US012388560B2

(12) **United States Patent**
Chen et al.

(10) **Patent No.: US 12,388,560 B2**
(45) **Date of Patent: Aug. 12, 2025**

(54) **MECHANISM TO CANCEL LTE CRS INTERFERENCE FROM NEIGHBORING CELL IN DSS**

(71) Applicant: **MEDIATEK INC.**, Hsinchu (TW)

(72) Inventors: **Yen-Chen Chen**, Hsinchu (TW); **Xiu-Sheng Li**, Hsinchu (TW)

(73) Assignee: **MEDIATEK INC.**, Hsinchu (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 340 days.

(21) Appl. No.: **17/700,595**

(22) Filed: **Mar. 22, 2022**

(65) **Prior Publication Data**

US 2022/0345240 A1 Oct. 27, 2022

Related U.S. Application Data

(60) Provisional application No. 63/177,469, filed on Apr. 21, 2021.

(51) **Int. Cl.**

H04L 1/00	(2006.01)
H04W 16/14	(2009.01)
H04W 24/08	(2009.01)

(52) **U.S. Cl.**
CPC ***H04L 1/0002*** (2013.01); ***H04W 16/14*** (2013.01); ***H04W 24/08*** (2013.01)

(58) **Field of Classification Search**
CPC H04L 1/0002; H04W 16/14; H04W 24/08
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,544,794 B2 *	1/2017	Kim	H04W 48/14
11,395,369 B2 *	7/2022	Gheorghiu	H04W 16/14
11,937,106 B2 *	3/2024	Ryu	H04L 5/0048
2011/0267937 A1	11/2011	Yoo et al.	
2012/0113961 A1	5/2012	Krishnamurthy	
2013/0182583 A1	7/2013	Siomina et al.	
2013/0294403 A1 *	11/2013	Srinivasan	H04W 88/12 370/328
2014/0233457 A1	8/2014	Koutsimanis et al.	

(Continued)

FOREIGN PATENT DOCUMENTS

CN	103024751 A	4/2013
CN	103096374 A	5/2013

(Continued)

OTHER PUBLICATIONS

China Patent Office, "Office Action", Jul. 12, 2024, China.

(Continued)

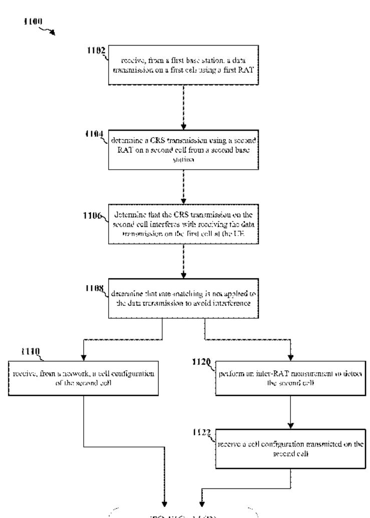
Primary Examiner — Bailor C Hsu

(74) *Attorney, Agent, or Firm* — Troutman Pepper Locke LLP; Tim Tingkang Xia, Esq.

(57) **ABSTRACT**

In an aspect of the disclosure, a method, a computer-readable medium, and an apparatus are provided. The apparatus may be a UE. The UE receives, from a first base station, a data transmission on a first cell using a first RAT. The UE determines a CRS transmission using a second RAT on a second cell from a second base station. The UE determines that the CRS transmission on the second cell interferes with receiving the data transmission on the first cell at the UE. The UE applies an interference cancellation on the first cell to mitigate an interference from the CRS transmission on the second cell to the data transmission on the first cell.

10 Claims, 15 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

2015/0365178	A1*	12/2015	Maattanen	H04L 5/1438 370/329
2016/0227426	A1*	8/2016	Hwang	H04B 17/309
2018/0205480	A1*	7/2018	Akkarakaran	H04L 5/0073
2019/0342820	A1*	11/2019	Chen	H04W 48/02
2022/0086844	A1*	3/2022	Rassam	H04W 72/541
2022/0210660	A1*	6/2022	Shahid	H04W 52/242
2022/0210662	A1*	6/2022	Wang	H04L 1/0069
2022/0240257	A1*	7/2022	Smith	H04W 72/541
2022/0312449	A1*	9/2022	Sun	H04L 5/0044
2022/0329300	A1*	10/2022	Wang	H04W 24/10
2022/0407568	A1*	12/2022	Nam	H04B 7/0452
2022/0417760	A1*	12/2022	Kumar	H04B 17/336

FOREIGN PATENT DOCUMENTS

CN	103220803	A	7/2013
CN	105531949	A	4/2016
WO	2020261095	A1	12/2020

OTHER PUBLICATIONS

China Patent Office, “Office Action”, Apr. 3, 2024, China.
Taiwan Patent Office, “Office Action”, Jul. 25, 2022, Taiwan.
Patent Office, “Office Action”, Jul. 31, 2023, Taiwan.

* cited by examiner

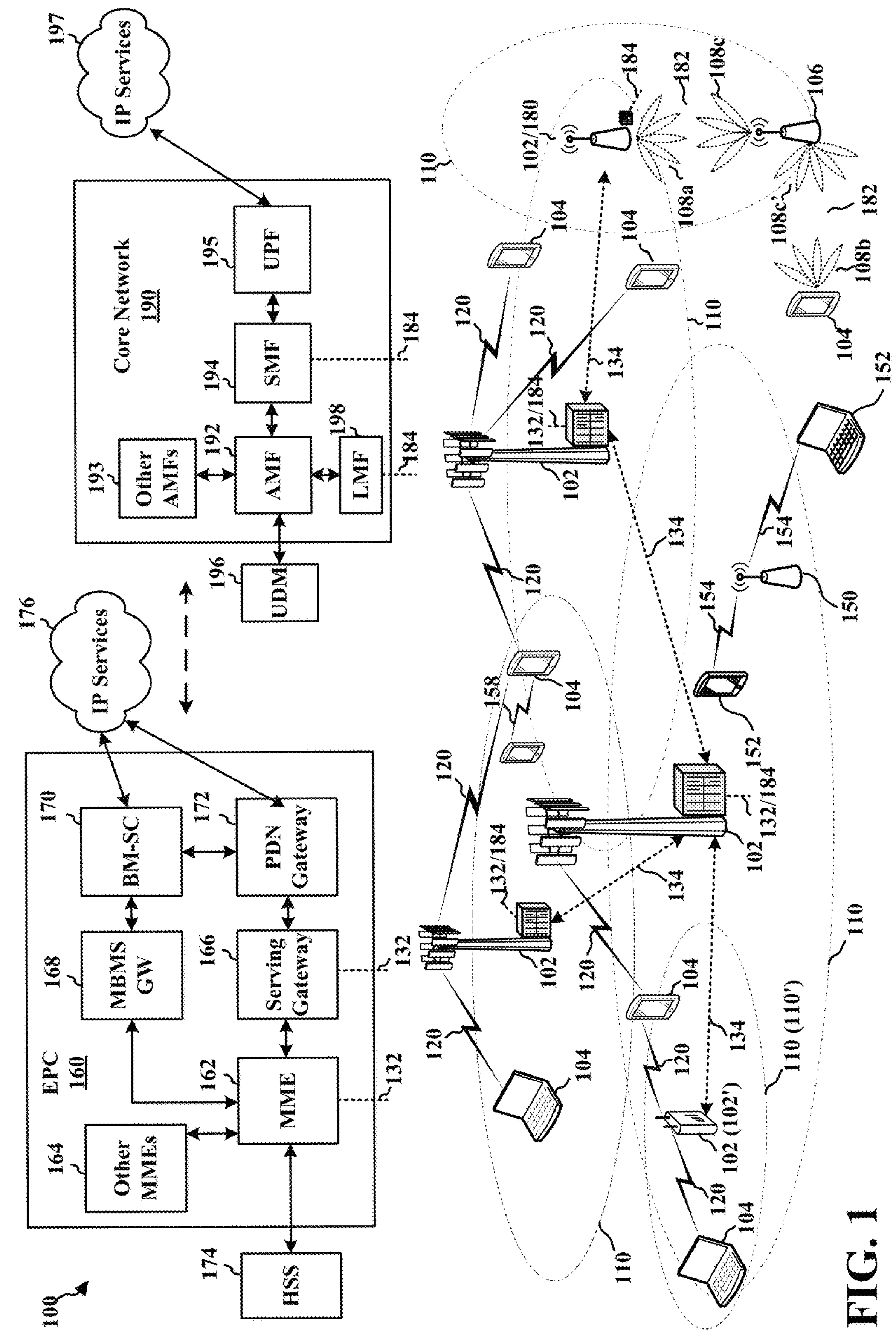
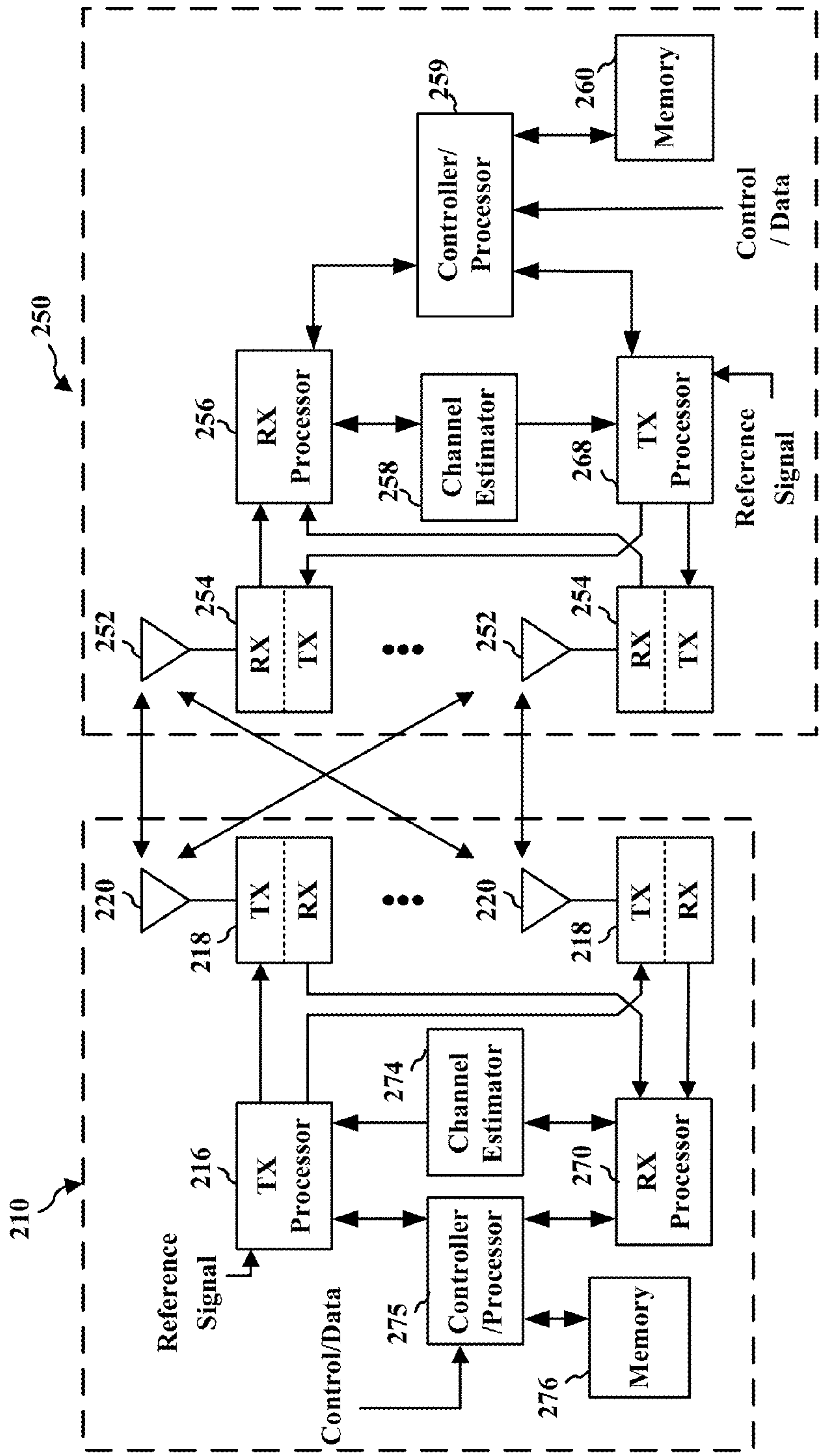

100
EPC
160
HSS
174
Other MMEs
164
MME
162
MBMS GW
168
Serving Gateway
166
BM-SC
170
PDN Gateway
172
IP Services
176
132
Core Network
190
Other AMFs
193
AMF
192
LMF
198
SMF
194
UPF
195
UDM
196
IP Services
197
184
102
132/184
134
120
104
158
110
110 (110')
102 (102')
152
154
150
102/180
182
108a
108b
108c
108c'
106

FIG. 1



210
Reference Signal
216
TX Processor
Control/Data
275
Controller /Processor
276
Memory
274
Channel Estimator
270
RX Processor
218
TX
RX
220
250
252
254
RX
TX
256
RX Processor
258
Channel Estimator
268
TX Processor
Reference Signal
259
Controller/ Processor
Control / Data
260
Memory

