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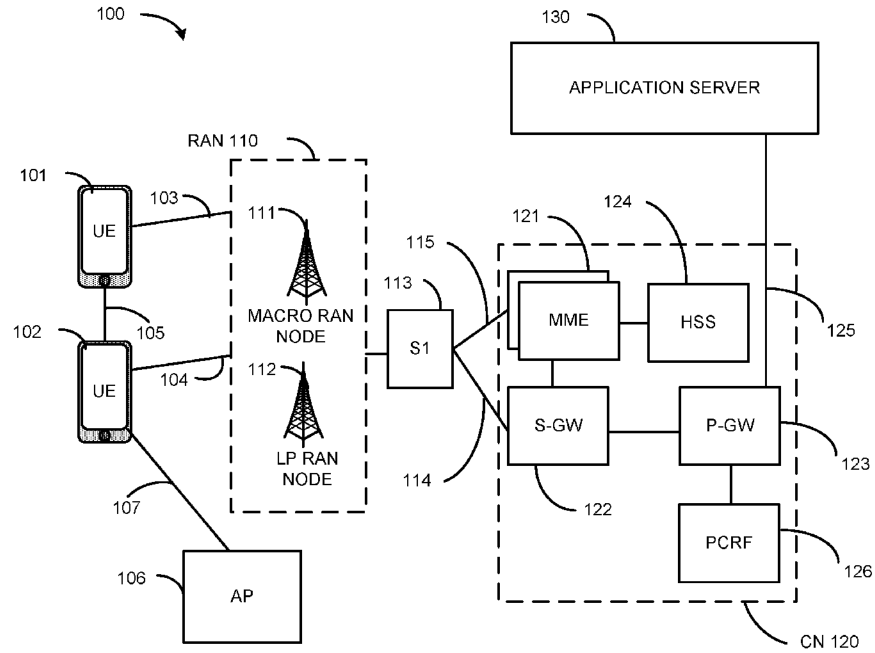

FIG. 1

(57) Abstract: Techniques for facilitating and/or performing interference cancellation on interfering CSI (Channel State Information)-RS (Reference Signal(s)) are discussed. In a first set of aspects, techniques are discussed that facilitate interference cancellation of interfering CSI-RS from PDSCH (Physical Downlink Shared Channel) or serving CSI-RS. In a second set of aspects, techniques are discussed that facilitate communication of parameters of interfering CSI-RS from a BS (Base Station) to a UE (User Equipment). In some such aspects, the parameters of the interfering CSI-RS can be communicated to the BS from a neighboring BS via X2 signaling.

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CSI (CHANNEL STATE INFORMATION)-RS (REFERENCE SIGNAL) TRANSMISSION WITH CSI-RS IC (INTERFERENCE CANCELLATION) RECEIVER

REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Applications No. 62/331,775 filed May 4, 2016, entitled "CHANNEL STATE INFORMATION REFERENCE SIGNAL TRANSMISSION FOR CHANNEL STATE INFORMATION REFERENCE SIGNAL INTERFERENCE CANCELLATION RECEIVER", the contents of which are herein incorporated by reference in their entirety.

FIELD

[0002] The present disclosure relates to wireless technology, and more specifically to techniques for reducing interference resulting from transmission of FD (Full Dimension)-MIMO (Multiple Input Multiple Output) CSI (Channel State Information)-RS (Reference Signal).

BACKGROUND

[0003] Elevation Beamforming/FD (Full Dimension)-MIMO (Multiple Input Multiple Output) for downlink data transmission was introduced for LTE (Long Term Evolution) in Rel-13 (3GPP (Third Generation Partnership Project) Release 13). The Rel-13 operation of elevation beamforming/FD-MIMO is based on two types of CSI feedback schemes with: (1) non-precoded CSI (Channel State Information)-RS (Reference Signals), that is, Class A FD-MIMO; or (2) beamformed CSI-RS, that is, Class B FD-MIMO. In Class A, each CSI-RS AP (antenna port) of a CSI-RS resource is transmitted by the eNB (evolved Node B) without beamforming, while in Class B the beamforming on CSI-RS antenna ports are used. The beamforming on CSI-RS APs provides an additional coverage advantage of Class B over Class A schemes.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] **FIG. 1** is a block diagram illustrating an example user equipment (UE) useable in connection with various aspects described herein.

[0005] **FIG. 2** is a diagram illustrating example components of a device that can be employed in accordance with various aspects discussed herein.

[0006] **FIG. 3** is a diagram illustrating example interfaces of baseband circuitry that can be employed in accordance with various aspects discussed herein.

[0007] **FIG. 4** is a diagram illustrating a normal CP (Cyclic Prefix) PRB (Physical Resource Block) showing the REs that can be used for Class A NZP CSI-RS transmission in connection with various aspects discussed herein.

[0008] **FIG. 5** is a diagram illustrating an example scenario of simultaneous transmission of CSI-RS signals using multiple beams, showing an example eNB (evolved Node B) employing elevation beamforming to transmit to a plurality of UEs at different elevations, in connection with various aspects described herein.

[0009] **FIG. 6** is a block diagram of a system that facilitates interference cancellation of interfering CSI (Channel State Information)-RS (Reference Signal(s)) at a UE (User Equipment), according to various aspects described herein.

[0010] **FIG. 7** is a block diagram of a system employable at a BS (Base Station) that facilitates interference cancellation of interfering CSI-RS by a UE, according to various aspects described herein.

[0011] **FIG. 8** is a flow diagram of an example method that facilitates cancellation of interference from CSI-RS of neighboring TP(s) (Transmission Point(s)) at a UE, according to various aspects discussed herein.

[0012] **FIG. 9** is a flow diagram of an example method employable at a BS that facilitates exchange of parameters of CSI-RS with neighboring TP(s), according to various aspects discussed herein.

[0013] **FIG. 10** is a flow diagram of an example method that facilitates cancellation of interference from CSI-RS (e.g., Class B CSI-RS) of a serving TP at a UE, according to various aspects discussed herein.

[0014] **FIG. 11** is a flow diagram of an example method employable at a BS that facilitates communication of parameters of interfering CSI-RS to served UEs, according to various aspects discussed herein.

DETAILED DESCRIPTION

[0015] The present disclosure will now be described with reference to the attached drawing figures, wherein like reference numerals are used to refer to like elements throughout, and wherein the illustrated structures and devices are not necessarily drawn to scale. As utilized herein, terms “component,” “system,” “interface,” and the like are intended to refer to a computer-related entity, hardware, software (e.g., in execution), and/or firmware. For example, a component can be a processor (e.g., a microprocessor, a controller, or other processing device), a process running on a processor, a controller, an object, an executable, a program, a storage device, a computer, a tablet PC and/or a user equipment (e.g., mobile phone, etc.) with a processing device. By way of illustration, an application running on a server and the server can also be a component. One or more components can reside within a process, and a component can be localized on one computer and/or distributed between two or more computers. A set of elements or a set of other components can be described herein, in which the term “set” can be interpreted as “one or more.”

[0016] Further, these components can execute from various computer readable storage media having various data structures stored thereon such as with a module, for example. The components can communicate via local and/or remote processes such as in accordance with a signal having one or more data packets (e.g., data from one component interacting with another component in a local system, distributed system, and/or across a network, such as, the Internet, a local area network, a wide area network, or similar network with other systems via the signal).

[0017] As another example, a component can be an apparatus with specific functionality provided by mechanical parts operated by electric or electronic circuitry, in which the electric or electronic circuitry can be operated by a software application or a firmware application executed by one or more processors. The one or more processors can be internal or external to the apparatus and can execute at least a part of the software or firmware application. As yet another example, a component can be an apparatus that provides specific functionality through electronic components without mechanical parts; the electronic components can include one or more processors therein to execute software and/or firmware that confer(s), at least in part, the functionality of the electronic components.

[0018] Use of the word exemplary is intended to present concepts in a concrete fashion. As used in this application, the term “or” is intended to mean an inclusive “or” rather than an exclusive “or”. That is, unless specified otherwise, or clear from context, “X employs A or B” is intended to mean any of the natural inclusive permutations. That is, if X employs A; X employs B; or X employs both A and B, then “X employs A or B” is satisfied under any of the foregoing instances. In addition, the articles “a” and “an” as used in this application and the appended claims should generally be construed to mean “one or more” unless specified otherwise or clear from context to be directed to a singular form. Furthermore, to the extent that the terms “including”, “includes”, “having”, “has”, “with”, or variants thereof are used in either the detailed description and the claims, such terms are intended to be inclusive in a manner similar to the term “comprising.”

[0019] As used herein, the term “circuitry” may refer to, be part of, or include an Application Specific Integrated Circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group), and/or memory (shared, dedicated, or group) that execute one or more software or firmware programs, a combinational logic circuit, and/or other suitable hardware components that provide the described functionality. In some embodiments, the circuitry may be implemented in, or functions associated with the circuitry may be implemented by, one or more software or firmware modules. In some embodiments, circuitry may include logic, at least partially operable in hardware.

[0020] Embodiments described herein may be implemented into a system using any suitably configured hardware and/or software. **FIG. 1** illustrates an architecture of a system 100 of a network in accordance with some embodiments. The system 100 is shown to include a user equipment (UE) 101 and a UE 102. The UEs 101 and 102 are illustrated as smartphones (e.g., handheld touchscreen mobile computing devices connectable to one or more cellular networks), but may also comprise any mobile or non-mobile computing device, such as Personal Data Assistants (PDAs), pagers, laptop computers, desktop computers, wireless handsets, or any computing device including a wireless communications interface.

[0021] In some embodiments, any of the UEs 101 and 102 can comprise an Internet of Things (IoT) UE, which can comprise a network access layer designed for low-power IoT applications utilizing short-lived UE connections. An IoT UE can utilize technologies such as machine-to-machine (M2M) or machine-type communications (MTC) for exchanging data with an MTC server or device via a public land mobile network (PLMN), Proximity-Based Service (ProSe) or device-to-device (D2D) communication, sensor networks, or IoT networks. The M2M or MTC exchange of data may be a machine-initiated exchange of data. An IoT network describes interconnecting IoT UEs, which may include uniquely identifiable embedded computing devices (within the Internet infrastructure), with short-lived connections. The IoT UEs may execute background applications (e.g., keep-alive messages, status updates, etc.) to facilitate the connections of the IoT network.

[0022] The UEs 101 and 102 may be configured to connect, e.g., communicatively couple, with a radio access network (RAN) 110 — the RAN 110 may be, for example, an Evolved Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access Network (E-UTRAN), a NextGen RAN (NG RAN), or some other type of RAN. The UEs 101 and 102 utilize connections 103 and 104, respectively, each of which comprises a physical communications interface or layer (discussed in further detail below); in this example, the connections 103 and 104 are illustrated as an air interface to enable communicative coupling, and can be consistent with cellular communications protocols, such as a Global System for Mobile Communications (GSM) protocol, a code-division multiple access (CDMA) network protocol, a Push-to-Talk (PTT) protocol, a PTT over Cellular (POC) protocol, a Universal Mobile Telecommunications System (UMTS) protocol, a 3GPP Long Term Evolution (LTE) protocol, a fifth generation (5G) protocol, a New Radio (NR) protocol, and the like.

[0023] In this embodiment, the UEs 101 and 102 may further directly exchange communication data via a ProSe interface 105. The ProSe interface 105 may alternatively be referred to as a sidelink interface comprising one or more logical channels, including but not limited to a Physical Sidelink Control Channel (PSCCH), a Physical Sidelink Shared Channel (PSSCH), a Physical Sidelink Discovery Channel (PSDCH), and a Physical Sidelink Broadcast Channel (PSBCH).

[0024] The UE 102 is shown to be configured to access an access point (AP) 106 via connection 107. The connection 107 can comprise a local wireless connection, such as a connection consistent with any IEEE 802.11 protocol, wherein the AP 106 would comprise a wireless fidelity (WiFi®) router. In this example, the AP 106 is shown to be connected to the Internet without connecting to the core network of the wireless system (described in further detail below).

[0025] The RAN 110 can include one or more access nodes that enable the connections 103 and 104. These access nodes (ANs) can be referred to as base stations (BSs), NodeBs, evolved NodeBs (eNBs), next Generation NodeBs (gNB), RAN nodes, and so forth, and can comprise ground stations (e.g., terrestrial access points) or satellite stations providing coverage within a geographic area (e.g., a cell). The RAN 110 may include one or more RAN nodes for providing macrocells, e.g., macro RAN node 111, and one or more RAN nodes for providing femtocells or picocells (e.g., cells having smaller coverage areas, smaller user capacity, or higher bandwidth compared to macrocells), e.g., low power (LP) RAN node 112.

[0026] Any of the RAN nodes 111 and 112 can terminate the air interface protocol and can be the first point of contact for the UEs 101 and 102. In some embodiments, any of the RAN nodes 111 and 112 can fulfill various logical functions for the RAN 110 including, but not limited to, radio network controller (RNC) functions such as radio bearer management, uplink and downlink dynamic radio resource management and data packet scheduling, and mobility management.

[0027] In accordance with some embodiments, the UEs 101 and 102 can be configured to communicate using Orthogonal Frequency-Division Multiplexing (OFDM) communication signals with each other or with any of the RAN nodes 111 and 112 over a multicarrier communication channel in accordance various communication techniques, such as, but not limited to, an Orthogonal Frequency-Division Multiple Access (OFDMA) communication technique (e.g., for downlink communications) or a Single Carrier Frequency Division Multiple Access (SC-FDMA) communication technique (e.g., for uplink and ProSe or sidelink communications), although the scope of the embodiments is not limited in this respect. The OFDM signals can comprise a plurality of orthogonal subcarriers.

[0028] In some embodiments, a downlink resource grid can be used for downlink transmissions from any of the RAN nodes 111 and 112 to the UEs 101 and 102, while uplink transmissions can utilize similar techniques. The grid can be a time-frequency grid, called a resource grid or time-frequency resource grid, which is the physical resource in the downlink in each slot. Such a time-frequency plane representation is a common practice for OFDM systems, which makes it intuitive for radio resource allocation. Each column and each row of the resource grid corresponds to one OFDM symbol and one OFDM subcarrier, respectively. The duration of the resource grid in the time domain corresponds to one slot in a radio frame. The smallest time-frequency unit in a resource grid is denoted as a resource element. Each resource grid comprises a number of resource blocks, which describe the mapping of certain physical channels to resource elements. Each resource block comprises a collection of resource elements; in the frequency domain, this may represent the smallest quantity of resources that currently can be allocated. There are several different physical downlink channels that are conveyed using such resource blocks.

