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ENHANCED GBBR WITH MRTD REPORTING FOR MTRP

Abstract

The techniques described herein may include solutions for enhanced group-based beam reporting (GBBR) with maximum receive timing difference (MRTD) reporting for multiple transmission reception points (mTRPs). One or more of these solutions may include communicating to user equipment (UE) configuration information for GBBR based on UE capability information and MRTD measurements received from UE. One or more of these solutions may also include receiving from a base station configuration information for performing GBBR, and determining and communicating to the base station, a receive timing difference (RTD) using GBBR. Also provided are solutions for structures of enhanced GBBR.

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Background/Summary

CROSS REFERENCE TO RELATED APPLICATIONS [0001] This application claims the benefit of U.S. Provisional Application No. 63/554,890, filed Feb. 16, 2024, the content of which is herein incorporated by reference in its entirety for all purposes.

FIELD
[0002] This disclosure relates to wireless communication networks and mobile device capabilities.
BACKGROUND
[0003] Wireless communication networks and wireless communication services are becoming increasingly dynamic, complex, and ubiquitous. For example, some wireless communication networks may be developed to implement fourth generation (4G), fifth generation (5G) or new radio (NR) technology. Such technology may include solutions for enabling user equipment (UE) and network devices, such as base stations, to communicate with one another. Some scenarios may involve enabling or configuring a UE to communicate with multiple network devices.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0004] The present disclosure will be readily understood and enabled by the detailed description and accompanying figures of the drawings. Like reference numerals may designate like features and structural elements. Figures and corresponding descriptions are provided as non-limiting examples of aspects, implementations, etc., of the present disclosure, and references to “an” or “one” aspect, implementation, etc., may not necessarily refer to the same aspect, implementation, etc., and may mean at least one, one or more, etc.
[0005] FIG. **1** is a diagram of an example of an overview of a UE in a multi TRP environment according to one or more implementations described herein.
[0006] FIG. **2** is a diagram of an example network according to one or more implementations described herein.
[0007] FIG. **3** is a diagram of an example of two channel measurement resource (CMR) sets according to one or more implementations described herein.
[0008] FIG. **4** is a diagram of an example of enhanced group-based beam reporting (GBBR) with maximum receiving timing difference (MRTD) reporting for multiple transmission reception points (mTRPs) according to one or more implementations described herein.
[0009] FIG. **5** is a diagram of an example of a data structure of an example GBBR report according to one or more implementations described herein.
[0010] FIG. **6** is a diagram of an example of an example of enhanced GBBR with MRTD reporting for mTRPs according to one or more implementations described herein.
[0011] FIG. **7** is a diagram of an example of a representation of a data structure of an example enhanced GBBR report according to one or more implementations described herein.
[0012] FIG. **8** is a diagram of an example of a representation of a data structure of an example enhanced GBBR report according to one or more implementations described herein.
[0013] FIG. **9** is a diagram of an example of a process for enhanced GBBR with MRTD reporting for mTRPs according to one or more implementations described herein.
[0014] FIG. **10** is a diagram of an example of a process for enhanced GBBR with MRTD reporting for mTRPs according to one or more implementations described herein.

[0015] FIG. **11** is a diagram of an example of components of a device according to one or more implementations described herein.

[0016] FIG. **12** is a block diagram illustrating components, according to one or more implementations described herein, able to read instructions from a machine-readable or computer-readable medium (e.g., a non-transitory machine-readable storage medium) and perform any one or more of the methodologies discussed herein.

DETAILED DESCRIPTION

[0017] The following detailed description refers to the accompanying drawings. Like reference numbers in different drawings may identify the same or similar features, elements, operations, etc. Additionally, the present disclosure is not limited to the following description as other implementations may be utilized, and structural or logical changes made, without departing from the scope of the present disclosure.

[0018] Telecommunication networks may include user equipment (UEs) capable of communicating with base stations and/or other network access nodes. UEs and base stations (or transmission reception points (TRPs)) may implement various techniques and communications standards for discovering one another, establishing and maintaining connectivity, exchanging information in an ongoing manner, and more. A TRP, as referred to herein, may refer to a base station, antenna, antenna port, and/or other device capable of transmitting and receiving wireless signals. Scenarios that involve multiple TRPs, therefore, may include a single base station with multiple TRPs, multiple base stations with one or more TRPs, etc. In such scenarios, different possible configurations of TRPs or multiple TRPs may be referred to generally as “network.” Objectives of such techniques may include improving the quality and reliability of signal transmissions during adverse synchronization conditions.

[0019] In multi-TRP (mTRP) environments, UEs may receive transmissions simultaneously from multiple TRPs. Each TRP may transmit a plurality of beams, each having a different transmission direction and other characteristics. For a given UE in such an environment, the network may determine a transmission direction for each TRP to ensure optimal reception at the UE. To that end, the network may configure a reporting mechanism for a UE to measure relevant downlink (DL) reception (Rx) parameters and report measurements to the network. In a two-TRP environment, for example, the network may configure channel measurement resource (CMR) sets for each TRP. A CMR, as referred to herein, may refer to a set of resources allocated by the network (e.g., a base station or a TRP) for measuring characteristics of channels between base stations or TRPs and UEs. Characteristics collected may including timing, signal strength, signal to noise ratio, among others. Thus, each CMR set may include resources allocated to reference signals of a base station or TRP. For each CMR set, the corresponding TRP may transmit one or more reference signals (RS), each having a different DL direction. In response, the UE may implement group-based beam reporting (GBBR) to report characteristics of pairs or groups of RS beams (one beam from each TRP) based on measured reference signal received power (RSRP), signal strength, etc. The GBBR may enable the network to select beam pairs for optimal DL Rx at the UE, and thereby provide and/or maintain superior coordinated service.

[0020] Existing reporting mechanisms and GBBR structures are often based on RSRP (or similar metrics) and may rely on network conditions where maximum receiving timing difference (MRTD) between beam pairs is less than a corresponding cycle prefix (CP). Receive timing difference (RTD), as referred to herein, may refer to a measure of a difference in the arrival time between signals received at the UE from multiple TRPs during coordinated transmission. The maximum RTD (MRTD), as referred to herein, may refer to a measure of a maximum difference in the arrival time or delay between the signals received at the UE from the multiple TRPs for which coordinated transmission can be maintained. The cycle prefix (CP), as referred to herein, refers to a duration of a buffer region or interval between symbols of a transmitted signal.

[0021] When MRTD is less than CP, a UE may operate based on the assumption of good TRP synchronization, which may simplify UE implementation by dispensing with the maintenance of a dedicated time tracking loop for each TRP. However, a MRTD that is less than CP conditions may be challenging to maintain for groups of TRPs due to relative time drifting and propagation delay differences resulting from, for example, frequent changes in a location of the UE relative to each of the TRPs.

[0022] One or more of the techniques described herein may address these and other deficiencies by providing solutions for an enhanced GBBR for MRTD reporting when MRTD is less than a CP or when MRTD greater is than CP for multiple TRPs. In particular, the techniques provided herein may include determining whether a UE is capable of supporting a scenario in which MRTD is greater than CP, and if so, configuring the UE to measure MRTD for reporting using GBBR. Accordingly, in some implementations, the network may configure the UE to measure and report MRTD and UE support for MRTD greater than CP by configuring “DL Rx Timing” in a TCI state for RSs. MRTD reporting may be configured for one, some, or all UEs. Based on the received MRTD, a base station may configure GBBRs for UEs that support MRTD greater than CP, enabling UE scheduling based on traditional GBBR reports in the multi-TRP environment when an RTD is greater than CP.

[0023] In another implementation, the network may configure the MRTD measurement to an enhanced GBBR according to the present disclosure. The MRTD measurement may be provided with an enhanced GBBR following an existing reporting structure, but that also includes an additional field for reporting the MRTD measurement for each RS beam pair. Alternatively, the enhanced GBBR may be provided as a two-part structure, each duplicating the legacy GBBR reporting structure, with a first part reporting RS beam pairs that support MRTD less than CP and the second part reporting beam pairs that support MRTD greater than CP. The enhanced GBBR featuring indications of timing measurements such as MRTD and related network timing conditions facilitates the scheduling of UEs and the maintenance of coordinated service in multi-TRP environments.

[0024] FIG. **1** is a diagram of an example of an overview **100** according to one or more implementations described herein. As shown, overview **100** includes UE **110** and TRPs **120** and **130**. TRPs **120** and **130** form a multi-TRP environment in which implementations of the present disclosure may operate. Each TRP may transmit a plurality of beams having different directions. TRP **120** may transmit beams **120-1**, **120-2**, **120-3**, and **120-4** (RSs collectively shown as RS **11-14**) and TRP **130** may transmit beams **130-1**, **130-2**, **130-3**, and **130-4** (RS **21-24**). It is understood that the number of beams transmitted by each of TRP **120** and **130** is illustrative and that the TRPs may transmit any number of beams.

[0025] UE **110** may be configured to simultaneously receive beams transmitted from both TRP **120** and **130**. The network (e.g., a base station) may determine a transmission direction (i.e., a beam) for each TRP that ensures optimal reception at UE **110**. To that end, the network may configure a reporting mechanism for UE **110** to measure relevant DL Rx parameters and report the measurements to the network. In some implementations, the network may receive from UE **110** reports of UE synchronization capability indicating whether UE **110** can support simultaneous reception from multiple TRPs when MRTD is greater than a corresponding CP. To evaluate network conditions (e.g., whether MRTD is greater or less than CP), the network may configure UE **110** to perform and report to a TRP (e.g., TRP **120**) timing measurements including MRTD for TRP **120** and **130**. In some implementations, the network may configure UE **110** for GBBR based on the UE capability and the reported timing measurements. Alternatively, such as illustrated in FIG. **1**, the network may dispense with measuring MRTD before configuring the UE to perform GBBR, and instead, may configure UE **110** to provide MRTD measurements for beam pairs of the TRPs as part of GBBR. The enhanced GBBR featuring indications of timing measurements such as MRTD and related network timing conditions facilitate the scheduling of UEs and the maintenance of coordinated service in multi-TRP environments.