FIG. 2

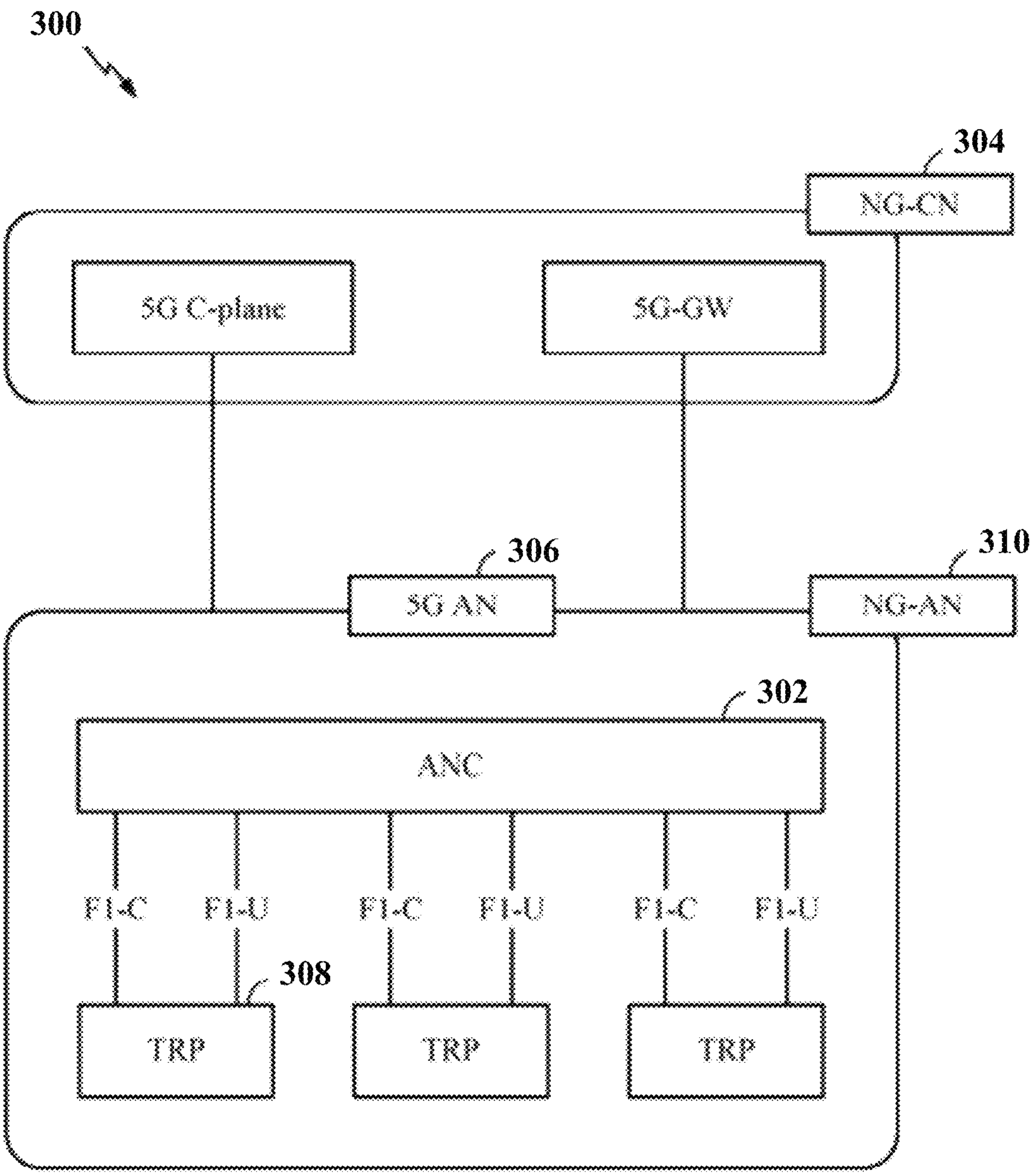

300
304
NG-CN
5G C-plane
5G-GW
306
5G AN
310
NG-AN
302
ANC
F1-C
F1-U
F1-C
F1-U
F1-C
F1-U
308
TRP
TRP
TRP

FIG. 3

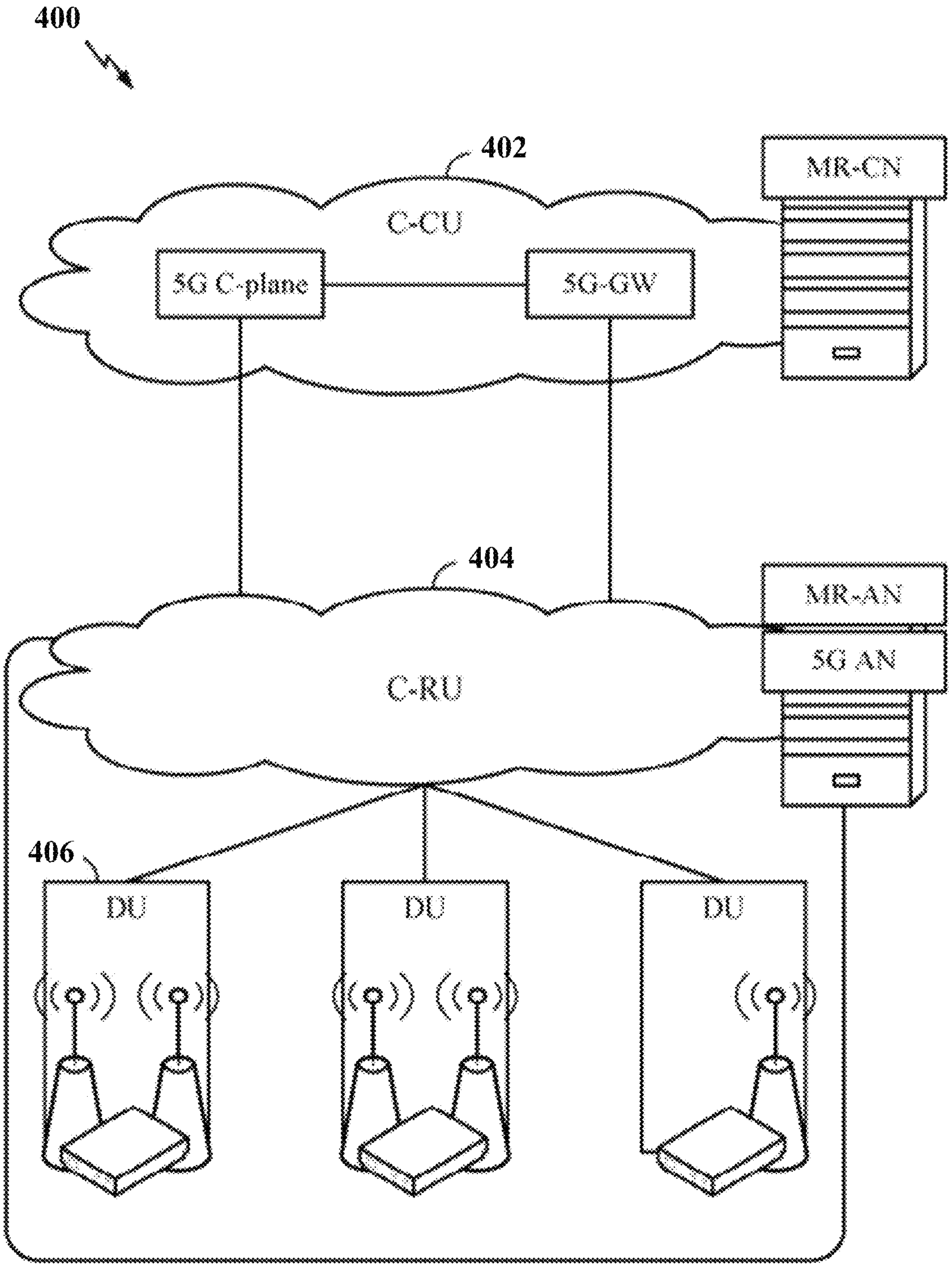


FIG. 4

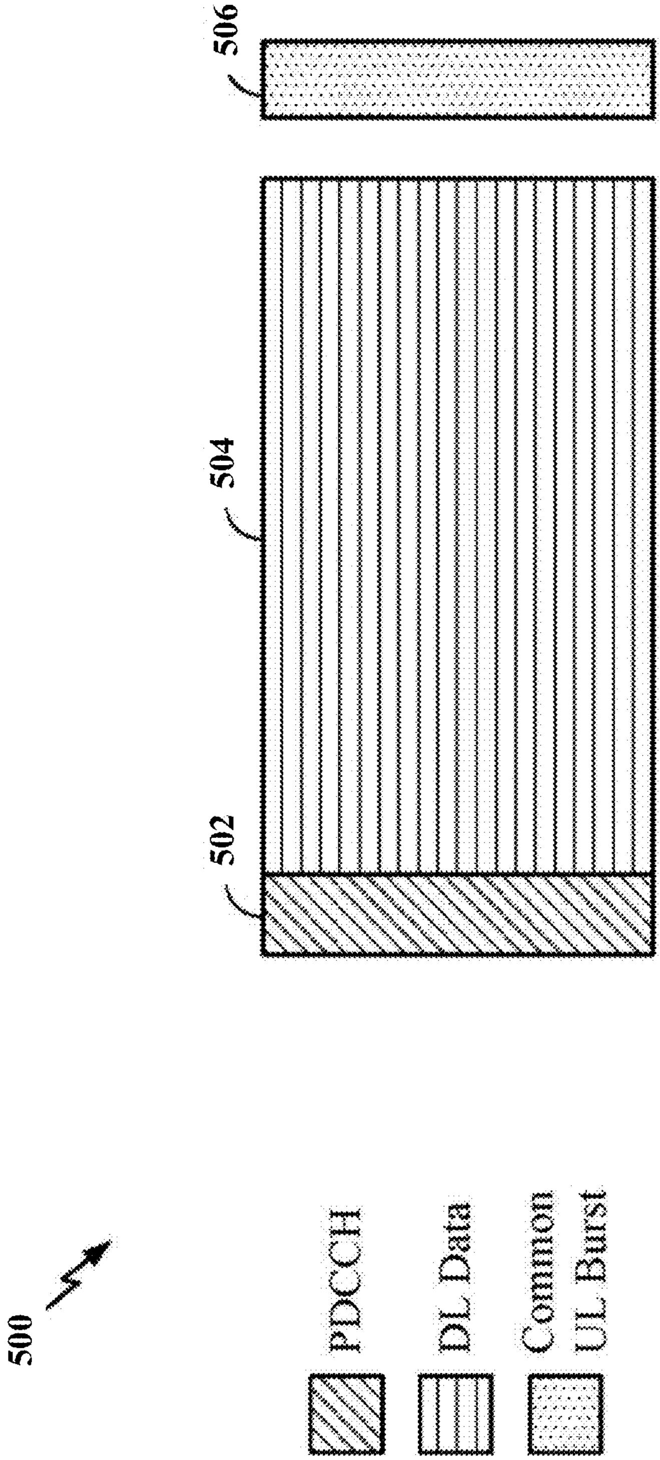


FIG. 5

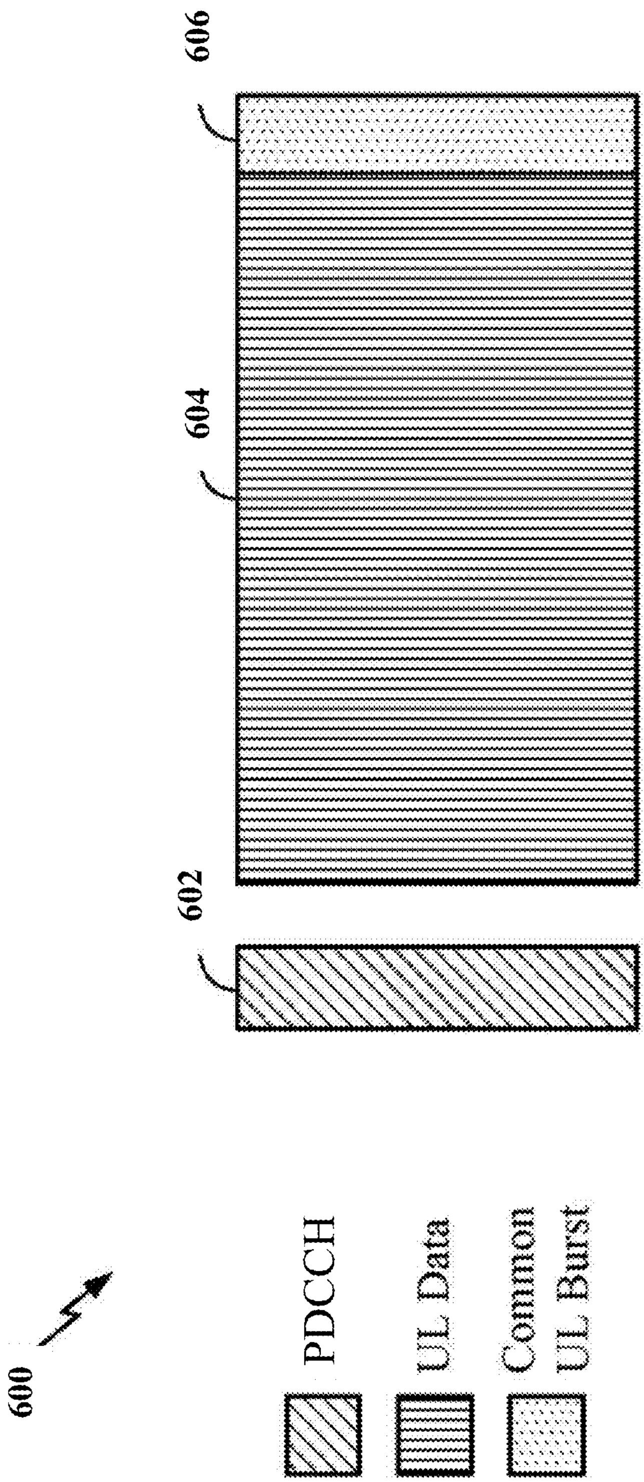


FIG. 6

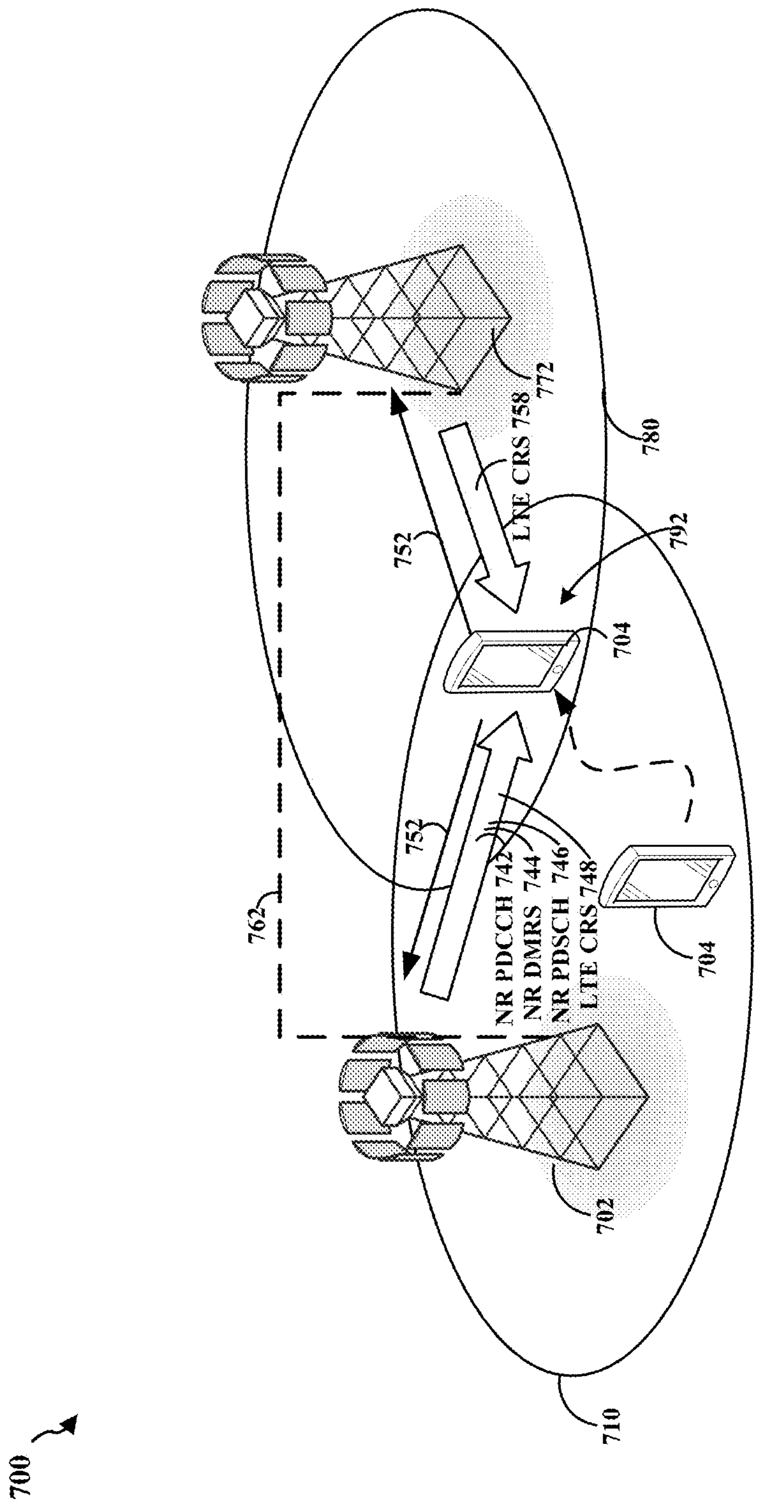

700
702
704
704
710
752
752
762
772
780
792
LTE CRS 758
NR PDCCH 742
NR DMRS 744