[0029] The physical downlink shared channel (PDSCH) may carry user data and higher-layer signaling to the UEs 101 and 102. The physical downlink control channel (PDCCH) may carry information about the transport format and resource allocations related to the PDSCH channel, among other things. It may also inform the UEs 101 and 102 about the transport format, resource allocation, and H-ARQ (Hybrid Automatic Repeat Request) information related to the uplink shared channel. Typically, downlink scheduling (assigning control and shared channel resource blocks to the UE 102 within a cell) may be performed at any of the RAN nodes 111 and 112 based on channel quality information fed back from any of the UEs 101 and 102. The downlink resource assignment information may be sent on the PDCCH used for (e.g., assigned to) each of the UEs 101 and 102.

[0030] The PDCCH may use control channel elements (CCEs) to convey the control information. Before being mapped to resource elements, the PDCCH complex-valued symbols may first be organized into quadruplets, which may then be permuted using a sub-block interleaver for rate matching. Each PDCCH may be transmitted using one or more of these CCEs, where each CCE may correspond to nine sets of four physical resource elements known as resource element groups (REGs). Four Quadrature Phase Shift Keying (QPSK) symbols may be mapped to each REG. The PDCCH can be transmitted using one or more CCEs, depending on the size of the downlink control information (DCI) and the channel condition. There can be four or more different PDCCH formats defined in LTE with different numbers of CCEs (e.g., aggregation level, L=1, 2, 4, or 8).

[0031] Some embodiments may use concepts for resource allocation for control channel information that are an extension of the above-described concepts. For example, some embodiments may utilize an enhanced physical downlink control channel (EPDCCH) that uses PDSCH resources for control information transmission. The EPDCCH may be transmitted using one or more enhanced the control channel elements (ECCEs). Similar to above, each ECCE may correspond to nine sets of four physical resource elements known as an enhanced resource element groups (EREGs). An ECCE may have other numbers of EREGs in some situations.

[0032] The RAN 110 is shown to be communicatively coupled to a core network (CN) 120 —via an S1 interface 113. In embodiments, the CN 120 may be an evolved packet core (EPC) network, a NextGen Packet Core (NPC) network, or some other type of CN. In this embodiment the S1 interface 113 is split into two parts: the S1-U interface 114, which carries traffic data between the RAN nodes 111 and 112 and the serving gateway (S-GW) 122, and the S1-mobility management entity (MME) interface 115, which is a signaling interface between the RAN nodes 111 and 112 and MMEs 121.

[0033] In this embodiment, the CN 120 comprises the MMEs 121, the S-GW 122, the Packet Data Network (PDN) Gateway (P-GW) 123, and a home subscriber server (HSS) 124. The MMEs 121 may be similar in function to the control plane of legacy Serving General Packet Radio Service (GPRS) Support Nodes (SGSN). The MMEs 121 may manage mobility aspects in access such as gateway selection and tracking area list management. The HSS 124 may comprise a database for network users, including subscription-related information to support the network entities' handling of communication sessions. The CN 120 may comprise one or several HSSs 124, depending on the number of mobile subscribers, on the capacity of the equipment, on the organization of the network, etc. For example, the HSS 124 can provide support for routing/roaming, authentication, authorization, naming/addressing resolution, location dependencies, etc.

[0034] The S-GW 122 may terminate the S1 interface 113 towards the RAN 110, and routes data packets between the RAN 110 and the CN 120. In addition, the S-GW 122 may be a local mobility anchor point for inter-RAN node handovers and also may provide an anchor for inter-3GPP mobility. Other responsibilities may include lawful intercept, charging, and some policy enforcement.

[0035] The P-GW 123 may terminate an SGi interface toward a PDN. The P-GW 123 may route data packets between the EPC network 123 and external networks such as a network including the application server 130 (alternatively referred to as application function (AF)) via an Internet Protocol (IP) interface 125. Generally, the application server 130 may be an element offering applications that use IP bearer resources with the core network (e.g., UMTS Packet Services (PS) domain, LTE PS data services, etc.). In this embodiment, the P-GW 123 is shown to be communicatively coupled to an application server 130 via an IP communications interface 125. The application server 130 can also be configured to support one or more communication services (e.g., Voice-over-Internet Protocol (VoIP) sessions, PTT sessions, group communication sessions, social networking services, etc.) for the UEs 101 and 102 via the CN 120.

[0036] The P-GW 123 may further be a node for policy enforcement and charging data collection. Policy and Charging Enforcement Function (PCRF) 126 is the policy and charging control element of the CN 120. In a non-roaming scenario, there may be a single PCRF in the Home Public Land Mobile Network (HPLMN) associated with a UE's Internet Protocol Connectivity Access Network (IP-CAN) session. In a roaming scenario with local breakout of traffic, there may be two PCRFs associated with a UE's IP-CAN session: a Home PCRF (H-PCRF) within a HPLMN and a Visited PCRF (V-PCRF) within a Visited Public Land Mobile Network (VPLMN). The PCRF 126 may be communicatively coupled to the application server 130 via the P-GW 123. The application server 130 may signal the PCRF 126 to indicate a new service flow and select the appropriate Quality of Service (QoS) and charging parameters. The PCRF 126 may provision this rule into a Policy and Charging Enforcement Function (PCEF) (not shown) with the appropriate traffic flow template (TFT) and QoS class of identifier

(QCI), which commences the QoS and charging as specified by the application server 130.

[0037] **FIG. 2** illustrates example components of a device 200 in accordance with some embodiments. In some embodiments, the device 200 may include application circuitry 202, baseband circuitry 204, Radio Frequency (RF) circuitry 206, front-end module (FEM) circuitry 208, one or more antennas 210, and power management circuitry (PMC) 212 coupled together at least as shown. The components of the illustrated device 200 may be included in a UE or a RAN node. In some embodiments, the device 200 may include less elements (e.g., a RAN node may not utilize application circuitry 202, and instead include a processor/controller to process IP data received from an EPC). In some embodiments, the device 200 may include additional elements such as, for example, memory/storage, display, camera, sensor, or input/output (I/O) interface. In other embodiments, the components described below may be included in more than one device (e.g., said circuitries may be separately included in more than one device for Cloud-RAN (C-RAN) implementations).

[0038] The application circuitry 202 may include one or more application processors. For example, the application circuitry 202 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The processor(s) may include any combination of general-purpose processors and dedicated processors (e.g., graphics processors, application processors, etc.). The processors may be coupled with or may include memory/storage and may be configured to execute instructions stored in the memory/storage to enable various applications or operating systems to run on the device 200. In some embodiments, processors of application circuitry 202 may process IP data packets received from an EPC.

[0039] The baseband circuitry 204 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The baseband circuitry 204 may include one or more baseband processors or control logic to process baseband signals received from a receive signal path of the RF circuitry 206 and to generate baseband signals for a transmit signal path of the RF circuitry 206. Baseband processing circuity 204 may interface with the application circuitry 202 for generation and processing of the baseband signals and for controlling operations of the RF circuitry 206. For example, in some embodiments, the baseband circuitry 204 may include a third generation (3G) baseband processor 204A, a fourth generation (4G) baseband processor 204B, a fifth generation (5G) baseband processor 204C, or other baseband processor(s) 204D for other existing generations, generations in development or to be developed in the future (e.g., second generation (2G), sixth generation (6G), etc.). The baseband circuitry 204 (e.g., one or more of baseband processors 204A-D) may handle various radio control functions that enable communication with one or more radio networks via the RF circuitry 206. In other embodiments, some or all of the functionality of baseband processors 204A-D may be included in modules stored in the memory 204G and executed via a Central Processing Unit (CPU) 204E. The radio control functions may include, but are not limited to, signal modulation/demodulation, encoding/decoding, radio frequency shifting, etc. In some embodiments, modulation/demodulation circuitry of the baseband circuitry 204 may include Fast-Fourier Transform (FFT), precoding, or constellation mapping/demapping functionality. In some embodiments, encoding/decoding circuitry of the baseband circuitry 204 may include convolution, tail-biting convolution, turbo, Viterbi, or Low Density Parity Check (LDPC) encoder/decoder functionality. Embodiments of modulation/demodulation and encoder/decoder functionality are not limited to these examples and may include other suitable functionality in other embodiments.

[0040] In some embodiments, the baseband circuitry 204 may include one or more audio digital signal processor(s) (DSP) 204F. The audio DSP(s) 204F may be include elements for compression/decompression and echo cancellation and may include other suitable processing elements in other embodiments. Components of the baseband circuitry may be suitably combined in a single chip, a single chipset, or disposed on a same circuit board in some embodiments. In some embodiments, some or all of the constituent components of the baseband circuitry 204 and the application circuitry 202 may be implemented together such as, for example, on a system on a chip (SOC).

[0041] In some embodiments, the baseband circuitry 204 may provide for communication compatible with one or more radio technologies. For example, in some embodiments, the baseband circuitry 204 may support communication with an evolved universal terrestrial radio access network (EUTRAN) or other wireless metropolitan area networks (WMAN), a wireless local area network (WLAN), a wireless personal area network (WPAN). Embodiments in which the baseband circuitry 204 is configured to support radio communications of more than one wireless protocol may be referred to as multi-mode baseband circuitry.

[0042] RF circuitry 206 may enable communication with wireless networks using modulated electromagnetic radiation through a non-solid medium. In various embodiments, the RF circuitry 206 may include switches, filters, amplifiers, etc. to facilitate the communication with the wireless network. RF circuitry 206 may include a receive signal path which may include circuitry to down-convert RF signals received from the FEM circuitry 208 and provide baseband signals to the baseband circuitry 204. RF circuitry 206 may also include a transmit signal path which may include circuitry to up-convert baseband signals provided by the baseband circuitry 204 and provide RF output signals to the FEM circuitry 208 for transmission.

[0043] In some embodiments, the receive signal path of the RF circuitry 206 may include mixer circuitry 206a, amplifier circuitry 206b and filter circuitry 206c. In some embodiments, the transmit signal path of the RF circuitry 206 may include filter circuitry 206c and mixer circuitry 206a. RF circuitry 206 may also include synthesizer circuitry 206d for synthesizing a frequency for use by the mixer circuitry 206a of the receive signal path and the transmit signal path. In some embodiments, the mixer circuitry 206a of the receive signal path may be configured to down-convert RF signals received from the FEM circuitry 208 based on the synthesized frequency provided by synthesizer circuitry 206d. The amplifier circuitry 206b may be configured to amplify the down-converted signals and the filter circuitry 206c may be a low-pass filter (LPF) or band-pass filter (BPF) configured to remove unwanted signals from the down-converted signals to generate output baseband signals. Output baseband signals may be provided to the baseband circuitry 204 for further processing. In some embodiments, the output baseband signals may be zero-frequency baseband signals, although this is not a requirement. In some embodiments, mixer circuitry 206a of the receive signal path may comprise passive mixers, although the scope of the embodiments is not limited in this respect.

[0044] In some embodiments, the mixer circuitry 206a of the transmit signal path may be configured to up-convert input baseband signals based on the synthesized frequency provided by the synthesizer circuitry 206d to generate RF output signals for the FEM circuitry 208. The baseband signals may be provided by the baseband circuitry 204 and may be filtered by filter circuitry 206c.

[0045] In some embodiments, the mixer circuitry 206a of the receive signal path and the mixer circuitry 206a of the transmit signal path may include two or more mixers and may be arranged for quadrature downconversion and upconversion, respectively. In some embodiments, the mixer circuitry 206a of the receive signal path and the mixer circuitry 206a of the transmit signal path may include two or more mixers and may be arranged for image rejection (e.g., Hartley image rejection). In some embodiments, the mixer circuitry 206a of the receive signal path and the mixer circuitry 206a may be arranged for direct downconversion and direct upconversion, respectively. In some embodiments, the mixer circuitry 206a of the receive signal path and the mixer circuitry 206a of the transmit signal path may be configured for super-heterodyne operation.

[0046] In some embodiments, the output baseband signals and the input baseband signals may be analog baseband signals, although the scope of the embodiments is not limited in this respect. In some alternate embodiments, the output baseband signals and the input baseband signals may be digital baseband signals. In these alternate embodiments, the RF circuitry 206 may include analog-to-digital converter (ADC) and digital-to-analog converter (DAC) circuitry and the baseband circuitry 204 may include a digital baseband interface to communicate with the RF circuitry 206.

[0047] In some dual-mode embodiments, a separate radio IC circuitry may be provided for processing signals for each spectrum, although the scope of the embodiments is not limited in this respect.

[0048] In some embodiments, the synthesizer circuitry 206d may be a fractional-N synthesizer or a fractional N/N+1 synthesizer, although the scope of the embodiments is not limited in this respect as other types of frequency synthesizers may be suitable. For example, synthesizer circuitry 206d may be a delta-sigma synthesizer, a frequency multiplier, or a synthesizer comprising a phase-locked loop with a frequency divider.

[0049] The synthesizer circuitry 206d may be configured to synthesize an output frequency for use by the mixer circuitry 206a of the RF circuitry 206 based on a frequency input and a divider control input. In some embodiments, the synthesizer circuitry 206d may be a fractional N/N+1 synthesizer.

[0050] In some embodiments, frequency input may be provided by a voltage controlled oscillator (VCO), although that is not a requirement. Divider control input may be provided by either the baseband circuitry 204 or the applications processor 202 depending on the desired output frequency. In some embodiments, a divider control input (e.g., N) may be determined from a look-up table based on a channel indicated by the applications processor 202.

[0051] Synthesizer circuitry 206d of the RF circuitry 206 may include a divider, a delay-locked loop (DLL), a multiplexer and a phase accumulator. In some embodiments, the divider may be a dual modulus divider (DMD) and the phase accumulator may be a digital phase accumulator (DPA). In some embodiments, the DMD may be configured to divide the input signal by either N or N+1 (e.g., based on a carry out) to provide a fractional division ratio. In some example embodiments, the DLL may include a set of cascaded, tunable, delay elements, a phase detector, a charge pump and a D-type flip-flop. In these embodiments, the delay elements may be configured to break a VCO period up into Nd equal packets of phase, where Nd is the number of delay elements in the delay line. In this way, the DLL provides negative feedback to help ensure that the total delay through the delay line is one VCO cycle.

[0052] In some embodiments, synthesizer circuitry 206d may be configured to generate a carrier frequency as the output frequency, while in other embodiments, the output frequency may be a multiple of the carrier frequency (e.g., twice the carrier frequency, four times the carrier frequency) and used in conjunction with quadrature generator and divider circuitry to generate multiple signals at the carrier frequency with multiple different phases with respect to each other. In some embodiments, the output frequency may be a LO frequency (fLO). In some embodiments, the RF circuitry 206 may include an IQ/polar converter.

[0053] FEM circuitry 208 may include a receive signal path which may include circuitry configured to operate on RF signals received from one or more antennas 210, amplify the received signals and provide the amplified versions of the received signals to the RF circuitry 206 for further processing. FEM circuitry 208 may also include a transmit signal path which may include circuitry configured to amplify signals for transmission provided by the RF circuitry 206 for transmission by one or more of the one or more antennas 210. In various embodiments, the amplification through the transmit or receive signal paths may be done solely in the RF circuitry 206, solely in the FEM 208, or in both the RF circuitry 206 and the FEM 208.