[0026] FIG. **2** is an example network **200** according to one or more implementations described herein. Example network **200** may include UEs **210**, **210-2**, etc. (referred to collectively as "UEs **210**" and individually as "UE **210**"), a radio access network (RAN) **220**, a core network (CN) **230**, application servers **240**, and external networks **250**.

[0027] The systems and devices of example network **200** may operate in accordance with one or more communication standards, such as 2nd generation (2G), 3rd generation (3G), 4th generation (4G) (e.g., long-term evolution (LTE)), and/or 5th generation (5G) (e.g., new radio (NR)) communication standards of the 3rd generation partnership project (3GPP). Additionally, or alternatively, one or more of the systems and devices of example network **200** may operate in accordance with other communication standards and protocols discussed herein, including future versions or generations of 3GPP standards (e.g., sixth generation (6G) standards, seventh generation (7G) standards, etc.), institute of electrical and electronics engineers (IEEE) standards (e.g., wireless metropolitan area network (WMAN), worldwide interoperability for microwave access (WiMAX), etc.), and more.

[0028] As shown, UEs **210** may include smartphones (e.g., handheld touchscreen mobile computing devices connectable to one or more wireless communication networks). Additionally, or alternatively, UEs **210** may include other types of mobile or non-mobile computing devices capable of wireless communications, such as personal data assistants (PDAs), pagers, laptop computers, desktop computers, wireless handsets, etc. In some implementations, UEs **210** may include internet of things (IoT) devices (or IoT UEs) that may comprise a network access layer designed for low-power IoT applications utilizing short-lived UE connections. Additionally, or alternatively, an IoT UE may utilize one or more types of technologies, such as machine-to-machine (M2M) communications or machine-type communications (MTC) (e.g., to exchanging data with an MTC server or other device via a public land mobile network (PLMN)), proximity-based service (ProSe) or device-to-device (D2D) communications, sensor networks, IoT networks, and more. Depending on the scenario, an M2M or MTC exchange of data may be a machine-initiated exchange, and an IoT network may include interconnecting IoT UEs (which may include uniquely identifiable embedded computing devices within an Internet infrastructure) with short-lived connections. In some scenarios, IoT UEs may execute background applications (e.g., keep-alive messages, status updates, etc.) to facilitate the connections of the IoT network.

[0029] UEs **210** may communicate and establish a connection with one or more other UEs **210** via one or more wireless channels **212**, each of which may comprise a physical communications interface/layer. The connection may include an M2M connection, MTC connection, D2D connection, SL connection, etc. The connection may involve a PC5 interface. In some implementations, UEs **210** may be configured to discover one another, negotiate wireless resources between one another, and establish connections between one another, without intervention or communications involving RAN node **222** or another type of network node. In some implementations, discovery, authentication, resource negotiation, registration, etc., may involve communications with RAN node **222** or another type of network node.

[0030] UEs **210** may use one or more wireless channels **212** to communicate with one another. As described herein, UE **210** may communicate with RAN node **222** to request SL resources. RAN node **222** may respond to the request by providing UE **210** with a dynamic grant (DG) or configured grant (CG) regarding SL resources. A DG may involve a grant based on a grant request from UE **210**. A CG may involve a resource grant without a grant request and may be based on a type of service being provided (e.g., services that have strict timing or latency requirements). UE **210** may perform a clear channel assessment (CCA) procedure based on the DG or CG, select SL resources based on the CCA procedure and the DG or CG; and communicate with another UE **210** based on the SL resources. The UE **210** may communicate with RAN node **222** using a licensed frequency band and communicate with the other UE **210** using an unlicensed frequency band.

[0031] UEs **210** may communicate and establish a connection with (e.g., be communicatively

coupled) with RAN **220**, which may involve one or more wireless channels **214-1** and **214-2**, each of which may comprise a physical communications interface/layer. In some implementations, a UE may be configured with dual connectivity (DC) as a multi-radio access technology (multi-RAT) or multi-radio dual connectivity (MR-DC), where a multiple receive and transmit (Rx/Tx) capable UE may use resources provided by different network nodes (e.g., **222-1** and **222-2**) that may be connected via non-ideal backhaul (e.g., where one network node provides NR access and the other network node provides either E-UTRA for LTE or NR access for 5G). In such a scenario, one network node may operate as a master node (MN) and the other as the secondary node (SN). The MN and SN may be connected via a network interface, and at least the MN may be connected to the CN **230**. Additionally, at least one of the MN or the SN may be operated with shared spectrum channel access, and functions specified for UE **210** can be used for an integrated access and backhaul mobile termination (IAB-MT). Similar for UE **210**, the IAB-MT may access the network using either one network node or using two different nodes with enhanced dual connectivity (EN-DC) architectures, new radio dual connectivity (NR-DC) architectures, or the like. In some implementations, a base station (as described herein) may be an example of network node **222**.
[0032] As described herein, UE **210** may receive and store one or more configurations, instructions, and/or other information for enabling SL-U communications with quality and priority standards. A PQI may be determined and used to indicate a QoS associated with an SL-U communication (e.g., a channel, data flow, etc.). Similarly, an L1 priority value may be determined and used to indicate a priority of an SL-U transmission, SL-U channel, SL-U data, etc. The PQI and/or L1 priority value may be mapped to a CAPC value, and the PQI, L1 priority, and/or CAPC may indicate SL channel occupancy time (COT) sharing, maximum (MCOT), timing gaps for COT sharing, LBT configuration, traffic and channel priorities, and more.
[0033] As shown, UE **210** may also, or alternatively, connect to access point (AP) **216** via connection interface **218**, which may include an air interface enabling UE **210** to communicatively couple with AP **216**. AP **216** may comprise a wireless local area network (WLAN), WLAN node, WLAN termination point, etc. The connection **216** may comprise a local wireless connection, such as a connection consistent with any IEEE 702.11 protocol, and AP **216** may comprise a wireless fidelity (Wi-Fi®) router or other AP. While not explicitly depicted in FIG. **2**, AP **216** may be connected to another network (e.g., the Internet) without connecting to RAN **220** or CN **230**. In some scenarios, UE **210**, RAN **220**, and AP **216** may be configured to utilize LTE-WLAN aggregation (LWA) techniques or LTE WLAN radio level integration with IPsec tunnel (LWIP) techniques. LWA may involve UE **210** in RRC_CONNECTED being configured by RAN **220** to utilize radio resources of LTE and WLAN. LWIP may involve UE **210** using WLAN radio resources (e.g., connection interface **218**) via IPsec protocol tunneling to authenticate and encrypt packets (e.g., Internet Protocol (IP) packets) communicated via connection interface **218**. IPsec tunneling may include encapsulating the entirety of original IP packets and adding a new packet header, thereby protecting the original header of the IP packets.
[0034] RAN **220** may include one or more RAN nodes **222-1** and **222-2** (referred to collectively as RAN nodes **222**, and individually as RAN node **222**) that enable channels **214-1** and **214-2** to be established between UEs **210** and RAN **220**. RAN nodes **222** may include network access points configured to provide radio baseband functions for data and/or voice connectivity between users and the network based on one or more of the communication technologies described herein (e.g., 2G, 3G, 4G, 5G, WiFi, etc.). As examples therefore, a RAN node may be an E-UTRAN Node B (e.g., an enhanced Node B, eNodeB, eNB, 4G base station, etc.), a next generation base station (e.g., a 5G base station, NR base station, next generation eNBs (gNB), etc.). RAN nodes **222** may include a roadside unit (RSU), a transmission reception point (TRxP or TRP), and one or more other types of ground stations (e.g., terrestrial access points). In some scenarios, RAN node **222** may be a dedicated physical device, such as a macrocell base station, and/or a low power (LP) base station for providing femtocells, picocells or the like having smaller coverage areas, smaller user

capacity, or higher bandwidth compared to macrocells.

[0035] Some or all of RAN nodes **222**, or portions thereof, may be implemented as one or more software entities running on server computers as part of a virtual network, which may be referred to as a centralized RAN (CRAN) and/or a virtual baseband unit pool (vBBUP). In these implementations, the CRAN or vBBUP may implement a RAN function split, such as a packet data convergence protocol (PDCP) split wherein radio resource control (RRC) and PDCP layers may be operated by the CRAN/vBBUP and other Layer 2 (L2) protocol entities may be operated by individual RAN nodes **222**; a media access control (MAC)/physical (PHY) layer split wherein RRC, PDCP, radio link control (RLC), and MAC layers may be operated by the CRAN/vBBUP and the PHY layer may be operated by individual RAN nodes **222**; or a “lower PHY” split wherein RRC, PDCP, RLC, MAC layers and upper portions of the PHY layer may be operated by the CRAN/vBBUP and lower portions of the PHY layer may be operated by individual RAN nodes **222**. This virtualized framework may allow freed-up processor cores of RAN nodes **222** to perform or execute other virtualized applications.