NR PDSCH 746
LTE CRS 748

FIG. 7

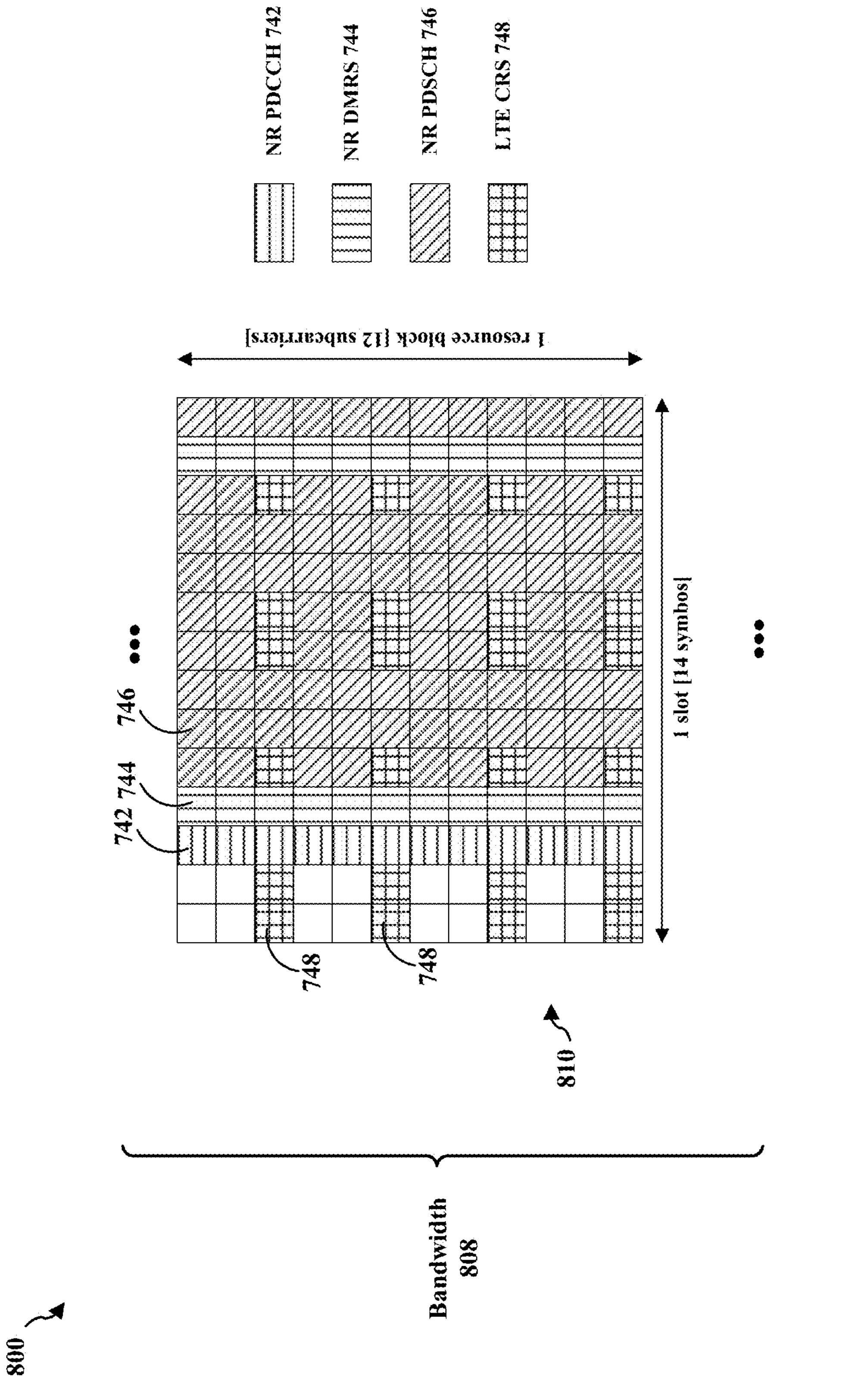

NR PDCCH 742
NR DMRS 744
NR PDSCH 746
LTE CRS 748
1 resource block [12 subcarriers]
1 slot [14 symbos]
742
744
746
748
748
810
Bandwidth
808
800

FIG. 8

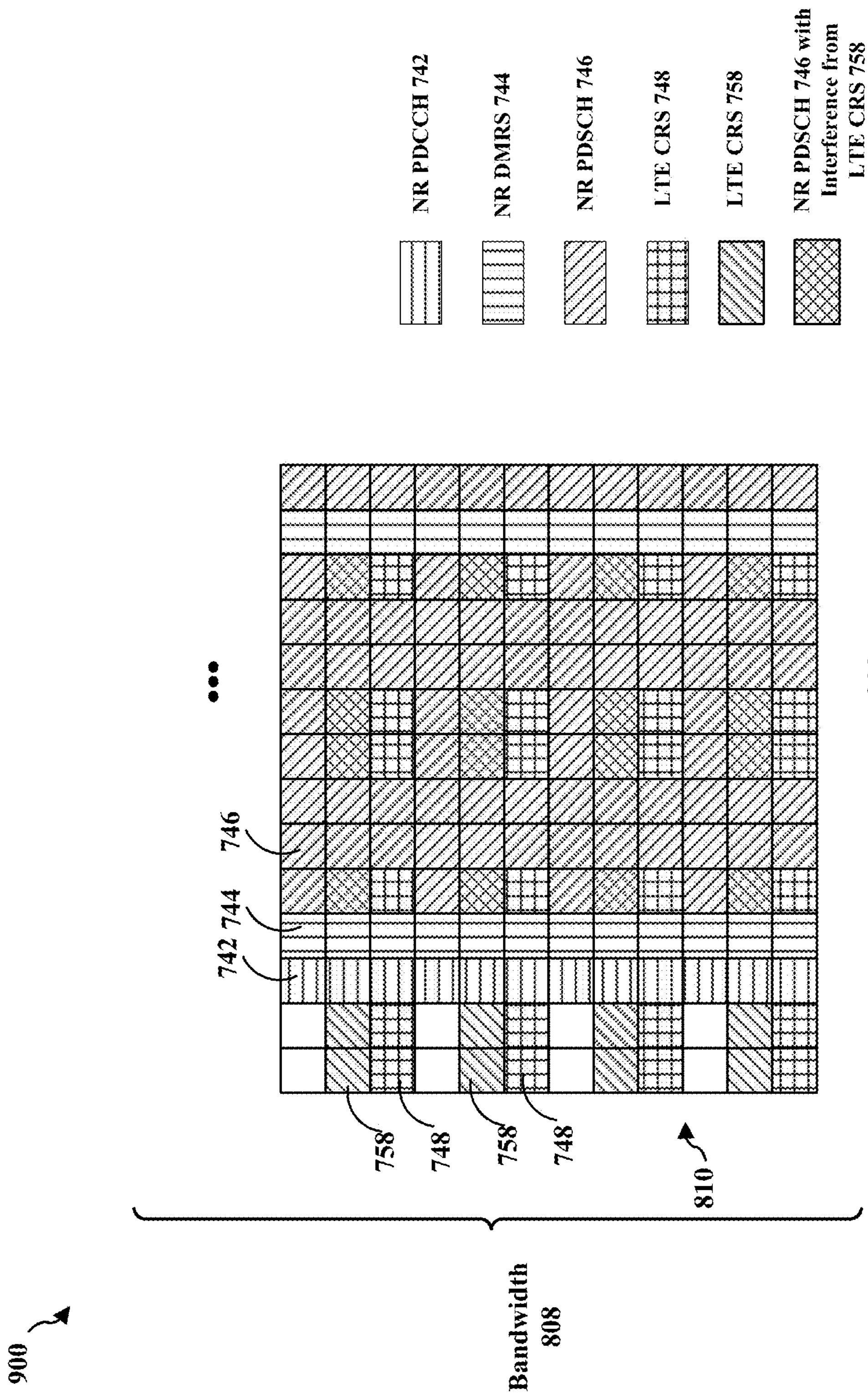

900
Bandwidth
808
810
758
748
758
748
742
744
746
NR PDCCH 742
NR DMRS 744
NR PDSCH 746
LTE CRS 748
LTE CRS 758
NR PDSCH 746 with
Interference from
LTE CRS 758