[0054] In some embodiments, the FEM circuitry 208 may include a TX/RX switch to switch between transmit mode and receive mode operation. The FEM circuitry may include a receive signal path and a transmit signal path. The receive signal path of the FEM circuitry may include an LNA to amplify received RF signals and provide the amplified received RF signals as an output (e.g., to the RF circuitry 206). The transmit signal path of the FEM circuitry 208 may include a power amplifier (PA) to amplify input RF signals (e.g., provided by RF circuitry 206), and one or more filters to generate RF signals for subsequent transmission (e.g., by one or more of the one or more antennas 210).

[0055] In some embodiments, the PMC 212 may manage power provided to the baseband circuitry 204. In particular, the PMC 212 may control power-source selection, voltage scaling, battery charging, or DC-to-DC conversion. The PMC 212 may often be included when the device 200 is capable of being powered by a battery, for example, when the device is included in a UE. The PMC 212 may increase the power conversion efficiency while providing desirable implementation size and heat dissipation characteristics.

[0056] While FIG. 2 shows the PMC 212 coupled only with the baseband circuitry 204. However, in other embodiments, the PMC 2 12 may be additionally or alternatively coupled with, and perform similar power management operations for, other components such as, but not limited to, application circuitry 202, RF circuitry 206, or FEM 208.

[0057] In some embodiments, the PMC 212 may control, or otherwise be part of, various power saving mechanisms of the device 200. For example, if the device 200 is in an RRC_Connected state, where it is still connected to the RAN node as it expects to receive traffic shortly, then it may enter a state known as Discontinuous Reception Mode (DRX) after a period of inactivity. During this state, the device 200 may power down for brief intervals of time and thus save power.

[0058] If there is no data traffic activity for an extended period of time, then the device 200 may transition off to an RRC_Idle state, where it disconnects from the network and does not perform operations such as channel quality feedback, handover, etc. The device 200 goes into a very low power state and it performs paging where again it periodically wakes up to listen to the network and then powers down again. The device 200 may not receive data in this state, in order to receive data, it must transition back to RRC_Connected state.

[0059] An additional power saving mode may allow a device to be unavailable to the network for periods longer than a paging interval (ranging from seconds to a few hours). During this time, the device is totally unreachable to the network and may power down completely. Any data sent during this time incurs a large delay and it is assumed the delay is acceptable.

[0060] Processors of the application circuitry 202 and processors of the baseband circuitry 204 may be used to execute elements of one or more instances of a protocol stack. For example, processors of the baseband circuitry 204, alone or in combination, may be used execute Layer 3, Layer 2, or Layer 1 functionality, while processors of the application circuitry 204 may utilize data (e.g., packet data) received from these layers and further execute Layer 4 functionality (e.g., transmission communication protocol (TCP) and user datagram protocol (UDP) layers). As referred to herein, Layer 3 may comprise a radio resource control (RRC) layer, described in further detail below. As referred to herein, Layer 2 may comprise a medium access control (MAC) layer, a radio link control (RLC) layer, and a packet data convergence protocol (PDCP) layer, described in further detail below. As referred to herein, Layer 1 may comprise a physical (PHY) layer of a UE/RAN node, described in further detail below.

[0061] **FIG. 3** illustrates example interfaces of baseband circuitry in accordance with some embodiments. As discussed above, the baseband circuitry 204 of FIG. 2 may comprise processors 204A-204E and a memory 204G utilized by said processors. Each of the processors 204A-204E may include a memory interface, 304A-304E, respectively, to send/receive data to/from the memory 204G.

[0062] The baseband circuitry 204 may further include one or more interfaces to communicatively couple to other circuitries/devices, such as a memory interface 312 (e.g., an interface to send/receive data to/from memory external to the baseband circuitry 204), an application circuitry interface 314 (e.g., an interface to send/receive data to/from the application circuitry 202 of FIG. 2), an RF circuitry interface 316 (e.g., an interface to send/receive data to/from RF circuitry 206 of FIG. 2), a wireless hardware connectivity interface 318 (e.g., an interface to send/receive data to/from Near Field Communication (NFC) components, Bluetooth® components (e.g., Bluetooth® Low Energy), Wi-Fi® components, and other communication components), and a power management interface 320 (e.g., an interface to send/receive power or control signals to/from the PMC 212).

[0063] Additionally, although the above example discussion of device 300 is in the context of a UE device, in various aspects, a similar device can be employed in connection with a base station (BS) such as an Evolved NodeB (eNB), etc.

[0064] In Rel-10 (3GPP Release 10) NZP (Non-Zero Power) CSI (Channel State Information)-RS (Reference Signals) were considered as low density signals due to the relatively large periodicity and the limited number of used REs (Resource Elements) in the subframe (up to 8 REs per PRB (Physical Resource Block) pair in the subframe). As a result, the inter-cell interference issue from Rel-10 NZP CSI-RS signals was not considered. In Rel-14 (3GPP Release 14), with the possible introduction of a larger number of CSI-RS antenna ports (e.g., up to 32 ports), for Class A FD-MIMO, the low density signal assumption may not be valid, and the impact of interference from CSI-RS transmission for UEs served by neighboring TPs (Transmission Points) can be considered (especially in TDD (Time Division Duplex) system).

[0065] For Class A CSI-RS, the number of REs used for Rel-14 NZP CSI-RS in the PRB may be increased to 32 REs. Moreover, in a given PRB and in a given OFDM (Orthogonal Frequency Division Multiplexing) symbol, NZP CSI-RS uses the same signal for modulation of the all antenna ports. In highly correlated interfering channels (e.g. corresponding to LOS (Line of Sight) propagation), the interference from NZP CSI-RS transmission may be correlated in a given PRB. Therefore, the impact of CSI-RS transmission with 32 antenna ports on PDSCH performance (and possibly colliding CSI-RS) of neighboring TPs could be more significant. Referring to **FIG. 4**, illustrated is a diagram of a normal CP (Cyclic Prefix) PRB (Physical Resource Block) showing the REs that can be used for Class A NZP CSI-RS transmission in connection with various aspects discussed herein.

[0066] For Class B FD-MIMO, CSI-RS can be transmitted to multiple UEs on the same time and frequency resources using different beamforming. Transmission of CSI-RS signals on the same REs (resource elements) increases the spectral efficiency due to spatial reuse of time and frequency resources. However, in addition to increased spectral efficiency, increased interference on the serving CSI-RS and/or PDSCH (Physical Downlink Shared CHannel) received from the same TPs (Transmission Points) can also result. Referring to **FIG. 5**, illustrated is a diagram of an example scenario of simultaneous transmission of CSI-RS signals using multiple beams, showing an example eNB 510 employing elevation beamforming to transmit to a plurality of UEs 520 at different elevations, in connection with various aspects described herein. From the perspective of a UE 520, some of the CSI-RS signals can be serving, and others can be interfering.

[0067] In various embodiments, techniques discussed herein can be employed in connection with Class A FD (Full Dimension)-MIMO (Multiple Input Multiple Output) and/or Class B FD-MIMO.

[0068] For Class A FD-MIMO with non precoded CSI-RS, higher layer signaling can be employed to indicate one or more parameters of CSI-RS transmitted by one or more neighboring transmission points (TPs). The parameter(s) of the CSI-RS can be used by a UE for interference cancellation from the CSI-RS colliding with PDSCH or CSI-RS transmitted by the serving transmission points. X2 signaling can be used to exchange information between neighboring eNBs about the CSI-RS signals transmitted by each TP.

[0069] For Class B FD-MIMO with beamformed CSI-RS, multiple CSI-RS signals (e.g., associated with antenna ports of one CSI-RS resource or different CSI-RS configurations) can be transmitted from the same serving TP using different beamforming, where some CSI-RS antenna ports and/or configurations can correspond to serving beams and others can correspond to interfering beams (interfering CSI-RS). Higher layer signaling can be employed to indicate parameter(s) of the interfering CSI-

RS signals to the UE. The CSI-RS parameter(s) can be used by the UE for interference cancellation on PDSCH and/or CSI-RS transmitted by the serving transmission point.

[0070] Referring to **FIG. 6**, illustrated is a block diagram of a system 600 that facilitates interference cancellation of interfering CSI (Channel State Information)-RS (Reference Signal(s)) at a UE (User Equipment), according to various aspects described herein. System 600 can include one or more processors 610 (e.g., one or more baseband processors such as one or more of the baseband processors discussed in connection with FIG. 2 and/or FIG. 3) comprising processing circuitry and associated memory interface(s) (e.g., memory interface(s) discussed in connection with FIG. 3), transceiver circuitry 620 (e.g., comprising one or more of transmitter circuitry or receiver circuitry, which can employ common circuit elements, distinct circuit elements, or a combination thereof), and a memory 630 (which can comprise any of a variety of storage mediums and can store instructions and/or data associated with one or more of processor(s) 610 or transceiver circuitry 620). In various aspects, system 600 can be included within a user equipment (UE). As described in greater detail below, system 600 can facilitate cancellation of Class A or Class B CSI-RS interfering with received PDSCH (Physical Downlink Shared CHannel) and/or CSI-RS.

[0071] Referring to **FIG. 7**, illustrated is a block diagram of a system 700 employable at a BS (Base Station) that facilitates interference cancellation of interfering CSI-RS by a UE (e.g., for which the BS is a serving BS, or for which the BS is a neighboring BS of a serving BS, etc.), according to various aspects described herein. System 700 can include one or more processors 710 (e.g., one or more baseband processors such as one or more of the baseband processors discussed in connection with FIG. 2 and/or FIG. 3) comprising processing circuitry and associated memory interface(s) (e.g., memory interface(s) discussed in connection with FIG. 3), communication circuitry 720 (e.g., which can comprise circuitry for one or more wired (e.g., X2, etc.) connections and/or transceiver circuitry that can comprise one or more of transmitter circuitry (e.g., associated with one or more transmit chains) or receiver circuitry (e.g., associated with one or more receive chains), wherein the transmitter circuitry and receiver circuitry can employ common circuit elements, distinct circuit elements, or a combination thereof), and memory 730 (which can comprise any of a variety of storage mediums and can store instructions and/or data associated with one or more of processor(s) 710 or communication circuitry 720). In various aspects, system 700 can be included within an Evolved Universal Terrestrial Radio Access Network (E-UTRAN) Node B (Evolved Node B, eNodeB, or eNB) or other base station in a wireless communications network. In some aspects, the processor(s) 710, communication circuitry 720, and the memory 730 can be included in a single device, while in other aspects, they can be included in different devices, such as part of a distributed architecture. As described in greater detail below, system 700 can facilitate UE interfere cancellation via one or more of sending (e.g., via an X2 protocol) parameters associated with CSI-RS signaling to a neighboring TP (Transmission Point), receiving parameters from at least one neighboring TP associated with CSI-RS signaling from the at least one neighboring TP, or transmitting to a UE parameters of CSI-RS (e.g., from a neighboring TP and/or associated with a non-serving CSI-RS resource from the BS employing system 700 (e.g., a CSI-RS resource other than serving CSI-RS resource(s) for the UE).

[0072] In aspects associated with Class A (non-precoded) FD-MIMO CSI-RS, a serving TP can transmit (e.g., via communication circuitry 720) and UEs may receive (e.g., via transceiver circuitry 620) and process (e.g., via processor(s) 610) parameters (e.g., in a message generated by processor(s) 710) of the NZP (Non-Zero Power) CSI-RS resource(s) transmitted by the neighboring transmission point(s). The parameters can be provided to the UE using higher layer signaling (e.g., RRC, etc., generated by processor(s) 710 and transmitted via communication circuitry 720) and can comprise one or more of the following information elements: (a) type of CSI-RS signal (e.g., Class A or Class B); (b) the number of NZP CSI-RS resource antenna ports (e.g., 12, 16, 20, 24, 28, 32, etc.); (c) subframe configuration indicating the periodicity and offset in the downlink subframes for CSI-RS transmission; (d) one or more CSI-RS configurations of the NZP CSI-RS resource; (e) scrambling identity used for generating sequence for modulations of NZP CSI-RS antenna port signals; (f) CDM (Code Division Multiplexing) type (e.g., 2, 4, or 8); and/or (g) optionally physical cell ID and/or number of CRS ports of the transmission point transmitting the CSI-RS. In some aspects, the type of CSI-RS signal and the number of NZP CSI-RS resource antenna ports can be indicated together, for example, wherein more than 8 APs can indicate Class A CSI-RS and 8 or less APs can indicate Class B CSI-RS.

[0073] After receiving (e.g., via higher layer signaling generated by processor(s) 710, transmitted via communication circuitry 720, and received via transceiver circuitry 620) the parameters describing NZP CSI-RS resource(s) of the neighboring TP(s), a UE can perform channel estimation (e.g., via processor(s) 610) corresponding to the antenna ports of the interfering CSI-RS signal(s) of the neighboring TPs and reconstruction (e.g., by processor(s) 610) of the received interfering CSI-RS signal(s) (e.g., received via transceiver circuitry 620 from the neighboring TP(s)). Depending on the type of received signal or message, processing (e.g., by processor(s) 610, processor(s) 710, etc.) can comprise one or more of: identifying physical resources associated with the signal/message, detecting the signal/message, resource element group deinterleaving, demodulation, descrambling, and/or decoding. The reconstructed CSI-RS signal can be employed at the UE (e.g., by processor(s) 610) to cancel or suppress interference from the CSI-RS signals on the received serving PDSCH or CSI-RS transmitted by the serving TP (e.g., received by transceiver circuitry 620). The cancellation or suppression can be accomplished by subtracting (e.g., by processor(s) 610) the reconstructed version of the received CSI-RS signal(s) of the neighboring TP(s) from the received signal (e.g., serving PDSCH or CSI-RS transmitted by the serving TP).

[0074] Referring to **FIG. 8**, illustrated is a flow diagram of an example method 800 that facilitates cancellation of interference from CSI-RS of neighboring TP(s) (e.g., Class A CSI-RS) at a UE, according to various aspects discussed herein. In other aspects, a machine readable medium can store instructions associated with method 800 that, when executed, can cause a UE to perform the acts of method 800.

[0075] At 810, a UE can receive (e.g., via transceiver circuitry 620) from a serving TP configuration parameters (e.g., generated by processor(s) 710 and transmitted (e.g., via higher layer signaling) by communication circuitry 720) of one or more interfering NZP CSI-RS resources corresponding to one or more neighboring TPs.

[0076] At 820, the UE can perform processing (e.g., via processor(s) 610) of the interfering NZP CSI-RS resource(s) using the received signal (e.g., the combined signal received at transceiver circuitry 620, comprising both the interfering NZP CSI-RS and a serving PDSCH or CSI-RS) and the received NZP CSI-RS resource parameters.