[0036] In some implementations, an individual RAN node **222** may represent individual gNB-distributed units (DUs) connected to a gNB-control unit (CU) via individual F1 or other interfaces. In such implementations, the gNB-DUs may include one or more remote radio heads or radio frequency (RF) front end modules (RFEMs), and the gNB-CU may be operated by a server (not shown) located in RAN **220** or by a server pool (e.g., a group of servers configured to share resources) in a similar manner as the CRAN/vBBUP. Additionally, or alternatively, one or more of RAN nodes **222** may be next generation eNBs (i.e., gNBs) that may provide evolved universal terrestrial radio access (E-UTRA) user plane and control plane protocol terminations toward UEs **210**, and that may be connected to a 5G core network (5GC) **230** via an NG interface.

[0037] Any of the RAN nodes **222** may terminate an air interface protocol and may be the first point of contact for UEs **210**. In some implementations, any of the RAN nodes **222** may fulfill various logical functions for the RAN **220** 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. UEs **210** may be configured to communicate using orthogonal frequency-division multiplexing (OFDM) communication signals with each other or with any of the RAN nodes **222** over a multicarrier communication channel in accordance with various communication techniques, such as, but not limited to, an 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 (SL) communications), although the scope of such implementations may not be limited in this regard. The OFDM signals may comprise a plurality of orthogonal subcarriers.

[0038] In some implementations, a downlink resource grid may be used for downlink transmissions from any of the RAN nodes **222** to UEs **210**, and uplink transmissions may utilize similar techniques. The grid may be a time-frequency grid (e.g., a resource grid or time-frequency resource grid) that represents the physical resource for 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 resource blocks, which describe the mapping of certain physical channels to resource elements. Each resource block may comprise a collection of resource elements (REs); in the frequency domain, this may represent the smallest quantity of resources that currently may be allocated. There are several different physical downlink channels that are conveyed using such resource blocks.

[0039] Further, RAN nodes **222** may be configured to wirelessly communicate with UEs **210**, and/or one another, over a licensed medium (also referred to as the “licensed spectrum” and/or the "licensed band"), an unlicensed shared medium (also referred to as the "unlicensed spectrum" and/or the "unlicensed band"), or combination thereof. A licensed spectrum may correspond to channels or frequency bands selected, reserved, regulated, etc., for certain types of wireless activity (e.g., wireless telecommunication network activity), whereas an unlicensed spectrum may correspond to one or more frequency bands that are not restricted for certain types of wireless activity. Whether a particular frequency band corresponds to a licensed medium or an unlicensed medium may depend on one or more factors, such as frequency allocations determined by a public-sector organization (e.g., a government agency, regulatory body, etc.) or frequency allocations determined by a private-sector organization involved in developing wireless communication standards and protocols, etc.

[0040] To operate in the unlicensed spectrum, UEs **210** and the RAN nodes **222** may operate using stand-alone unlicensed operation, licensed assisted access (LAA), eLAA, and/or feLAA mechanisms. In these implementations, UEs **210** and the RAN nodes **222** may perform one or more known medium-sensing operations or carrier-sensing operations in order to determine whether one or more channels in the unlicensed spectrum is unavailable or otherwise occupied prior to transmitting in the unlicensed spectrum. The medium/carrier sensing operations may be performed according to a listen-before-talk (LBT) protocol.

[0041] The PDSCH may carry user data and higher layer signaling to UEs **210**. The physical downlink control channel (PDCCH) may carry information about the transport format and resource allocations related to the PDSCH channel, among other things. The PDCCH may also inform UEs **210** about the transport format, resource allocation, and hybrid automatic repeat request (HARQ) information related to the uplink shared channel. Typically, downlink scheduling (e.g., assigning control and shared channel resource blocks to UE **210** within a cell) may be performed at any of the RAN nodes **222** based on channel quality information fed back from any of UEs **210**. The downlink resource assignment information may be sent on the PDCCH used for (e.g., assigned to) each of UEs **210**.

[0042] One or more of the techniques, described herein, may enable UE **210** to perform GBBR. For example, UE **210** may provide UE capability information indicating support for MRTD greater than CP to a base station. UE **210** may provide MRTD measurements for multiple TRPs to the base station. UE **210** may receive configuration information for GBBR when MRTD is less than CP or when MRTD is greater than CP for a plurality of TRPs and UE capability information indicates support for MRTD is greater than CP. In some implementations, UE **210** may receive from a base station operating as a TRP configuration information for performing GBBR. UE **210** may determine based on the configuration information a MRTD and communicate to the base station the MRTD in accordance with the performance of GBBR.

[0043] The RAN nodes **222** may be configured to communicate with one another via interface **223**. In implementations where the system is an LTE system, interface **223** may be an X2 interface. In NR systems, interface **223** may be an Xn interface. The X2 interface may be defined between two or more RAN nodes **222** (e.g., two or more eNBs/gNBs or a combination thereof) that connect to evolved packet core (EPC) or CN **230**, or between two eNBs connecting to an EPC. In some implementations, the X2 interface may include an X2 user plane interface (X2-U) and an X2 control plane interface (X2-C). The X2-U may provide flow control mechanisms for user data packets transferred over the X2 interface and may be used to communicate information about the delivery of user data between eNBs or gNBs. For example, the X2-U may provide specific sequence number information for user data transferred from a master eNB (MeNB) to a secondary eNB (SeNB); information about successful in sequence delivery of PDCP packet data units (PDUs) to a UE **210** from an SeNB for user data; information of PDCP PDUs that were not delivered to a UE **210**; information about a current minimum desired buffer size at the SeNB for transmitting to the UE user data; and the like. The X2-C may provide intra-LTE access mobility functionality (e.g., including context transfers from source to target eNBs, user plane transport control, etc.), load management functionality, and inter-cell interference coordination functionality.

[0044] As shown, RAN **220** may be connected (e.g., communicatively coupled) to CN **230**. CN **230** may comprise a plurality of network elements **232**, which are configured to offer various data and telecommunications services to customers/subscribers (e.g., users of UEs **210**) who are connected to the CN **230** via the RAN **220**. In some implementations, CN **230** may include an evolved packet core (EPC), a 5G CN, and/or one or more additional or alternative types of CNs. The components of the CN **230** may be implemented in one physical node or separate physical nodes including components to read and execute instructions from a machine-readable or computer-readable medium (e.g., a non-transitory machine-readable storage medium). In some implementations, network function virtualization (NFV) may be utilized to virtualize any or all the above-described network node roles or functions via executable instructions stored in one or more computer-readable storage mediums (described in further detail below). A logical instantiation of the CN **230** may be referred to as a network slice, and a logical instantiation of a portion of the CN **230** may be referred to as a network sub-slice. Network Function Virtualization (NFV) architectures and infrastructures may be used to virtualize one or more network functions, alternatively performed by proprietary hardware, onto physical resources comprising a combination of industry-standard server hardware, storage hardware, or switches. In other words, NFV systems may be used to execute virtual or reconfigurable implementations of one or more EPC components/functions.

[0045] As shown, CN **230**, application servers **240**, and external networks **250** may be connected to one another via interfaces **234**, **236**, and **238**, which may include IP network interfaces. Application servers **240** may include one or more server devices or network elements (e.g., virtual network functions (VNFs) offering applications that use IP bearer resources with CN **230** (e.g., universal mobile telecommunications system packet services (UMTS PS) domain, LTE PS data services, etc.). Application servers **240** may also, or alternatively, be configured to support one or more communication services (e.g., voice over IP (VOIP sessions, push-to-talk (PTT) sessions, group communication sessions, social networking services, etc.) for UEs **210** via the CN **230**. Similarly, external networks **250** may include one or more of a variety of networks, including the Internet, thereby providing the mobile communication network and UEs **210** of the network access to a variety of additional services, information, interconnectivity, and other network features.

[0046] FIG. **3** is a diagram of an example **300** of a representation of two CMR sets, CMR1 **310** and CMR2 **320**, according to an implementation described herein. CMR1 and CMR2 may represent sets of resources allocated by a network (e.g., base station **222**) for measuring characteristics of beams received by UE **210**. As shown, each CMR set may include resources allocated to reference signals of a base station or TRP. As such, CMR1 may include measurement sets for RS**11**-RS**14**, and CMR2 may include resource sets for RS**21**-RS**24**.

[0047] The network (e.g., base station **222**) may configure UE **210** to measure characteristics of each RS transmitted by each TRP. Indeed, each beam may be received by UE **210** from a TRP with a different angle of arrival (AoA) and may exhibits one or more characteristics that may distinguish it from other beams received by UE **210**. UE **210** may thus be configured to measure one or more characteristics of the RSs of TRP **120**, and one or more characteristics of the RSs of TRP **130**. The measurements may be used to determine how well each beam is transmitted by the TRPs toward UE **210**, and may be used to determine in which DL transmission directions the network may transmit for reception by UE **210**. In particular, the measurements may serve to determine which beams may be simultaneously received by UE **210**.

[0048] Traditionally, one of the beam characteristics the network may configure the CMR sets to measure is the RSRP or signal strength of each beam. RSRP measurements may enable the network to determine and select beams having sufficient signal strength for reception by UE **210**. Implementations of the present disclosure may enable the network to configure additional measurements such as DL Rx timing and RTD to help evaluate signal synchronization between

TRPs.

[0049] FIG. **4** is a diagram of an example **400** of an GBBR process, according to one or more implementations described herein. Process **400** may be implemented by UE **210** and base station **222**. In some implementations, some or all of process **400** may be performed by one or more other systems or devices, including one or more of the devices of FIG. **2**. Additionally, process **400** may include one or more fewer, additional, differently ordered and/or arranged operations than those shown in FIG. **4**. Some or all of the operations of process **400** may be performed independently, successively, simultaneously, etc., of one or more of the other operations of process **400**. Further, one or more of the operations of process **400** may include one or more of the features, conditions, information, characteristics, etc., described elsewhere herein. As such, the techniques described herein are not limited to the number, sequence, arrangement, timing, type, etc., of the operations or processes depicted in FIG. **4**.