FIG. 9

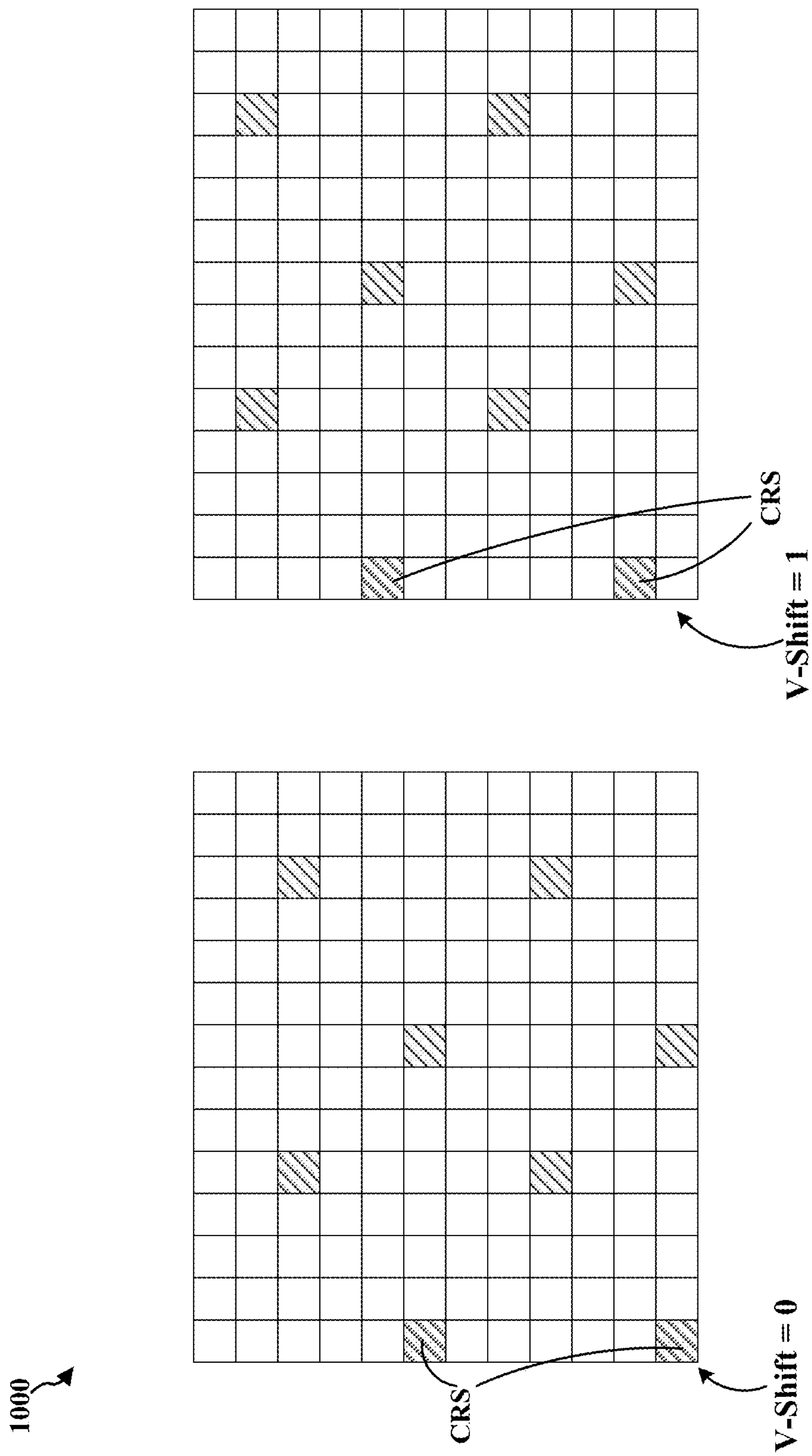


FIG. 10

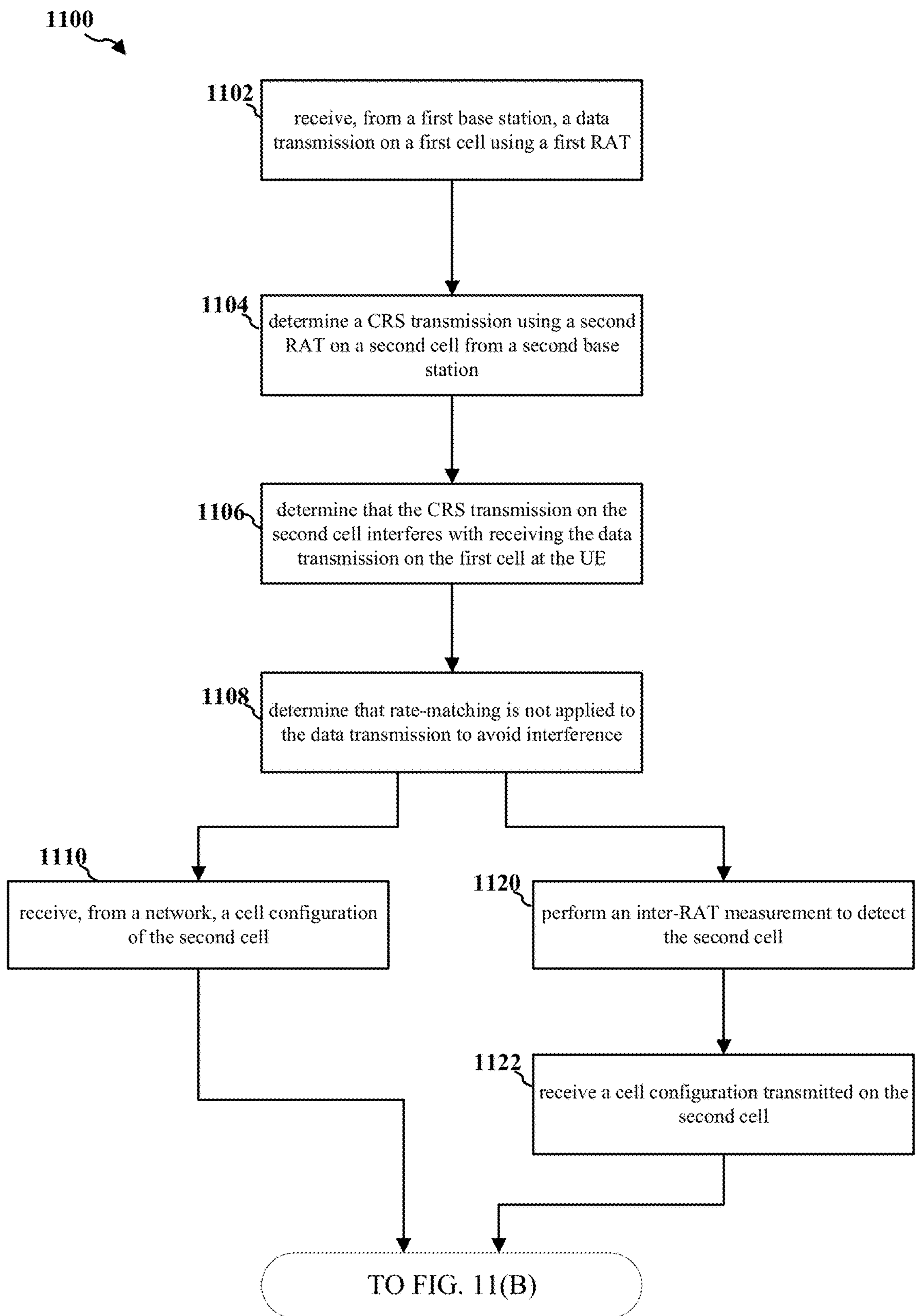

1100
1102
receive, from a first base station, a data transmission on a first cell using a first RAT
1104
determine a CRS transmission using a second RAT on a second cell from a second base station
1106
determine that the CRS transmission on the second cell interferes with receiving the data transmission on the first cell at the UE
1108
determine that rate-matching is not applied to the data transmission to avoid interference
1110
receive, from a network, a cell configuration of the second cell
1120
perform an inter-RAT measurement to detect the second cell
1122
receive a cell configuration transmitted on the second cell
TO FIG. 11(B)

FIG. 11(A)

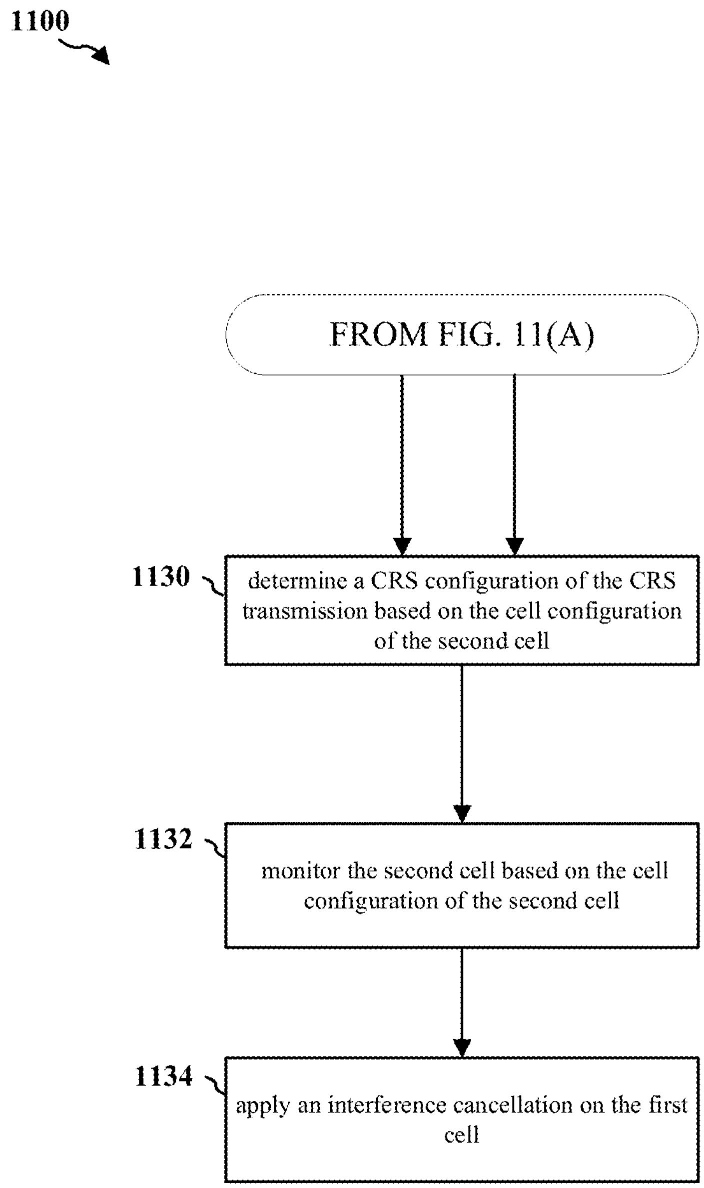

1100
FROM FIG. 11(A)
1130
determine a CRS configuration of the CRS transmission based on the cell configuration of the second cell
1132
monitor the second cell based on the cell configuration of the second cell
1134
apply an interference cancellation on the first cell

FIG. 11(B)

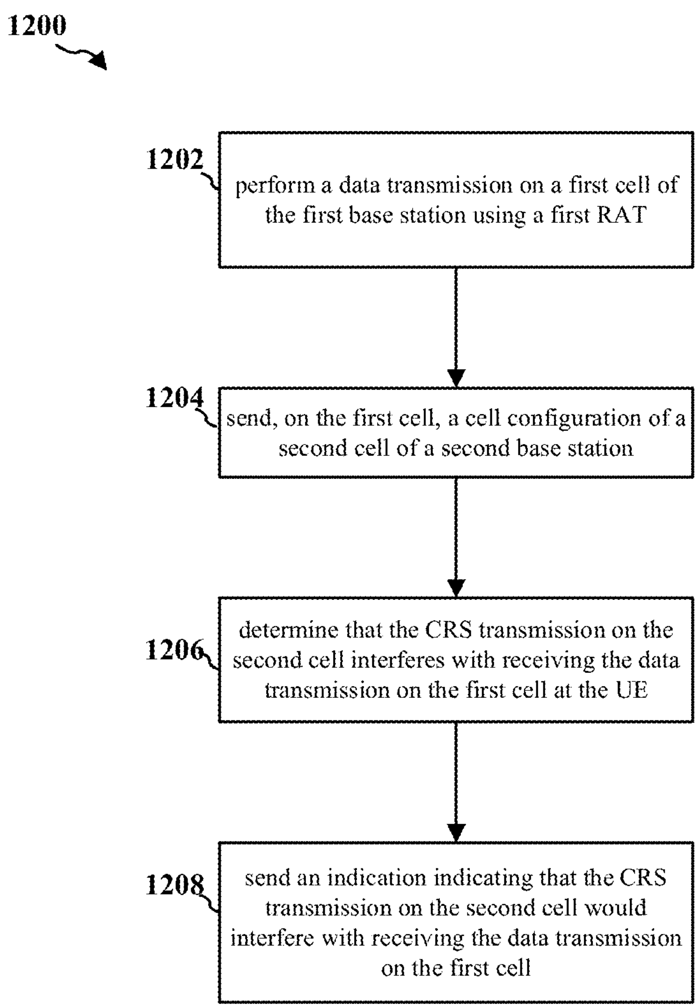

1200
1202
perform a data transmission on a first cell of the first base station using a first RAT
1204
send, on the first cell, a cell configuration of a second cell of a second base station
1206
determine that the CRS transmission on the second cell interferes with receiving the data transmission on the first cell at the UE
1208
send an indication indicating that the CRS transmission on the second cell would interfere with receiving the data transmission on the first cell