[0077] At 830, the UE (e.g., via processor(s) 610) can cancel or suppress interference on the PDSCH or NZP CSI-RS transmitted (e.g., via communication circuitry 720) by the serving TP (e.g., and received via transceiver circuitry 620) using the processed interfering NZP CSI-RS signals.

[0078] Additionally or alternatively, method 800 can include one or more other acts described herein in connection with system 600.

[0079] In various embodiments, a TP (e.g., BS such as an eNB, etc.) can employ X2 signaling to exchange information with neighboring TPs about the CSI-RS signals (e.g., various parameters discussed herein, etc.) transmitted by the TP and the neighboring TPs. The exchanged information can be used to assist the serving UEs about parameters of the CSI-RS of interfering TPs. Referring to **FIG. 9**, illustrated is a flow diagram of an example method 900 employable at a BS that facilitates exchange of parameters of CSI-RS with neighboring TP(s), according to various aspects discussed herein. In other aspects, a machine readable medium can store instructions associated with method 900 that, when executed, can cause a BS to perform the acts of method 900.

[0080] At 910, CSI-RS signals (e.g., generated by processor(s) 710) can be transmitted (e.g., via communication circuitry 720) to one or more UEs (e.g., which can receive the CSI-RS via transceiver circuitry 620 and process the CSI-RS via processor(s) 610) based on a CSI-RS configuration. Depending on the type of signal or message generated, outputting for transmission (e.g., by processor(s) 610, processor(s) 710, etc.) can comprise one or more of the following: generating a set of associated bits that indicate the content of the signal or message, coding (e.g., which can include adding a cyclic redundancy check (CRC) and/or coding via one or more of turbo code, low density parity-check (LDPC) code, tailbiting convolution code (TBCC), etc.), scrambling (e.g., based on a scrambling seed), modulating (e.g., via one of binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), or some form of quadrature amplitude modulation (QAM), etc.), and/or resource mapping (e.g., to a scheduled set of resources, to a set of time and frequency resources granted for uplink transmission, etc.).

[0081] At 920, one or more neighboring BSs can be informed about the transmitted CSI-RS (e.g., via a message indicating one or more CSI-RS parameters discussed herein) via X2 protocol signaling, such as in one or more X2 messages generated by processor(s) 710 and sent via communication circuitry 720.

[0082] Additionally or alternatively, method 900 can include one or more other acts described herein in connection with system 700.

[0083] In embodiments employing Class B FD-MIMO with beamformed CSI-RS, multiple CSI-RS signals can be transmitted by the serving TP using the same REs (Resource Elements). The transmitted CSI-RS signals can correspond to different beamforming at the serving TP. Some CSI-RS signals can correspond to the serving beam(s) on which channel for CSI can be derived at the UE, while the other beam(s) can correspond to the interfering beams (interfering CSI-RS) which can be transmitted to other UEs. Higher layer signaling (e.g. RRC, etc.) can be employed to indicate the parameters of the interfering CSI-RS signals corresponding to the same TP. Examples of parameters that can be indicated comprise: (a) type of CSI-RS signal (e.g., Class A or Class B); (b) the number of NZP CSI-RS resource antenna ports (e.g., 1, 2, 4, or 8, etc.); (c) subframe configuration indicating the periodicity and offset in the downlink subframes for CSI-RS transmission; (d) one or more CSI-RS configurations of the NZP CSI-RS resource; (e) scrambling identity used for generating sequence for modulations of NZP CSI-RS antenna port signals; and/or (f) CDM (Code Division Multiplexing) type (e.g., 2, 4, or 8). In some aspects, the type of CSI-RS signal and the number of NZP CSI-RS resource antenna ports can be indicated together, for example, wherein more than 8 APs can indicate Class A CSI-RS and 8 or less APs can indicate Class B CSI-RS.

[0084] After receiving (e.g., via communication circuitry 620) the parameters describing interfering CSI-RS signals of the serving TP, a UE can perform channel estimation (e.g., via processor(s) 610) corresponding to the antenna ports of the interfering CSI-RS and can reconstruct (e.g., via processor(s) 610) the received interfering CSI-RS signals. The reconstructed signals can be used to cancel or suppress interference on the served PDSCH or CSI-RS signals (e.g., via processor(s) 610). The cancellation or suppression can be accomplished by subtracting from the received signal the reconstructed interfering CSI-RS signals corresponding to interfering beams (e.g., via processor(s) 610).

[0085] Referring to **FIG. 10**, illustrated is a flow diagram of an example method 1000 that facilitates cancellation of interference from CSI-RS (e.g., Class B CSI-RS) of a serving TP at a UE, according to various aspects discussed herein. In other aspects, a machine readable medium can store instructions associated with method 1000 that, when executed, can cause a UE to perform the acts of method 1000.

[0086] At 1010, a UE can receive (e.g., via transceiver circuitry 620), from a serving TP, configuration parameters (e.g., generated by processor(s) 710 and transmitted (e.g., via higher layer signaling) by communication circuitry 720) of one or more interfering NZP CSI-RS resources (e.g., Class B) corresponding to the serving TP.

[0087] At 1020, the UE can perform processing (e.g., via processor(s) 610) of the interfering NZP CSI-RS resource(s) using the received signal (e.g., the combined signal received at transceiver circuitry 620, comprising both the interfering NZP CSI-RS and a serving PDSCH or CSI-RS) and the received NZP CSI-RS resource parameters.

[0088] At 1030, the UE (e.g., via processor(s) 610) can cancel or suppress interference on the PDSCH or NZP CSI-RS transmitted (e.g., via communication circuitry 720) by the serving TP (e.g., and received via transceiver circuitry 620) using the processed interfering NZP CSI-RS signals.

[0089] Additionally or alternatively, method 1000 can include one or more other acts described herein in connection with system 600.

[0090] In various embodiments, a UE need not perform PDSCH REs mapping (e.g., by processor(s) 610) around all configured interfering CSI-RS signals. In the same or other embodiments, the set of CSI-RS signals around which PDSCH REs mapping is to be performed (e.g., by processor(s) 610) can be indicated to the UE using DCI signaling (e.g., generated by processor(s) 710, sent via communication circuitry 720, received via communication circuitry 620, and processed via processor(s) 610). As an example, an N (e.g., 2) bit field can be used in DCI (e.g., similar to PDSCH RE mapping and QCL (Quasi Co-Location) to indicate a CSI-RS set among up to 2^N (e.g., 4) sets, wherein the indicated CSI-RS set is to be used for determination of the PDSCH REs mapping (e.g., by processor(s) 610).

[0091] Referring to **FIG. 11**, illustrated is a flow diagram of an example method 1100 employable at a BS that facilitates communication of parameters of interfering CSI-RS to served UEs, according to various aspects discussed herein. In other aspects, a machine readable medium can store instructions associated with method 1100 that, when executed, can cause a BS to perform the acts of method 1100.

[0092] At 1110, optionally, one or more neighboring BSs can be informed (e.g., via X2 messaging generated by processor(s) 710 and sent via communication circuitry 720) about one or more parameters of CSI-RS signals (e.g., Class A CSI-RS generated by processor(s) 710) transmitted or to be transmitted (e.g., via communication circuitry 720) to one or more UEs.

[0093] At 1120, optionally, one or more X2 messages can be received (e.g., via communication circuitry 720, and processed via processor(s) 710) from one or more TPs that indicates parameters of CSI-RS signaling transmitted by those TP(s).

[0094] At 1130, one or more UEs served by a BS employing method 1100 can be informed (e.g., via higher layer (e.g., RRC) signaling generated by processor(s) 710 and sent via communication circuitry 720) about parameters of interfering CSI-RS (e.g., interfering with CSI-RS and/or PDSCH scheduled for or transmitted to those UE(s)). In various aspects, the interfering CSI-RS can be Class A CSI-RS transmitted by neighboring TPs (e.g., in embodiments wherein 1110 and/or 1120 are performed), Class B CSI-RS transmitted to other UE(s) by the BS employing method 1100, or a combination thereof.

[0095] At 1140, signaling (e.g., CSI-RS, PDSCH, etc.) can be transmitted to the UE(s) via one or more REs that are also employed for transmission (e.g., by neighboring TP(s) and/or the BS employing method 1100) of the interfering CSI-RS.

[0096] Additionally or alternatively, method 1100 can include one or more other acts described herein in connection with system 700.

[0097] Examples herein can include subject matter such as a method, means for performing acts or blocks of the method, at least one machine-readable medium including executable instructions that, when performed by a machine (e.g., a processor with memory, an application-specific integrated circuit (ASIC), a field programmable gate array (FPGA), or the like) cause the machine to perform acts of the method or of an apparatus or system for concurrent communication using multiple communication technologies according to embodiments and examples described.

[0098] Example 1 is an apparatus configured to be employed in a User Equipment (UE), comprising: a memory interface; and processing circuitry configured to: process higher layer signaling indicating one or more parameters of one or more interfering CSI (Channel State Information)-RS (Reference Signal) signals; process one or more received signals, wherein each received signal comprises a serving signal and an associated interfering CSI-RS signal of the one or more interfering CSI-RS signals; for each of the one or more received signals, cancel interference on the serving signal caused by the associated interfering CSI-RS signal based at least in part on the one or more parameters; and send the one or more parameters to a memory via the memory interface.

[0099] Example 2 comprises the subject matter of any variation of any of example(s) 1, wherein the one or more parameters comprise a CSI-RS type of the one or more interfering CSI-RS signals.

[00100] Example 3 comprises the subject matter of any variation of any of example(s) 1, wherein the one or more parameters comprise a number of NZP (Non-Zero Power) CSI-RS APs (Antenna Ports) of the one or more interfering CSI-RS signals.

[00101] Example 4 comprises the subject matter of any variation of any of example(s) 1, wherein the one or more parameters comprise a subframe configuration of the one or more interfering CSI-RS signals, wherein the subframe configuration indicates a periodicity and an offset for DL (Downlink) subframes for transmission of the interfering CSI-RS signals.

[00102] Example 5 comprises the subject matter of any variation of any of example(s) 1, wherein the one or more parameters comprise one or more CSI-RS configurations of a CSI-RS resource of the one or more interfering CSI-RS signals.

[00103] Example 6 comprises the subject matter of any variation of any of example(s) 1, wherein the one or more parameters comprise a scrambling identity of the one or more interfering CSI-RS signals.

[00104] Example 7 comprises the subject matter of any variation of any of example(s) 1, wherein the one or more parameters comprise a CDM (Code Division Multiplexing) type of the one or more interfering CSI-RS signals, wherein the CDM type is one of 2, 4, or 8.

[00105] Example 8 comprises the subject matter of any variation of any of example(s) 1, wherein the one or more parameters comprise a physical cell ID (identity) and a number of CRS (Cell-specific Reference Signal) ports associated with the one or more interfering CSI-RS signals.

[00106] Example 9 comprises the subject matter of any variation of any of example(s) 1, wherein the processing circuitry is further configured to perform channel estimation for one or more APs (antenna ports) corresponding to the one or more interfering CSI-RS signals and to reconstruct the one or more reconstructed interfering CSI-RS signals based on the channel estimation.

[00107] Example 10 comprises the subject matter of any variation of any of example(s) 9, wherein the processing circuitry is further configured to subtract the one or more reconstructed interfering CSI-RS signals from the one or more received signals.

[00108] Example 11 comprises the subject matter of any variation of any of example(s) 1-10, wherein the one or more interfering CSI-RS signals comprises Class A FD (Full Dimension)-MIMO (Multiple Input Multiple Output) CSI-RS signals associated with one or more neighboring TPs (Transmission Points).

[00109] Example 12 comprises the subject matter of any variation of any of example(s) 1-10, wherein the one or more interfering CSI-RS signals comprises Class B FD (Full Dimension)-MIMO (Multiple Input Multiple Output) CSI-RS signals associated with a serving BS (Base Station).

[00110] Example 13 comprises the subject matter of any variation of any of example(s) 1-10, wherein for at least one of the one or more received signals, the serving signal comprises a serving CSI-RS signal.

[00111] Example 14 comprises the subject matter of any variation of any of example(s) 1-10, wherein for at least one of the one or more received signals, the serving signal comprises a PDSCH (Physical Downlink Shared Channel) signal.

[00112] Example 15 comprises the subject matter of any variation of any of example(s) 14, wherein the processing circuitry is configured to perform PDSCH RE

(Resource Element) mapping around fewer than all of the one or more interfering CSI-RS signals.

[00113] Example 16 comprises the subject matter of any variation of any of example(s) 1-2, wherein the one or more parameters comprise a number of NZP (Non-Zero Power) CSI-RS APs (Antenna Ports) of the one or more interfering CSI-RS signals.

[00114] Example 17 comprises the subject matter of any variation of any of example(s) 1-2 or 16, wherein the one or more parameters comprise a subframe configuration of the one or more interfering CSI-RS signals, wherein the subframe configuration indicates a periodicity and an offset for DL (Downlink) subframes for transmission of the interfering CSI-RS signals.

[00115] Example 18 comprises the subject matter of any variation of any of example(s) 1-2 or 16-17, wherein the one or more parameters comprise one or more CSI-RS configurations of a CSI-RS resource of the one or more interfering CSI-RS signals.

[00116] Example 19 comprises the subject matter of any variation of any of example(s) 1-2 or 16-18, wherein the one or more parameters comprise a scrambling identity of the one or more interfering CSI-RS signals.

[00117] Example 20 comprises the subject matter of any variation of any of example(s) 1-2 or 16-19, wherein the one or more parameters comprise a CDM (Code Division Multiplexing) type of the one or more interfering CSI-RS signals, wherein the CDM type is one of 2, 4, or 8.

[00118] Example 21 comprises the subject matter of any variation of any of example(s) 1-2 or 16-20, wherein the one or more parameters comprise a physical cell ID (identity) and a number of CRS (Cell-specific Reference Signal) ports associated with the one or more interfering CSI-RS signals.

[00119] Example 22 comprises the subject matter of any variation of any of example(s) 1-2 or 16-21, wherein the processing circuitry is further configured to perform channel estimation for one or more APs (antenna ports) corresponding to the one or more interfering CSI-RS signals and to reconstruct the one or more reconstructed interfering CSI-RS signals based on the channel estimation.

[00120] Example 23 comprises the subject matter of any variation of any of example(s) 22, wherein the processing circuitry is further configured to subtract the one or more reconstructed interfering CSI-RS signals from the one or more received signals.

[00121] Example 24 comprises the subject matter of any variation of any of example(s) 1-2 or 16-23, wherein the one or more interfering CSI-RS signals comprises one of: Class A FD (Full Dimension)-MIMO (Multiple Input Multiple Output) CSI-RS signals associated with one or more neighboring TPs (Transmission Points), or Class B FD (Full Dimension)-MIMO (Multiple Input Multiple Output) CSI-RS signals associated with a serving BS (Base Station).