[0050] Process **400** may be implemented when base station **222** is unable to guarantee mTRP network conditions, where MRTD is less than a corresponding CP. Process **400** may involve determining UE capability for measuring and reporting when MRTD is greater than CP and configuring UE **210** to measure MRTD for reporting. UE capability for measuring and reporting when MRTD greater than CP may be determined by receiving UE reports of the presence or absence of such capabilities; the absence of supporting an MRTD greater than CP scenario may also be inferred from a lack of response from UE **210**. Base station **222** may configure UE **210** to report RTD measurements to the TRPs. Accordingly, in some implementations, base station **222** may configure UE **210** to measure and report MRTD, and UE **210** may indicate whether UE **210** may support an MRTD greater than CP scenario. Base station **222** may configure UE **210** to measure and report MRTD by configuring “DL Rx Timing” in a TCI state for RSs. MRTD reporting may be configured to all UEs **210**, only some UEs **210**, or only one UE **210** that supports measuring and reporting when MRTD is greater than CP. Based on the received RTD, base station may configure GBBR for UEs **210** that support MRTD greater than CP scenario, enabling UE scheduling based on traditional GBBR reports in the multi-TRP environment with adverse RTD greater than CP network conditions.

[0051] Process **400** may include UE **210** reporting to the network whether UE **210** supports the network condition of MRTD being greater than CP (block **410**). Determining whether a UE supports MRTD greater than CP may enable base station **222** to determine whether to configure “DL Rx timing” in a TCI state for UE **210** and therefore configure UE **210** to perform an RTD measurement. Base station **222** may receive UE capability information from multiple UEs **210**. For UE **210**, the base station **222** may determine that UE **210** is capable of handling MRTD greater than CP conditions when UE **210** reports such capability. The base station **222** may determine that UE **210** has no capability for supporting MRTD greater than CP conditions if the UE reports a lack of such a capability. The base station **222** may also determine that UE **210** has no capability for supporting MRTD greater than CP conditions if UE **210** does not report the capability (in other words, base station **222** may infer a lack of capability of UE **210** from a lack of response from UE **210**).

[0052] Process **400** may include base station **222** configuring all UEs **210** in the multi-TRP network environment to perform RTD measurements and provide MRTD for TRPs of base station **222** (block **420**). In some implementation, to enable UE **210** to measure RTD, base station **222** may configure the QCL property of “DL Rx timing” in a TCI state for RSs for all UEs **210** in the multi-TRP environment. For example, base station **222** may transmit information and/or instructions to UE **210** (e.g., the “DL Rx timing” property) that are configured to cause or enable UE **210** to perform RTD measurements between TRP1 and TRP2 beam pairs (see, e.g., FIG. **1**). In such implementations, as this configuration is provided to all UEs **210** in the network environment, UE **210** may be configured to perform the RTD measurement regardless of whether it has reported support for measuring and reporting when an MRTD is greater than CP. The RTD measurement may be configured for UE **210** when UE **210** has actively reported support for measuring and reporting when MRTD is greater than CP or when UE **210** has not reported such support. Configuring "DL Rx timing" for all UEs **210** in the environment thus may enable base station **222** to skip the steps of determining which UEs **210** support for measuring and reporting when the MRTD is greater than CP. However, configuring a measurement may incur a measurement overhead at UE **210**. For example, UE **210** may have to pause data reception to perform the RTD measurement. As a result, the measurement overhead incurred by requesting every UE **210** to perform an RTD measurement regardless of support for MRTD greater than CP network conditions may yield an inefficient network operation in some examples. These inefficiencies may be mitigated or avoided by limiting the configuration of "DL Rx timing" in a TCI state for RSs and the RTD measurement request to a subset of UEs **210** in the multi TRP environment, as will be described in the alternative steps that follow.

[0053] As shown, process **400** may include base station **222** configuring only UEs **210** that support the network condition of MRTD greater than CP to perform RTD measurements and provide an MRTD to base station **222** (block **430**). In some implementation, to enable UEs **210** to measure RTD, base station **222** may configure a QCL property of "DL Rx timing" in a TCI state for RSs only for a pool of UEs **210** that have reported support for MRTD greater than CP (at block **410**). Base station **222** may forego configuring for the RTD measurement and reporting the UEs **210** that reported a lack of MRTD greater CP capability or that have not reported at all. Limiting the RTD measurement to a subset of UEs **210**. may prevent over encumbrance of UEs that do not support MRTD greater than CP network conditions with measurements that are useless to the network. Configuring a measurement may incur a measurement overhead at UE **210**, for example, causing UE **210** to pause reception to perform an RTD measurement. Limiting the request to measure the RTD to the pool or subset of UEs **210** that support network conditions where such measurements can be useful (e.g., when MRTD is greater than CP) may promote network efficiency.

[0054] As shown, in some implementations, process **400** may include the base station **222** configuring select UEs **210** at different locations of the multi-TRP environment to perform RTD measurements and provide MRTD to base station **222** (block **440**). In some implementation, to enable the UEs **210** to measure RTD, base station **222** may configure the QCL property of "DL Rx timing" in a TCI state for the select UEs **210** in the network environment. Base station **222** may utilize the multiple reports of MRTD at different locations to determine whether network conditions warrant configuring all UEs **210** for MRTD measurement and reporting based on whether and where MRTD greater than CP is observed. For example, base station **222** may determine based on the MRTD reports from multiple UEs **210** at different locations that a network condition of MRTD greater than CP is widespread enough to warrant configuring all UEs **210** in the network environment for MRTD reporting. Alternatively, base station **222** may determine based on the limited reports that MRTD is less than CP across the network such that no MRTD reporting from additional UEs **210** is warranted.

[0055] Process **400** may include the UE **210** performing the RTD measurement (block **450**) as configured by the base station **222**. UE **210** may perform RTD measurements based on information and/or instructions received from base station **222** that are configured to cause or enable UE **210** to perform RTD measurements between beams beam pairs, as previously described. In some implementations, RTD measurements at UE **210** may be enabled by base station **222**'s configuration of the QCL property of "DL Rx timing" in a TCI state. For example, performing the RTD measurement may include determining the DL timing for each RS (i.e., RS**11**-RS**14**) of TRP **120** and each RS (i.e., R**21**-R**24**) of TRP **130** as listed in the representations of CMR sets CMR1 and CMR2 in FIG. **3**.

[0056] Process **400** may include reporting RTD measurements to base station **222** (block **460**). UE **210** may thus transmit information and/or instructions to base station **222** that include the measured RTD.

[0057] Process **400** may include determining whether to configure UE **210** for GBBR (block **470**). Base station **222** may perform this determination based on the network condition report (whether RTD is greater than CP) provided by UE **210** at block **460** and UE capability report (whether UE **210** supports MRTD greater than CP) provided by UE **210** at block **410**. If the RTD as measured and provided by UE **210** is less than CP, this indicates that network conditions may be favorable to coordinated service between UE **210** and TRPs (such as TRP **120** and TRP **130** as shown in FIG. **1**) in the multi-TRP environment. In that scenario, UE **210** support for MRTD greater than CP network conditions may be ignored. In this case, base station **222** may configure UE **210** for GBBR (block **480**). Configuring UE **210** for GBBR can include setting a parameter that enables the UE **210** to perform GBBR and transmit a GBBR report to base station **222**. If RTD as measured and provided by UE **210** is greater than CP, network conditions may be less favorable for coordinated transmission from multiple TRPs and GBBR can be performed only if UE **210** has reported support for MRTD greater than CP (see block **410**). In this case, base station **222** may also configure UE **210** for GBBR for the two TRPs (block **480**). Accordingly, in this implementation, base station **222** may configure GBBR for the two TRPs to enable UE **210** to report on beam pairs based on RSRP when either MRTD as reported by the UE **210** at block **410** is less than CP, or when MRTD is greater than CP and UE **210** has reported support for MRTD greater than CP. When MRTD is greater than CP but UE **210** either has reported that it does not support this network condition, or that the UE **210** has failed to report on its capability to support the MRTD greater than CP condition, GBBR may not be configured and a simultaneous physical data shared channel (PDSCH) may not be scheduled.

[0058] Process **400** may include UE **210** performing GBBR (block **490**) and reporting to base station **222** RS beam pairs based on measured RSRP (block **495**). In this implementation, as previously described, GBBR may be performed when either MRTD as reported by UE **210** at block **410** is less than CP, or when MRTD is greater than CP and UE **210** has reported support for MRTD greater than CP. The GBBR may enable base station **222** to select beam pairs for optimal DL reception at UE **210**.

[0059] FIG. **5** is a diagram of an example of a data structure of an example GBBR report according to one or more implementations described herein. GBBR report **500** may provide information about DL beams received at UE **210** from TRPs in a multi-TRP environment to enable base station **222** to select beam pairs for optimal DL Rx at the UE **210**. In particular, the GBBR report **500** to base station **222** may report RS beam pairs **510** based on measured reference signal received power (RSRP) or signal strength. The GBBR report **500** may provide the report as a channel state information (CSI) report that includes resource groups, each resource group often comprising a pair of beams (e.g., **510-1**, **510-2**) that UE **210** is able to receive simultaneously. Each beam may be identified by either a CSI Resource Indicator (CRI) or a SS/PBCH Block Resource Indicator (SSBRI). The first beam (e.g., **510-1**) of each pair **510** or resource group may be received from TRP **120** and the second beam (**510-2**) of the resource group **510** may be received from TRP **130**. The GBBR report **500** may further identify the beam **530** having the largest measured RSRP (the beam having the strongest signal). The RSRPs of other beams of the report may be provided as differential RSRPs (against the strongest signal **530**), which may facilitate the assessment of signal strength between different beams of the report.