FIG. 12

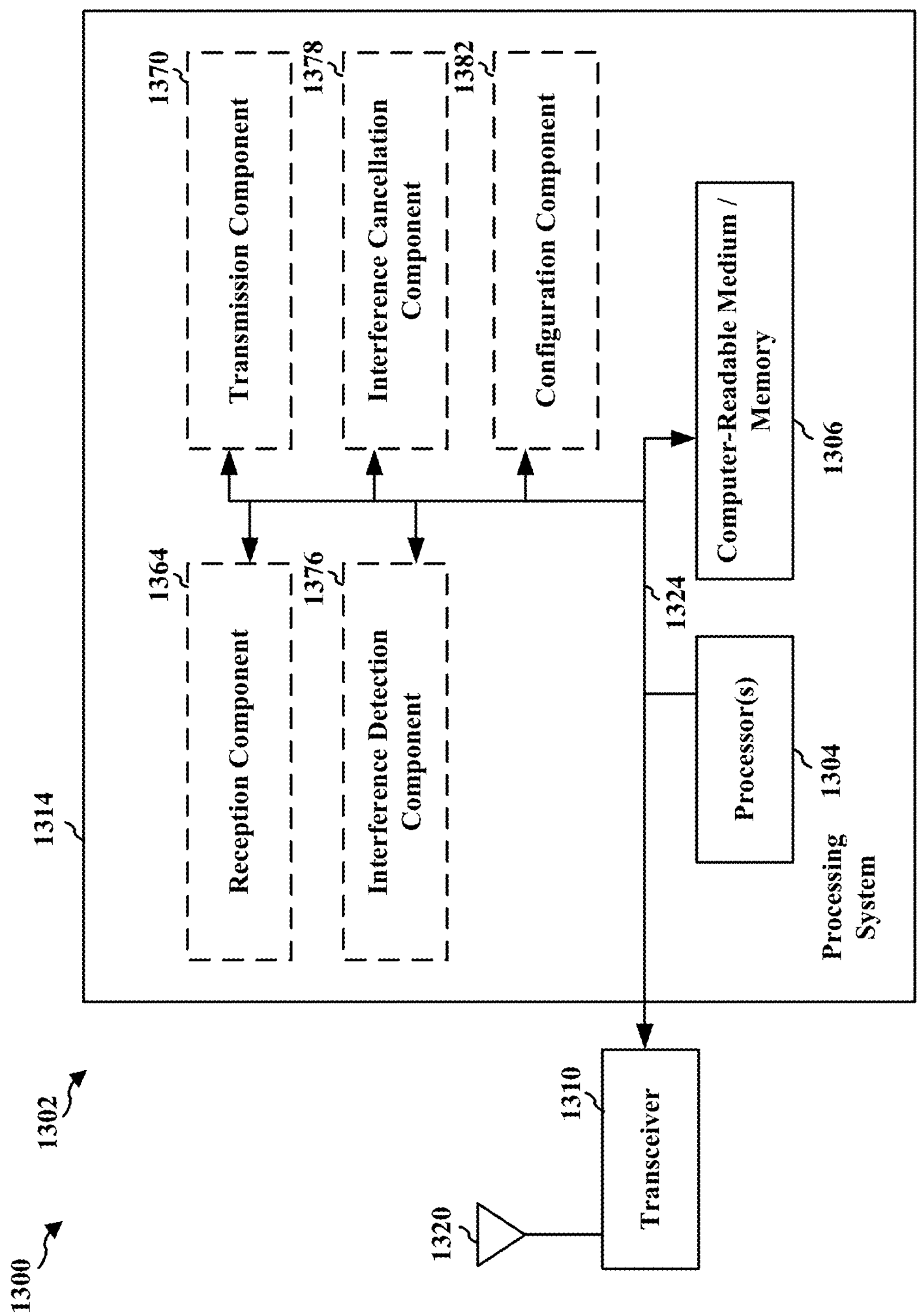

1300
1302
1314
1364
Reception Component
1376
Interference Detection Component
1370
Transmission Component
1378
Interference Cancellation Component
1382
Configuration Component
1324
Computer-Readable Medium / Memory
1306
Processor(s)
1304
Processing System
1310
Transceiver
1320

FIG. 13

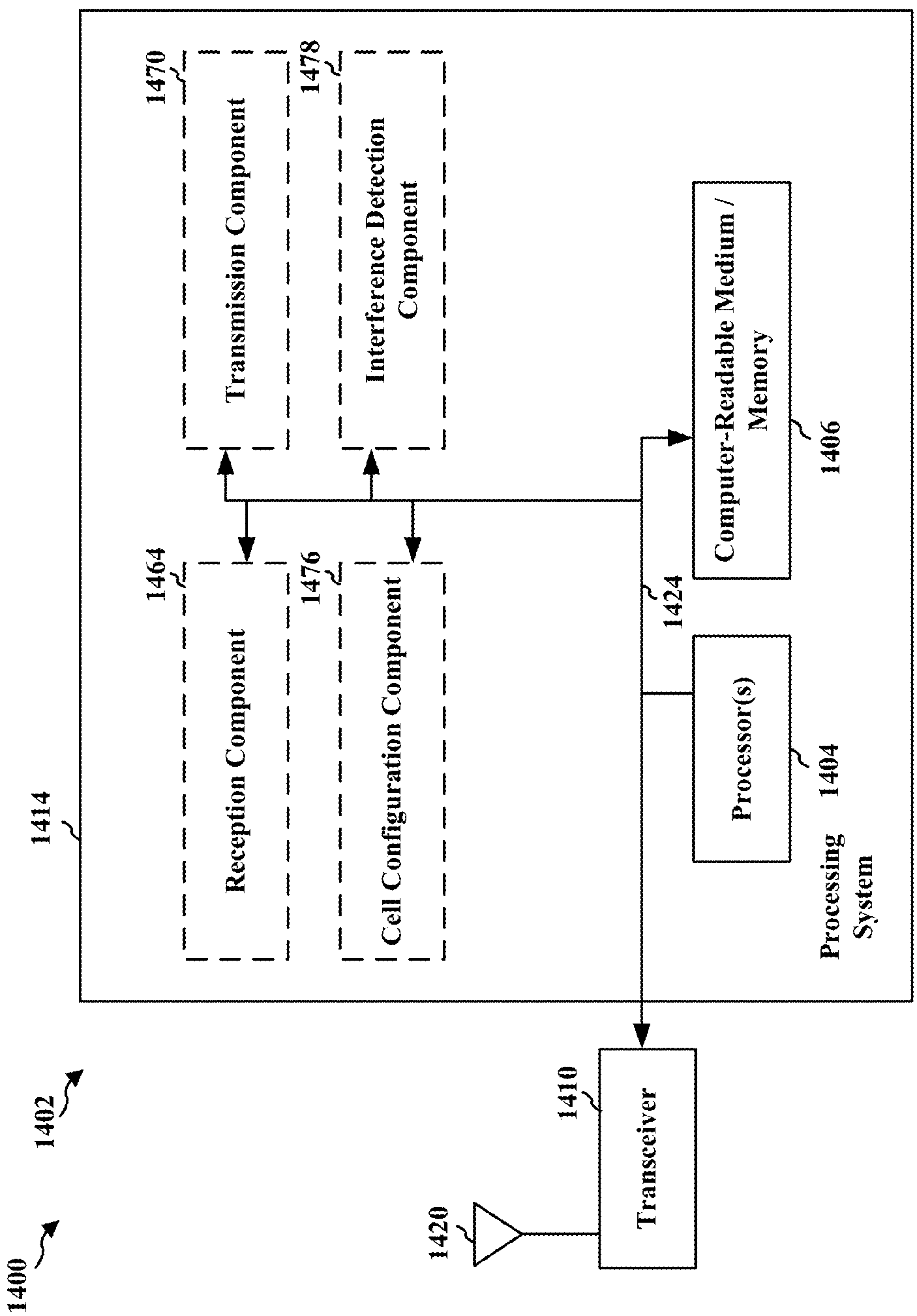

1400
1402
1414
1470
Transmission Component
1478
Interference Detection Component
1464
Reception Component
1476
Cell Configuration Component
Computer-Readable Medium / Memory
1406
1424
Processor(s)
1404
Processing System
1410
Transceiver
1420

FIG. 14

MECHANISM TO CANCEL LTE CRS INTERFERENCE FROM NEIGHBORING CELL IN DSS

CROSS-REFERENCE TO RELATED APPLICATION(S)

This application claims the benefit of U.S. Provisional Application Ser. No. 63/177,469, entitled "MECHANISM TO CANCEL LTE CRS INTERFERENCE FROM NEIGHBORING CELL IN DSS" and filed on Apr. 21, 2021, which is expressly incorporated by reference herein in its entirety.

BACKGROUND

Field

The present disclosure relates generally to communication systems, and more particularly, to techniques of interference mitigation in dynamic spectrum sharing (DSS).

Background

The statements in this section merely provide background information related to the present disclosure and may not constitute prior art.

Wireless communication systems are widely deployed to provide various telecommunication services such as telephony, video, data, messaging, and broadcasts. Typical wireless communication systems may employ multiple-access technologies capable of supporting communication with multiple users by sharing available system resources. Examples of such multiple-access technologies include code division multiple access (CDMA) systems, time division multiple access (TDMA) systems, frequency division multiple access (FDMA) systems, orthogonal frequency division multiple access (OFDMA) systems, single-carrier frequency division multiple access (SC-FDMA) systems, and time division synchronous code division multiple access (TD-SCDMA) systems.

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

SUMMARY

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

In an aspect of the disclosure, a method, a computer-readable medium, and an apparatus are provided. The apparatus may be a UE. The UE receives, from a first base station, a data transmission on a first cell using a first radio access technology (RAT). The UE determines a cell-specific reference signal (CRS) transmission using a second RAT on a second cell from a second base station. The UE determines that the CRS transmission on the second cell interferes with receiving the data transmission on the first cell at the UE. The UE applies an interference cancellation on the first cell to mitigate an interference from the CRS transmission on the second cell to the data transmission on the first cell.

In another aspect of the disclosure, a method, a computer-readable medium, and an apparatus are provided. The apparatus may be a first base station. The first base station performs a data transmission on a first cell of the first base station using a first RAT. The second base station sends, on the first cell, a cell configuration of a second cell of a second base station for a UE to detect a CRS transmission on the second cell using a second RAT.

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

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. **2** is a diagram illustrating a base station in communication with a UE in an access network.

FIG. **3** illustrates an example logical architecture of a distributed access network.

FIG. **4** illustrates an example physical architecture of a distributed access network.

FIG. **5** is a diagram showing an example of a DL-centric slot.

FIG. **6** is a diagram showing an example of an UL-centric slot.

FIG. **7** is a diagram illustrating communications among base stations and UEs.

FIG. **8** is a diagram illustrating a slot of a cell in DSS configuration.

FIG. **9** is a diagram illustrating a slot in an overlapping area of two cells.

FIG. **10** is a diagram illustrating a parameter v-shift used in configuring locations of CRSs.

FIGS. **11** (A) and (B) are a flow chart of a method (process) for mitigating interference.

FIG. **12** is a flow chart of a method (process) for detecting interference.

FIG. **13** is a diagram illustrating an example of a hardware implementation for an apparatus employing a processing system.

FIG. **14** is a diagram illustrating an example of a hardware implementation for another apparatus employing a processing system.

DETAILED DESCRIPTION

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

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

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

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

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

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

The base stations **102** may wirelessly communicate with the UEs **104**. Each of the base stations **102** may provide communication coverage for a respective geographic coverage area **110**. There may be overlapping geographic coverage areas **110**. For example, the small cell **102'** may have a coverage area **110'** that overlaps the coverage area **110** of one or more macro base stations **102**. A network that includes both small cell and macrocells may be known as a heterogeneous network. A heterogeneous network may also include Home Evolved Node Bs (eNBs) (HeNBs), which may provide service to a restricted group known as a closed subscriber group (CSG). The communication links **120** between the base stations **102** and the UEs **104** may include uplink (UL) (also referred to as reverse link) transmissions from a UE **104** to a base station **102** and/or downlink (DL) (also referred to as forward link) transmissions from a base station **102** to a UE **104**. The communication links **120** may use multiple-input and multiple-output (MIMO) antenna technology, including spatial multiplexing, beamforming, and/or transmit diversity. The communication links may be through one or more carriers. The base stations **102**/UEs **104** may use spectrum up to 7 MHz (e.g., 5, 10, 15, 20, 100, 400, etc. MHz) bandwidth per carrier allocated in a carrier aggregation of up to a total of Yx MHz (x component carriers) used for transmission in each direction. The carriers may or may not be adjacent to each other. Allocation of carriers may be asymmetric with respect to DL and UL (e.g., more or fewer carriers may be allocated for DL than for UL). The component carriers may include a primary component carrier and one or more secondary component carriers. A primary component carrier may be referred to as a primary cell (PCell) and a secondary component carrier may be referred to as a secondary cell (SCell).

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

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

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

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

The base station **180** may transmit a beamformed signal to the UE **104** in one or more transmit directions **108***a*. The UE **104** may receive the beamformed signal from the base station **180** in one or more receive directions **108***b*. The UE **104** may also transmit a beamformed signal to the base station **180** in one or more transmit directions. The base station **180** may receive the beamformed signal from the UE **104** in one or more receive directions. The base station **180**/UE **104** may perform beam training to determine the best receive and transmit directions for each of the base station **180**/UE **104**. The transmit and receive directions for the base station **180** may or may not be the same. The transmit and receive directions for the UE **104** may or may not be the same.

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

The core network **190** may include a Access and Mobility Management Function (AMF) **192**, other AMFs **193**, a location management function (LMF) **198**, a Session Management Function (SMF) **194**, and a User Plane Function (UPF) **195**. The AMF **192** may be in communication with a Unified Data Management (UDM) **196**. The AMF **192** is the control node that processes the signaling between the UEs **104** and the core network **190**. Generally, the SMF **194** provides QoS flow and session management. All user Internet protocol (IP) packets are transferred through the UPF **195**. The UPF **195** provides UE IP address allocation as well as other functions. The UPF **195** is connected to the IP Services **197**. The IP Services **197** may include the Internet, an intranet, an IP Multimedia Subsystem (IMS), a PS Streaming Service, and/or other IP services.