[00122] Example 25 is an apparatus configured to be employed in an Evolved NodeB (eNB), comprising: a memory interface; and processing circuitry configured to: generate a set of CSI (Channel State Information)-RS (Reference Signal) signals for one or more UEs (User Equipments); generate one or more X2 messages for one or more neighboring TP (Transmission Point), wherein each of the one or more X2 messages indicates one or more parameters of the set of CSI-RS signals; and send the one or more parameters to a memory via the memory interface.

[00123] Example 26 comprises the subject matter of any variation of any of example(s) 25, wherein the one or more parameters comprise a CSI-RS type of the one or more interfering CSI-RS signals.

[00124] Example 27 comprises the subject matter of any variation of any of example(s) 25, wherein the one or more parameters comprise a number of NZP (Non-Zero Power) CSI-RS APs (Antenna Ports) of the one or more interfering CSI-RS signals.

[00125] Example 28 comprises the subject matter of any variation of any of example(s) 25, wherein the one or more parameters comprise a subframe configuration of the one or more interfering CSI-RS signals, wherein the subframe configuration indicates a periodicity and an offset for DL (Downlink) subframes for transmission of the interfering CSI-RS signals.

[00126] Example 29 comprises the subject matter of any variation of any of example(s) 25, wherein the one or more parameters comprise one or more CSI-RS configurations of a CSI-RS resource of the one or more interfering CSI-RS signals.

[00127] Example 30 comprises the subject matter of any variation of any of example(s) 25, wherein the one or more parameters comprise a scrambling identity of the one or more interfering CSI-RS signals.

[00128] Example 31 comprises the subject matter of any variation of any of example(s) 25, wherein the one or more parameters comprise a CDM (Code Division Multiplexing) type of the one or more interfering CSI-RS signals, wherein the CDM type is one of 2, 4, or 8.

[00129] Example 32 comprises the subject matter of any variation of any of example(s) 25-31, wherein the one or more parameters comprise a physical cell ID (identity) and a number of CRS (Cell-specific Reference Signal) ports associated with the one or more interfering CSI-RS signals.

[00130] Example 33 comprises the subject matter of any variation of any of example(s) 25-31, wherein the processing circuitry is further configured to generate one or more DCI (Downlink Control Information) messages that indicates at least a subset of the set of interfering CSI-RS signals, wherein PDSCH (Physical Downlink Shared Channel) RE (Resource Element) mapping is to be performed around at least the subset.

[00131] Example 34 comprises the subject matter of any variation of any of example(s) 33, wherein each of the one or more DCI messages comprises a 2 bit field that indicates the subset as one of four possible subsets.

[00132] Example 35 comprises the subject matter of any variation of any of example(s) 25-26, wherein the one or more parameters comprise a number of NZP (Non-Zero Power) CSI-RS APs (Antenna Ports) of the one or more interfering CSI-RS signals.

[00133] Example 36 comprises the subject matter of any variation of any of example(s) 25-26 or 35, wherein the one or more parameters comprise a subframe configuration of the one or more interfering CSI-RS signals, wherein the subframe configuration indicates a periodicity and an offset for DL (Downlink) subframes for transmission of the interfering CSI-RS signals.

[00134] Example 37 is an apparatus configured to be employed in an Evolved NodeB (eNB), comprising: a memory interface; and processing circuitry configured to: generate higher layer signaling for one or more UEs (User Equipments), wherein the higher layer signaling indicates one or more parameters of a set of interfering CSI (Channel State Information)-RS (Reference Signal) signals, wherein the set of interfering CSI-RS are associated with a set of REs (Resource Elements); generate one or more serving signals for the one or more UEs via at least a subset of the set of REs; and send the one or more parameters to a memory via the memory interface.

[00135] Example 38 comprises the subject matter of any variation of any of example(s) 37, wherein the one or more parameters comprise one or more of: a CSI-RS signal type, a number of NZP (Non-Zero Power) CSI-RS resource APs (antenna ports), a subframe configuration indicating a periodicity and an offset in downlink subframes for transmission of the set of interfering CSI-RS signals, one or more CSI-RS configurations that constitute a NZP CSI-RS resource, a scrambling identity used for generating a sequence for modulations of NZP CSI-RS antenna port signals, a CDM (Code Division Multiplexing) type, a physical cell ID (Identity), or a number of CRS (Cell-specific) ports of a TP (transmission point) associated with the set of interfering CSI-RS signals.

[00136] Example 39 comprises the subject matter of any variation of any of example(s) 37-38, wherein the processing circuitry is further configured to generate one or more DCI (Downlink Control Information) messages that indicates the set of interfering CSI-RS signals around which PDSCH (Physical Downlink Shared Channel) RE (Resource Element) mapping is to be performed.

[00137] Example 40 comprises the subject matter of any variation of any of example(s) 39, wherein each of the one or more DCI messages comprises a 2 bit field that indicates the set of interfering CSI-RS signals as one of four possible sets of interfering CSI-RS signals.

[00138] The above description of illustrated embodiments of the subject disclosure, including what is described in the Abstract, is not intended to be exhaustive or to limit the disclosed embodiments to the precise forms disclosed. While specific embodiments and examples are described herein for illustrative purposes, various modifications are possible that are considered within the scope of such embodiments and examples, as those skilled in the relevant art can recognize.

[00139] In this regard, while the disclosed subject matter has been described in connection with various embodiments and corresponding Figures, where applicable, it is to be understood that other similar embodiments can be used or modifications and additions can be made to the described embodiments for performing the same, similar, alternative, or substitute function of the disclosed subject matter without deviating therefrom. Therefore, the disclosed subject matter should not be limited to any single embodiment described herein, but rather should be construed in breadth and scope in accordance with the appended claims below.

[00140] In particular regard to the various functions performed by the above described components or structures (assemblies, devices, circuits, systems, etc.), the terms (including a reference to a “means”) used to describe such components are intended to correspond, unless otherwise indicated, to any component or structure which performs the specified function of the described component (e.g., that is functionally equivalent), even though not structurally equivalent to the disclosed structure which performs the function in the herein illustrated exemplary implementations. In addition, while a particular feature may have been disclosed with respect to only one of several implementations, such feature may be combined with one or more other features of the other implementations as may be desired and advantageous for any given or particular application.

CLAIMS

What is claimed is:

1. An apparatus configured to be employed in a User Equipment (UE), comprising:
a memory interface; and
processing circuitry configured to:
process higher layer signaling indicating one or more parameters of one or more interfering CSI (Channel State Information)-RS (Reference Signal) signals;
process one or more received signals, wherein each received signal comprises a serving signal and an associated interfering CSI-RS signal of the one or more interfering CSI-RS signals;
for each of the one or more received signals, cancel interference on the serving signal caused by the associated interfering CSI-RS signal based at least in part on the one or more parameters; and
send the one or more parameters to a memory via the memory interface.

2. The apparatus of claim 1, wherein the one or more parameters comprise a CSI-RS type of the one or more interfering CSI-RS signals.

3. The apparatus of claim 1, wherein the one or more parameters comprise a number of NZP (Non-Zero Power) CSI-RS APs (Antenna Ports) of the one or more interfering CSI-RS signals.

4. The apparatus of claim 1, wherein the one or more parameters comprise a subframe configuration of the one or more interfering CSI-RS signals, wherein the subframe configuration indicates a periodicity and an offset for DL (Downlink) subframes for transmission of the interfering CSI-RS signals.

5. The apparatus of claim 1, wherein the one or more parameters comprise one or more CSI-RS configurations of a CSI-RS resource of the one or more interfering CSI-RS signals.

6. The apparatus of claim 1, wherein the one or more parameters comprise a scrambling identity of the one or more interfering CSI-RS signals.

7. The apparatus of claim 1, wherein the one or more parameters comprise a CDM (Code Division Multiplexing) type of the one or more interfering CSI-RS signals, wherein the CDM type is one of 2, 4, or 8.

8. The apparatus of claim 1, wherein the one or more parameters comprise a physical cell ID (identity) and a number of CRS (Cell-specific Reference Signal) ports associated with the one or more interfering CSI-RS signals.

9. The apparatus of claim 1, wherein the processing circuitry is further configured to perform channel estimation for one or more APs (antenna ports) corresponding to the one or more interfering CSI-RS signals and to reconstruct the one or more reconstructed interfering CSI-RS signals based on the channel estimation.

10. The apparatus of claim 9, wherein the processing circuitry is further configured to subtract the one or more reconstructed interfering CSI-RS signals from the one or more received signals.

11. The apparatus of any of claims 1-10, wherein the one or more interfering CSI-RS signals comprises Class A FD (Full Dimension)-MIMO (Multiple Input Multiple Output) CSI-RS signals associated with one or more neighboring TPs (Transmission Points).

12. The apparatus of any of claims 1-10, wherein the one or more interfering CSI-RS signals comprises Class B FD (Full Dimension)-MIMO (Multiple Input Multiple Output) CSI-RS signals associated with a serving BS (Base Station).

13. The apparatus of any of claims 1-10, wherein for at least one of the one or more received signals, the serving signal comprises a serving CSI-RS signal.

14. The apparatus of any of claims 1-10, wherein for at least one of the one or more received signals, the serving signal comprises a PDSCH (Physical Downlink Shared Channel) signal.

15. The apparatus of claim 14, wherein the processing circuitry is configured to perform PDSCH RE (Resource Element) mapping around fewer than all of the one or more interfering CSI-RS signals.

16. An apparatus configured to be employed in an Evolved NodeB (eNB), comprising:

a memory interface; and

processing circuitry configured to:

generate a set of CSI (Channel State Information)-RS (Reference Signal) signals for one or more UEs (User Equipments);

generate one or more X2 messages for one or more neighboring TP (Transmission Point), wherein each of the one or more X2 messages indicates one or more parameters of the set of CSI-RS signals; and

send the one or more parameters to a memory via the memory interface.

17. The apparatus of claim 16, wherein the one or more parameters comprise a CSI-RS type of the one or more interfering CSI-RS signals.

18. The apparatus of claim 16, wherein the one or more parameters comprise a number of NZP (Non-Zero Power) CSI-RS APs (Antenna Ports) of the one or more interfering CSI-RS signals.

19. The apparatus of claim 16, wherein the one or more parameters comprise a subframe configuration of the one or more interfering CSI-RS signals, wherein the subframe configuration indicates a periodicity and an offset for DL (Downlink) subframes for transmission of the interfering CSI-RS signals.

20. The apparatus of claim 16, wherein the one or more parameters comprise one or more CSI-RS configurations of a CSI-RS resource of the one or more interfering CSI-RS signals.

21. The apparatus of claim 16, wherein the one or more parameters comprise a scrambling identity of the one or more interfering CSI-RS signals.

22. The apparatus of claim 16, wherein the one or more parameters comprise a CDM (Code Division Multiplexing) type of the one or more interfering CSI-RS signals, wherein the CDM type is one of 2, 4, or 8.

23. The apparatus of any of claims 16-22, wherein the one or more parameters comprise a physical cell ID (identity) and a number of CRS (Cell-specific Reference Signal) ports associated with the one or more interfering CSI-RS signals.

24. The apparatus of any of claims 16-22, wherein the processing circuitry is further configured to generate one or more DCI (Downlink Control Information) messages that indicates at least a subset of the set of interfering CSI-RS signals, wherein PDSCH (Physical Downlink Shared Channel) RE (Resource Element) mapping is to be performed around at least the subset.

25. The apparatus of claim 24, wherein each of the one or more DCI messages comprises a 2 bit field that indicates the subset as one of four possible subsets.

26. An apparatus configured to be employed in an Evolved NodeB (eNB), comprising:

a memory interface; and

processing circuitry configured to:

generate higher layer signaling for one or more UEs (User Equipments), wherein the higher layer signaling indicates one or more parameters of a set of interfering CSI (Channel State Information)-RS (Reference Signal) signals, wherein the set of interfering CSI-RS are associated with a set of REs (Resource Elements);

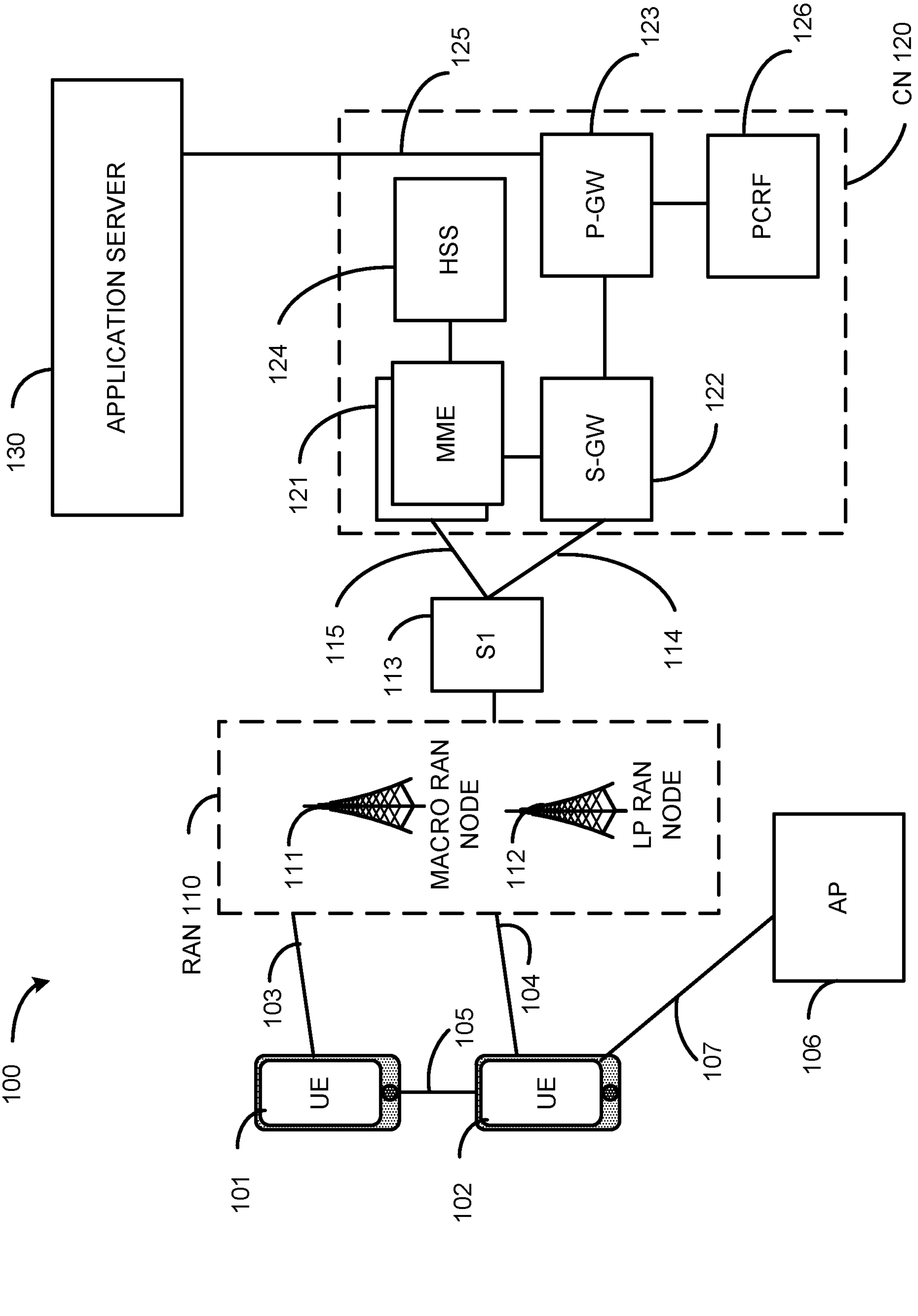
generate one or more serving signals for the one or more UEs via at least a subset of the set of REs; and

send the one or more parameters to a memory via the memory interface.