[0060] FIG. **6** is a diagram of an example of an example of enhanced GBBR with MRTD reporting for mTRPs according to one or more implementations described herein. Process **600** may be implemented by UE **210** and base station **222**. In some implementations, some or all of process **400** may be performed by one or more other systems or devices, including one or more of the devices of FIG. **2**. Additionally, process **600** may include one or more fewer, additional, differently ordered and/or arranged operations than those shown in FIG. **6**. Some or all of the operations of process **600** may be performed independently, successively, simultaneously, etc., of one or more of the other operations of process **600**. Further, one or more of the operations of process **600** may include one or more of the features, conditions, information, characteristics, etc., described elsewhere herein. As such, the techniques described herein are not limited to the number, sequence, arrangement, timing, type, etc., of the operations or processes depicted in FIG. **6**.

[0061] Process **600** may include UE **210** reporting to base station **222** whether the UE **210** supports enhanced GBBR and supports MRTD greater than CP (block **610**). Determining whether UE **210** supports enhanced GBBR (i.e., measuring and reporting RTD) and MRTD greater than CP, enables base station **222** to determine whether to configure “DL Rx timing” in a TCI state for the UE **210** and therefore configure the UE **210** to perform an RTD measurement. Base station **222** may receive UE capability report from multiple UEs. For a UE **210**, base station **222** determines that the UE **210** is capable of handling MRTD greater than CP if the UE **210** reports such capability. Base station **222** may determine that a UE **210** has no capability for MRTD greater than CP if the UE **210** reports a lack of such capability. Base station **222** may also determine that the UE **210** has no capability for MRTD greater than CP conditions if the UE **210** does not report on the capability (in other words, base station **222** can infer the lack of capability from the lack of response from a UE).

[0062] Process **600** may further include base station **222** configuring an RTD measurement to the UE as part of enhanced GBBR (block **620**). Unlike process **400**, process **600** may dispense with configuring an RTD measurement at UE **210** before base station **222** configures GBBR to the UE **210**. Instead, base station **222** configures the RTD measurement to UE **210** as part of GBBR. Accordingly, base station **222** may configure GBBR for the two TRPs (TRP **120** and TRP **130**). Configuring a GBBR for the two TRPs may include setting a parameter that enables UE **210** to perform GBBR and transmit a GBBR report to base station **222**. The configuration may further include one or more parameters that are instructions to cause UE **210** to perform and report RTD measurements in addition to the RSRP measurements for beams grouped in beam pairs as described in reference to FIG. **5**. The RTD measurements provided to base station **222** as part of GBBR for each beam pair may enable base station **222** to selected beam pairs for optimal coordinated transmissions by the two TRPs based on timing or synchronization factors (RTD) in addition to signal strength (RSRP). UE **210** performs GBBR (block **630**) and reports to the TRP (block **640**).

[0063] FIG. **7** is a diagram of an example of a representation of a data structure of an example enhanced GBBR report according to one or more implementations described herein. As previously described in reference to FIG. **5**, the enhanced GBBR report **700** to base station **222** may report RS beam pairs based on measured RSRP or signal strength. The GBBR report **700** may exhibit the same report structure as report **500**, and thus may provide the report as a channel state information (CSI) report that includes resource groups, each resource group comprising a pair of beams that UE **210** is able to receive simultaneously. Each beam may be identified by either CSI Resource Indicator (CRI) or its SS/PBCH Block Resource Indicator (SSBRI). As with report **500**, the first beam **710-1** of each pair or resource group **710** may be received from TRP **120** (e.g., RS**11-14** as listed in FIG. **3**) and the second beam **710-2** of the resource group may be received from TRP **130** (e.g., RS**21-24**). However, base station **222** may also have configured MRTD measurements as part of enhanced GBBR **700**, as previously described. The configuration thus may include one or more parameters that are instructions to cause the UE **210** to perform and report RTD measurements in addition to the RSRP measurements for beams grouped in beam pairs as described in reference to FIG. **5**. Thus in FIG. **7**, enhanced GBBR **700** may also provide MRTD **720** for each resource group or beam pair **710**. As illustrated, the MRTD measurement **720** is shown for the first resource group or beam pair. MRTD measurement **720** thus is provided for every beam pair **710** in the enhanced report **700**. The RTD measurements provided to base station **222** as part of the enhanced GBBR **700** for each beam pair **710** may enable base station **222** to selected beam pairs for optimal coordinated transmissions by two TRPs (e.g., TRP **120** and TRP **130**) based on timing or synchronization parameters (RTD) in addition to signal strength (RSRP).

[0064] FIG. **8** is a diagram of an example of a representation of a data structure of an example enhanced GBBR report according to another example of the disclosure. In this implementation, base station **222** may configure the UE **210** to provide enhanced GBBR **800** as a two-part data structure. In some implementations, each part may duplicate GBBR report **500**'s reporting structure as described in reference to FIG. **5**. Accordingly, enhanced GBBR report **800** to base station **222** may report RS beam pairs based on measured reference signal received power (RSRP) or signal strength. The enhanced GBBR report **800** may exhibit a similar report structure as report **500**, and may thus provide the report **800** as a channel state information (CSI) report that may include resource groups, each resource group comprising a pair of beams that the UE is able to receive simultaneously. Each beam may be identified by either CSI Resource Indicator (CRI) or its SS/PBCH Block Resource Indicator (SSBRI). As with report **500**, the first beam **810-1** of each pair or resource group **810** may be received from TRP **120** (e.g., RS **11-14** as listed in FIG. **3**) and the second beam **810-2** of the resource group **810** may be received from TRP **130**. As with report **700**, base station **222** may also have configure MRTD measurements as part of enhanced GBBR report **800**. The configuration may thus include one or more parameters that are instructions to cause the UE **210** to perform and report RTD measurements in addition to the RSRP measurements for beams grouped in beam pairs as described in reference to FIG. **5**. However, base station **222** may also configure GBBR **800** to group the reports by whether MRTD is greater than CP and/or whether MRTD is less than CP for any resource group or beam pair **810**. Accordingly, in a first GBBR part **850**, the GBBR **800** may report RS beam pairs **810** (formed by beam **810-1** and **810-2**) that support MRTD less than CP. GBBR part **850** may comprise the whole of the GBBR **800** in cases where base station **222** has configured a report only for beam pairs that satisfy MRTD less than CP condition. Additionally, or alternatively, GBBR **800** may include a second GBBR part **860** configured to report beam pairs **820** that support MRTD greater than CP. The GBBR part **860** may comprise the whole of GBBR **800** in cases where base station **222** has configured a report only for beam pairs that satisfy MRTD greater than CP. The grouping of resource groups or beam pairs by MRTD less or more than CP is provided to base station **222** as part of enhanced GBBR **800** to enable base station **222** to selected beam pairs for optimal coordinated transmissions by two TRPs (e.g., TRP **120** and TRP **130**) based on synchronization parameters (MRTD) in addition to signal strength (RSRP).

[0065] FIG. **9** is a diagram of an example of a process **900** for enhanced GBBR with MRTD reporting for mTRPs according to one or more implementations described herein. In some scenarios, process **900** may include receiving (**910**), from a UE of a plurality of UEs, UE capability information indicating support for when a MRTD is greater than a corresponding CP. In some scenarios, the process may comprise receiving (**920**), from the UE, MRTD measurements for multiple transmission and reception points (TRPs). In some scenarios, the process may include communicating (**930**), to the UE, configuration information for GBBR when MRTD is less than the corresponding CP. In some scenarios, the process may also include communicating (**940**), to the UE, configuration information for GBBR when MRTD is greater than the corresponding CP for a plurality of TRPs.

[0066] FIG. **10** is a diagram of an example of a process **1000** for enhanced GBBR with MRTD reporting for mTRPs according to one or more implementations described herein. In some scenarios, a UE may comprise a memory and one or more processors configured to, when executing instructions stored in the memory, cause the UE to receive (**1010**), from a base station operating as a transmission and reception point (TRP), configuration information for performing group-based beam reporting (GBBR). In some scenarios, the one or more processors may be configured to, when executing instructions stored in the memory, cause the UE to determine (**1020**), for the TRP, a receiving timing difference (RTD). In some scenarios, the one or more processors may be configured to, when executing instructions stored in the memory, cause the UE to communicate (**1030**), to the base station, the RTD using GBBR.

[0067] FIG. **11** is a diagram of an example of components of a device according to one or more implementations described herein. In some implementations, the device **1100** can include application circuitry **1102**, baseband circuitry **1104**, RF circuitry **1106**, front-end module (FEM) circuitry **1108**, one or more antennas **1110**, and power management circuitry (PMC) **1112** coupled together at least as shown. The components of the illustrated device **1100** can be included in a UE or a RAN node. In some implementations, the device **1100** can include fewer elements (e.g., a RAN node may not utilize application circuitry **1102**, and instead include a processor/controller to process IP data received from a CN or an Evolved Packet Core (EPC)). In some implementations, the device **1100** can include additional elements such as, for example, memory/storage, display, camera, sensor (including one or more temperature sensors, such as a single temperature sensor, a plurality of temperature sensors at different locations in device **1100**, etc.), or input/output (I/O) interface. In other implementations, the components described below can be included in more than one device (e.g., said circuitries can be separately included in more than one device for Cloud-RAN (C-RAN) implementations).