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

Although the present disclosure may reference 5G New Radio (NR), the present disclosure may be applicable to other similar areas, such as LTE, LTE-Advanced (LTE-A), Code Division Multiple Access (CDMA), Global System for Mobile communications (GSM), or other wireless/radio access technologies.

FIG. **2** is a block diagram of a base station **210** in communication with a UE **250** in an access network. In the DL, IP packets from the EPC **160** may be provided to a controller/processor **275**. The controller/processor **275** implements layer 3 and layer 2 functionality. Layer 3 includes a radio resource control (RRC) layer, and layer 2 includes a packet data convergence protocol (PDCP) layer, a radio link control (RLC) layer, and a medium access control (MAC) layer. The controller/processor **275** provides RRC layer functionality associated with broadcasting of system information (e.g., MIB, SIBs), RRC connection control (e.g., RRC connection paging, RRC connection establishment, RRC connection modification, and RRC connection release), inter radio access technology (RAT) mobility, and measurement configuration for UE measurement reporting; PDCP layer functionality associated with header compression/decompression, security (ciphering, deciphering, integrity protection, integrity verification), and handover support functions; RLC layer functionality associated with the transfer of upper layer packet data units (PDUs), error correction through ARQ, concatenation, segmentation, and reassembly of RLC service data units (SDUs), re-segmentation of RLC data PDUs, and reordering of RLC data PDUs; and MAC layer functionality associated with mapping between logical channels and transport channels, multiplexing of MAC SDUs onto transport blocks (TBs), demultiplexing of MAC SDUs from TBs, scheduling information reporting, error correction through HARQ, priority handling, and logical channel prioritization.

The transmit (TX) processor **216** and the receive (RX) processor **270** implement layer 1 functionality associated with various signal processing functions. Layer 1, which includes a physical (PHY) layer, may include error detection on the transport channels, forward error correction (FEC) coding/decoding of the transport channels, interleaving, rate matching, mapping onto physical channels, modulation/demodulation of physical channels, and MIMO antenna processing. The TX processor **216** handles mapping to signal constellations based on various modulation schemes (e.g., binary phase-shift keying (BPSK), quadrature phase-shift keying (QPSK), M-phase-shift keying (M-PSK), M-quadrature amplitude modulation (M-QAM)). The coded and modulated symbols may then be split into parallel streams. Each stream may then be mapped to an OFDM subcarrier, multiplexed with a reference signal (e.g., pilot) in the time and/or frequency domain, and then combined together using an Inverse Fast Fourier Transform (IFFT) to produce a physical channel carrying a time domain OFDM symbol stream. The OFDM stream is spatially precoded to produce multiple spatial streams. Channel estimates from a channel estimator **274** may be used to determine the coding and modulation scheme, as well as for spatial processing. The channel estimate may be derived from a reference signal and/or channel condition feedback transmitted by the UE **250**. Each spatial stream may then be provided to a different antenna **220** via a separate transmitter **218**TX. Each transmitter **218**TX may modulate an RF carrier with a respective spatial stream for transmission.

At the UE **250**, each receiver **254**RX receives a signal through its respective antenna **252**. Each receiver **254**RX recovers information modulated onto an RF carrier and provides the information to the receive (RX) processor **256**. The TX processor **268** and the RX processor **256** implement layer 1 functionality associated with various signal processing functions. The RX processor **256** may perform spatial processing on the information to recover any spatial streams destined for the UE **250**. If multiple spatial streams are destined for the UE **250**, they may be combined by the RX processor **256** into a single OFDM symbol stream. The RX processor **256** then converts the OFDM symbol stream from the time-domain to the frequency domain using a Fast Fourier Transform (FFT). The frequency domain signal comprises a separate OFDM symbol stream for each subcarrier of the OFDM signal. The symbols on each subcarrier, and the reference signal, are recovered and demodulated by determining the most likely signal constellation points transmitted by the base station **210**. These soft decisions may be based on channel estimates computed by the channel estimator **258**. The soft decisions are then decoded and deinterleaved to recover the data and control signals that were originally transmitted by the base station **210** on the physical channel. The data and control signals are then provided to the controller/processor **259**, which implements layer 3 and layer 2 functionality.

The controller/processor **259** can be associated with a memory **260** that stores program codes and data. The memory **260** may be referred to as a computer-readable medium. In the UL, the controller/processor **259** provides demultiplexing between transport and logical channels, packet reassembly, deciphering, header decompression, and control signal processing to recover IP packets from the EPC **160**. The controller/processor **259** is also responsible for error detection using an ACK and/or NACK protocol to support HARQ operations.

Similar to the functionality described in connection with the DL transmission by the base station **210**, the controller/processor **259** provides RRC layer functionality associated with system information (e.g., MIB, SIBs) acquisition, RRC connections, and measurement reporting; PDCP layer functionality associated with header compression/decompression, and security (ciphering, deciphering, integrity protection, integrity verification); RLC layer functionality associated with the transfer of upper layer PDUs, error correction through ARQ, concatenation, segmentation, and reassembly of RLC SDUs, re-segmentation of RLC data PDUs, and reordering of RLC data PDUs; and MAC layer functionality associated with mapping between logical channels and transport channels, multiplexing of MAC SDUs onto TBs, demultiplexing of MAC SDUs from TBs, scheduling information reporting, error correction through HARQ, priority handling, and logical channel prioritization.

Channel estimates derived by a channel estimator **258** from a reference signal or feedback transmitted by the base station **210** may be used by the TX processor **268** to select the appropriate coding and modulation schemes, and to facilitate spatial processing. The spatial streams generated by the TX processor **268** may be provided to different antenna **252** via separate transmitters **254**TX. Each transmitter **254**TX may modulate an RF carrier with a respective spatial stream for transmission. The UL transmission is processed at the base station **210** in a manner similar to that described in connection with the receiver function at the UE **250**. Each receiver **218**RX receives a signal through its respective antenna **220**. Each receiver **218**RX recovers information modulated onto an RF carrier and provides the information to a RX processor **270**.

The controller/processor **275** can be associated with a memory **276** that stores program codes and data. The memory **276** may be referred to as a computer-readable medium. In the UL, the controller/processor **275** provides demultiplexing between transport and logical channels, packet reassembly, deciphering, header decompression, control signal processing to recover IP packets from the UE **250**. IP packets from the controller/processor **275** may be provided to the EPC **160**. The controller/processor **275** is also responsible for error detection using an ACK and/or NACK protocol to support HARQ operations.

New radio (NR) may refer to radios configured to operate according to a new air interface (e.g., other than Orthogonal Frequency Divisional Multiple Access (OFDMA)-based air interfaces) or fixed transport layer (e.g., other than Internet Protocol (IP)). NR may utilize OFDM with a cyclic prefix (CP) on the uplink and downlink and may include support for half-duplex operation using time division duplexing (TDD). NR may include Enhanced Mobile Broadband (eMBB) service targeting wide bandwidth (e.g. 80 MHz beyond), millimeter wave (mmW) targeting high carrier frequency (e.g. 60 GHz), massive MTC (mMTC) targeting non-backward compatible MTC techniques, and/or mission critical targeting ultra-reliable low latency communications (URLLC) service.

A single component carrier bandwidth of 100 MHz may be supported. In one example, NR resource blocks (RBs) may span 12 sub-carriers with a sub-carrier bandwidth of 60 kHz over a 0.25 ms duration or a bandwidth of 30 kHz over a 0.5 ms duration (similarly, 50 MHz BW for 15 kHz SCS over a 1 ms duration). Each radio frame may consist of 10 subframes (10, 20, 40 or 80 NR slots) with a length of 10 ms. Each slot may indicate a link direction (i.e., DL or UL) for data transmission and the link direction for each slot may be dynamically switched. Each slot may include DL/UL data as well as DL/UL control data. UL and DL slots for NR may be as described in more detail below with respect to FIGS. **5** and **6**.

The NR RAN may include a central unit (CU) and distributed units (DUs). A NR BS (e.g., gNB, 5G Node B, Node B, transmission reception point (TRP), access point (AP)) may correspond to one or multiple BSs. NR cells can be configured as access cells (ACells) or data only cells (DCells). For example, the RAN (e.g., a central unit or distributed unit) can configure the cells. DCells may be cells used for carrier aggregation or dual connectivity and may not be used for initial access, cell selection/reselection, or handover. In some cases DCells may not transmit synchronization signals (SS) in some cases DCells may transmit SS. NR BSs may transmit downlink signals to UEs indicating the cell type. Based on the cell type indication, the UE may communicate with the NR BS. For example, the UE may determine NR BSs to consider for cell selection, access, handover, and/or measurement based on the indicated cell type.

FIG. **3** illustrates an example logical architecture of a distributed RAN **300**, according to aspects of the present disclosure. A 5G access node **306** may include an access node controller (ANC) **302**. The ANC may be a central unit (CU) of the distributed RAN. The backhaul interface to the next generation core network (NG-CN) **304** may terminate at the ANC. The backhaul interface to neighboring next generation access nodes (NG-ANs) **310** may terminate at the ANC. The ANC may include one or more TRPs **308** (which may also be referred to as BSs, NR BSs, Node Bs, 5G NBs, APs, or some other term). As described above, a TRP may be used interchangeably with “cell.”

The TRPs **308** may be a distributed unit (DU). The TRPs may be connected to one ANC (ANC **302**) or more than one ANC (not illustrated). For example, for RAN sharing, radio as a service (RaaS), and service specific ANC deployments, the TRP may be connected to more than one ANC. A TRP may include one or more antenna ports. The TRPs may be configured to individually (e.g., dynamic selection) or jointly (e.g., joint transmission) serve traffic to a UE.

The local architecture of the distributed RAN **300** may be used to illustrate fronthaul definition. The architecture may be defined that support fronthauling solutions across different deployment types. For example, the architecture may be based on transmit network capabilities (e.g., bandwidth, latency, and/or jitter). The architecture may share features and/or components with LTE. According to aspects, the next generation AN (NG-AN) **310** may support dual connectivity with NR. The NG-AN may share a common fronthaul for LTE and NR.

The architecture may enable cooperation between and among TRPs **308**. For example, cooperation may be preset within a TRP and/or across TRPs via the ANC **302**. According to aspects, no inter-TRP interface may be needed/present.

According to aspects, a dynamic configuration of split logical functions may be present within the architecture of the distributed RAN **300**. The PDCP, RLC, MAC protocol may be adaptably placed at the ANC or TRP.

FIG. **4** illustrates an example physical architecture of a distributed RAN **400**, according to aspects of the present disclosure. A centralized core network unit (C-CU) **402** may host core network functions. The C-CU may be centrally deployed. C-CU functionality may be offloaded (e.g., to advanced wireless services (AWS)), in an effort to handle peak capacity. A centralized RAN unit (C-RU) **404** may host one or more ANC functions. Optionally, the C-RU may host core network functions locally. The C-RU may have distributed deployment. The C-RU may be closer to the network edge. A distributed unit (DU) **406** may host one or more TRPs. The DU may be located at edges of the network with radio frequency (RF) functionality.

FIG. **5** is a diagram **500** showing an example of a DL-centric slot. The DL-centric slot may include a control portion **502**. The control portion **502** may exist in the initial or beginning portion of the DL-centric slot. The control portion **502** may include various scheduling information and/or control information corresponding to various portions of the DL-centric slot. In some configurations, the control portion **502** may be a physical DL control channel (PDCCH), as indicated in FIG. **5**. The DL-centric slot may also include a DL data portion **504**. The DL data portion **504** may sometimes be referred to as the payload of the DL-centric slot. The DL data portion **504** may include the communication resources utilized to communicate DL data from the scheduling entity (e.g., UE or BS) to the subordinate entity (e.g., UE). In some configurations, the DL data portion **504** may be a physical DL shared channel (PDSCH).

The DL-centric slot may also include a common UL portion **506**. The common UL portion **506** may sometimes be referred to as an UL burst, a common UL burst, and/or various other suitable terms. The common UL portion **506** may include feedback information corresponding to various other portions of the DL-centric slot. For example, the common UL portion **506** may include feedback information corresponding to the control portion **502**. Non-limiting examples of feedback information may include an ACK signal, a NACK signal, a HARQ indicator, and/or various other suitable types of information. The common UL portion **506** may include additional or alternative information, such as information pertaining to random access channel (RACH) procedures, scheduling requests (SRs), and various other suitable types of information.

As illustrated in FIG. **5**, the end of the DL data portion **504** may be separated in time from the beginning of the common UL portion **506**. This time separation may sometimes be referred to as a gap, a guard period, a guard interval, and/or various other suitable terms. This separation provides time for the switch-over from DL communication (e.g., reception operation by the subordinate entity (e.g., UE)) to UL communication (e.g., transmission by the subordinate entity (e.g., UE)). One of ordinary skill in the art will understand that the foregoing is merely one example of a DL-centric slot and alternative structures having similar features may exist without necessarily deviating from the aspects described herein.