27. The apparatus of claim 26, wherein the one or more parameters comprise one or more of: a CSI-RS signal type, a number of NZP (Non-Zero Power) CSI-RS resource APs (antenna ports), a subframe configuration indicating a periodicity and an offset in downlink subframes for transmission of the set of interfering CSI-RS signals, one or more CSI-RS configurations that constitute a NZP CSI-RS resource, a scrambling identity used for generating a sequence for modulations of NZP CSI-RS antenna port signals, a CDM (Code Division Multiplexing) type, a physical cell ID (Identity), or a number of CRS (Cell-specific) ports of a TP (transmission point) associated with the set of interfering CSI-RS signals.

28. The apparatus of any of claims 26-27, wherein the processing circuitry is further configured to generate one or more DCI (Downlink Control Information) messages that indicates the set of interfering CSI-RS signals around which PDSCH (Physical Downlink Shared Channel) RE (Resource Element) mapping is to be performed.

29. The apparatus of claim 28, wherein each of the one or more DCI messages comprises a 2 bit field that indicates the set of interfering CSI-RS signals as one of four possible sets of interfering CSI-RS signals.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APPLICATION SERVER
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HSS
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MME
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S-GW
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P-GW
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PCRF
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CN 120
S1
113
115
114
RAN 110
MACRO RAN NODE
111
LP RAN NODE
112
103
104
105
UE
101
UE
102
107
AP
106

FIG. 1

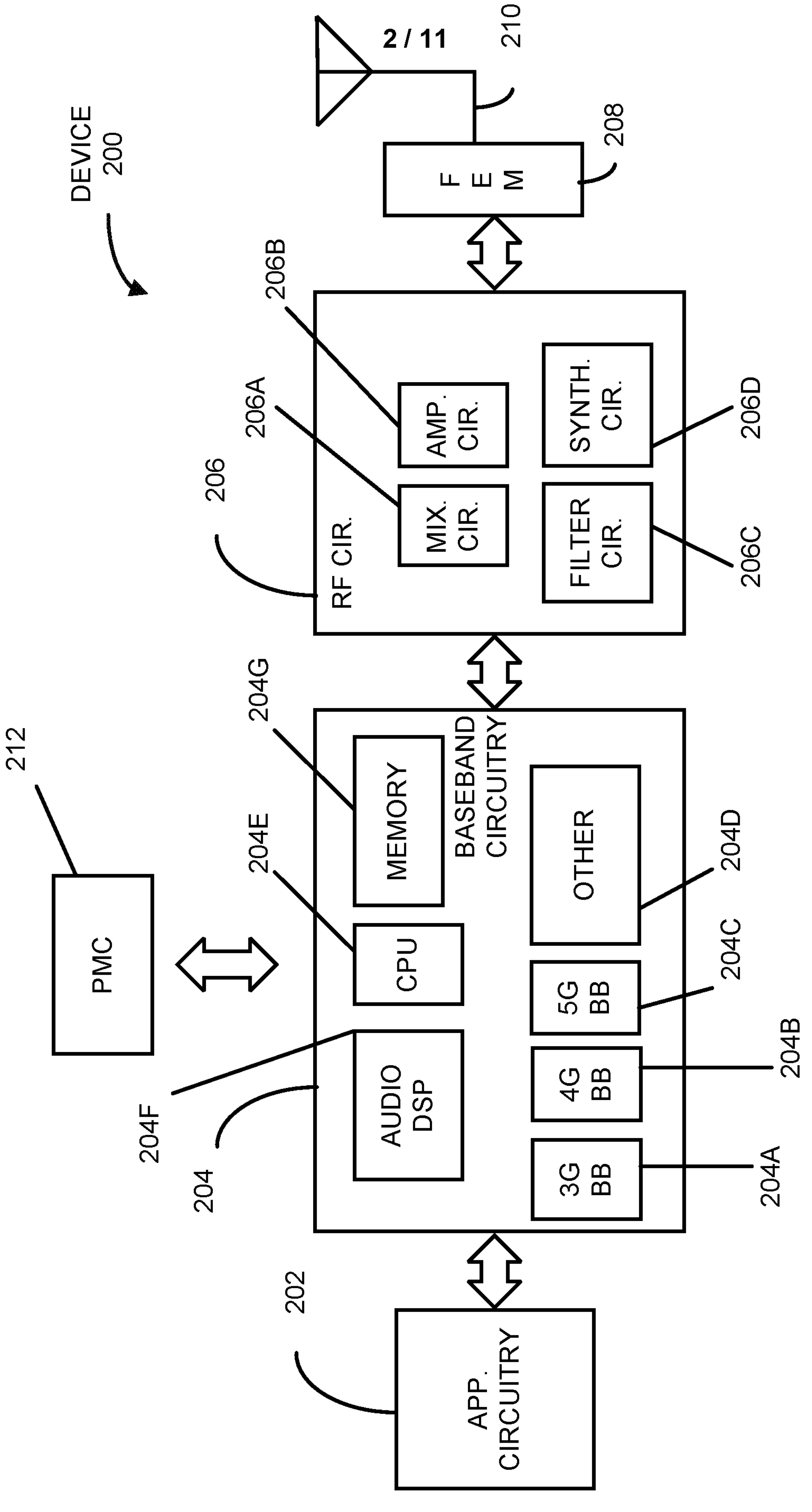

DEVICE 200
210
208
FEM
206B
206A
206
RF CIR.
AMP. CIR.
MIX. CIR.
SYNTH. CIR.
FILTER CIR.
206D
206C
212
PMC
204G
MEMORY
BASEBAND CIRCUITRY
204E
CPU
OTHER
204D
204C
5G BB
4G BB
204B
3G BB
204A
AUDIO DSP
204F
204
202
APP. CIRCUITRY

FIG. 2

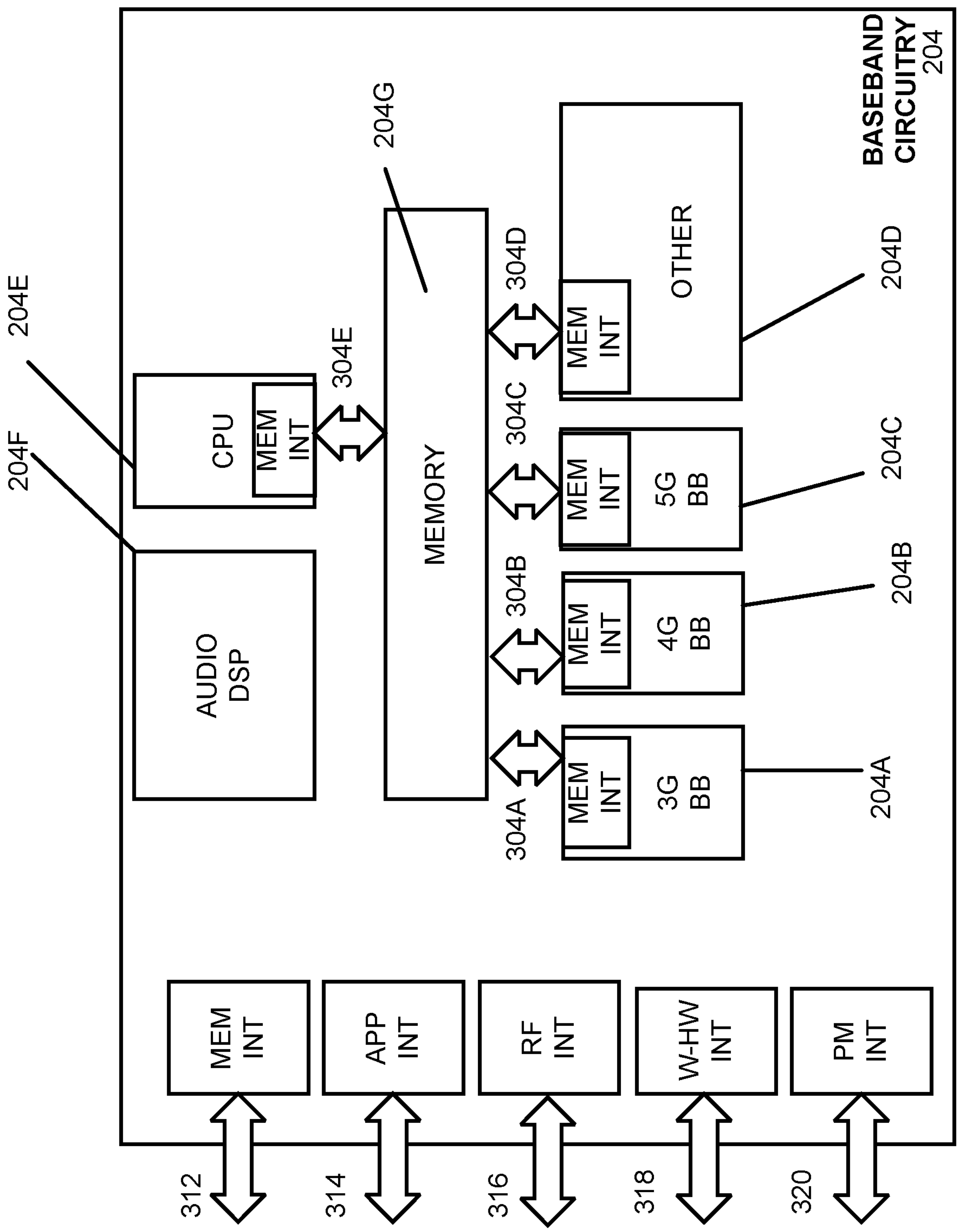

BASEBAND CIRCUITRY
204
204E
204F
CPU
MEM INT
304E
204G
MEMORY
AUDIO DSP
OTHER
MEM INT
304D
204D
5G BB
MEM INT
304C
204C
4G BB
MEM INT
304B
204B
3G BB
MEM INT
304A
204A
MEM INT
APP INT
RF INT
W-HW INT
PM INT
312
314
316
318
320

FIG. 3

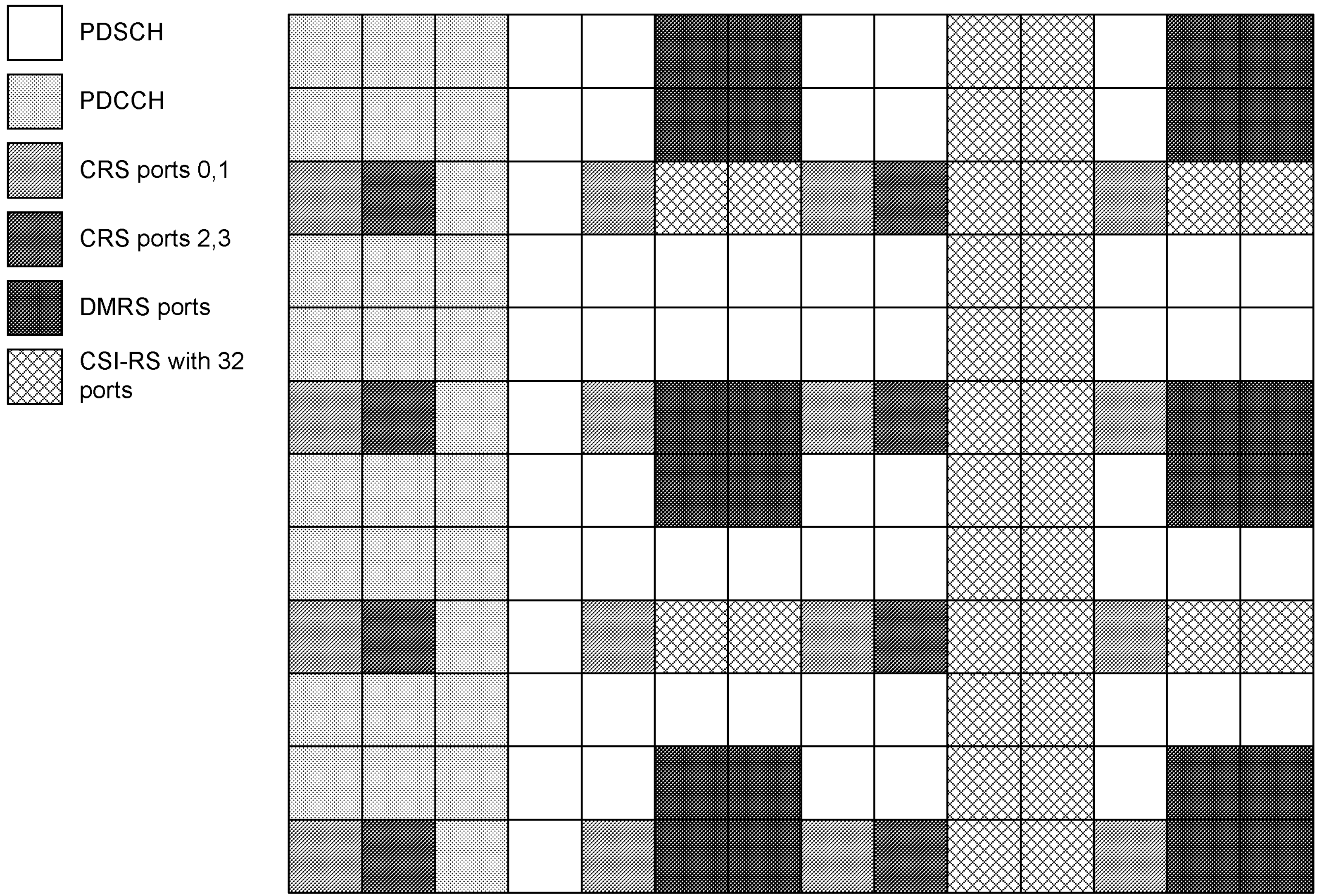
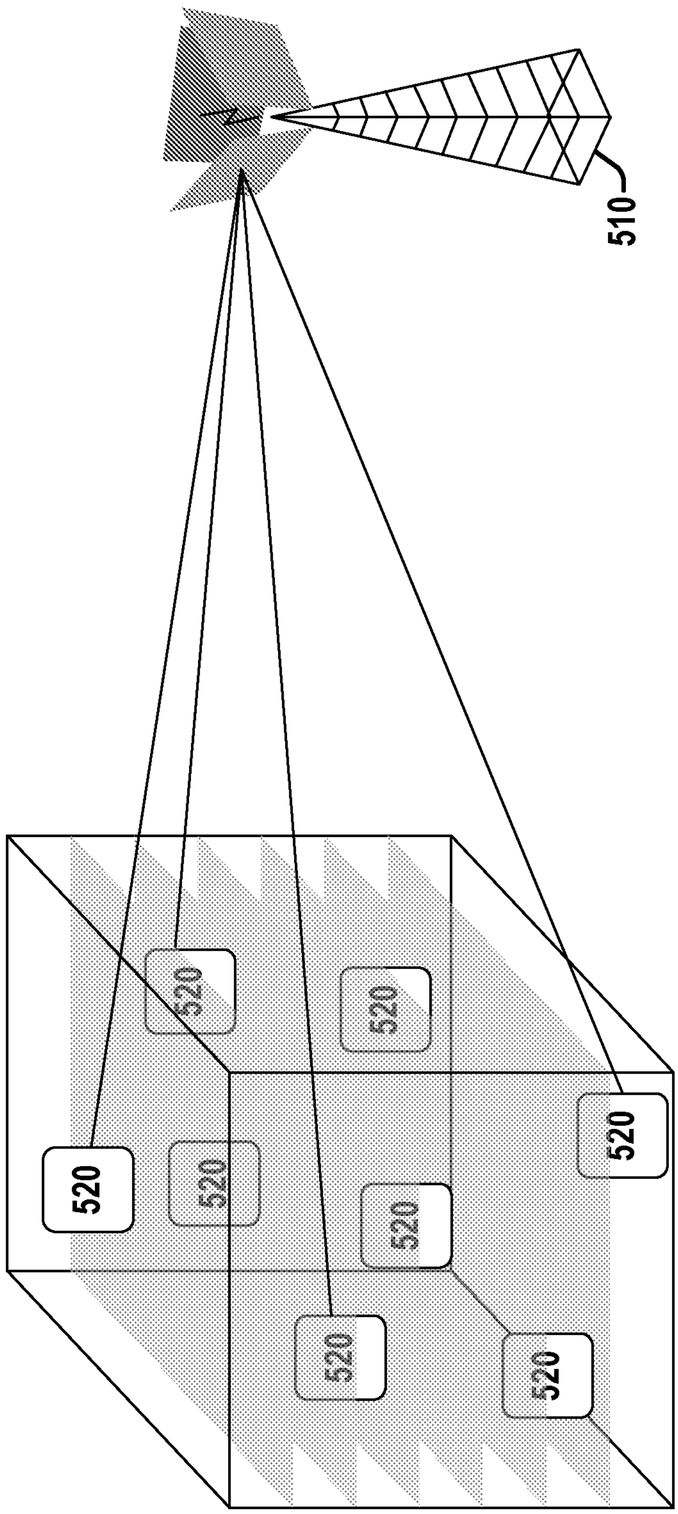