[0068] The application circuitry **1102** can include one or more application processors. For example, the application circuitry **1102** can include circuitry such as, but not limited to, one or more single-core or multi-core processors. The processor(s) can include any combination of general-purpose processors and dedicated processors (e.g., graphics processors, application processors, etc.). The processors can be coupled with or can include memory/storage and can be configured to execute instructions stored in the memory/storage to enable various applications or operating systems to run on the device **1100**. In some implementations, processors of application circuitry **1102** can process IP data packets received from an EPC.

[0069] The baseband circuitry **1104** can include circuitry such as, but not limited to, one or more single-core or multi-core processors. The baseband circuitry **1104** can include one or more baseband processors or control logic to process baseband signals received from a receive signal path of the RF circuitry **1106** and to generate baseband signals for a transmit signal path of the RF circuitry **1106**. Baseband circuity **1104** can interface with the application circuitry **1102** for generation and processing of the baseband signals and for controlling operations of the RF circuitry **1106**. For example, in some implementations, the baseband circuitry **1104** can include a 3G baseband processor **1104**A, a 4G baseband processor **1104**B, a 5G baseband processor **1104**C, or other baseband processor(s) **1104**D for other existing generations, generations in development or to be developed in the future (e.g., 5G, 6G, etc.). The baseband circuitry **1104** (e.g., one or more of baseband processors **1104**A-D) can handle various radio control functions that enable communication with one or more radio networks via the RF circuitry **1106**. In other implementations, some or all of the functionality of baseband processors **1104**A-D can be included in modules stored in the memory **1104**G and executed via a Central Processing Unit (CPU) **1104**E. The radio control functions can include, but are not limited to, signal modulation/demodulation, encoding/decoding, radio frequency shifting, etc. In some implementations, modulation/demodulation circuitry of the baseband circuitry **1104** can include Fast-Fourier Transform (FFT), precoding, or constellation mapping/de-mapping functionality. In some implementations, encoding/decoding circuitry of the baseband circuitry **1104** can include convolution, tail-biting convolution, turbo, Viterbi, or Low-Density Parity Check (LDPC) encoder/decoder functionality. Implementations of modulation/demodulation and encoder/decoder functionality are not limited to these examples and can include other suitable functionality in other implementations.

[0070] In some implementations, memory **1104**G may receive and/or store information and instructions for enabling UE **210**, and/or one or more components thereof, to perform GBBR. For example, the information and instructions may cause and/or enable UE **210** to provide UE capability information indicating support for MRTD greater than CP to a base station. The information and instructions may cause and/or enable UE **210** to provide RTD measurements for multiple TRPs to the base station. The information and instructions may cause and/or enable UE

210 to receive configuration information for GBBR when MRTD is less than CP or when MRTD is greater than CP for a plurality of TRPs. In some implementations, the information and instructions may cause and/or enable UE **210** to receive from a base station operating as a TRP configuration information for GBBR. The information and instructions may cause and/or enable UE **210** to determine for the TRP a RTD and communicate to the base station the RTD using GBBR.

[0071] In some implementations, the baseband circuitry **1104** can include one or more audio digital signal processor(s) (DSP) **1104**F. The audio DSPs **1104**F can include elements for compression/decompression and echo cancellation and can include other suitable processing elements in other implementations. Components of the baseband circuitry can be suitably combined in a single chip, a single chipset, or disposed on a same circuit board in some implementations. In some implementations, some or all of the constituent components of the baseband circuitry **1104** and the application circuitry **1102** can be implemented together such as, for example, on a system on a chip (SOC).

[0072] In some implementations, the baseband circuitry **1104** can provide for communication compatible with one or more radio technologies. For example, in some implementations, the baseband circuitry **1104** can support communication with a NG-RAN, 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), etc. Implementations in which the baseband circuitry **1104** is configured to support radio communications of more than one wireless protocol can be referred to as multi-mode baseband circuitry.

[0073] RF circuitry **1106** can enable communication with wireless networks using modulated electromagnetic radiation through a non-solid medium. In various implementations, the RF circuitry **1106** can include switches, filters, amplifiers, etc. to facilitate the communication with the wireless network. RF circuitry **1106** can include a receive signal path which can include circuitry to down-convert RF signals received from the FEM circuitry **1108** and provide baseband signals to the baseband circuitry **1104**. RF circuitry **1106** can also include a transmit signal path which can include circuitry to up-convert baseband signals provided by the baseband circuitry **1104** and provide RF output signals to the FEM circuitry **1108** for transmission.

[0074] In some implementations, the receive signal path of the RF circuitry **1106** can include mixer circuitry **1106**A, amplifier circuitry **1106**B and filter circuitry **1106**C. In some implementations, the transmit signal path of the RF circuitry **1106** can include filter circuitry **1106**C and mixer circuitry **1106**A. RF circuitry **1106** can also include synthesizer circuitry **1106**D for synthesizing a frequency for use by the mixer circuitry **1106**A of the receive signal path and the transmit signal path. In some implementations, the mixer circuitry **1106**A of the receive signal path can be configured to down-convert RF signals received from the FEM circuitry **1108** based on the synthesized frequency provided by synthesizer circuitry **1106**D. The amplifier circuitry **1106**B can be configured to amplify the down-converted signals and the filter circuitry **1106**C can 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 can be provided to the baseband circuitry **1104** for further processing. In some implementations, the output baseband signals can be zero-frequency baseband signals, although this is not a requirement. In some implementations, mixer circuitry **1106**A of the receive signal path can comprise passive mixers, although the scope of the implementations is not limited in this respect.

[0075] In some implementations, the mixer circuitry **1106**A of the transmit signal path can be configured to up-convert input baseband signals based on the synthesized frequency provided by the synthesizer circuitry **1106**D to generate RF output signals for the FEM circuitry **1108**. The baseband signals can be provided by the baseband circuitry **1104** and can be filtered by filter circuitry **1106**C.

[0076] In some implementations, the mixer circuitry **1106**A of the receive signal path and the mixer

circuitry **1106**A of the transmit signal path can include two or more mixers and can be arranged for quadrature down conversion and up conversion, respectively. In some implementations, the mixer circuitry **1106**A of the receive signal path and the mixer circuitry **1106**A of the transmit signal path can include two or more mixers and can be arranged for image rejection (e.g., Hartley image rejection). In some implementations, the mixer circuitry **1106**A of the receive signal path and the mixer circuitry **1106**A can be arranged for direct down conversion and direct up conversion, respectively. In some implementations, the mixer circuitry **1106**A of the receive signal path and the mixer circuitry **1106**A of the transmit signal path can be configured for super-heterodyne operation.
[0077] In some implementations, the output baseband signals, and the input baseband signals can be analog baseband signals, although the scope of the implementations is not limited in this respect. In some alternate implementations, the output baseband signals, and the input baseband signals can be digital baseband signals. In these alternate implementations, the RF circuitry **1106** can include analog-to-digital converter (ADC) and digital-to-analog converter (DAC) circuitry and the baseband circuitry **1104** can include a digital baseband interface to communicate with the RF circuitry **1106**.
[0078] In some dual-mode implementations, a separate radio IC circuitry can be provided for processing signals for each spectrum, although the scope of the implementations is not limited in this respect.
[0079] In some implementations, the synthesizer circuitry **1106**D can be a fractional-N synthesizer or a fractional N/N+1 synthesizer, although the scope of the implementations is not limited in this respect as other types of frequency synthesizers can be suitable. For example, synthesizer circuitry **1106**D can be a delta-sigma synthesizer, a frequency multiplier, or a synthesizer comprising a phase-locked loop with a frequency divider.
[0080] The synthesizer circuitry **1106**D can be configured to synthesize an output frequency for use by the mixer circuitry **1106**A of the RF circuitry **1106** based on a frequency input and a divider control input. In some implementations, the synthesizer circuitry **1106**D can be a fractional N/N+1 synthesizer.
[0081] In some implementations, frequency input can be provided by a voltage-controlled oscillator (VCO), although that is not a requirement. Divider control input can be provided by either the baseband circuitry **1104** or the applications circuitry **1102** depending on the desired output frequency. In some implementations, a divider control input (e.g., N) can be determined from a look-up table based on a channel indicated by the applications circuitry **1102**.
[0082] Synthesizer circuitry **1106**D of the RF circuitry **1106** can include a divider, a delay-locked loop (DLL), a multiplexer and a phase accumulator. In some implementations, the divider can be a dual modulus divider (DMD) and the phase accumulator can be a digital phase accumulator (DPA). In some implementations, the DMD can 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 implementations, the DLL can include a set of cascaded, tunable, delay elements, a phase detector, a charge pump and a D-type flip-flop. In these implementations, the delay elements can 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.
[0083] In some implementations, synthesizer circuitry **1106**D can be configured to generate a carrier frequency as the output frequency, while in other implementations, the output frequency can 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 implementations, the output frequency can be a LO frequency (fLO). In some implementations, the RF circuitry **1106** can include an IQ/polar converter.
[0084] FEM circuitry **1108** can include a receive signal path which can include circuitry configured

to operate on RF signals received from one or more antennas **1110**, amplify the received signals and provide the amplified versions of the received signals to the RF circuitry **1106** for further processing. FEM circuitry **1108** can also include a transmit signal path which can include circuitry configured to amplify signals for transmission provided by the RF circuitry **1106** for transmission by one or more of the one or more antennas **1110**. In various implementations, the amplification through the transmit or receive signal paths can be done solely in the RF circuitry **1106**, solely in the FEM circuitry **1108**, or in both the RF circuitry **1106** and the FEM circuitry **1108**.