FIG. **6** is a diagram **600** showing an example of an UL-centric slot. The UL-centric slot may include a control portion **602**. The control portion **602** may exist in the initial or beginning portion of the UL-centric slot. The control portion **602** in FIG. **6** may be similar to the control portion **502** described above with reference to FIG. **5**. The UL-centric slot may also include an UL data portion **604**. The UL data portion **604** may sometimes be referred to as the pay load of the UL-centric slot. The UL portion may refer to the communication resources utilized to communicate UL data from the subordinate entity (e.g., UE) to the scheduling entity (e.g., UE or BS). In some configurations, the control portion **602** may be a physical DL control channel (PDCCH).

As illustrated in FIG. **6**, the end of the control portion **602** may be separated in time from the beginning of the UL data portion **604**. This time separation may sometimes be referred to as a gap, guard period, guard interval, and/or various other suitable terms. This separation provides time for the switch-over from DL communication (e.g., reception operation by the scheduling entity) to UL communication (e.g., transmission by the scheduling entity). The UL-centric slot may also include a common UL portion **606**. The common UL portion **606** in FIG. **6** may be similar to the common UL portion **506** described above with reference to FIG. **5**. The common UL portion **606** may additionally or alternatively include information pertaining to channel quality indicator (CQI), sounding reference signals (SRSs), and various other suitable types of information. One of ordinary skill in the art will understand that the foregoing is merely one example of an UL-centric slot and alternative structures having similar features may exist without necessarily deviating from the aspects described herein.

In some circumstances, two or more subordinate entities (e.g., UEs) may communicate with each other using sidelink signals. Real-world applications of such sidelink communications may include public safety, proximity services, UE-to-network relaying, vehicle-to-vehicle (V2V) communications, Internet of Everything (IoE) communications, IoT communications, mission-critical mesh, and/or various other suitable applications. Generally, a sidelink signal may refer to a signal communicated from one subordinate entity (e.g., UE1) to another subordinate entity (e.g., UE2) without relaying that communication through the scheduling entity (e.g., UE or BS), even though the scheduling entity may be utilized for scheduling and/or control purposes. In some examples, the sidelink signals may be communicated using a licensed spectrum (unlike wireless local area networks, which typically use an unlicensed spectrum).

FIG. **7** is a diagram **700** illustrating communications among base stations and UEs. In this example, a base station **702** has established a cell **710** with a UE **704**. In particular, the cell **710** may be a dynamic spectrum sharing (DSS) cell. The base station **702** and the UE **704** can use one or more radio access technologies (RATs) for communication concurrently. In particular, the base station **702** can share the spectrum of the cell **710** between the 5G NR and 4G LTE. For example, the base station **702** may transmit LTE CRSs **748**, a NR PDCCH **742**, NR DMRS **744**, and a NR PDSCH **746** on the cell **710**. Further, a base station **772** is a neighboring base station of the base station **702**. The base station **772** may transmit signals (e.g., LTE CRSs **758**) on a cell **780**.

FIG. **8** is a diagram **800** illustrating a slot **810** of the cell **710** in DSS configuration. As shown, the base station **702** may transmit the LTE CRSs **748**, the NR PDCCH **742**, the NR DMRS **744**, and the NR PDSCH **746** in resource elements of the slot **810**. The cell **710** has a bandwidth **808**. In certain configurations, the LTE CRSs **748** overlap with the NR PDSCH **746**. As such, the LTE CRSs **748** may cause interference to the reception of the NR PDSCH **746** at the UE **704**. The UE **704** may apply rate-matching to the NR PDSCH **746** to puncture the data bits of the NR PDSCH **746** to be transmitted in the resource elements that also contain the LTE CRSs **748**. As a result, in those resource elements, only LTE CRSs **748** will be transmitted and no NR PDSCH **746** will be transmitted. Therefore, the interference caused by the LTE CRSs **748** to the reception of the NR PDSCH **746** in those resource elements at the UE **704** can be mitigated.

Referring back to FIG. **7**, in certain scenarios, the UE **704** may move into an overlapping area **792** in which the cell **710** and the cell **780** overlap. FIG. **9** is a diagram **900** illustrating the slot **810** in the overlapping area **792**, where the resource elements of the slot **810** may contain transmissions from both the cell **710** and the cell **780**. In this example, in addition to the LTE CRSs **748**, the NR PDCCH **742**, the NR DMRS **744**, and the NR PDSCH **746** on the cell **710** transmitted from the base station **702**, the slot **810** may also contain the LTE CRSs **758** on the cell **780** transmitted from the base station **772**. In some of the resource elements of the slot **810**, the LTE CRSs **758** overlap with the NR PDSCH **746** and, thus, may cause interference at the UE **704** for receiving the NR PDSCH **746**.

Referring to FIGS. **7-9**, in certain configurations, the UE **704** may implement procedures to mitigate the interference caused by the LTE CRSs **758** transmission on the cell **780** to its reception of the NR PDSCH **746** on the cell **710**. In a first procedure, the UE **704** may determine whether the reception of the NR PDSCH **746** on the cell **710** may be interfered by transmissions from another cell. In a technique A(1), the UE **704** may determine whether the cell **710** is a DSS cell. If the cell **710** is a DSS cell, the transmission on the cell **710** is likely to be interfered by transmission from a neighboring cell (e.g., another DSS cell or LTE cell).

In the technique A(1), the UE **704** may check whether the cell **710** is in a lookup table listing DSS cells, for example, based on a cell ID of the cell **710**. If the cell **710** is in the lookup table, the cell **710** is a DSS cell.

In the technique A(1), additionally or alternatively, the UE **704** may determine whether a radio resource control (RRC) information element (IE) received from the base station **702** includes a configuration "lte-CRS-ToMatchAround" and, if yes, whether the "lte-CRS-ToMatchAround" indicates LTE E-UTRA Absolute Radio Frequency Channel Number (EARFCN) associated with the cell **710** or any neighboring cells. The configuration "lte-CRS-ToMatchAround" indicates that UE **704** may need to apply rate-matching around certain LTE CRSs (e.g., the LTE CRSs **748**). It can be inferred from the presence of the configuration that the cell **710** is a DSS cell.

In a technique A(2), the base station **772** may receive uplink signals **752** transmitted from the UE **704**. The base station **772** can detect that the UE **704** is camped on the cell **710** of the base station **702**, e.g., based on information carried in the uplink signals **752**. The base station **772** also measures the signal power and the angle of arrival of the uplink signals **752** received. Based on those measurements, the base station **702** can estimate the location of the UE **704**. The base station **702** can further determine whether its transmission of the LTE CRSs **758** may cause interference at the UE **704** at that location. If yes, the base station **772** can send network-assisted information to the base station **702** through a backhaul **762**; the network-assisted information indicates that the transmission from the base station **772** may cause interference at the reception of the UE **704**.

In a technique A(3), the UE **704** may determine whether it has received a configuration of a rate-matching pattern. For example, as described supra, the UE **704** may receive a rate-matching pattern from the base station **702** to puncture the data bits of the NR PDSCH **746** to be transmitted in the resource elements that also contain the LTE CRSs **748**. As a result, the interference caused by the LTE CRSs **748** to the reception of the NR PDSCH **746** in those resource elements at the UE **704** may be mitigated. In certain circumstances, the UE **704** may also detect the cell **780**, but does not receive a rate-matching pattern from the base station **702** to mitigate the interference caused by transmission (e.g., the LTE CRSs **758**) on the cell **780**. Accordingly, the UE **704** may determine that the transmission from the cell **780** may cause interference to its reception of the NR PDSCH **746** on the cell **710**.

In a technique A(4), the UE **704** can measure Reference Signal Received Power (RSRP) and/or Signal to Interference and Noise Ratio (SINR) of signals received from the cell **710** and/or the cell **780**. Based on the measurements, the UE **704** may determine whether the signals (e.g., the LTE CRSs **758**) from the cell **780** may cause interference to its reception at the cell **710**.

By implementing one or more of the techniques A(1) to A(4) described supra, the UE **704** may determine that transmission from the cell **780** or other neighboring cells will cause interference to its reception on the cell **710**.

In a second procedure, the UE **704** determines the resource elements in the slot **810** that may have interference. (This allows the UE **704** to enable interference cancellation (IC) at those resource elements in subsequent procedures.) In this example, the UE **704** may use implicit or explicit CRS configuration in neighboring cell information received from the base station **702** to make such a determination. In a technique B(1), the UE **704** receives certain configuration information of the cell **780** (e.g., "neighCellConfig") from the base station **702**. Those configurations, although not explicitly listing the CRSs configurations on the cell **780**, may specify subframe configuration and other configurations of the cell **780**. Based on those configurations, the UE **704** may estimate the locations of the CRSs in the subframe. As such, the UE **704** can determine the resource elements in the slot **810** that may contain the LTE CRSs **758**.

In a technique B(2), the UE **704** may receive explicit CRS configurations in the neighboring cell information received. The neighboring cell information may include one or more of a physical cell ID (PCI) (e.g., the ID of the cell **780**), a bandwidth (e.g., the bandwidth of the cell **780**), CRS v-shift, CRS antenna port numbers (e.g., the antenna ports of the base station **772** used for transmitting the LTE CRSs **758**), and configurations of a Multicast Broadcast Single Frequency Network (MBSFN) subframe. Those configurations may be carried in "CRS-AssistanceInfoList-r11," "CRS-AssistanceInfoList-r13," "NeighCellsInfo-r12," and/or other network configurations sent to the UE **704** from the base station **702**. FIG. **10** is a diagram **1000** illustrating the parameter v-shift used in configuring the locations of CRSs. Based on those configurations, the UE **704** may estimate the locations of the CRSs on the cell **780**. As such, the UE **704** can determine the resource elements in the slot **810** that contain the LTE CRSs **758**.

In a technique B(3), in addition to the explicit CRS configurations listed in the technique B(2), the base station **702** may send additional CRS configurations to the UE **704**. In particular, the CRS configuration may also include a carrier frequency and/or a timing offset. In this example, the configuration of the LTE CRSs **758** may induce a center frequency of a bandwidth of the cell **780**. Based on those configurations, the UE **704** may estimate the locations of the CRSs on the cell **780**. As such, the UE **704** can determine the resource elements in the slot **810** that contain LTE CRSs **758**. The timing offset of two cells indicates the observed timing difference of the two cells (e.g., the cell **710** and the cell **780**) in terms of frame boundaries, subframe boundaries, or slot boundaries.

In a third procedure, after the UE **704** determines the locations of the interference, the UE **704** may apply an interference cancellation operation at those locations to mitigate the interference. In a technique C(1), the base station **702** send configurations of the intra-frequency neighboring LTE cells to the UE **704**. The configurations may include a PCI, a CRS v-shift, a bandwidth, a carrier frequency (e.g., center frequency), a configuration of frame structure and MBSFN subframe, and/or a timing offset of the neighboring cell (e.g., the cell **780**).

In this example, the UE **704** searches and monitors LTE aggressor cells while in locations covered by the cell **710**. When UE **704** moves into the overlapping area **792**, the UE **704** can detect the cell **780**, which is an LTE aggressor cell to the UE **704**. Further, the UE **704** has received cell configurations of the cell **780** under the technique C(1). As described supra, the UE **704** may execute the second procedure to determine locations of the LTE CRSs **758**. As such, the UE **704** may implement a suitable interference cancellation operation based on the cell configurations of the cell **780** to mitigate the interference caused by the LTE CRSs **758**.

In a technique C(2), the UE **704** may not receive cell configuration information of the neighboring cells. The base station **702** may configure the UE **704** with inter-RAT measurement objects for intra-frequency LTE cell measurement (e.g., through "measGapConfig" configuration). Whether or not the UE **704** has received inter-RAT measurement objects, in this example, the UE **704** searches and monitors LTE aggressor cells while in locations covered by the cell **710**. When UE **704** moves into the overlapping area **792**, the UE **704** can detect the cell **780**, which is an LTE aggressor cell to the UE **704**. As described supra, the UE **704** may execute the second procedure to determine locations of the LTE CRSs **758**. As such, the UE **704** may implement a suitable interference cancellation operation to mitigate the interference caused by the LTE CRSs **758**.

FIG. **11** is a flow chart **1100** of a method (process) for mitigating interference. The method may be performed by a UE (e.g., the UE **704**). At operation **1102**, the UE receives, from a first base station (e.g., the base station **702**), a data transmission (e.g., the NR PDSCH **746**) on a first cell (e.g., the cell **710**) using a first RAT (e.g., 5G NR). At operation **1104**, the UE determines a CRS transmission (e.g., the LTE CRSs **758**) using a second RAT (e.g., 4G LTE) on a second cell (e.g., the cell **780**) from a second base station (e.g., the base station **772**). At operation **1106**, the UE determines that the CRS transmission on the second cell interferes with receiving the data transmission on the first cell at the UE. In certain configurations, to determine that the CRS transmission interferes with receiving the data transmission, the UE determines that the first cell employs DSS of the first RAT and the second RAT.

In certain configurations, to determine that the first cell employs DSS, the UE finds an identifier of the first cell in a record of DSS cells. In certain configurations, to determine that the first cell employs DSS, the UE receives, from a network, a configuration for applying rate-matching to the data transmission to avoid interference from a CRS transmission on the first cell using the second RAT.

In certain configurations, to determine that the CRS transmission interferes with receiving the data transmission at the UE, the UE receives, from a network, an indication indicating that the CRS transmission on the second cell would interfere with receiving the data transmission on the first cell. In certain configurations, to determine that the CRS transmission interferes with receiving the data transmission at the UE, the UE receives, from a network, a configuration for applying a given rate-matching to the data transmission to avoid interference from a transmission from a given base station using the second RAT. In certain configurations, to determine that the CRS transmission interferes with receiving the data transmission at the UE, the UE measures a strength of the CRS transmission on the second cell.