PDSCH
PDCCH
CRS ports 0,1
CRS ports 2,3
DMRS ports
CSI-RS with 32 ports

FIG. 4

FIG. 5



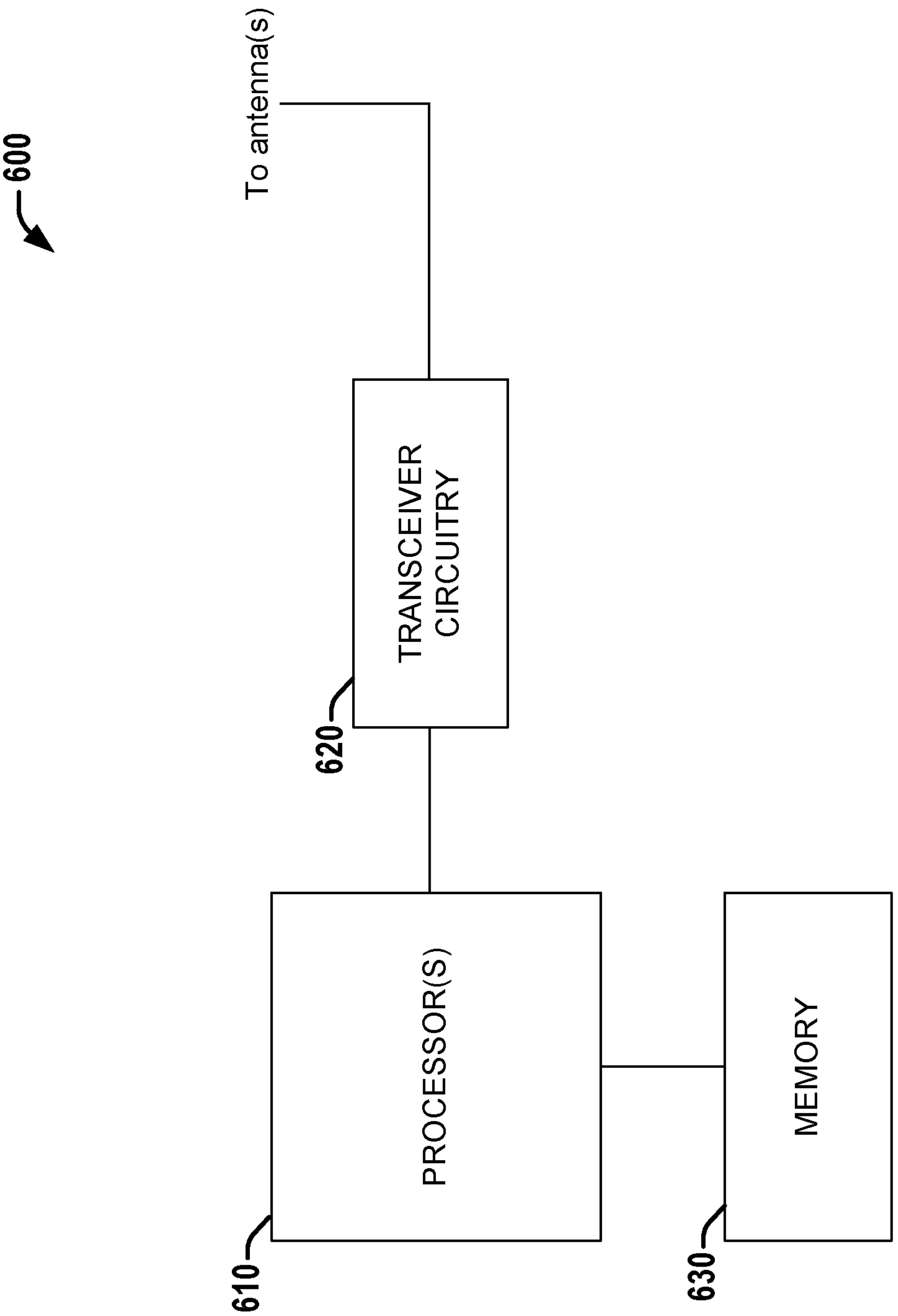

600
To antenna(s)
TRANSCEIVER CIRCUITRY
620
PROCESSOR(S)
610
MEMORY
630

FIG. 6

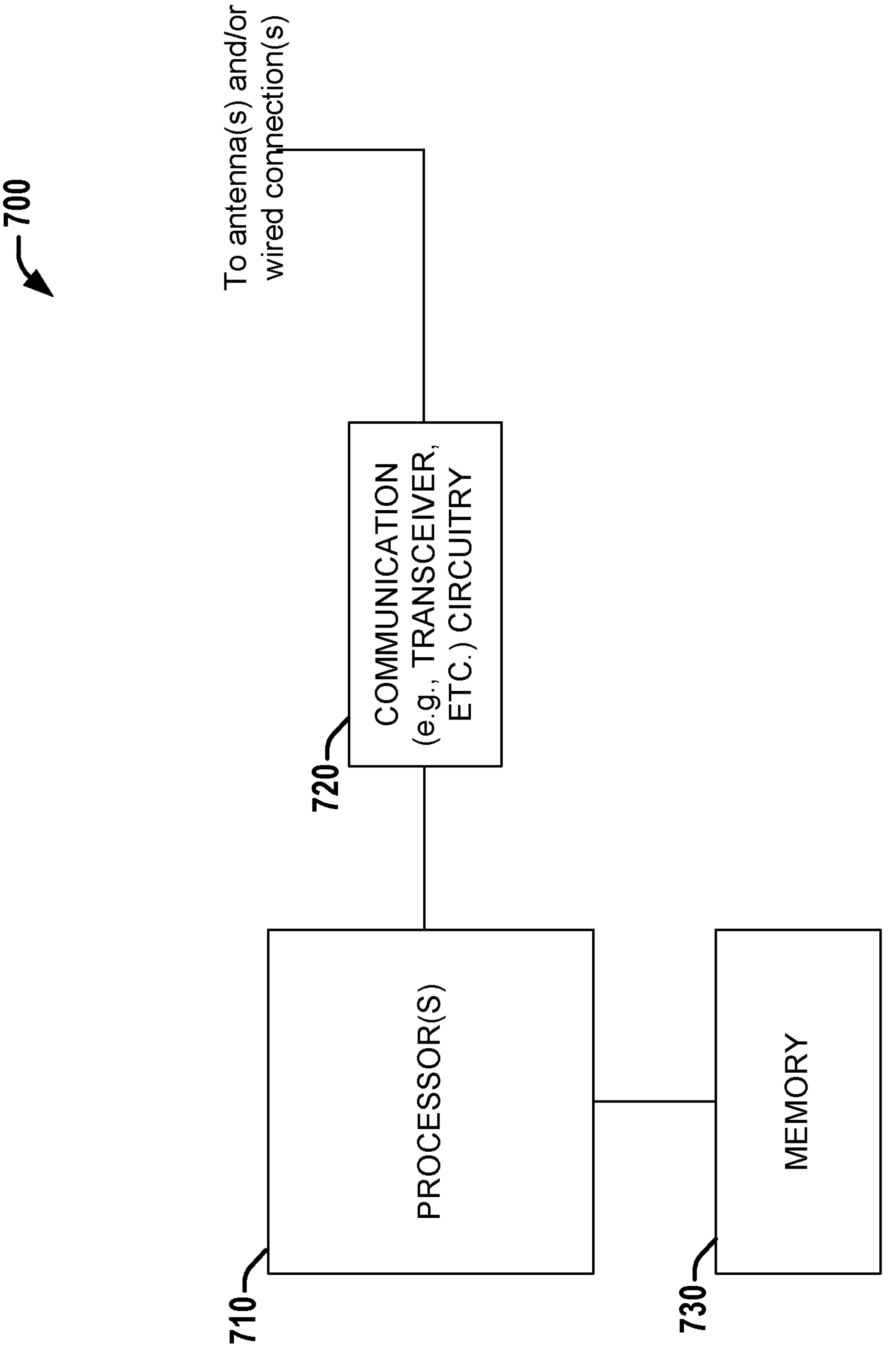

700
To antenna(s) and/or wired connection(s)
720
COMMUNICATION (e.g., TRANSCEIVER, ETC.) CIRCUITRY
710
PROCESSOR(S)
730
MEMORY

FIG. 7

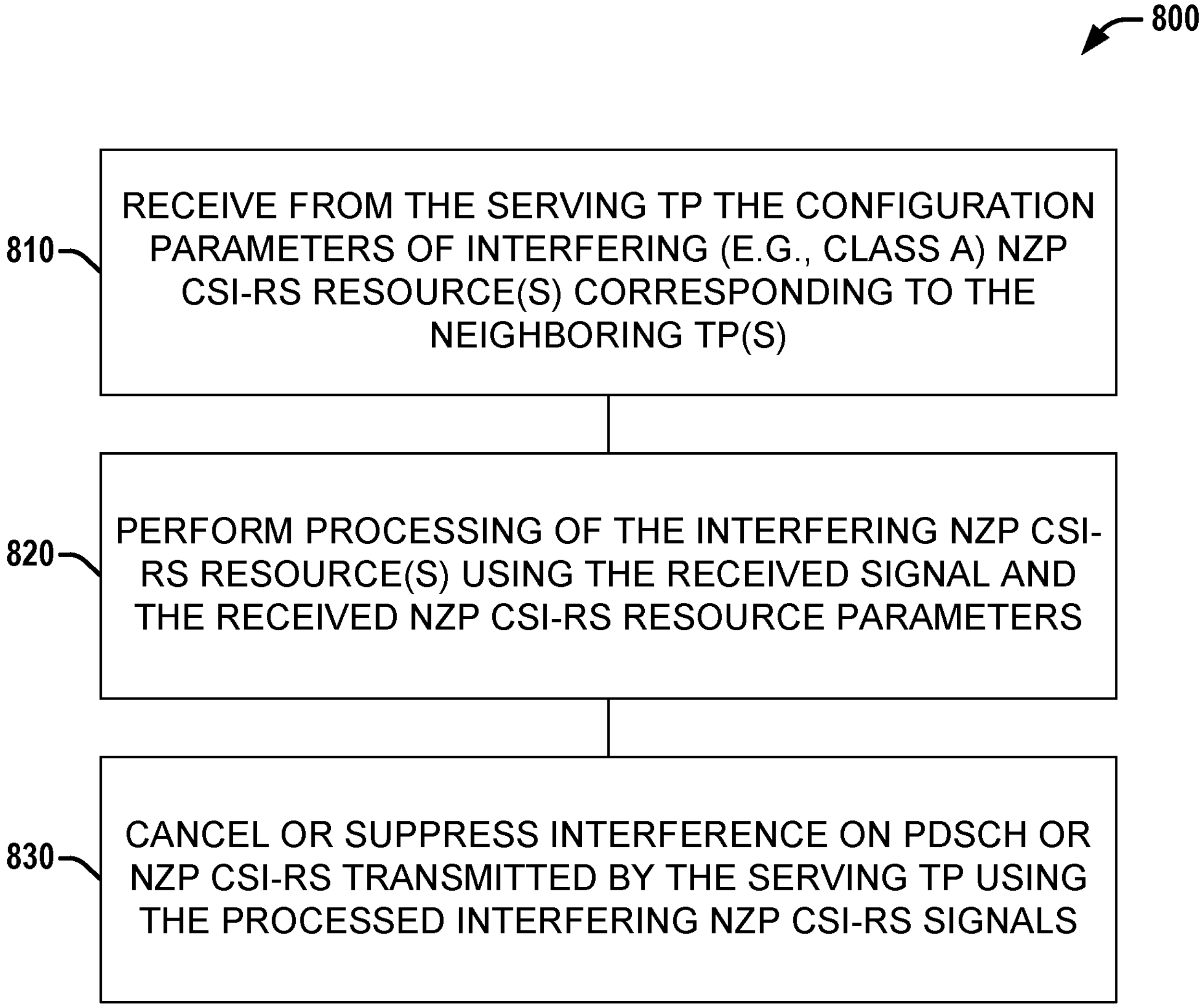

800
810
RECEIVE FROM THE SERVING TP THE CONFIGURATION PARAMETERS OF INTERFERING (E.G., CLASS A) NZP CSI-RS RESOURCE(S) CORRESPONDING TO THE NEIGHBORING TP(S)
820
PERFORM PROCESSING OF THE INTERFERING NZP CSI-RS RESOURCE(S) USING THE RECEIVED SIGNAL AND THE RECEIVED NZP CSI-RS RESOURCE PARAMETERS
830
CANCEL OR SUPPRESS INTERFERENCE ON PDSCH OR NZP CSI-RS TRANSMITTED BY THE SERVING TP USING THE PROCESSED INTERFERING NZP CSI-RS SIGNALS