[0085] In some implementations, the FEM circuitry **1108** can include a TX/RX switch to switch between transmit mode and receive mode operation. The FEM circuitry can include a receive signal path and a transmit signal path. The receive signal path of the FEM circuitry can include an LNA to amplify received RF signals and provide the amplified received RF signals as an output (e.g., to the RF circuitry **1106**). The transmit signal path of the FEM circuitry **1108** can include a power amplifier (PA) to amplify input RF signals (e.g., provided by RF circuitry **1106**), and one or more filters to generate RF signals for subsequent transmission (e.g., by one or more of the one or more antennas **1110**).

[0086] In some implementations, the PMC **1112** can manage power provided to the baseband circuitry **1104**. In particular, the PMC **1112** can control power-source selection, voltage scaling, battery charging, or DC-to-DC conversion. The PMC **1112** can often be included when the device **1100** is capable of being powered by a battery, for example, when the device is included in a UE. The PMC **1112** can increase the power conversion efficiency while providing desirable implementation size and heat dissipation characteristics.

[0087] While FIG. **11** shows the PMC **1112** coupled only with the baseband circuitry **1104**. However, in other implementations, the PMC **1112** may be additionally or alternatively coupled with, and perform similar power management operations for, other components such as, but not limited to, application circuitry **1102**, RF circuitry **1106**, or FEM circuitry **1108**.

[0088] In some implementations, the PMC **1112** can control, or otherwise be part of, various power saving mechanisms of the device **1100**. For example, if the device **1100** is in an RRC_Connected state, where it is still connected to the RAN node as it expects to receive traffic shortly, then it can enter a state known as Discontinuous Reception Mode (DRX) after a period of inactivity. During this state, the device **1100** can power down for brief intervals of time and thus save power.

[0089] If there is no data traffic activity for an extended period of time, then the device **1100** can 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 **1100** 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 **1100** may not receive data in this state; in order to receive data, it can transition back to RRC_Connected state.

[0090] An additional power saving mode can 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 unreachable to the network and can power down completely. Any data sent during this time incurs a large delay and it is assumed the delay is acceptable.

[0091] Processors of the application circuitry **1102** and processors of the baseband circuitry **1104** can be used to execute elements of one or more instances of a protocol stack. For example, processors of the baseband circuitry **1104**, alone or in combination, can be used execute Layer 3, Layer 2, or Layer 1 functionality, while processors of the baseband circuitry **1104** can 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 can comprise a RRC layer, described in further detail below. As referred to herein, Layer 2 can 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 can comprise a physical (PHY) layer of a UE/RAN node, described in

further detail below.
[0092] FIG. **12** is a block diagram illustrating components, according to some example implementations, able to read instructions from a machine-readable or computer-readable medium (e.g., a non-transitory machine-readable storage medium) and perform any one or more of the methodologies discussed herein. Specifically, FIG. **12** shows a diagrammatic representation of hardware resources **1200** including one or more processors (or processor cores) **1210**, one or more memory/storage devices **1220**, and one or more communication resources **1230**, each of which may be communicatively coupled via a bus **1240**. For implementations where node virtualization (e.g., NFV) is utilized, a hypervisor **1202** may be executed to provide an execution environment for one or more network slices/sub-slices to utilize the hardware resources **1200**.
[0093] The processors **1210** (e.g., a central processing unit (CPU), a reduced instruction set computing (RISC) processor, a complex instruction set computing (CISC) processor, a graphics processing unit (GPU), a digital signal processor (DSP) such as a baseband processor, an application specific integrated circuit (ASIC), a radio-frequency integrated circuit (RFIC), another processor, or any suitable combination thereof) may include, for example, a processor **1212** and a processor **1214**.
[0094] The memory/storage devices **1220** may include main memory, disk storage, or any suitable combination thereof. The memory/storage devices **1220** may include, but are not limited to any type of volatile or non-volatile memory such as dynamic random-access memory (DRAM), static random-access memory (SRAM), erasable programmable read-only memory (EPROM), electrically erasable programmable read-only memory (EEPROM), Flash memory, solid-state storage, etc.
[0095] In some implementations, memory/storage devices **1220** receive and/or store information and instructions **1255** for enabling UE **210**, and/or one or more components thereof, to perform GBBR. For example, the information and instructions may cause and/or enable UE **210** to provide UE capability information indicating support for MRTD greater than CP to a base station. The information and instructions may cause and/or enable UE **210** to provide RTD measurements for multiple TRPs to the base station. The information and instructions may cause and/or enable UE **210** to receive configuration information for GBBR when MRTD is less than CP or when MRTD is greater than CP for a plurality of TRPs. In some implementations, the information and instructions may cause and/or enable UE **210** to receive from a base station operating as a TRP configuration information for GBBR. The information and instructions may cause and/or enable UE **210** to determine for the TRP a RTD and communicate to the base station the RTD using GBBR.
[0096] The communication resources **1230** may include interconnection or network interface components or other suitable devices to communicate with one or more peripheral devices **1204** or one or more databases **1206** via a network **1208**. For example, the communication resources **1230** may include wired communication components (e.g., for coupling via a Universal Serial Bus (USB)), cellular communication components, NFC components, Bluetooth® components (e.g., Bluetooth® Low Energy), Wi-Fi® components, and other communication components.
[0097] Instructions **1250** may comprise software, a program, an application, an applet, an app, or other executable code for causing at least any of the processors **1210** to perform any one or more of the methodologies discussed herein. The instructions **1250** may reside, completely or partially, within at least one of the processors **1210** (e.g., within the processor's cache memory), the memory/storage devices **1220**, or any suitable combination thereof. Furthermore, any portion of the instructions **1250** may be transferred to the hardware resources **1200** from any combination of the peripheral devices **1204** or the databases **1206**. Accordingly, the memory of processors **1210**, the memory/storage devices **1220**, the peripheral devices **1204**, and the databases **1206** are examples of computer-readable and machine-readable media.
[0098] Examples and/or implementations herein may 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 (e.g., processor, etc.) 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 implementations and examples described.

[0099] In example 1, which may also include one or more of the examples described herein, a method may comprise receiving, from a user equipment (UE) of a plurality of UEs, UE capability information indicating support for when a maximum received timing difference (MRTD) is greater than a corresponding cycle prefix (CP); receiving, from the UE, MRTD measurements for multiple transmission and reception points (TRPs); communicating, to the UE, configuration information for group-based beam reporting (GBBR) when MRTD is less than the corresponding CP or when MRTD is greater than the corresponding CP for a plurality of TRPs and the UE capability information indicates support for when MRTD is greater than the corresponding CP.

[0100] In example 2, which may also include one or more of the examples described herein, the method further comprises communicating to all UEs of the plurality of UEs, configuration information for performing the MRTD measurements.

[0101] In example 3, which may also include one or more of the examples described herein, the method further comprises communicating to UEs of the plurality of UEs from which the UE capability information was received indicating support for when MRTD is greater than the corresponding CP, configuration information for performing the MRTD measurements.

[0102] In example 4, which may also include one or more of the examples described herein, the method further comprises: communicating to one or more UEs of the plurality of UEs located at different locations, configuration information for performing the MRTD measurements; receiving, from the one or more UEs, the MRTD measurements for TRPs; and communicating, to all UEs of the plurality of UEs, configuration information for performing the MRTD measurements.

[0103] In example 5, which may also include one or more of the examples described herein, communicating configuration information for performing the MRTD measurements comprises configuring DL Rx timing in a transmission configuration indicator (TCI) state for reference signals (RS) to enable UEs to perform the MRTD measurements.

[0104] In example 6, which may also include one or more of the examples described herein, the GBBR comprises one or more pairs of identifiers for reference signals (RS), each RS of a pair received from a different TRP and identified by the UE for simultaneous reception.

[0105] In example 7, which may also include one or more of the examples described herein, the method further comprises receiving the GBBR report and scheduling the UE based on the GBBR report.

[0106] In example 8, which may also include one or more of the examples described herein, a method comprises communicating, to a user equipment (UE), configuration information for performing group-based beam reporting (GBBR), the configuration information including configuration information for performing a received timing difference (RTD) measurement; receiving GBBR information comprising a timing measurement; and communicating, to the UE, scheduling information based on the GBBR information.

[0107] In example 9, which may also include one or more of the examples described herein, the timing measurement comprises a determination of a maximum RTD (MRTD).

[0108] In example 10, which may also include one or more of the examples described herein, the GBBR information comprises one or more pairs of reference signal (RS) identifiers, each RS of a pair received from a different transmission and reception point (TRP) and identified by the UE for simultaneous reception. In example 11, which may also include one or more of the examples described herein, the GBBR information further comprises a MRTD measurement associated with each pair of RS. In example 12, which may also include one or more of the examples described herein, performing the RTD measurement comprises determining whether a MRTD is greater or less than a corresponding cycle prefix (CP) and wherein the GBBR information comprises a first GBBR information part comprising RS pairs that satisfy MRTD greater than the corresponding CP and a second GBBR information part comprising RS pairs that satisfy MRTD less than the corresponding CP.

[0109] In example 13, which may also include one or more of the examples described herein, a user device (UE), may comprise: a memory; and one or more processors configured to, when executing instructions stored in the memory, cause the UE to: receive, from a base station operating as a transmission and reception point (TRP), configuration information for performing group-based beam reporting (GBBR); determine, based on the configuration information a maximum receive timing difference (MRTD) based on a plurality of reference signals (RS), each RS of the plurality of RS being received from a different TRP; and communicate, to the base station, the MRTD in accordance with performance of the GBBR.