At operation **1108**, the UE determines that rate-matching is not applied to the data transmission to avoid interference from the CRS transmission on the second cell to the data transmission on the first cell. Subsequently, in certain configurations, the UE enters operation **1110**, in which the UE receives, from a network, a cell configuration of the second cell. The cell configuration of the second cell includes at least one of: a physical cell ID (PCI), a CRS v-shift, a bandwidth, a CRS antenna port number, and a configuration of a MBSFN subframe. In certain configurations, the cell configuration of the second cell further includes at least one of a center frequency of the second cell and a timing offset. Then, the UE enters operation **1130**.

In certain configurations, subsequent to operation **1108**, the UE enters operation **1120**, in which the UE performs, while receiving the data transmission on the first cell, an inter-RAT measurement to detect the second cell. At operation **1122**, the UE receives a cell configuration transmitted on the second cell. Then, the UE enters operation **1130**.

At operation **1130**, the UE determines a CRS configuration of the CRS transmission based on the cell configuration of the second cell. In certain configurations, the determining the CRS transmission is based on the CRS configuration. At operation **1132**, the UE monitors the second cell based on the cell configuration of the second cell. At operation **1134**, the UE applies, based on the cell configuration, an interference cancellation on the first cell to mitigate an interference from the CRS transmission on the second cell to the data transmission on the first cell.

FIG. **12** is a flow chart **1200** of a method (process) for detecting interference. The method may be performed by a first base station (e.g., the base station **702**). At operation **1202**, the first base station performs a data transmission (e.g., the NR PDSCH **746**) on a first cell (e.g., the cell **710**) of the first base station using a first RAT (e.g., 5G NR). At operation **1204**, the first base station sends, on the first cell, a cell configuration of a second cell (e.g., the cell **780**) of a second base station (e.g., the base station **772**) for a UE (e.g., the UE **704**) to detect a CRS transmission (e.g., the LTE CRSs **758**) on the second cell using a second RAT (e.g., 4G LTE). In certain configurations, the cell configuration of the second cell is sent through a neighboring cell configuration regarding the second cell.

In certain configurations, the cell configuration of the second cell includes at least one of: a PCI, a CRS v-shift, a bandwidth, a CRS antenna port number, and a configuration of a MBSFN subframe. In certain configurations, the cell configuration of the second cell further includes at least one of a center frequency of the second cell and a timing offset. In certain configurations, the first base station may send, on the first cell, another cell configuration of the second cell for the UE to apply an interference cancellation to mitigate an interference to receiving the data transmission on the first cell from the CRS transmission on the second cell.

At operation **1206**, the first base station determines that the CRS transmission on the second cell interferes with receiving the data transmission on the first cell at the UE. At operation **1208**, the first base station sends, to the UE, an indication indicating that the CRS transmission on the second cell would interfere with receiving the data transmission on the first cell.

In certain configurations, to determine that the CRS transmission interferes with receiving the data transmission at the UE, the first base station receives an uplink signal from the UE. The first base station measures a strength or an angle of arrival of the uplink signal.

FIG. **13** is a diagram **1300** illustrating an example of a hardware implementation for an apparatus **1302** employing a processing system **1314**. The apparatus **1302** may be a UE. The processing system **1314** may be implemented with a bus architecture, represented generally by a bus **1324**. The bus **1324** may include any number of interconnecting buses and bridges depending on the specific application of the processing system **1314** and the overall design constraints. The bus **1324** links together various circuits including one or more processors and/or hardware components, represented by one or more processors **1304**, a reception component **1364**, a transmission component **1370**, an interference detection component **1376**, an interference cancellation component **1378**, a configuration component **1382**, and a computer-readable medium/memory **1306**. The bus **1324** may also link various other circuits such as timing sources, peripherals, voltage regulators, and power management circuits, etc.

The processing system **1314** may be coupled to a transceiver **1310**, which may be one or more of the transceivers **354**. The transceiver **1310** is coupled to one or more antennas **1320**, which may be the communication antennas **352**.

The transceiver **1310** provides a means for communicating with various other apparatus over a transmission medium. The transceiver **1310** receives a signal from the one or more antennas **1320**, extracts information from the received signal, and provides the extracted information to the processing system **1314**, specifically the reception component **1364**. In addition, the transceiver **1310** receives information from the processing system **1314**, specifically the transmission component **1370**, and based on the received information, generates a signal to be applied to the one or more antennas **1320**.

The processing system **1314** includes one or more processors **1304** coupled to a computer-readable medium/memory **1306**. The one or more processors **1304** are responsible for general processing, including the execution of software stored on the computer-readable medium/memory **1306**. The software, when executed by the one or more processors **1304**, causes the processing system **1314** to perform the various functions described supra for any particular apparatus. The computer-readable medium/memory **1306** may also be used for storing data that is manipulated by the one or more processors **1304** when executing software. The processing system **1314** further includes at least one of the reception component **1364**, the transmission component **1370**, the interference detection component **1376**, the interference cancellation component **1378**, and the configuration component **1382**. The components may be software components running in the one or more processors **1304**, resident/stored in the computer readable medium/memory **1306**, one or more hardware components coupled to the one or more processors **1304**, or some combination thereof. The processing system **1314** may be a component of the UE **350** and may include the memory **360** and/or at least one of the TX processor **368**, the RX processor **356**, and the communication processor **359**.

In one configuration, the apparatus **1302** for wireless communication includes means for performing each of the operations of FIGS. **11**(A) and **11**(B). The aforementioned means may be one or more of the aforementioned components of the apparatus **1302** and/or the processing system **1314** of the apparatus **1302** configured to perform the functions recited by the aforementioned means.

As described supra, the processing system **1314** may include the TX Processor **368**, the RX Processor **356**, and the communication processor **359**. As such, in one configuration, the aforementioned means may be the TX Processor **368**, the RX Processor **356**, and the communication processor **359** configured to perform the functions recited by the aforementioned means.

FIG. **14** is a diagram **1400** illustrating an example of a hardware implementation for an apparatus **1402** employing a processing system **1414**. The apparatus **1402** may be a base station. The processing system **1414** may be implemented with a bus architecture, represented generally by a bus **1424**. The bus **1424** may include any number of interconnecting buses and bridges depending on the specific application of the processing system **1414** and the overall design constraints. The bus **1424** links together various circuits including one or more processors and/or hardware components, represented by one or more processors **1404**, a reception component **1464**, a transmission component **1470**, a cell configuration component **1476**, a interference detection component **1478**, and a computer-readable medium/memory **1406**. The bus **1424** may also link various other circuits such as timing sources, peripherals, voltage regulators, and power management circuits, etc.

The processing system **1414** may be coupled to a transceiver **1410**, which may be one or more of the transceivers **354**. The transceiver **1410** is coupled to one or more antennas **1420**, which may be the communication antennas **320**.

The transceiver **1410** provides a means for communicating with various other apparatus over a transmission medium. The transceiver **1410** receives a signal from the one or more antennas **1420**, extracts information from the received signal, and provides the extracted information to the processing system **1414**, specifically the reception component **1464**. In addition, the transceiver **1410** receives information from the processing system **1414**, specifically the transmission component **1470**, and based on the received information, generates a signal to be applied to the one or more antennas **1420**.

The processing system **1414** includes one or more processors **1404** coupled to a computer-readable medium/memory **1406**. The one or more processors **1404** are responsible for general processing, including the execution of software stored on the computer-readable medium/memory **1406**. The software, when executed by the one or more processors **1404**, causes the processing system **1414** to perform the various functions described supra for any particular apparatus. The computer-readable medium/memory **1406** may also be used for storing data that is manipulated by the one or more processors **1404** when executing software. The processing system **1414** further includes at least one of the reception component **1464**, the transmission component **1470**, the cell configuration component **1476**, and the interference detection component **1478**. The components may be software components running in the one or more processors **1404**, resident/stored in the computer readable medium/memory **1406**, one or more hardware components coupled to the one or more processors **1404**, or some combination thereof. The processing system **1414** may be a component of the base station **310** and may include the memory **376** and/or at least one of the TX processor **316**, the RX processor **370**, and the controller/processor **375**.

In one configuration, the apparatus **1402** for wireless communication includes means for performing each of the operations of FIG. **12**. The aforementioned means may be one or more of the aforementioned components of the apparatus **1402** and/or the processing system **1414** of the apparatus **1402** configured to perform the functions recited by the aforementioned means.

As described supra, the processing system **1414** may include the TX Processor **316**, the RX Processor **370**, and the controller/processor **375**. As such, in one configuration, the aforementioned means may be the TX Processor **316**, the RX Processor **370**, and the controller/processor **375** configured to perform the functions recited by the aforementioned means.

It is understood that the specific order or hierarchy of blocks in the processes/flowcharts disclosed is an illustration of exemplary approaches. Based upon design preferences, it is understood that the specific order or hierarchy of blocks in the processes/flowcharts may be rearranged. Further, some blocks may be combined or omitted. The accompanying method claims present elements of the various blocks in a sample order, and are not meant to be limited to the specific order or hierarchy presented.

The previous description is provided to enable any person skilled in the art to practice the various aspects described herein. Various modifications to these aspects will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other aspects. Thus, the claims are not intended to be limited to the aspects shown herein, but is to be accorded the full scope consistent with the language claims, wherein reference to an element in the singular is not intended to mean "one and only one" unless specifically so stated, but rather "one or more." The word "exemplary" is used herein to mean "serving as an example, instance, or illustration." Any aspect described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other aspects. Unless specifically stated otherwise, the term "some" refers to one or more. Combinations such as "at least one of A, B, or C," "one or more of A, B, or C," "at least one of A, B, and C," "one or more of A, B, and C," and "A, B, C, or any combination thereof" include any combination of A, B, and/or C, and may include multiples of A, multiples of B, or multiples of C. Specifically, combinations such as "at least one of A, B, or C," "one or more of A, B, or C," "at least one of A, B, and C," "one or more of A, B, and C," and "A, B, C, or any combination thereof" may be A only, B only, C only, A and B, A and C, B and C, or A and B and C, where any such combinations may contain one or more member or members of A, B, or C. All structural and functional equivalents to the elements of the various aspects described throughout this disclosure that are known or later come to be known to those of ordinary skill in the art are expressly incorporated herein by reference and are intended to be encompassed by the claims. Moreover, nothing disclosed herein is intended to be dedicated to the public regardless of whether such disclosure is explicitly recited in the claims. The words "module," "mechanism," "element," "device," and the like may not be a substitute for the word "means." As such, no claim element is to be construed as a means plus function unless the element is expressly recited using the phrase "means for."

What is claimed is:

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

receiving, from a first base station, a data transmission on a first cell using a first radio access technology (RAT);

determining a cell-specific reference signal (CRS) transmission using a second RAT on a second cell from a second base station;

determining that the CRS transmission on the second cell interferes with receiving the data transmission on the first cell at the UE, wherein determining that the CRS transmission interferes with receiving the data transmission at the UE includes:

receiving, from a network, a configuration for applying a given rate-matching to the data transmission to avoid interference from a transmission from a given base station using the second RAT, wherein determining that the first cell employs dynamic spectrum sharing (DSS) of the first RAT and the second RAT is based on receiving, from the network, a configuration for applying rate-matching to the data transmission to avoid interference from a CRS transmission on the first cell using the second RAT; and

applying an interference cancellation on the first cell to mitigate an interference from the CRS transmission on the second cell to the data transmission on the first cell.

2. The method of claim **1**, further comprising:

determining that the rate-matching is not applied to the data transmission to avoid interference from the CRS transmission on the second cell to the data transmission on the first cell.

3. The method of claim **1**, wherein the determination that the first cell employs DSS is further based on finding an identifier of the first cell in a record of DSS cells.

4. The method of claim **1**, wherein the determining that the CRS transmission interferes with receiving the data transmission at the UE includes:

receiving, from a network, an indication indicating that the CRS transmission on the second cell would interfere with receiving the data transmission on the first cell.

5. The method of claim **1**, wherein the determining that the CRS transmission interferes with receiving the data transmission at the UE includes:

measuring a strength of the CRS transmission on the second cell.

6. The method of claim **1**, further comprising:

determining a CRS configuration of the CRS transmission based on a cell configuration of the second cell, wherein the determining the CRS transmission is based on the CRS configuration.

7. The method of claim **1**, further comprising:

receiving, from a network, a cell configuration of the second cell, wherein the cell configuration of the second cell includes at least one of: a physical cell ID (PCI), a CRS v-shift, a bandwidth, a CRS antenna port number, and a configuration of a Multicast Broadcast Single Frequency Network (MBSFN) subframe.

8. The method of claim **7**, wherein the cell configuration of the second cell further includes at least one of a center frequency of the second cell and a timing offset.

9. The method of claim **1**, further comprising:

receiving, from a network, a cell configuration of the second cell for applying the interference cancellation; and

monitoring the second cell based on the cell configuration of the second cell.

10. The method of claim **1**, further comprising:

performing, while receiving the data transmission on the first cell, an inter-RAT measurement to detect the second cell; and

receiving a cell configuration transmitted on the second cell, wherein the application of the interference cancellation is based on the cell configuration.

* * * * *