FIG. 8

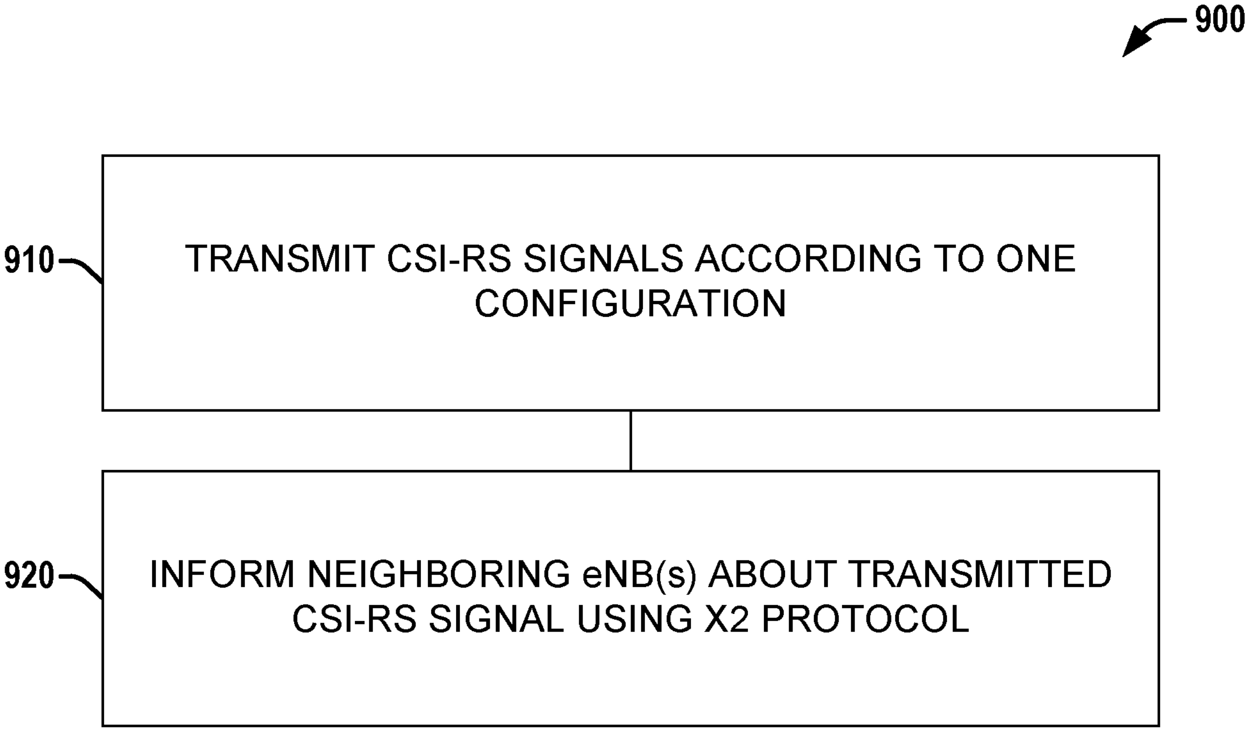

900
910
TRANSMIT CSI-RS SIGNALS ACCORDING TO ONE CONFIGURATION
920
INFORM NEIGHBORING eNB(s) ABOUT TRANSMITTED CSI-RS SIGNAL USING X2 PROTOCOL

FIG. 9

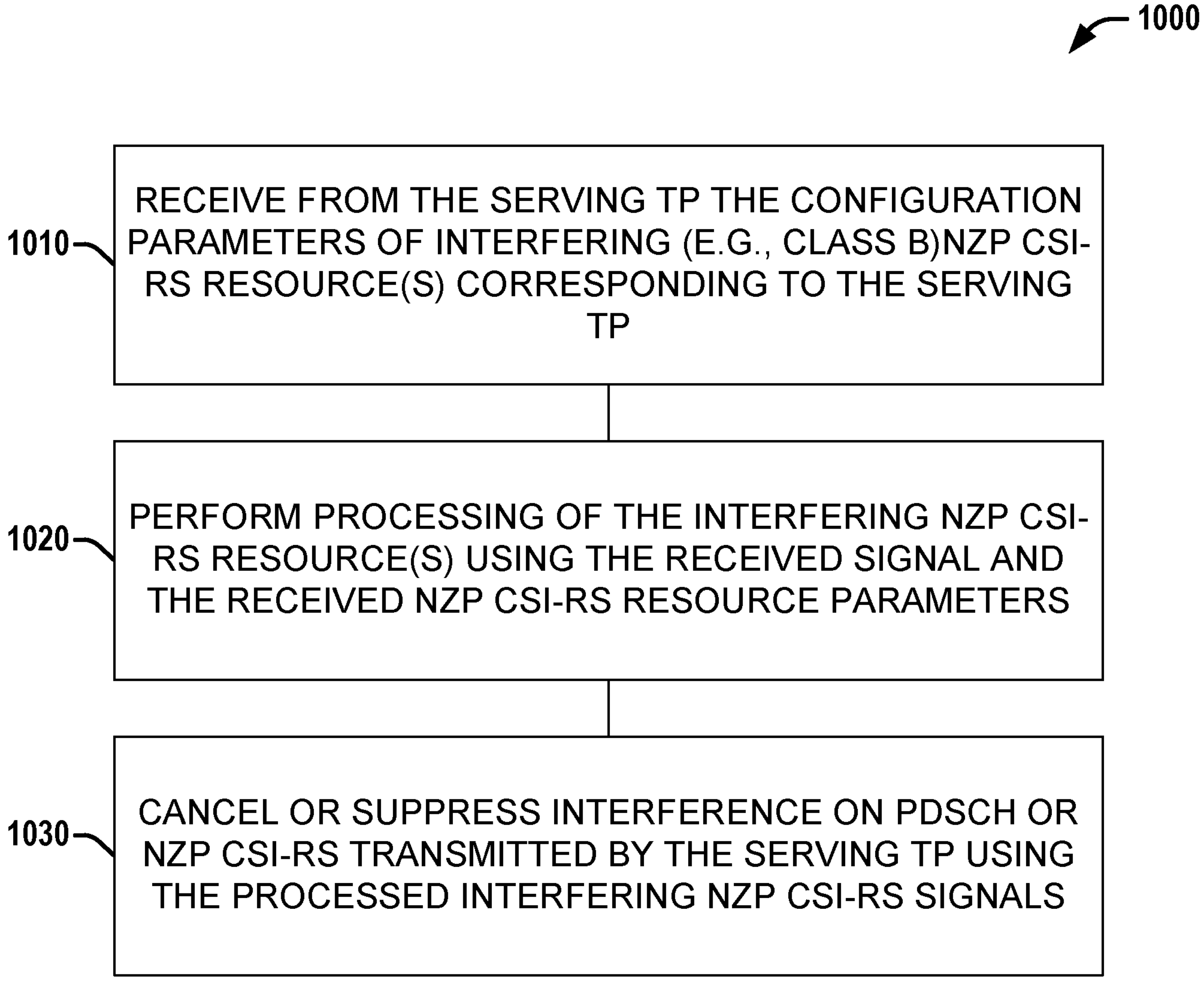

1000
1010
RECEIVE FROM THE SERVING TP THE CONFIGURATION PARAMETERS OF INTERFERING (E.G., CLASS B)NZP CSI-RS RESOURCE(S) CORRESPONDING TO THE SERVING TP
1020
PERFORM PROCESSING OF THE INTERFERING NZP CSI-RS RESOURCE(S) USING THE RECEIVED SIGNAL AND THE RECEIVED NZP CSI-RS RESOURCE PARAMETERS
1030
CANCEL OR SUPPRESS INTERFERENCE ON PDSCH OR NZP CSI-RS TRANSMITTED BY THE SERVING TP USING THE PROCESSED INTERFERING NZP CSI-RS SIGNALS

FIG. 10

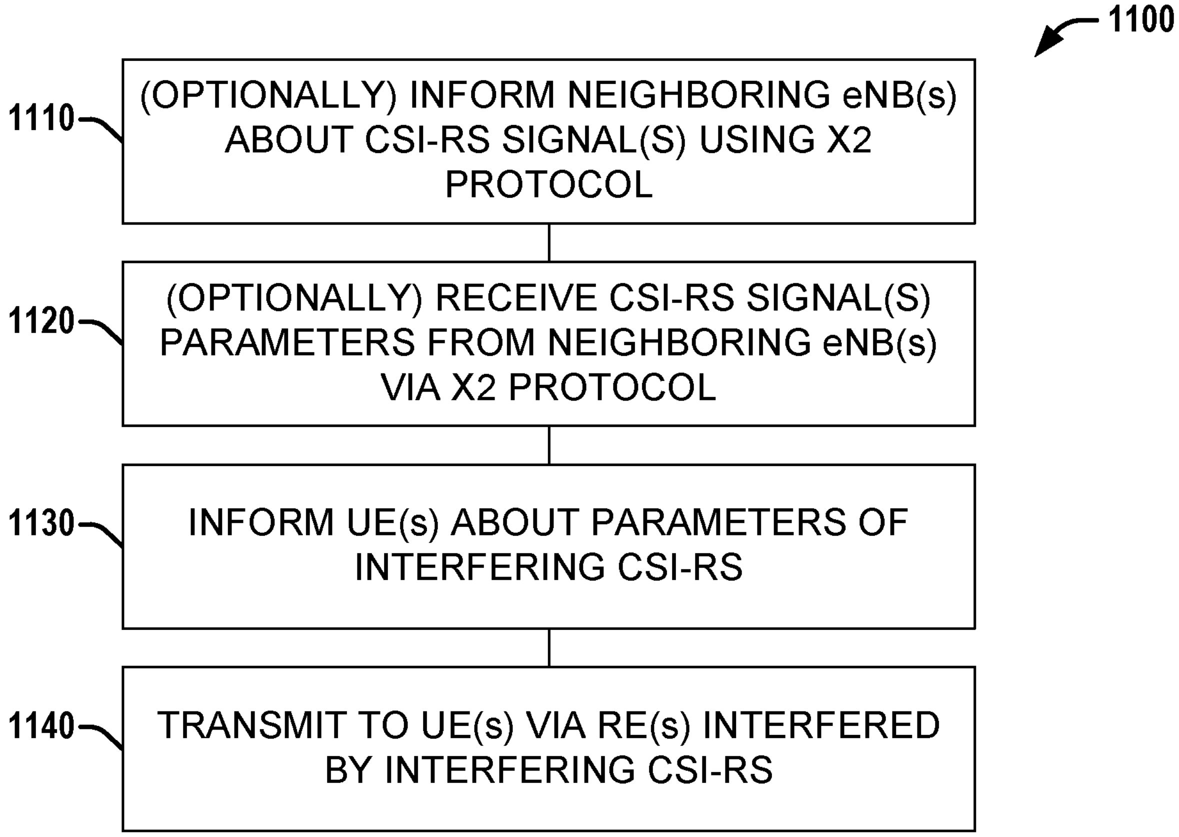

1100
1110
(OPTIONALLY) INFORM NEIGHBORING eNB(s) ABOUT CSI-RS SIGNAL(S) USING X2 PROTOCOL
1120
(OPTIONALLY) RECEIVE CSI-RS SIGNAL(S) PARAMETERS FROM NEIGHBORING eNB(s) VIA X2 PROTOCOL
1130
INFORM UE(s) ABOUT PARAMETERS OF INTERFERING CSI-RS
1140
TRANSMIT TO UE(s) VIA RE(s) INTERFERED BY INTERFERING CSI-RS

FIG. 11

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/030010

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04B7/022 H04J11/00 H04L25/00
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04B H04J H04L

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2015/124691 A1 (LI JIANJUN [KR]) 7 May 2015 (2015-05-07) paragraphs [0026], [0048], [0059] - [0060], [0103] - [0106], [0108], [0110] - [0118], [0128], [0135], [0143] - [0144]; figures 4,5,7,9; tables 6,7,10,11,12 -----	1-29
X	US 2015/373569 A1 (HWANG JINYUP [KR] ET AL) 24 December 2015 (2015-12-24) paragraphs [0046], [0118], [0135], [0139], [0142], [0174], [0195] - [0198], [0200] - [0205]; figures 13a-c,15; tables 1,5 -----	1-29
	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 July 2017	13/07/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Franz, Volker

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/030010

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	ERICSSON ET AL: "Way forward on 4 CRS APs", 3GPP DRAFT; R4-147573-WAY FORWARD 4CRS APS, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG4, no. San Francisco, USA; 20141116 - 20141120 17 November 2014 (2014-11-17), XP050896296, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN4/Docs/ [retrieved on 2014-11-17] page 2 -----	25,29
A	INTEL CORPORATION: "CSI enhancements for hybrid FD-MIMO", 3GPP DRAFT; R1-163187 CSI ENHANCEMENTS FOR HYBRID FD-MIMO, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Busan, Korea; 20160411 - 20160415 2 April 2016 (2016-04-02), XP051080585, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_84b/Docs/ [retrieved on 2016-04-02] pages 1-2 -----	11,12
A	ERICSSON: "Correction to FD-MIMO field descriptions", 3GPP DRAFT; 36331_CRYYYY_(REL-13)_R2-163114, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. Dubrovnik, Croatia; 20160411 - 20160415 15 April 2016 (2016-04-15), XP051098958, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN2/Docs/ [retrieved on 2016-04-15] page 3 -----	2,11,12, 17,27

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2017/030010

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2015124691 A1	07-05-2015	KR 20150050893 A	11-05-2015
		US 2015124691 A1	07-05-2015
		US 2017126388 A1	04-05-2017
		WO 2015065087 A1	07-05-2015
US 2015373569 A1	24-12-2015	US 2015373569 A1	24-12-2015
		WO 2014123389 A1	14-08-2014