[0110] In example 14, which may also include one or more of the examples described herein, the GBBR comprises one or more pairs of RS, each RS identifier of the one or more pairs of RS identifiers corresponding to a RS of the plurality of RS, each of the one or more pairs of RS identifiers being identified by the UE for simultaneous reception. In example 15, which may also include one or more of the examples described herein, the GBBR further comprises a MRTD measurement associated with each of the one or more pairs of RS identifiers. In example 16, which may also include one or more of the examples described herein, the MRTD measurement comprises a determination of whether MRTD is greater or less than a corresponding cycle prefix (CP). In example 17, which may also include one or more of the examples described herein, the GBBR comprises a first GBBR part comprising RS pairs that satisfy MRTD greater than the corresponding CP. In example 18, which may also include one or more of the examples described herein, the GBBR comprises a second GBBR part comprising RS pairs that satisfy MRTD less than the corresponding CP.

[0111] In example 19, which may also include one or more of the examples described herein, the configuration information includes an instruction to perform a MRTD measurement.

[0112] In example 20, which may also include one or more of the examples described herein, a baseband processor may comprise: one or more processors configured to: receive, from a base station operating as a transmission and reception point (TRP), configuration information for performing group-based beam reporting (GBBR); determine, based on the configuration information a maximum receive timing difference (MRTD) based on a plurality of reference signals (RS), each RS of the plurality of RS being received from a different TRP; and communicate, to the base station, the MRTD in accordance with performance of the GBBR.

[0113] In example 21, which may also include one or more of the examples described herein, the GBBR comprises one or more pairs of RS, each RS identifier of the one or more pairs of RS identifiers corresponding to a RS of the plurality of RS, each of the one or more pairs of RS identifiers being identified by the baseband processor for simultaneous reception. In example 22, which may also include one or more of the examples described herein, the GBBR further comprises a MRTD measurement associated with each of the one or more pairs of RS identifiers. In example 23, which may also include one or more of the examples described herein, the MRTD measurement comprises a determination of whether MRTD is greater or less than a corresponding cycle prefix (CP). In example 24, which may also include one or more of the examples described herein, the GBBR comprises a first GBBR part comprising RS pairs that satisfy MRTD greater than the corresponding CP. In example 25, which may also include one or more of the examples described herein, the GBBR comprises a second GBBR part comprising RS pairs that satisfy MRTD less than the corresponding CP.

[0114] In example 26, which may also include one or more of the examples described herein, the configuration information includes an instruction to perform a MRTD measurement.

[0115] In example 27, which may also include one or more of the examples described herein, a method at a user equipment (UE) may comprise receiving, from a base station operating as a transmission and reception point (TRP), configuration information for performing group-based beam reporting (GBBR); determining, based on the configuration information a maximum receive timing difference (MRTD) based on a plurality of reference signals (RS), each RS of the plurality of RS being received from a different TRP; and communicating, to the base station, the MRTD in accordance with performance of the GBBR.

[0116] In example 28, which may also include one or more of the examples described herein, the GBBR comprises one or more pairs of RS, each RS identifier of the one or more pairs of RS identifiers corresponding to a RS of the plurality of RS, each of the one or more pairs of RS identifiers being identified by the UE for simultaneous reception. In example 29, which may also include one or more of the examples described herein, the GBBR further comprises a MRTD measurement associated with each of the one or more pairs of RS identifiers. In example 30, which may also include one or more of the examples described herein, the MRTD measurement comprises a determination of whether MRTD is greater or less than a corresponding cycle prefix (CP). In example 31, which may also include one or more of the examples described herein, the GBBR comprises a first GBBR part comprising RS pairs that satisfy MRTD greater than the corresponding CP. In example 32, which may also include one or more of the examples described herein, the GBBR comprises a second GBBR part comprising RS pairs that satisfy MRTD less than the corresponding CP.

[0117] In example 33, which may also include one or more of the examples described herein, the configuration information includes an instruction to perform a MRTD measurement.

[0118] The examples discussed above also extend to method, computer-readable medium, and means-plus-function claims and implementations, an of which may include one or more of the features or operations of any one or combination of the examples mentioned above.

[0119] The above description of illustrated examples, implementations, aspects, etc., of the subject disclosure, including what is described in the Abstract, is not intended to be exhaustive or to limit the disclosed aspects to the precise forms disclosed. While specific examples, implementations, aspects, etc., are described herein for illustrative purposes, various modifications are possible that are considered within the scope of such examples, implementations, aspects, etc., as those skilled in the relevant art can recognize.

[0120] In this regard, while the disclosed subject matter has been described in connection with various examples, implementations, aspects, etc., and corresponding Figures, where applicable, it is to be understood that other similar aspects can be used or modifications and additions can be made to the disclosed subject matter for performing the same, similar, alternative, or substitute function of the subject matter without deviating therefrom. Therefore, the disclosed subject matter should not be limited to any single example, implementation, or aspect described herein, but rather should be construed in breadth and scope in accordance with the appended claims below.

[0121] 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 application.

[0122] As used herein, 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 or the claims, such terms are intended to be inclusive in a manner similar to the term “comprising.” Additionally, in situations wherein one or more numbered items are discussed (e.g., a “first X”, a “second X”, etc.), in general the one or more numbered items can be distinct, or they can be the same, although in some situations the context may indicate that they are distinct or that they are the same.
[0123] It is well understood that the use of personally identifiable information should follow privacy policies and practices that are generally recognized as meeting or exceeding industry or governmental requirements for maintaining the privacy of users. In particular, personally identifiable information data should be managed and handled to minimize risks of unintentional or unauthorized access or use, and the nature of authorized use should be clearly indicated to users.

Claims

1. A user device (UE), comprising: a memory; and one or more processors configured to, when executing instructions stored in the memory, cause the UE to: receive, from a base station operating as a transmission and reception point (TRP), configuration information for performing group-based beam reporting (GBBR); determine, based on the configuration information a maximum receive timing difference (MRTD) based on a plurality of reference signals (RS), each RS of the plurality of RS being received from a different TRP; and communicate, to the base station, the MRTD in accordance with performance of the GBBR.
2. The UE of claim 1, wherein the GBBR comprises one or more pairs of RS identifiers, each RS identifier of the one or more pairs of RS identifiers corresponding to a RS of the plurality of RS, each of the one or more pairs of RS identifiers being identified by the UE for simultaneous reception.
3. The UE of claim 2, wherein the GBBR further comprises a MRTD measurement associated with each of the one or more pairs of RS identifiers.
4. The UE of claim 3, wherein the MRTD measurement comprises a determination of whether MRTD is greater or less than a corresponding cycle prefix (CP).
5. The UE of claim 4, wherein the GBBR comprises a first GBBR part comprising RS pairs that satisfy MRTD greater than the corresponding CP.
6. The UE of claim 5, wherein the GBBR comprises a second GBBR part comprising RS pairs that satisfy MRTD less than the corresponding CP.
7. The UE of claim 1, wherein the configuration information includes an instruction to perform a MRTD measurement.
8. A baseband processor, comprising: one or more processors configured to: receive, from a base station operating as a transmission and reception point (TRP), configuration information for performing group-based beam reporting (GBBR); determine, based on the configuration information a maximum receive timing difference (MRTD) based on a plurality of reference signals (RS), each RS of the plurality of RS being received from a different TRP; and instruct a transceiver to transmit, to the base station, the MRTD in accordance with performance of the GBBR.
9. The baseband processor of claim 8, wherein the GBBR comprises one or more pairs of RS identifiers, each RS identifier of the one or more pairs of RS identifiers corresponding to a RS of the plurality of RS, each of the one or more pairs of RS identifiers being identified by the baseband processor for simultaneous reception.
10. The baseband processor of claim 9, wherein the GBBR further comprises a MRTD measurement associated with each of the one or more pairs of RS identifiers.

11. The baseband processor of claim 10, wherein the MRTD measurement comprises a determination of whether MRTD is greater or less than a corresponding cycle prefix (CP).
12. The baseband processor of claim 11, wherein the GBBR comprises a first GBBR part comprising RS pairs that satisfy MRTD greater than the corresponding CP.
13. The baseband processor of claim 12, wherein the GBBR comprises a second GBBR part comprising RS pairs that satisfy MRTD less than the corresponding CP.
14. The baseband processor of claim 8, wherein the configuration information includes an instruction to perform a MRTD measurement.
15. A method at a user equipment (UE), the method comprising: receiving, from a base station operating as a transmission and reception point (TRP), configuration information for performing group-based beam reporting (GBBR); determining, based on the configuration information a maximum receive timing difference (MRTD) based on a plurality of reference signals (RS), each RS of the plurality of RS being received from a different TRP; and communicating, to the base station, the MRTD in accordance with performance of the GBBR.
16. The method of claim 15, wherein the GBBR comprises one or more pairs of RS identifiers, each RS identifier of the one or more pairs of RS identifiers corresponding to a RS of the plurality of RS, each of the one or more pairs of RS identifiers being identified for simultaneous reception.
17. The method of claim 16, wherein the GBBR further comprises a MRTD measurement associated with each of the one or more pairs of RS identifiers.
18. The method of claim 17, wherein the MRTD measurement comprises a determination of whether MRTD is greater or less than a corresponding cycle prefix (CP).
19. The method of claim 18, wherein the GBBR comprises a first GBBR part comprising RS pairs that satisfy MRTD greater than the corresponding CP and a second GBBR part comprising RS pairs that satisfy MRTD less than the corresponding CP.
20. The method of claim 15, wherein the configuration information includes an instruction to perform a MRTD measurement.