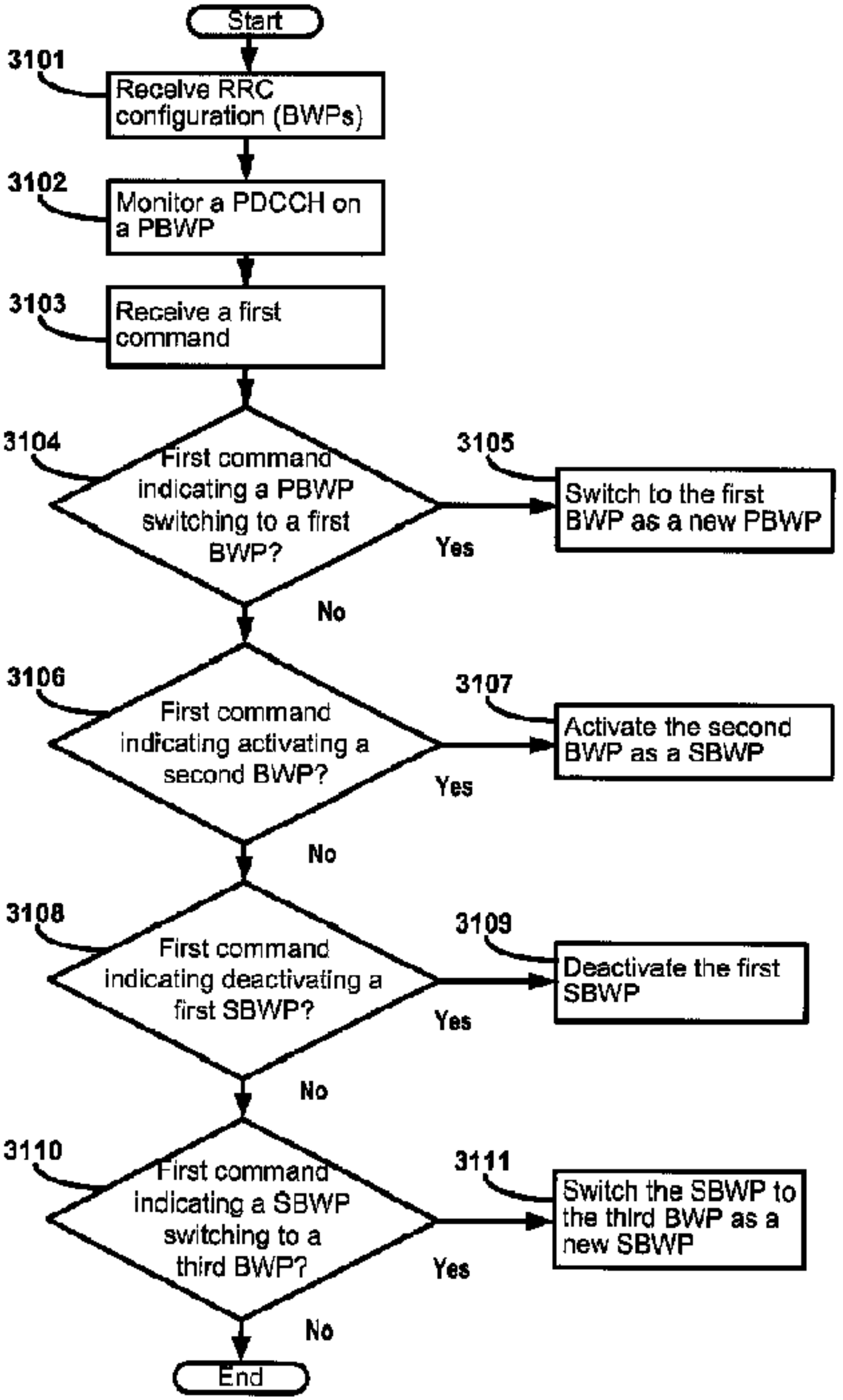

5006
Network
5010
5000
DEVICE
CONTROLLER
5007
NETWORK
I/O
5009
ROM
5002
REMOVABLE
MEDIA
5004
PROCESSOR
5001
RAM
5003
GPS
5011
HARD DRIVE
5005
WiFi
5013
Bluetooth
5012
5008

FIG. 50


Start
3101
Receive RRC configuration (BWPs)
3102
Monitor a PDCCH on a PBWP
3103
Receive a first command
3104
First command indicating a PBWP switching to a first BWP?
Yes
3105
Switch to the first BWP as a new PBWP
No
3106
First command indicating activating a second BWP?
Yes
3107
Activate the second BWP as a SBWP
No
3108
First command indicating deactivating a first SBWP?
Yes
3109
Deactivate the first SBWP
No
3110
First command indicating a SBWP switching to a third BWP?
Yes
3111
Switch the SBWP to the third BWP as a new SBWP
No
End